ECOLOGICAL STUDIES ON JHUM FALLOWS OF BYRNIHAT (MEGHALAYA) WITH PARTICULAR REFERENCE TO SOIL FAUNA

by

PRAMOD KUMAR VATSAULIYA, M. Sc.

DEPARTMENT OF ZOOLOGY

SCHOOL OF LIFE SCIENCES

SUBMITTED IN FULFILMENT OF THE REQUIREMENT OF THE DEGREE OF

DOCTOR OF PHILOSOPHY

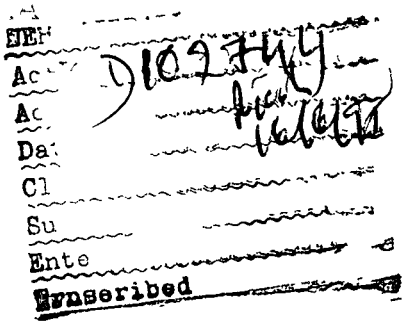
TO

THE NORTH-EASTERN HILL UNIVERSITY

SHILLONG - 793001, INDIA

JULY, 1981

DS
631.5810954164
VAT;1



phone :
Grams · NEHU

North-Eastern Hill University

Lower Lachaumiere, Shillong - 793001 (Meghalaya)

Dr. J.R.B. Alfred,
Reader

Department of Zoology,
School of Life Sciences,
Shillong-793014.

I certify that the thesis entitled "Ecological Studies of Jhum-fallows of Byrnihat (Meghalaya) with particular reference to soil fauna", submitted by Mr. Pramod Kumar Vatsauliya for the Degree of Doctor of Philosophy of the North Eastern Hill University, Shillong embodies the record of original investigation carried out by him under my supervision. He has been duly registered and the thesis presented is worthy of being considered for the Award of Ph.D. Degree. This work has not been submitted for any Degree of any other University.

DATED : 31st July 1989
PLACE : SHILLONG.

Signature of the Supervisor.

ACKNOWLEDGEMENTS

I take this opportunity to express my gratitude to Dr. J.R.B. Alfred, my mentor, for his optimism, creativity and needed support, more so, for his constant encouragement and direction throughout my work. Gratitude is expressed to Prof. M.K. Khare, Head of the Department of Zoology for his making available necessary facilities. I am indebted to my mother, Mrs. Sarwati Singh who encouraged me in the present undertaking. To Mr. Khambor Tariang, I am grateful for his help in the typing of the manuscript. Thanks are expressed to Dr. Keiko Niijima, Japan Forest Station for the identification of the Collembola species.

The investigation was possible due to funding from the Department of Science and Technology, New Delhi (Project M & B).

P Vatsauliya 30.III.81

(Pramod Kumar Vatsauliya)

CONTENTS

....

PLATES

FIGURES

TABLES

GENERAL INTRODUCTION

GENERAL INTRODUCTION

Soil fauna and its studies are a relatively recent field in biology, not only in the temperate latitudes but more so in tropics. Other than the initial general studies today the interaction and interrelationships of soil fauna and its habitats is seen from the Anthropogenic gradient. This relates to the study, taking "natural" as baseline ecosystems, the measurements of dynamic aspects of soil faunal variables, in systems which are subjected to either agricultural activities or to degrees of manipulation and perturbation by the impact of man. This was what is referred to as "rule of the zonal change of strata" (Ghilyarov, 1964). Studies on the ecology of the soil invertebrates, though have been undertaken in the humid tropics (Dammerman, 1945; Williams, 1947; Beak, 1962; Maldague and Hilger, 1963; Toye, 1967; Madge, 1969; Fittkau and Klinge, 1973), yet only that of Lasebikan (1975) is directly concerned with the impact of agricultural practices on the soil fauna. Other than the above studies on the immediate effects on land usage, interest in the restoration of severely damaged landscape is of very recent time, primarily due to increasing human populations and the threat of nuclear devastation.

With this background in mind the present study was undertaken to see the effects of excessive land use on soil faunal dynamics in tropical environments of this part of the world, particularly to aspects of recycling, succession and stabilization of soil fauna in lands left fallow after intensive agriculture for a number of years. The uniqueness of the situation was that these fallow lands were the results of shifting cultivation, as

practiced in many regions of the world. Shifting cultivation, though is regarded as the primitive agricultural systems of the tropics, it is not only confined to tropics, but elsewhere also in the world. In these regions of North-Eastern India, shifting cultivation is referred to as "Jhumming" where farmers move their homes and settlements as well as the fields they cultivate, at frequent intervals (UNESCO, 1952). Jhumming, as for general shifting cultivation involves a similar clearing of the forest by felling, logging and finally burning the undergrowth, then ploughed for agriculture (Plates 1,2,3). Hence it is frequently called as "Slash and burn" agriculture referred to as Swidden farming (Ekwall, 1955). Many studies have existed on the immediate effects of disturbing the ecosystem by either burning, logging or agriculturing (Nye and Greenland, 1960). However very little if at all exist on the land after such usage and the agricultural yield falls well below the inputs when it is left abandoned or fallow for a number of years. It is with this reason, that we were interested in such fallows left abandoned for a considerable time, to investigate the influences of soil fauna and soil on one another on an ecological approach. This was primarily due to the fact that land after cultivation, when abandoned, the life forms passes through several secondary successional stages with acute competition of elimination of undesirable species all directly correlated to the length of the fallow period.

The present investigation was taken up therefore on abandoned fallows of different ages from a period of one year to twenty years. It was seen in these fallows the general population dynamics of various groups of soil fauna in relation to the age of these fallows and to identify the colonization and successional

trend if existing in relation to the general physical factors of the environment and chemical nature of the soil. In addition to find out whether the biology and the nutrition affects the soil fauna for dominant species of Collembola, two from the youngest aged fallow and two from the oldest aged fallow were taken up for detail study. The second aspect therefore deals with these four species life history studies under the impact of various combinations of three environmental factors like temperature, pH and salinity, helping in the identification of the fecundity and mortality, therefore the population status comparable to the field. The third investigation was directed to the understanding of the nutritional status of these same four species and compared with field. This was thought to help in finding out the strategies involved in the life history processes and therefore the population dynamics in relation to either the abundants and scarcity of food resources studies.

The study though was aimed at the academic understanding of such disturbed ecosystems, yet it was thought to bring recommendation of land use practice based on such studies to the regional government.

Plate 1a : Showing the cut down branches and stems of trees and bamboos. The process of logging.

Plate 1b : Showing fire in action burning the undergrowth.

Plate 2a : Showing the total area after the fire has consumed the undergrowth leaving behind the grey-ash.

Plate 2b : Showing the same area cultivated with Rice.

Plate 3 : Showing a typical fallow land after 2 or 3 years of cultivation.

REFERENCES

Beck, L.	1962	Zur Okologie und Taxonomic der tropischen Bodentiere. 1. Zur Oribatiden fauna Perus. Thesis, Braunschweig.
Dammerman, K.W.	1925	First contribution to a study of the tropical soil and surface fauna. Treubia, 6 : 107-139.
Ekwall, E.	1955	Slash and burn cultivation a contribution to anthropological terminology. Man, 55 : 135-136.
Fittkau, E.J. & H. Klinge	1973	On biomass and trophic structure of the central Amazonian rain forest ecosystem. Biotropica, 5 : 2-11.
Gilyarov, M.S.	1964	Opreditel obitayushchikh V pochve lichinok harekomykh, Akademiya Nauk, SSSR, Moskva, 919 p.
Lasebikan, B,A.	1975	The effect of clearing on the soil arthropods of a Nigerian rain forest Biotropica 7 : 84-89.
Madge, D.S.	1965	A study of arthropod fauna of four contrasting environments. Pedobiologia 5: 289-303.
Maldague, M.E. & F. Hilger	1963	Observations faunistique et microbiologique dans quelque biotopes forestiers equatoriaux. In: Doeksen & J. Van Der Drift eds. Soil organisms. North Holland Publ. Co. Amsterdam.
Nye, P.H. & D.J.Greenland	1960	The soil under shifting cultivation. Commonwealth. Agricultural Bureaux Farnham, Royal Bucks. England. 156 p.
Toye, S.A.	1967	Observations on the biology of three species of Nigerian millipedes. J. Zool. Lond. 152 : 67-78.
UNESCO.	1952	Report of the Commission on World land use survey for the Period 1949-1952. UNESCO, Worcester.
Williams, D.E.	1966	Slash burning research. British Columbia. Lumberman, June 1966. 32-41.

STUDY AREA

LOCATION

Byrnihat (Meghalaya State) at 100 m asl; (Latitude 26°02' and 30"; Longitude 91°52'), situated approximately 90 kms from Shillong and 14 kms from Gauhati on the main Gauhati-Shillong trunk road (Fig. 1) was chosen as the main study area. Four different study sites from this region were taken up. These were fallows left after Jhumming cultivation was over for a specific period of time. In this respect the study sites in the general study area was chosen on the basis of one year fallow till 20 year fallows (1 yr, 5 yr, 10 yr and 20 yr) (Plates 4a,5a,6a & 7a).

ORIGIN

Physiogeographically the Assam divisions are the narrow Brahmaputra valley behind the Arunachal-Himalayan area in the North and North-Eastern region, Patkai-Naga Hills in the East and the Lushai Hills and Shillong plateau in the South. The Surma river is led by the numerous small tributaries from Shillong plateau and North Cachar Hills. The Surma valley occupies a triangular area between Meghalaya on the West, North Cachar and Manipuri Hills to the East and Mizoram and Tripura Hills on the South. The valley is peculiarly low lying with swamps and perfected level of aluvial flats stretching upto the base of the steep rocky enscapment of the Shillong Plateau. The river and tributaries only for a short distance have a steep fall in shallow and variables beds over the coarse debris brought down by them. They lose all perceptible falls and became tortuous anastomosing water channels. The drainage pattern over the Mikir Hills is similar to that over the Shillong Plateau.

The present changes of the Brahmaputra valley is the result of uplift and subsidence of different blocks of the precambian crystalline, the remnant of which is now represented by the Mikir Hills (Assam) and Shillong Plateau (Meghalaya).

THE SOIL ENVIRONMENT

Soil is lateritic brown or orange brown in colour. It is generally acidic. The characteristic of soil in the different sites are shown in Table-I for all the four sites. Further their profiles are shown in Plates 4b, 5b, 6b and 7b.

VEGETATION

At all the experimental sites mostly Dendrocalamus hamiltonii was found. Table-II presents the vegetation in the different sites with a comparison of dominance of each species.

CLIMATE

The region experiences a sub-tropical monsoon climate, the summer temperatures reaching 35°C and mean winter temperatures falling upto 15°C. The frost was observed sometimes in winter early in the morning. The maximum precipitation was observed from May to August ranging from 70.0 to 355.0 cm, showing an average of 125 cms monthly.

Fig. 1 : Showing the map of Meghalaya and the location of study area (Byrnihat).

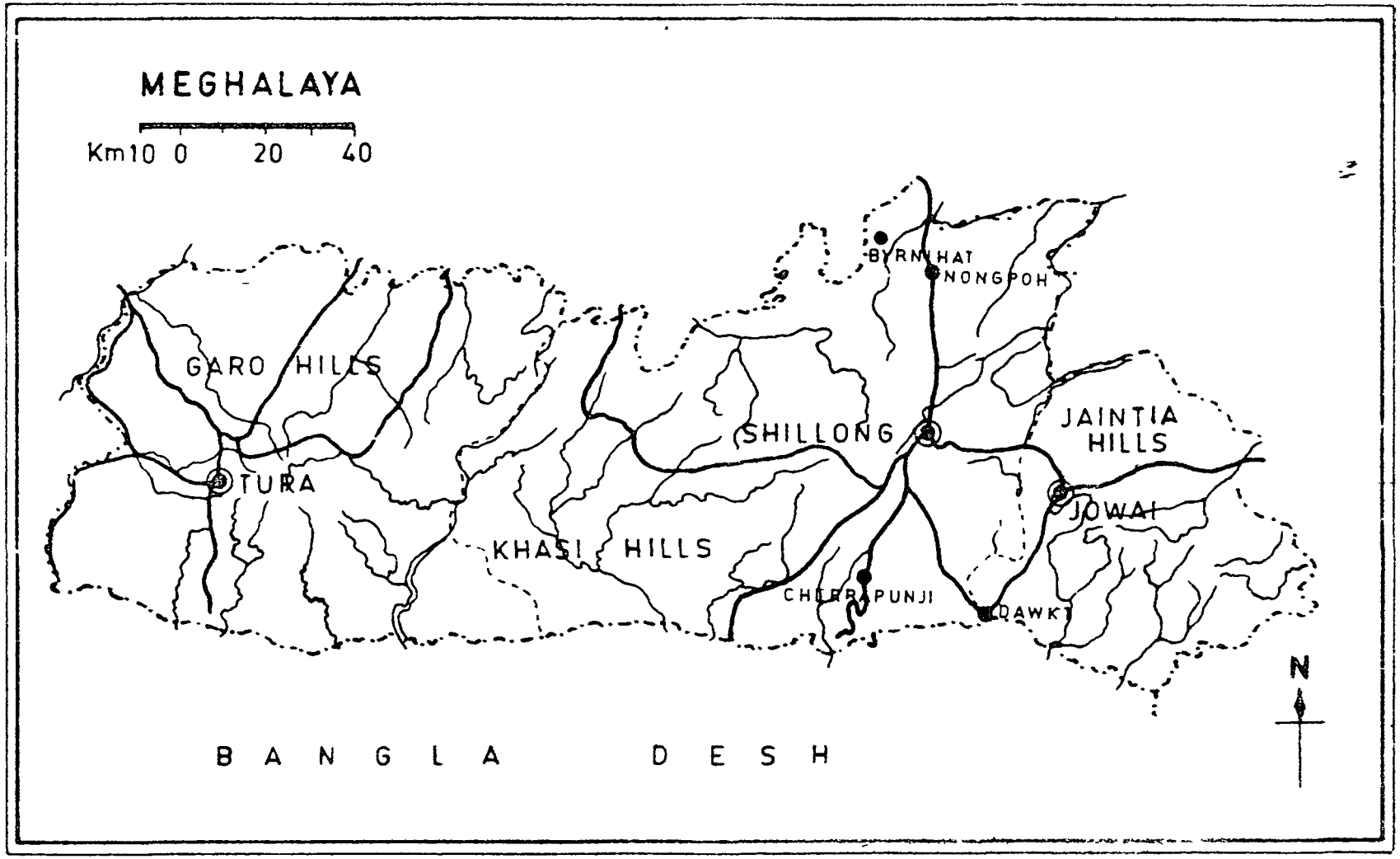

MEGHALAYA
Km10 0 20 40
BYRNIHAT
NONGPOH
GARO HILLS
SHILLONG
JAINTIA HILLS
TURA
JOWAI
KHASI HILLS
CHERRAPUNJI
DAWKI
N
BANGLA DESH

Plate 4a : Showing the study site of the youngest fallow (1 year old), referred to as study site A in the text.

Plate 4b : Showing the soil profile in the same study site.

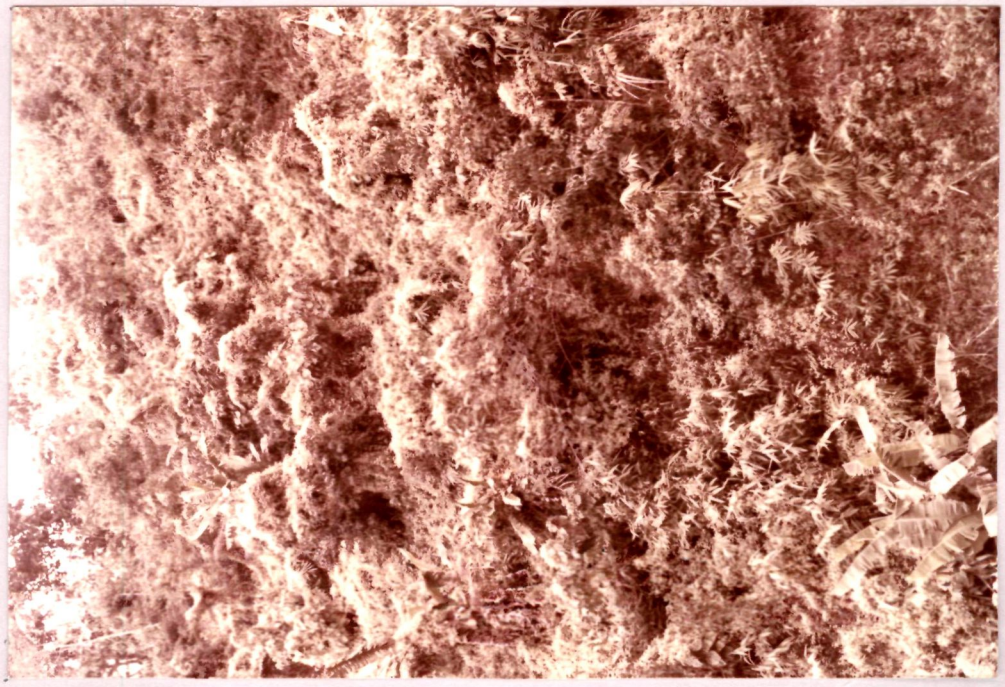


Plate 5a : Showing the study site of the middle age fallow (5 years old), referred to as study site B in the text.

Plate 5b : Showing the soil profile in the same study site.

Plate 6a : Showing the study site of the middle age fallow (10 years old), referred to as study site C in the text.

Plate 6b : Showing the soil profile in the same study site.

Plate 7a : Showing the study site of the oldest fallow (20 years old), referred to as study site D in the text.

Plate 7b : Showing the soil profile in the same study site.

Table I : Showing the soil types and texture in the four different study sites.

TABLE-I

Morphology	Site A	Site B	Site C	Site D
Type	Lateritic	Lateritic	Lateritic	Lateritic
Colour	Yellowish brown	Brown	Reddish brown	Dark brown
Texture	Sandy loam	Sandy loam	Coarse sandy loam	Fine sandy loam
Structure	Nutty	Blocky	Granular	Granular
Gravity	Higher	Lower	Lower	Lower
Porosity	More	More	Less	Less
pH	Mostly acidic occassionally alkaline	Acidic	Acidic	Acidic

Table II : Showing the vegetation at the four different study sites and their dominance.

TABLE-II

Species	Site A	Site B	Site C	Site D
Ageratum conyzoides Linn	+++	-	-	-
Arundinella bengalensis (Spreng.) Druce	++	+++	-	-
Bauhinia variegata Linn	++++	-	-	-
Borreria hispida (Linn) K.Schum	+	++	++++	-
Cyperus globosus Allioni	++	+++	++++	++++
Carex cruciata Nees	-	++	++++	++++
Careya arborea Rox.	++	-	++++	++++
Callicarpa tocna Roxb.	+	++	+++	++++
Combretum decandrium Roxb.	+	+	++	++
Desmodium triquetrum DC.	++	++++	++++	++++
Dendrocalamus hamiltonii Nees & Arn.	++	++++	++++	++++
Dillenia indica Linn.	+	+++	-	++++
Eupatorium odoratum Linn.	++++	++++	++	++
Eugenia tetragona Wight	+	++	++	+++
Ficus hispida Linn.	++	-	++++	++++
Gregia elastica Royle	++	-	-	-
Litsala assmica H.R.F.	+	-	++	-
Mikania micrantha H.B. & SK.	+	-	++	-
Imperata cylindrica (L.)Beaure	++++	++++	-	-
Macaranga denticulata Muell.	++	+++	-	++++
Melia azadirachta Linn.	-	+	+	-
Machillus khasyana Meissn.	+	-	-	++
Maesa indica Wall.	+	++	++	-
Osbeckia crinita Benth.	++	-	-	-
Panicum maximum Jacq.	++	+++	++++	++++
P. khasianum Munro	++	+++	-	-
Setaria tessellata Willd.	-	++	++++	++++
Schima wallichii Chois	++	-	++++	++++
Sapium buccatum Roxb	+	-	++	+++
Thysanolaena maxima Kuntze	++	+++	-	-
Vitex peduncularis Wall	++	+++	++++	-
V. glabrata Br.	++	+++	++++	++++

++++ = highly dominant; +++ = dominant; ++ = poorly dominant;
+ = present; - = absent

POPULATION DYNAMICS

INTRODUCTION

The purpose of the present work was primarily directed towards the understanding of the nature and biology of soil-fauna in these regions where land pressure and usage is very high. At the outset it is advisable to indicate that soil fauna as implied by us, are those soil animals which pass one or more active stages wholly or largely either in soil or litter (Drift, 1951). Though our studies have been confined to the soil layers, it is understood that the faunal elements are those which move either between the litter and the soil layers or within the soil layers themselves

For the sake of convenience, though several methods exist, for the classification of soil fauna, other than their systematic arrangements (Haarlov, 1960; Kevan, 1962), we have followed the body size as the main criteria after Wallwork (1970). Hence those soil fauna which range between 20 u and 200 u as microfauna, those between 200 u and 1 cm as mesofauna and finally those greater than 1 cm as macrofauna. If so, from our collections, microfauna included Protozoa and prostigmatid mites, mesofauna comprised of mesostigmata, cryptostigmata, astigmata, collembola, araneida, chelonethi and isopoda, while macrofauna included all the soil insects (Dermaptera, Coleoptera, Hymenoptera, Hemiptera, Lepidoptera, Diptera, Orthoptera and Thysanoptera), Myriapods (Symphyla, Chilopoda and Diplopoda), Mollusca and Annelida.

Soil fauna and their scientific studies was developed as a discipline very recently though general observations on them have been in existence since White (1789) who did throw some light on earthworms and mole-crickets. The earliest foundations laid towards the understanding of soil fauna were those of Darwin (1840,

1881) and of Miller (1879, 1884), though they had restricted themselves primarily to the role of earthworms in humus formation. The place of honour as the pioneer in the general study of soil fauna goes to Diem (1903) when he worked with certain Swiss alpine soils

It was not untill the first half of the present century that far reaching results based on the general studies of soil fauna was available. The earliest of these were those of Bornebusch (1930); Frenzel (1936); Joffe (1936); Forsslund (1945) and Kubiena (1948). A treatise by Gilyarov (1949) appeared at the end of the present half century. The discreet discipline of soil zoology took shape perhaps from the beginning of the second half of the present century. It was in fact at the beginning of the second half century when Kuhnelt (1950) published what was known about soils animals in a single volume, Bodenbiologie and Franz (1950) whose publications emphasized the practical implications of the study of soil fauna again in a single volume, Bodenzoologie. Simultaneously a year later Delamore Deboutteville (1951), Hartmann (1951) and Drift (1951) brought out works on tropical soils, classification of forest soils, and in the tradition of Bornebusch respectively. All were based on the influence and activity of soil animals. Ever since, soil fauna and its research has been persued by a logarithmic increasing number of investigators with vigour as had not existed earlier exclusively in this field of study.

It was in the next ten to fifteen years when soil biology as a distinct discipline was available in text-book form. Landmarks in this maturation process were symposia denoted entirely to soil animals held in a number of places. The major works and the coming in of the reviews were done in the years around 1952 to 1967. Those which take the pride of places were Lawrence (1953),

Eglitis (1954), Kevan (1955a, 1960, 1961, 1962), Kuhnelt (1957, 1961, 1963), Nosek (1957), Farb (1959), Kipenvarlitz (1961), Murphy (1962), Schaller (1962), Delamare Debotteville and Rapoport, (1962, 1963), Doeksen and Van der Drift (1963), Dunger (1964), Gilyarov (1964), Burges and Raw (1967) and Graff and Satchell, (1967). It was again during this period that the creation of international Journal of Soil Biology, Pedobiologia in 1961 which served as an important media of exchange of ideas was brought out.

All the above, though are collections of research reports and extremely valuable reference works, they do not qualify as textbooks in the conventional sense. Those which came out with increasing recognition to the soil fauna were also during the fifties and middle sixties such as Kubiena (1953), Sharma and Kevan (1953b,c), Handley (1954), Wilde (1954), Tischler (1955), Macfadyen (1957, 1963), Russell (1957), Balogh (1958), Wallwork (1958), Takeda (1979) and Wiggin et.al. (1979). The relative increase in publication during this period could be traced to the availability and improved techniques of soil arthropod sampling. Some of the important techniques were those of Murphy (1952, 1955), Haarlov and Weisfogh (1953), Macfadyen (1953, 1955, 1961), Alexander and Jackson (1955), Schuster (1956), O'Connor (1957), Heydemann (1958), Averback and Crossley (1960a, 1960b), Tribe (1960, 1961), though most were the improvement and modifications of Tullgren (1918).

In addition to those which have been mentioned above on general soil fauna, literature exists for micro, meso and macro soil fauna separately. Those of importance for microfauna are the works of Carpenter (1897, 1906, 1907, 1908, 1911, 1913), Halbert (1915, 1920, 1923), Lawrence (1961). Those who studied the vertical distribution of microfauna and attributed its occurrence to the upper layers of the soil were Drift (1951), Riha (1951),

Macfadyen (1952), Wallwork (1959), Haarlov (1960), Lebrun (1965) and Anderson (1971). Microfauna and its relation to abiotic factors affecting their distribution seasonally have been studied by Ford (1937), Strickland (1947), Drift (1951), Lawrence (1953), Karppinen (1955), Belfield (1956, 1967), Sheals (1957), Wallwork (1959, 1967, 1970), Haarlov (1960), Hale (1967), Tarras-Wahlberg (1961), Aucamp and Ryke (1965), Di Castri,(1973), Price (1973, 1975) and Mitchell (1977). Correlations of soil microfauna with that of soil fertility and their impact on soil formation indicative of soil quality have been studied by workers like Bornebusch (1930), Edwards and Heath (1963), Balogh (1963), Gilyarov (1965), Burges (1967), Karg (1968) and Fujikawa (1970a, 1970b).

However, most of the work in soil fauna have been largely confined to studies on soil mesofauna, in general and Collembola and Acarina in particular. Some of the important works on Collembola are studies in relation to their population density, seasonal fluctuation and in particular their abundance as related to soil moisture content are those of Agrell (1941), Gisin (1943, 1952, 1960), Hammer (1934, 1937, 1953), Stach (1947), Strenzke (1949a, 1949b), Salmon (1951, 1956), Maynard (1951), Nosek (1952), Salt (1952, 1955), Macfadyen (1954, 1963), Murphy (1955), Kitazawa (1962), Milne (1962), Pitelka (1964), Kevan (1962), Mina (1962), Drift (1963), Di Castri (1963a), Christiansen (1964), Dunger (1964) Torne (1965), Ogino et. al. (1965), Witkamp and Crossley (1966), Hale (1966a,b), Naglitsch (1966), Hermosilla and Murua (1966), Poinsot (1968), Wise (1967), Choudhury and Roy (1967), Stebaeva (1967), Greenslade and Greenslade (1968), Joosse (1968, 1969b), Usher et. al. (1970), Marcuzzi et. al. (1970), Wood (1970), Di Castri et. al. (1971), Niijima (1971, 1973), Kaczmarek (1973) and Davidson (1979).

Work on acari and in particular most of the mites either free living in soil or litter inhabiting have been done by Baker and Wharton (1952), Dunger (1956, 1958), Stockli (1957), Stammer (1957, 1959, 1963), Hirschmann (1957), Schuster (1958), Baker et al. (1958), Hughes (1959), Evans et. al. (1961), Poole (1961), Kevan (1965), Wallwork (1967, 1976), Usher (1967, 1975), Fuzikawa (1970a,b,c), Butcher et. al. (1971), Price (1973, 1975), Webb and Eimes (1973), Pande and Berthet (1975), Price and Benham (1977) and Aitchen (1979).

Among the less represented groups of mesofauna are those of Spiders, Chelonethi, Diplura, Protura and Isopoda, though have been shown in many of the general soil fauna papers in relation either to their abundance or seasonal variations yet there exist literature on the works of some of these lesser represented mesofauna like Diplura, Protura. Work on their taxonomy and ecological studies in relation to species density and distribution have been done by Godfrey (1910), Tuxen (1949), Browney (1954), Paclt (1956), Raw (1956), Ressl and Beier (1958), Sturm (1959), Engelmann (1961), Gasdorf and Goodnight (1963), Gabbutt and Vachan (1963, 1965, 1967) and Gabbutt (1967).

Macrofauna as has already been mentioned earlier are those which are greater than 1 cm body size. Though the present study includes almost all insect orders available, myriapods (Symphyla, Chilopoda and Diplopoda), mollusca and annelids, yet even some mammals could be included (Wallwork, 1970). Extensive work in macrofauna have been on annelida and ants, followed closely by Hymenoptera. Taxonomical work on soil macrofauna, their sampling techniques and ecological studies in particular to earthworms have been done by Nielsen, 1955a, 1955b), Peachey (1962, 1963), Satchell (1963, 1967), Gerard (1964, 1967), O'Connor (1957, 1958, 1967)

and Huhta (1979). Important work on termites have been done by Gilyarov (1949, 1964), Snider (1949, 1956, 1961). Soil inhabiting diptera have been described by Drift (1951), Brauns (1954, 1955), Schuster (1958), Thiele (1959), Kuhnelt (1961), Freeman (1967), Altmuller (1979) and Coleoptera by Coiffait (1958) and Raw (1967). The distribution of slugs and snails in the soil have been done by Drift (1951), Quick (1960), Lozek (1962), Janus (1965) and Newell (1967). The taxonomy and ecology of isopoda and their seasonal fluctuations and distributional patterns can be found in the works of Hatchett (1947), Palmen (1951), Edney (1953, 1968), Dunger (1958) and Frankel (1979). Similar works on Chilopoda and Diplopoda have been by Verhoeff (1928, 1932, 1934a), Manton (1954), Blower (1955), Eason (1964) and Loksiva and Golovatch (1979). Works on ants are probably only second to those available on Collembola and Acari. Most ecological studies in relation to mark-recapture methods and estimation of population density along with their seasonal fluctuations have been done by Holt (1955), Odum and Pontin (1961), Baroni-Urbani (1963, 1969), Abe (1971), Petal (1972, 1974), Galle (1972), Nielsen (1972), Hemmingsen (1973) and Hunt (1974). The larvae of lepidoptera and their effect on vegetation have been shown by Brenchley (1935, 1969) and Williams (1974).

In contrast to the abundant literature available for the temperate regions of the world very little is available to the extent one would like to have for tropical conditions. Some of the relevant works of South-Africa includes those by Den Heyer and Ryke (1966), Loots and Ryke (1967), Van der Berg and Ryke (1967, 1968), Greenslade and Greenslade (1968), Greenslade (1969) and Theron and Ryke (1969). Drift (1963), has made far reaching results by providing data to prove that very little significant differences exist between tropical and temperate regions after his

work in Surinam. Some of the early tropical ground fauna density have been studied by Beebe (1916), Dammerman (1925, 1937), Williams (1941), Strickland (1945, 1947). Salt (1952, 1955) along with Drift (1963) and Raw (1967) have the recent figures for soil faunal densities under tropical conditions.

With this in background it can be seen that even much less work has been done on soils from the Indian sub-continent. Though the first work in India can be traced to Trehan (1945) where he related the seasonal fluctuations of soil-microfauna with some abiotic factors in Lyallpur now in West Pakistan. It was not until nearly two decades after Trehan's work that Indian Scientists had contributed to our understanding of the soil fauna and its relationship to the environment, These include works of Choudhuri and Roy (1967, 1970, 1971a, 1972), Baduri and Raychoudhury (1968), Mukerjee and Singh (1967, 1970, 1976); Singh and Mukerjee (1971, 1973), Prabhoo (1971, 1972, 1976), Singh and Pillai (1975a), Singh and Singh (1975), Gupta and Mukerjee (1976a, 1976b) and Veeresh (1974, 1977, 1979). All these have been confined primarily to the Peninsular India and there has not been any work in existence till the late seventies for the North-Eastern Regions of India and in particular to the Hilly terraces. The works of Reddy and Alfred (1977a, 1977b, 1978), were probably the first of its kind for these regions though confined to pine-forest floors, Therefore, rather than a typical tropical condition their work was more of a sub-tropical nature, or more so in an ecotone-belt between the temperate and tropical conditions. The only available work under real tropical conditions for North-East India is that Vatsauliya and Alfred (1980) for bamboo forest floors and Darlong and Alfred (1981) for different altitudes in the same regions.

The aim of our present work was not only to identify the

ecological characteristics of the soil faunal elements in this region of the world but also to find out the successional pattern of these soil faunal elements under stress due to the pressure on the land. In addition, our aim was to identify the exact time for the total colonization of the original soil fauna, after the land has been allowed to lie fallow for recuperation, after jhum cultivation. Though literature abounds in slash burning and shifting cultivation very little exist on the understanding of the soil fauna under these peculiar conditions. The nearest to such conditions like the effect of fire on soil fauna have been studied by Pearse (1934), Heyward and Tissot (1936), Macfadyen (1952), Terrant (1956), Ahlgren and Ahlgren (1960), Bennet (1960), Smith (1962), Berthet (1963), Moritz (1965), Williams (1966), Buffington (1967), Huhta et. al. (1967, 1969), Metz and Farrier (1971, 1973) and Critchley et. al.(1979). However, the practical implication of shifting cultivation on soil fauna was done by Strickland as early as 1947. The nearest to such a work was available only in the context of logging and slash-burning affecting the soil acari and Collembola populations in coastal British Columbia (Vlug and Borden, 1973). A similar work under tropical conditions at the foothills of Meghalaya (N.E. India) is available from our study (Vatsauliya and Alfred, 1980).

The present study though has its own academic understanding of the ecosystem under consideration, one of the major aims of the work was to arrive at concrete recommendations for the local government.in relation to the land usage pattern based on soil fauna. This is obvious as soil fauna play a major role in soil fertility and help in restoration of overused land to conditions of utility.

MATERIALS AND METHODS

Soil samples were regularly collected for a period of 24 months, beginning from January, 1978 till December, 1979 at monthly intervals from each site in four different age fallows (Sites A,B,C,D). In each site, 96 sub-plots of 1X5 m^2 were demarcated and each time replicate samples were taken. Soil from each sub-plot was removed with a rectangular iron sampler (5X5X10 cms). Such samples were taken from four different depths of 0-10 cm, 10-20 cm, 20-30 cm and 30-40 cm from each sub-plot at each site. Hence each soil sample was 250 cu. cm from each site and comprised of four soil-layers with a total of 384 soil samples were collected from each site, throughout the study period. Therefore a total of 1536 soil samples were collected from all the four different sites throughout the period of investigation.

All the soil samples were collected during the morning hours between 0800 and 1100 hrs. On collection of soil samples from the field, they were immediately transferred into individual polythene bags, labelled and packed to prevent loss of moisture as far as possible. Such labelled soil samples were transferred to the laboratory from the field within four hours. Two samples out of the replicate soil collections were pooled and extracted under large modified dry Tullgren Funnel series at 40°C (Macfadyen, 1955; Southwood, 1966) with 100 W lamps for seven days. The third soil sample was used for protozoa by the Berlese floatation techniques (Berlese, 1905). The fourth soil sample was used for the moisture content, measured by dry weight method (Niijima, 1971), pH by pH meter (Toshniwal No. CE.43), conductivity by Conductivity Bridge (Elico CM-82), the latter two by the help of soil suspensions. Bulk density and soil porosity were measured after Keen (1931),

and finally the chemical factors like organic carbon, nitrogen, phosphorus and potassium after Walkey and Black (1934). All the above starting from the extraction for larger groups, protozoa and the physico-chemical parameters were done for all the four different soil layers in four different sites in duplicate and the mean values are presented in the results, where these were converted for the soil fauna into an area of m^2.

Further at the time of collection in the field both air temperature and soil temperature were recorded. Air temperature was recorded at each site at about 1 m above each sub-plot using an ordinary mercury thermometer. The soil temperature was measured by placing the soil thermometer a few centimeters into each soil layer in different sub-plots at the different sites.

RESULTS

The present work was carried out for a period of two years beginning January, 1978. The results obtained in the different fallows of one, five, ten and twenty year old, at the time of the initiation of collection, becomes during the second annual cycle as two, six, eleven and twenty-one year old fallows respectively. These are, therefore, referred to hereinafter for sake of convenience and easy interpretation as sites A,B,C and D in accordance to the age of the fallows, with four depth layers of soil at each site.

On a general comparison between the four sites (Table-III), it revealed that there was a consistency of total soil fauna present in each site for both the years under study. There was however a definite pattern in their abundance during both the years, in that, site B recorded the lowest ($1,758 \times 10^2/m^2$ (1978), ($1,850 \times 10^2/m^2$ (1979) and site D the highest ($22,448 \times 10^2/m^2$ (1978), ($23,384 \times 10^2/m^2$ (1979). A similar pattern as seen in the total soil fauna was observed for total mesofauna, when a categorization was made into micro-, meso and macrofauna. This is understandable, primarily due to the fact as clearly seen from Table-III that the abundance of total mesofauna (nearly 60%) affects the total soil-faunal pattern.

While considering the different major groups among total soil fauna, it was seen that microfauna in both the years was nearly consistent in their number for each site undertaken. However, they revealed a minimum number in site B and maximum in site D. But when their relative percentage abundance was considered it was seen that though the lowest was again recorded in site B, the highest however was seen to be in site C for both the

years of study. As in case of microfauna the numbers recorded for mesofauna were also similar during both the years of investigation for each site considered, recording minimum again in site B and maximum in site D. However, unlike microfauna, while the relative percentage abundance of mesofauna was considered, it was seen that their maximum relative abundance was in site A and minimum in site D for both the years. Further, though, the numbers remained more or less constant for both the years, the relative percentage abundance dropped by nearly 3% in the second year of study in all the sites. The third and last major group, the macrofauna unlike the other two earlier groups did not show a consistency in their numbers for the two years under study in any of the sites. In fact they revealed an increase in their numbers of nearly 800 to $900 \times 10^2/m^2$ during the second year of study. The minimum numbers recorded for macrofauna was seen to be in site A for both the years of study, while the maximum was recorded in site D. A similar pattern was also seen when the relative percentage abundance was considered. Moreover the increase in numbers from the first to second year was nearly 3% increase in all the sites for total macrofauna (Table-III).

While considering the different depths at the different sites, it was seen that there was a steady decrease in the total soil fauna as one goes from the top to the bottom layers of the soil. This was seen in all the sites for both the years. Further, it was seen that, though there existed minor variations in the actual numbers present, while considering the two annual cycles at the different depths in all the sites, there was a clear consistency in their percentage composition for all the depths in all the sites for both the years when each depth and each site was compared with one another. The change of about 29% to 33% was seen

Table III : Showing the total number of soil fauna, microfauna, mesofauna and macrofauna and their percentages for the total study period in the four different sites for each annual cycle.

TABLE III

Site	Total microfauna		Total mesofauna		Total macrofauna		Total soil fauna	
	1978	1979	1978	1979	1978	1979	1978	1979
A	1080 (5.26)	1080 (5.03)	13498 (65.72)	13582 (63.28)	5960 (29.01)	6800 (31.68)	20538	21462
B	840 (4.78)	844 (4.56)	10756 (61.17)	10784 (58.29)	5988 (34.05)	6872 (37.15)	17584	18500
C	1092 (5.50)	1092 (5.28)	12108 (60.97)	12040 (58.23)	6660 (33.53)	7544 (36.49)	19860	20676
D	1136 (5.06)	1140 (4.88)	13524 (60.25)	13532 (57.87)	7788 (34.69)	8712 (37.26)	22448	23384

Table IV : Showing the total number of soil fauna, microfauna, mesofauna and macrofauna and their relative percentages for the total study period in the four different study sites at four different depths for each annual cycles.

a : Numbers and percentages among themselves.

b : Percentages in total soil fauna.

I : 0-10 cms
II : 10-20 cms
III : 20-30 cms
IV : 30-40 cms

TABLE IV

SITES		TOTAL MICROFAUNA				TOTAL MESOFAUNA				TOTAL MACROFAUNA				TOTAL SOIL FAUNA	
		1978		1979		1978		1979		1978		1979		1978	1979
		a	b	a	b	a	b	a	b	a	b	a	b	a	b
A	I	388 (35.90)	6.53	388 (35.93)	6.32	3996 (29.60)	67.18	4016 (29.57)	65.41	1564 (26.25)	26.29	1736 (25.53)	28.27	5948 (28.96)	6140 (28.61)
	II	364 (33.70)	6.34	364 (33.70)	6.12	3640 (26.97)	63.46	3660 (26.95)	61.53	1732 (29.06)	30.20	1924 (28.29)	32.35	2736 (27.93)	5948 (27.71)
	III	148 (13.70)	3.08	148 (13.70)	2.92	3130 (23.19)	65.07	3174 (23.37)	62.75	1532 (25.70)	31.85	1736 (25.53)	34.42	4810 (23.42)	5058 (23.57)
	IV	180 (16.67)	4.45	180 (16.67)	4.17	2732 (20.24)	67.56	2732 (20.11)	63.30	1132 (18.99)	27.99	1404 (20.65)	32.53	4044 (19.69)	4316 (20.11)
B	I	236 (28.10)	4.43	236 (27.96)	4.28	3320 (30.86)	62.41	3340 (30.97)	60.55	1764 (29.46)	33.15	1940 (28.22)	35.17	5320 (30.25)	5516 (29.81)
	II	184 (21.90)	4.19	184 (21.80)	3.98	2648 (24.62)	60.29	2648 (24.55)	57.27	1560 (26.05)	35.52	1792 (26.08)	38.75	4392 (24.98)	4624 (25.01)
	III	220 (26.19)	5.14	224 (26.54)	4.96	2636 (24.51)	61.65	2636 (24.44)	58.32	1420 (23.72)	33.21	1660 (24.16)	36.72	4276 (24.32)	4520 (24.93)
	IV	200 (23.81)	5.56	200 (23.70)	5.20	2152 (20.01)	59.84	2160 (20.04)	56.25	1244 (20.77)	34.59	1480 (21.54)	38.54	3596 (20.45)	3840 (20.75)
C	I	344 (31.50)	5.33	344 (31.50)	5.18	3932 (32.47)	60.98	3932 (32.66)	59.29	2172 (32.61)	33.68	2356 (31.23)	35.52	6448 (32.47)	6632 (32.07)
	II	308 (28.21)	6.08	308 (28.21)	5.83	3016 (24.91)	59.51	3008 (24.98)	57.01	1744 (26.19)	34.41	1960 (25.98)	37.15	5068 (25.52)	5276 (25.52)
	III	240 (21.97)	5.25	240 (21.97)	5.02	2820 (23.29)	61.90	2816 (23.29)	58.86	1496 (22.46)	32.84	1728 (22.91)	36.12	4556 (22.94)	4784 (23.14)
	IV	200 (18.32)	5.27	200 (18.32)	5.02	2340 (19.33)	61.77	2284 (18.97)	57.33	1248 (18.74)	32.95	1500 (19.88)	37.65	3788 (19.07)	3984 (19.27)
D	I	396 (34.86)	5.31	396 (34.74)	5.17	4424 (32.71)	59.30	4432 (32.75)	57.86	2640 (33.90)	35.39	2832 (32.51)	36.97	7460 (33.23)	7660 (32.76)
	II	380 (33.45)	5.99	380 (33.33)	5.81	3736 (27.62)	58.89	3736 (27.61)	57.13	2228 (28.61)	35.12	2424 (27.80)	37.06	6344 (28.26)	6540 (27.96)
	III	208 (18.31)	4.43	212 (18.60)	4.28	2860 (21.15)	61.00	2860 (21.14)	57.89	1620 (20.80)	34.60	1868 (21.44)	37.82	4688 (20.89)	4940 (21.13)
	IV	152 (13.38)	3.84	152 (13.33)	3.58	2504 (18.52)	63.30	2504 (18.50)	59.00	1300 (16.69)	32.86	1588 (18.23)	37.42	3956 (17.62)	4244 (18.15)

in the top most layer of the soil for all the sites for both the years, while it ranged from about 25% to 28% in the next layer (10-20 cm), about 20 to 25% in the next (20-30 cm) and it was between the range of about 17 to 20% in the lower most layer (30-40 cm) (Table-IV). Similarly while analysing the break-up of soil-fauna into micro, meso and macrofauna, it was seen that there was a steady decrease in numbers only in the case of mesofauna for both years in all the sites from the top to the bottom layers. However, when microfauna was considered, a similar trend as in mesofauna was seen only in site D. The microfauna in site A for both the years though decreasing till the third layer (20-30 cm), increased slightly by about 3% in the bottom most fourth soil layer, whereas in site B though there was a decrease in the second layer, the third layer increased to a level nearly as the first layer with only a small fall of 3% in last layer during both the years. In site C there was an immediate increase in the second layer of about 3%, which thereafter fell steadily till the bottom layer. An observation similar to mesofauna was also seen for total macrofauna in all the sites for both the years except in site A where the maximum was recorded in the second (10-20 cm) layer of the soil, which thereafter decreased steadily.

Though this trend was seen in the different depths when compared among themselves as actual numbers, it was felt also to find out if a similar trend existed, if and when the micro, meso and macro-fauna were compared as percentages of the total soil fauna for all the soil layers in all the sites. When so considered it was seen for microfauna that except for a similar pattern in site A in all the layers for both years as above, there was a different pattern in the remaining sites. In site B the last layer for both the years which should have been lower than the third

layer, however revealed an increase in percentages of nearly 0.5% between the third and fourth layer when actually among the vertical distribution in site B, the microfauna decreased by 3% for the same layer under consideration. A similar phenomenon was seen in site C for both the years except that in this case the two layers were the first and second layers, where the increase from first to second layer was nearly 1% when compared with the total soil-fauna, when they actually reduced in the second layer by nearly 3%. Another interesting observation in site C was in the third and fourth layers, where the decrease from third to fourth layer was nearly 3%, while the percentages were more or less constant for both these layers when compared with the total soil-fauna for the same site for both the years. When site D was considered for total microfauna and its relation to total soil fauna for different layers, the first two layers had a similar phenomenon as was seen for site C, except that the percentage variation of increase in the reverse was very negligible (0.55 to 1.50%) (Table-IV).

If the total mesofauna and their relationship in terms of their relative percentages for all the layers, for all the sites for both the years when compared with the total soil fauna, it was seen that in sites A and D there was an increase of nearly 2% in the abundance of total microfauna for the last two bottom layers of soil, when actually in their vertical distribution they had steadily decreased by nearly 3% as mentioned earlier. However, in the case of site B and site C, the rise of about nearly 1.0% was seen between the second and third layers for both the years when among themselves they were nearly the same percentages in their vertical distribution for these layers.

The total macrofauna as mentioned earlier had a decreasing phenomenon from top to the bottom layers of soil in all the sites for both the years except site A where the second layer recorded maximum for both the years. But on a comparison of their numbers with that of the total soil fauna, it was seen that for site A, the maximum percentage was seen in the third layer with an increase of abbut nearly 4%. In case of sites B and C the second and the third layers registered an increase of nearly 2% during both the years, when the actual vertical distribution had a decrease of nearly 3% for these layers. In site D, during the first year of study it followed the similar pattern as for its vertical distribution when either compared among itself or when compared with the total soil fauna. Surprisingly enough, it was not so for the same site D during the second annual cycle. Here, though the decreasing trend was observed when compared among themselves, yet when their numbers at the different layers were compared with the total soil fauna for the same period, it was seen that there was an increase in their percentages in the second and third layers with only a slight fall in the fourth layer. In fact the percentages were more or less constant for all the layers when they were nearly recording a difference of 5% decrease from top to the bottom layers (Table-IV).

Though the major trends have been seen among the broader divisions of soil-fauna, it was now left to see the intricate relationships, when each of the three major groups were broken down into the possible sub-groups. It was ideal to go upto species level, but due to the great lacuna of taxonomic works in this region and particularly in India, the sub-groups thereafter described were the only possible levels in classification which permitted us, due to limitations. Therefore among microfauna, the

division was broadly categorized into Prostigmatid mites and Protozoa and the latter being further subdivided into flagellata, ciliata and amoebae.

While considering the Prostigmatid mites it was seen that there was a steady decrease in numbers from top to bottom layers in only sites C and D, for both the years of study. In site A, though it decreased till the third layer, an increase by nearly 4% in the fourth bottom soil layer and in site B in the third layer, for both the years of study. However, while analyzing their relative percentage of abundance among microfauna it was seen that only in site C, they followed a similar pattern as for their own vertical distribution, while in sites A and D, they recorded an increase of 0.5% to 1.0%, from the first to second layer, they actually decreased by nearly 2% and 1% respectively. In site B though the increase observed from second to third layer was nearly 4%, yet their relative percentage of increase among total microfauna was only 1%. When the prostigmatid mites as percentages of the total soil fauna was observed it was seen that only in site A they followed a trend similar to their own vertical distribution. In site B however, though the trend was similar to their vertical distribution till the third layer, with a increase in the fourth layer by about 0.2%, they had actually recorded a decrease of nearly 3% for the same layers during both the years. In sites C and D their percentages among the total soil-fauna increased from the first to the second layer by nearly 0.5%, when actually they had decreased by about 4% and 1% in both the sites respectively (Table-V).

The second major sub-group was total Protozoa within microfauna. This group was seen to have the same numbers of abundance in both the years of study in all the sites, though the minimum

Table V : Showing the total number of Prostigmata and its relative percentages for the study period in the four different study sites at four different depths for each annual cycle.

Table VI : Showing the total number of Protozoa and its relative percentages for the study period in the four different study sites at four different depths for each annual cycle.

a : Numbers and Percentages among themselves.

b : Percentages in microfauna.

c : Percentages in total soil fauna.

TABLE V

1978			1979		
a	b	c	a	b	c
356 (37.08)	91.75	5.99	356 (37.08)	91.76	5.80
336 (35.00)	92.30	5.85	336 (37.08)	92.30	5.65
116 (12.08)	78.38	2.41	116 (12.08)	78.38	2.29
152 (15.84)	84.44	3.76	152 (15.84)	84.44	3.52
204 (28.98)	86.44	3.83	204 (28.81)	86.44	3.70
152 (21.59)	82.61	3.46	152 (21.47)	82.61	3.29
184 (26.14)	83.64	4.30	188 (26.55)	83.92	4.16
164 (23.30)	82.00	4.56	164 (23.16)	82.00	4.27
312 (32.50)	90.70	4.84	312 (32.50)	90.70	4.70
276 (28.75)	89.61	5.45	276 (28.75)	89.61	5.23
212 (22.08)	88.33	4.64	212 (22.08)	88.34	4.43
160 (16.67)	88.00	4.22	160 (16.67)	80.00	4.02
352 (35.20)	88.89	4.72	352 (35.06)	88.89	4.60
348 (34.80)	91.58	5.49	348 (34.66)	91.58	5.32
176 (17.60)	84.61	3.75	180 (17.93)	84.91	3.64
124 (12.40)	81.58	3.13	124 (12.35)	81.58	2.92

TABLE VI

1978			1979			
SITES	a	b	c	a	b	c
A	32 (26.67)	8.25	0.54	32 (26.67)	8.25	0.52
	28 (23.33)	7.70	0.49	28 (23.33)	7.70	0.47
	32 (26.67)	21.62	0.67	32 (26.67)	21.62	0.63
	28 (23.33)	15.56	0.69	28 (23.33)	15.56	0.65
B	32 (23.53)	13.57	0.60	32 (23.53)	13.56	0.58
	32 (23.53)	17.39	0.73	32 (23.53)	17.39	0.69
	36 (26.47)	16.36	0.84	36 (26.47)	16.36	0.80
	36 (26.47)	18.00	1.00	36 (26.47)	18.00	0.93
C	32 (24.24)	9.30	0.49	32 (24.24)	9.30	0.48
	32 (24.24)	10.39	0.63	32 (24.24)	10.39	0.60
	28 (21.21)	11.67	0.61	28 (21.21)	11.67	0.59
	40 (30.30)	20.00	1.05	40 (30.30)	20.00	1.00
D	44 (32.35)	11.11	0.59	44 (32.35)	11.11	0.57
	32 (23.53)	8.42	0.50	32 (23.53)	8.42	0.49
	32 (23.53)	15.38	0.68	32 (23.53)	15.39	0.65
	28 (20.59)	18.42	0.71	28 (20.59)	18.42	0.66

was seen to be in site A and the maximum was in site B and site D with site C following close behind with only a difference of $4X10^2/m^2$. Their vertical distribution in the different depths in different sites revealed a highly erratic phenomena, in that in site A, though it decreased in the second layer, increased to a level of exactly that of the first layer, which decreased again in the fourth layer exactly similar as in the second layer. In site B the first and second layers have the same numbers and increased to nearly 3% with the same numbers of increase in the third and fourth layers, both of these being similar. As was seen in site B, in site C, the first two layers were the same in numbers except that they dropped by nearly 3% in the third layer, to rise drastically by 9% in the fourth layer. In site D a totally different phenomenon was seen, in that, though there was a decrease in the second, third and fourth layer, the second and third layers revealed the same numbers. While observing the protozoan relative abundances with total microfauna it was seen in site A though the first and third, second and fourth had the same numbers of protozoa, yet their range of difference among microfauna was nearly 13% for the first and third layer and nearly 7% for the second and fourth layers on the increasing side. In site B though there was a difference of nearly 3% between depths first, second and third-fourth, yet the second, third and fourth layers revealed the same relative percentages among the microfauna. In site C though there was a decrease in the third layer by nearly 3% from the first and second layers, the latter two being constant, there was an increase of nearly 1% in the third layer. In site D,though the second and third layers had the same numbers, they revealed an increase of nearly 7% from second to the third layer, and while they dropped nearly 3% in their own vertical distribution from the third to the fourth layer, yet they showed an increase

of nearly 3% when compared with total microfauna for both the years of study. While considering their relative percentages among the total soil fauna it was seen that they nearly followed the same pattern as in total microfauna except that the range of differences was negligible (Table-VI).

When Protozoa was further broken down, it was seen that flagellata comprised of more than 55-80% among the total Protozoa. The total flagellata showed either a consistency in their numbers among the different depths for all the sites in both the years as seen in site B or a decreasing phenomenon with consistency in depth (first, second and third) as in site A, and second, third and fourth in site D. Only in site C did they reveal a reverse trend in that they were consistent in the first three layers and increased suddenly by nearly 13% in the fourth layer. However, they were consistent in all the layers in site B, yet, when they were compared with total Protozoa, it was seen that the first two layers had nearly 7% more than in the bottom two layers. Similarly, though the first three layers in site A had the same numbers yet the second layer revealed nearly 10% increase among total Protozoa, as was also seen for the second and third layer in site C except that it was in the reverse. In site D, a nearly similar observation was seen in that though the numbers for the second, third and fourth layers were same yet the fourth layer showed an increase of about 10% as was seen for the first layer when considered among the Protozoa, while the second, third and fourth layers were nearly 13% lower than the first layer. When the total flagellata and its relative percentages among the total microfauna was considered, it was seen with minor fluctuation in their ranges to be nearly similar to their own vertical distribution in sites B and C. However, in site A they revealed an increase of 8% in the third layer, while actually they were consistent from the

Table VII : Showing the total number of Flagellata and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table VIII : Showing the total number of Ciliata and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in Protozoa.

c : Percentages in Microfauna.

d : Percentages in Total soil fauna.

TABLE VII

1978				1979				SITE
a	b	c	d	a	b	c	d	
20 (26.32)	62.50	5.16	0.34	20 (26.32)	62.50	5.15	0.32	
20 (26.32)	71.42	5.49	0.35	20 (26.32)	71.43	5.50	0.33	
20 (26.32)	62.50	13.51	0.42	20 (26.32)	62.50	13.51	0.39	A
16 (21.05)	57.14	8.90	0.40	16 (21.05)	57.14	8.89	0.37	
20 (25.00)	62.50	8.47	0.37	20 (25.00)	62.50	8.47	0.36	
20 (25.00)	62.50	10.87	0.46	20 (25.00)	62.50	10.87	0.43	
20 (25.00)	55.56	9.09	0.47	20 (25.00)	55.56	8.93	0.44	B
20 (25.00)	55.56	10.00	0.56	20 (25.00)	55.56	10.00	0.52	
20 (21.74)	62.50	5.81	0.31	20 (21.74)	62.50	5.81	0.30	
20 (21.74)	62.50	6.49	0.39	20 (21.74)	62.50	6.49	0.38	
20 (21.74)	71.47	8.33	0.44	20 (21.74)	71.43	8.33	0.42	C
32 (34.78)	80.00	16.00	0.84	20 (21.74)	80.00	16.00	0.80	
32 (34.78)	72.73	8.08	0.43	32 (34.78)	72.73	8.08	0.42	
20 (21.74)	62.50	5.26	0.31	20 (21.74)	62.50	5.26	0.31	
20 (21.74)	62.50	9.62	0.43	20 (21.74)	62.50	9.43	0.40	D
20 (21.74)	71.43	13.16	0.51	20 (21.74)	71.43	13.16	0.47	

TABLE VIII

1978				1979				SITE
a	b	c	d	a	b	c	d	
8 (28.57)	25.00	2.06	0.13	8 (28.57)	25.00	2.06	0.13	
4 (14.29)	14.29	1.11	0.07	4 (14.29)	14.29	1.10	0.07	
8 (28.57)	25.00	5.41	0.17	8 (28.57)	25.00	5.41	0.16	A
8 (28.57)	28.57	4.40	0.20	8 (28.57)	28.57	4.44	0.19	
8 (20.00)	25.00	3.39	0.15	8 (20.00)	25.00	3.39	0.15	
0 (20.00)	25.00	4.35	0.18	8 (20.00)	25.00	4.35	0.17	
12 (30.00)	33.33	5.45	0.28	12 (30.00)	33.33	5.36	0.27	B
12 (30.00)	33.33	6.00	0.33	12 (30.00)	33.33	6.00	0.31	
8 (25.00)	25.00	2.33	0.12	8 (25.00)	25.00	2.33	0.12	
8 (25.00)	25.00	2.60	0.16	8 (25.00)	25.00	2.60	0.15	
8 (25.00)	28.57	3.33	0.18	8 (25.00)	28.57	3.33	0.17	C
8 (25.00)	20.07	4.00	0.21	8 (25.00)	20.00	4.00	0.20	
8 (25.00)	18.18	2.02	0.11	8 (25.00)	18.18	2.02	0.10	
8 (25.00)	25.00	2.11	0.13	8 (25.00)	25.00	2.11	0.12	
8 (25.00)	25.00	3.85	0.17	8 (25.00)	25.00	3.77	0.16	D
8 (25.00)	28.57	5.26	0.20	8 (25.00)	28.57	5.26	0.19	

first to the third in their numbers and though they decreased by 5% in the fourth layer, however they had increased by nearly 3% from the first two layers, though their numbers were similar. In site D, a more or less similar observation was seen except that it was in the reverse. While considering the total flagellates among the total soil fauna, they had a similar pattern as for their vertical distribution with only a variation of 0.2% in their fluctuation among the depths, in different sites for both the years (Table-VII).

The next dominant group after flagellata among Protozoa were the total ciliata, which comprised of nearly 15-33% of the total Protozoa. The total ciliata either had the same numbers in all the depths as in sites C and D or they had an increase in numbers from third to fourth as in sites A and B, except that in the former there was a drop in the second layer by nearly 50%. The similarity between their vertical distribution among themselves was also seen when they were compared with the total Protozoa in site B. In site C, though the numbers present in all the depths were the same, yet their relative percentage among Protozoa increased by 3% in the third layer to drop by nearly 8% in the fourth layer. In site D as in site C though the number of ciliata present in all the depths were the same, yet they showed an increasing trend from first to the fourth layer by nearly 10%, while their relative percentage among the total Protozoa when considered were nearly 3% increase from third to fourth soil layer. A similar observation as the latter phenomenon in site D was also observed in site A. While considering the total ciliata among the group microfauna, it was seen that there was a steady increase in their relative percentage from the top to the bottom layers in sites C and D for both the years of study, when the numbers were constant. In site A though

the numbers in first, third and fourth layers were same, yet they increased in the third layer by nearly 2% and fell by 1% in the fourth layer, when their relative percentages among the total microfauna was considered, In site B they more or less followed their own trend among the different layers, When the total ciliata were compared with the total soil fauna, it was seen that their relative percentages for the different layers in all sites had a similar pattern as was seen for the total ciliata and its relative percentages among the total microfauna (Table-VII),

The last group among Protozoa were the amoebae, which ranged from nearly 0-14% of the total Protozoa, In all the sites their numbers were same for both the years of study, whenever they were present, The relative percentages among the Protozoa was seen to differ by nearly 2% even though the numbers remained constant, Similarly they were nearly 1% and 0.2% differences when the total amoebae relative percentages were compared either with total microfauna or total soil fauna respectively. As there were very minor variations we anticipate a very negligible effect on the total study (Table-IX),

The next major group of soil fauna, mesofauna was broadly divided into Collembola, Acarina, Araneida, Diplura, Protura, Isopoda and Chelonethi. The first three of these sub-groups were further categorised into either families or sub-orders, former levels for Collembola and Araneida while the latter for Acari.

While considering Collembola it was seen that there was a steady decrease in their numbers at the different soil layers in all the sites for both the years. Moreover in both the years, the numbers were very consistent for each site, at all the layers. However, when a comparison was made on their relative abundance

Table IX : Showing the total number of Amoebae and its relative percentage for the t total study period in the four different sites at four different depths for each annual cycle.

Table X : Showing the total number of Collembola and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in Protozoa.

c : Percentages in Microfauna.

d : Percentages in Total soil fauna.

TABLE IX

1978				1979			
a	b	c	d	a	b	c	d
4 (25.00)	12.50	1.03	0.07	4 (25.00)	12.50	1.03	0.07
4 (25.00)	14.29	1.10	0.07	4 (25.00)	14.20	1.10	0.07
4 (25.00)	12.50	2.70	0.08	4 (25.00)	12.50	2.70	0.08
4 (25.00)	14.29	2.22	0.10	4 (25.00)	14.28	2.22	0.09
4 (25.00)	12.50	1.69	0.08	4 (25.00)	12.50	1.70	0.07
4 (25.00)	12.50	2.17	0.09	4 (25.00)	12.50	2.17	0.09
4 (25.00)	11.11	1.82	0.09	4 (25.00)	11.11	1.79	0.09
4 (25.00)	11.11	2.00	0.11	4 (25.00)	11.11	2.00	0.10
4 (50.00)	12.50	1.16	0.06	4 (50.00)	12.50	1.16	0.06
4 (50.00)	12.50	1.30	0.09	4 (50.00)	12.50	1.30	0.07
0 (00.00)	00.00	0.00	0.00	0 (00.00)	00.00	0.00	0.00
0 (00.00)	00.00	0.00	0.00	0 (00.00)	00.00	0.00	0.00
4 (33.33)	9.09	1.01	0.05	4 (33.33)	9.09	1.01	0.05
4 (33.33)	12.50	1.05	0.06	4 (33.33)	12.50	1.05	0.06
4 (33.33)	12.50	1.92	0.08	4 (33.33)	12.50	1.89	0.08
0 (00.00)	00.00	0.00	0.00	0 (00.00)	00.00	0.00	0.00

TABLE X

SITES	1978			1979		
	a	b	c	a	b	c
A	1700 (27.87)	42.54	28.58	1700 (27.87)	42.33	27.69
	1604 (26.30)	44.06	27.96	1604 (26.30)	43.83	26.97
	1400 (22.95)	44.73	29.11	1400 (22.95)	44.11	27.68
	1396 (22.88)	51.09	34.52	1396 (22.88)	51.09	32.34
B	1392 (35.51)	41.93	26.17	1408 (35.77)	42.16	25.52
	940 (23.98)	35.50	21.40	940 (23.88)	35.50	20.33
	916 (23.37)	34.75	21.42	916 (23.27)	34.75	20.27
	672 (17.14)	31.23	18.69	672 (17.14)	31.11	17.50
C	1580 (34.61)	40.18	24.50	1580 (34.65)	40.18	23.82
	1192 (26.12)	39.52	23.52	1188 (26.05)	39.49	22.52
	1008 (22.09)	35.74	22.12	1008 (22.11)	35.80	21.07
	784 (17.18)	33.50	20.70	784 (17.19)	34.33	19.68)
D	1664 (31.88)	37.61	22.31	1664 (31.88)	37.55	21.72
	1368 (26.20)	36.61	21.56	1368 (26.21)	36.62	20.92
	1212 (23.22)	42.38	25.85	1212 (23.22)	42.38	24.53
	976 (18.70)	38.98	24.67	976 (18.70)	38.98	23.00

among mesofauna, it was seen that a decreasing trend as for their vertical distribution was only observed in sites B and C. In site A there was an increase by nearly 1% in the second and third layer and nearly 10% in the fourth layer as compared to the two top layers. Site D, though revealed a drop in the second layer, rose in the third layer to nearly 5% more than in the first layer, but dropped by only 3% in the last layer. Similarly, when Collembola was seen as a percentage of total soil fauna except for site B and site C, where it showed a steady decrease in trend from top to the bottom layers, in sites A and D they dropped in second layer though insignificantly but rose in the third layer to nearly 1% and 3% respectively. The difference however in these two sites (A and D) was in the fourth layer where in site A it rose nearly 1 to 6% more than in the third layer, while it dropped by 1% in site D. This was observed to be true for both the years of study (Table-)

The families under Collembola which occurred in the present investigation were Entomobryidae, Hypogastruridae, Sminthuridae and Isotomidae in that order of abundance. Entomobryidae comprised of nearly 40-42% of Collembola. Here, again as in Collembola the numbers in the different layers for both the years was consistent in all the sites, and there was a steady decrease from the top to the bottom layers, When their relative percentage among Collembol was considered, it was seen that in sites A, C and D they dropped in the second soil layer but rose quite drastically in the third layer to fall again in the fourth layer. In site B, it nearly rose to 5% in the second to fall steadily thereafter. When their relative percentages among mesofauna was taken into consideration it was seen that a steady decrease from top to bottom layers for both the years was observed only in sites B and C. In case of sites A and D though it fell in the second layer, it rose in the

third layer and continued steadily in case of site A, whereas fell again in site D. While considering the relative percentages of Entomobryidae among the total soil fauna it was seen again, as for the relative percentages of mesofauna to drop steadily from top to the bottom layers in sites B and C only. Interestingly enough, the same phenomenon as in total mesofauna, so also in total soil fauna the relative percentages of abundance followed the same pattern in sites A and D (Table-XI).

The next abundant family among Collembola recorded was the family Hypogastruridae. Whereas for Entomobryidae and for the whole group of Collembola there was a steady decrease in their numbers in the different layers for both the years of study. Hypogastruridae which formed nearly 26 to 30% of Collembola, was not seen to decrease steadily in any of the sites during both the years of study. Sites A and B showed an immediate increase in second and third layers and though dropped in the fourth layer, yet they formed the percentage of at least 1% more than the first layer. In sites C and D, there was an increase only till the second layer which dropped in the third layer to again rise in the fourth layer to levels nearly as the second layer. The percentage of Hypogastruridae as a percentage of total mesofauna showed a trend in reverse in sites A and D, the former being significant. In site B it dropped in the second layer, rose in third to drop further in fourth layer, while in site C it increased in the second layer to steadily decrease thereafter. A phenomenon as seen for their relative percentages among total mesofauna, was also seen when the percentages was considered as for the total soil fauna in the same sites A and D except that it was significant in latter than the former. Site C however showed a steady decrease while site B had a similar situation as for the percentages among the mesofauna (Table-XII).

Table XI : Showing the total number of Family Entomobryidae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XII : Showing the total number of Family Hypogastruidae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in Collembola.

c : Percentages in Mesofauna.

d : Percentages in Total soil fauna.

TABLE XI

1978				1979			
a	b	c	d	a	b	c	d
748 (29.40)	44.00	18.72	12.58	748 (29.40)	44.00	18.62	12.0
660 (25.94)	41.15	18.13	11.51	660 (25.94)	41.15	18.03	11.0
592 (23.28)	42.29	18.91	12.31	592 (23.28)	42.29	19.00	12.0
544 (25.44)	38.97	19.91	12.39	544 (25.44)	38.97	20.00	13.0
556 (34.24)	39.94	16.75	10.45	556 (34.24)	39.49	17.00	10.0
424 (26.10)	45.11	16.01	9.65	424 (26.10)	45.11	16.00	9.0
384 (23.65)	41.92	14.57	8.98	384 (23.65)	41.92	15.00	8.0
260 (16.01)	38.69	12.08	7.23	260 (16.01)	38.69	12.00	7.0
656 (34.53)	41.52	16.68	10.17	656 (34.60)	41.52	17.00	10.0
488 (25.68)	40.94	16.18	9.63	484 (25.53)	40.74	16.00	9.0
428 (22.53)	42.46	15.18	9.39	428 (22.57)	42.46	15.00	9.0
328 (17.26)	41.83	14.02	8.66	328 (17.30)	41.84	14.00	8.0
668 (32.36)	40.15	15.10	8.95	668 (32.36)	40.14	15.00	9.0
536 (25.97)	39.18	14.35	8.45	536 (25.97)	19.18	14.00	8.0
484 (23.45)	39.94	16.92	10.32	484 (23.45)	39.93	16.92	9.8
376 (18.22)	38.53	15.02	9.50	376 (18.22)	38.52	15.02	8.9

TABLE XII

SITES	1978				1979			
	a	b	c	d	a	b	c	d
A	488 (26.87)	28.71	12.20	8.20	488 (26.87)	28.71	12.15	7.95
	488 (26.87)	30.42	13.41	8.51	488 (26.87)	30.42	13.33	8.20
	428 (23.57)	30.57	13.67	8.00	428 (23.57)	30.57	13.48	8.46
	412 (22.69)	29.51	15.08	10.20	412 (22.69)	29.51	15.08	9.55
B	376 (34.06)	27.01	11.33	7.07	392 (35.00)	27.85	11.74	7.11
	260 (23.55)	27.66	9.82	5.92	260 (23.20)	27.66	9.82	5.62
	272 (24.64)	29.69	10.32	6.36	272 (24.29)	29.69	10.32	6.02
	196 (17.75)	29.17	9.11	5.45	196 (17.60)	29.17	9.07	5.10
C	428 (34.08)	27.09	10.89	6.64	428 (34.08)	27.09	10.86	6.40
	332 (26.43)	27.85	11.00	6.05	332 (26.43)	27.95	11.04	6.29
	272 (21.66)	26.98	9.64	5.97	272 (21.66)	26.98	9.66	5.69
	224 (17.83)	28.57	9.57	5.91	224 (17.83)	28.57	9.81	5.62
D	432 (30.77)	25.96	9.76	5.79	432 (30.77)	25.96	9.75	5.64
	380 (27.07)	27.77	10.17	5.99	380 (27.07)	27.77	10.47	5.81
	320 (22.79)	26.40	11.19	6.83	320 (22.79)	26.40	11.19	6.48
	272 (19.37)	27.87	10.86	6.88	272 (19.37)	27.86	10.86	6.41

The third family of dominance among Collembola was Sminthuridae which formed nearly 14 to 27% of Collembola. Here too, as for the other families and Collembola, there was not only consistent number present in both the years at the different soil layers in all the sites, the decrease in the different soil layers was also seen though not very significantly, when this family was taken as the percentage of Collembola, in sites A, C and D. However, in site B, the trend was in the reverse when Sminthuridae was considered as a percentage of total mesofauna. The phenomenon of decrease from top to the bottom soil layers was seen only in sites B and C, while it was in reverse in site A and in site D, it dropped in second layer, rose in third, to the levels higher than the first layer and dropped in fourth layer again. As their presence among total mesofauna, it was also true when this family was considered as the percentage of total soil fauna (Table-XIII).

The fourth and last family among the Collembola was the family Isotomidae which was nearly 9 to 15% of Collembola. This family however had one departure from others and Collembola, in that though the numbers were consistent for both the years for the different soil layers, yet the steady decrease from top to the bottom layers was seen only in sites C and D. Here too, the decrease was seen only till the third layer which increased in fourth layer, in site A there was an increase of nearly 1% in the second layer which fell by 5% in the third layer but rose quite significantly by nearly 20% of the third layer and fourth layer, in site B; though there was a steady decrease upto third layer, yet it rose in fourth to the levels as in the second layer. When their percentages was considered among Collembola, it followed a pattern of their own vertical distribution in sites A and B. The trend was in the reverse in sites C and D from the top to the

Table XIII: Showing the total number of Family Sminthuridae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XIV: Showing the total number of Family Isotomidae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentage in Collembola.

c : Percentage in Mesofauna.

d : Percentage in Total soil fauna.

TABLE XIII

1978				1979				SITES
a	b	c	d	a	b	c	d	
304 (28.15)	17.88	7.61	5.11	304 (28.15)	17.88	7.57	4.95	
288 (26.67)	17.96	7.91	5.02	288 (26.67)	17.96	7.87	4.84	
244 (22.59)	17.43	7.80	5.07	244 (22.59)	17.43	8.00	4.82	A
244 (22.59)	17.48	8.93	6.04	244 (22.59)	17.40	9.93	5.65	
248 (33.33)	17.82	7.47	4.66	248 (33.33)	17.61	7.43	4.50	
176 (23.66)	18.72	6.65	4.01	176 (23.66)	18.72	6.65	3.81	
184 (24.73)	20.09	6.98	4.00	184 (24.73)	20.09	6.98	4.07	B
136 (18.28)	20.24	6.32	3.78	136 (18.28)	20.24	6.30	3.54	
304 (36.71)	19.24	7.73	4.71	304 (36.71)	19.24	7.73	4.58	
224 (27.05)	18.79	7.43	4.42	224 (27.05)	18.86	7.45	4.25	
188 (22.71)	18.65	6.66	4.13	188 (22.71)	18.65	6.68	3.93	C
112 (13.53)	14.29	4.79	2.96	112 (13.53)	14.29	4.90	2.81	
352 (34.78)	21.15	7.96	4.72	352 (34.78)	21.15	7.94	4.60	
260 (25.69)	19.01	6.96	4.10	260 (25.69)	19.01	6.96	3.98	
240 (23.72)	19.80	8.39	5.12	240 (23.72)	19.80	8.39	4.86	D
160 (15.81)	16.39	6.39	4.04	160 (15.81)	16.39	6.39	3.77	

TABLE XIV

1978				1979				SITES
a	b	c	d	a	b	c	d	
160 (21.05)	9.41	4.00	2.69	160 (21.05)	9.41	3.98	2.61	
168 (22.11)	10.47	4.62	2.93	168 (22.11)	10.47	4.59	2.82	
136 (38.95)	9.71	4.35	2.82	136 (38.95)	9.71	4.28	2.69	A
196 (38.95)	14.04	7.17	4.85	196 (38.95)	14.04	7.17	4.54	
212 (47.32)	15.23	6.39	3.98	212 (47.32)	15.06	6.35	3.20	
80 (17.86)	8.51	3.02	1.82	80 (17.86)	8.51	3.02	1.73	
76 (16.96)	8.30	2.88	1.78	76 (16.96)	8.30	2.88	1.68	B
80 (17.86)	11.90	3.72	2.22	80 (17.86)	11.90	3.70	2.08	
192 (33.10)	12.15	4.88	2.98	192 (33.10)	12.15	4.88	2.90	
148 (25.52)	12.42	4.91	2.92	148 (25.52)	12.45	4.92	2.81	
120 (20.69)	11.91	4.26	2.63	120 (20.69)	11.91	4.26	2.51	C
120 (20.69)	15.31	5.13	3.17	120 (20.69)	15.30	5.25	3.01	
212 (28.65)	12.74	4.79	2.84	212 (28.05)	12.75	4.78	2.77	
192 (25.95)	14.04	5.14	3.03	192 (25.95)	14.04	5.14	2.94	
168 (22.70)	13.86	5.87	3.58	168 (22.70)	13.86	5.87	3.40	D
168 (22.70)	17.21	6.71	4.25	168 (22.70)	17.22	6.71	3.96	

bottom layers, the latter recording the highest with a difference of nearly 4% between itself and in the third layer, though the actual numbers present were same. Whatever was seen for their percentages among Collembola was also observed, to follow the same pattern when their percentages were considered, either as of total mesofauna or of total soil fauna in sites A, B and C. However in site D, their percentages among the total mesofauna and the total soil fauna was seen to increase from top to the bottom layers (Table-XIV).

The major sub-group next to Collembola among the mesofauna was Acarina which comprised of 25 to 38% of the total mesofauna. As in Collembola, so also here in Acarina the number present in different soil layers for both the years were the same. This was seen to be true in all the sites. However, the steady decrease in number from top to the bottom layers was seen only in the third layer in sites A, C and D, while in site B it fell in the second layer by nearly 8%, but rose to nearly 5% in third and fourth soil layers. When their percentage of abundance as in total mesofauna was observed they followed the pattern similar to their vertical distribution only in site A, while in site B though similar till the third layer, yet in the fourth when they actually should have dropped, they rose nearly by 6% in site C. The percentage of abundance in the total mesofauna was seen to increase from top to the bottom layers when actually their numbers decreased. In site D, it rose and fell in the alternative layers, though they did show a steady decrease in their actual numbers. A trend as observed for relative percentages of total mesofauna was also seen to be very similar to the trend when Acarina was considered as percentages of the total soil fauna (Table-XV).

The major sub-division of Acarina comprised of sub-orders Mesostigmata, Cryptostigmata and Astigmata in that order of abundance in the present investigation. The sub-order Mesostigmata made up nearly 40 to 60% of Acarina and their numbers were constant for both the years in all the layers for all the sites. However, they did not show a trend of decreasing order from the top to the bottom soil layers in any of the sites except in site A. In the other three sites they dropped till the third layer but rose to nearly 1% in the fourth layer. Their relative percentage as of Acarina when considered was seen to follow a trend just in the reverse in site A, while they rose in the alternate even layers in sites B and C while they fell in the second layer in site D, to rise steadily thereafter till the fourth layer. This pattern was also seen to be similar when Mesostigmata was taken as a percentage of either mesofauna or total soil fauna in all the sites except in site B where their percentage abundance of total soil fauna showed a steady increase from top to the bottom layers (Table-XVI).

The sub-order Cryptostigmata came second in terms of abundance in Acarina comprising of nearly 23-48%. Their numbers of occurrence were the same for both the years in different soil layers in all the sites. Except in site D, none of the other sites revealed a steady fall in their numbers from the top to the bottom layers. In the three other sites A, B and C, the numbers fell and rose in the alternate layers. When the sub-order Cryptostigmata was considered as the percentage of Acarina, it was seen that they followed a trend of their actual numbers more or less in the sites A and B, while in site C they steadily increased from top to the bottom layers and in site D there was an inverse pattern till the third layer and a sudden fall in the fourth. This trend

Table XV : Showing the total number of Acarina and its relative percentages for the total study period in the four differerent sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in mesofauna.

c : Percentages in Total soil fauna.

Table XVI : Showing the total number of Mesostigmata and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in Acari.

c : Percentages in mesofauna.

d : Percentages in Total soil fauna.

TABLE XV

1978			1979			SITES
a	b	c	a	b	c	
1364 (32.64)	34.13	22.93	1364 (32.64)	33.96	22.21	
1208 (28.64)	33.19	21.06	1208 (28.64)	33.01	20.31	A
954 (22.62)	30.48	19.83	954 (22.62)	30.06	18.86	
692 (16.40)	25.33	17.11	692 (16.40)	25.33	16.03	
928 (28.12)	27.95	17.44	928 (28.12)	27.78	16.82	
692 (20.97)	26.13	15.76	692 (20.97)	26.13	14.97	B
852 (25.82)	32.32	19.93	852 (25.82)	32.32	18.85	
828 (25.09)	38.48	23.03	828 (25.09)	28.33	21.56	
1096 (29.02)	27.87	17.00	1096 (29.02)	27.87	16.33	
956 (25.32)	31.70	18.86	956 (25.32)	31.78	18.12	C
916 (24.26)	32.48	20.11	916 (24.26)	32.53	19.15	
808 (21.40)	34.53	21.33	808 (21.40)	35.38	20.28	
1180 (32.31)	26.67	15.82	1180 (32.31)	26.62	15.40	
1040 (28.48)	27.84	16.39	1040 (28.48)	27.84	15.90	D
720 (19.72)	25.17	15.36	720 (19.72)	25.17	14.57	
712 (19.49)	28.43	18.00	712 (19.49)	28.43	16.78	

TABLE XVI

1978				1979			
a	b	c	d	a	b	c	d
592 (30.02)	43.40	14.81	9.95	592 (30.02)	43.40	14.74	9.64
520 (26.37)	43.05	14.29	9.07	520 (26.37)	43.05	14.21	8.74
436 (22.11)	45.70	13.93	9.06	436 (22.11)	45.70	13.74	8.62
424 (21.50)	61.27	15.52	10.50	424 (21.50)	61.27	15.52	9.82
404 (28.29)	43.53	12.17	7.59	404 (28.29)	43.53	12.10	7.32
340 (23.81)	49.13	12.84	7.74	340 (23.81)	49.13	12.84	7.35
336 (23.53)	39.44	12.75	7.86	336 (23.53)	39.44	12.75	7.43
348 (24.37)	42.03	16.17	9.68	348 (24.37)	42.03	16.11	9.06
524 (30.04)	47.81	13.13	8.13	524 (30.04)	47.81	13.33	7.90
464 (26.60)	48.52	13.38	9.16	464 (26.60)	48.54	15.43	8.79
376 (21.56)	41.05	13.33	8.25	376 (21.56)	41.05	13.35	7.86
380 (21.79)	47.03	16.24	10.03	380 (21.79)	17.03	16.64	9.54
532 (31.89)	45.08	12.03	7.13	532 (31.89)	45.08	12.00	6.95
408 (24.47)	39.23	10.92	6.43	408 (24.47)	39.23	10.92	6.24
360 (21.58)	50.00	12.59	7.68	360 (21.58)	50.00	12.59	7.29
368 (22.06)	51.69	14.70	9.30	368 (22.06)	51.69	14.70	8.67

was also true when this sub-order Cryptostigmata was considered either as the percentage of mesofauna or total soil fauna (Table-XVII).

The last sub-order among Acarina was Astigmata which comprised of 7% to nearly 23%. As in the other cases they also showed the consistency in numbers in both the years in different layers in all the sites. However, no one site showed a steady decrease in their numbers from top to the bottom layers. Sites B and C fell and rose in the alternate layers, while in site A, there was a steady decrease in their numbers till the third layer but rose significantly in the fourth layer. In site D it rose and fell in the alternate layers in contrast to sites B and C. This trend in different layers in different sites for both the years was similar also in the case of relative abundances of the sub-order Astigmata in Acarina, mesofauna and total soil fauna, except that in site B their percentages among total mesofauna and total soil fauna increased from third to fourth layer when in reality there should have been a decrease (Table-XVIII).

The third major group under mesofauna comprised of Araneida which formed nearly 13 to 22% of the total soil fauna. As in the earlier cases so also here, the numbers were consistent in different layers for both the years in the various sites. However, the steady decrease from top to the bottom layers was seen only in site D. Sites A and C revealed a fall and rise in the alternate layers, while in site B there was a rise in second layer which thereafter fell steadily till the fourth layer. When their percentages of abundance as in total mesofauna was considered it was seen that in site D that the trend was in the reverse, while in sites A and B they more or less followed the trend as for their vertical distribution numbers. In site C though they fell and

Table XVII : Showing the total number of Cryptostigmata and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XVIII : Showing the total number of Astigmata and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in Acari.

c : Percentages in mesofauna.

d : Percentages in Total soil fauna.

TABLE XVII

1978				1979			
a	b	c	d	a	b	c	d
460 (30.96)	33.73	11.51	7.73	460 (30.96)	33.72	11.45	7.49
408 (27.46)	33.77	11.21	7.11	408 (27.46)	33.77	11.15	6.86
458 (30.82)	48.01	14.63	9.52	458 (30.82)	48.00	14.43	9.05
160 (10.76)	23.12	5.86	3.96	160 (10.76)	23.12	5.86	3.71
352 (25.43)	37.93	10.60	6.62	352 (25.43)	37.93	10.54	6.38
280 (20.23)	40.46	10.57	6.38	280 (20.23)	40.46	10.57	6.08
392 (28.33)	46.01	14.87	9.17	392 (28.33)	46.01	14.87	8.67
360 (26.01)	43.48	16.73	10.01	360 (26.01)	43.48	16.67	9.38
364 (27.00)	33.21	9.26	5565	364 (27.00)	33.21	9.26	5.49
316 (23.44)	33.05	10.48	6.24	316 (23.44)	33.05	10.51	5.99
344 (25.52)	37.55	12.20	7.55	344 (25.52)	37.55	12.22	7.19
324 (24.04)	40.10	13.85	8.55	324 (24.04)	40.10	14.19	8.13
472 (33.24)	40.00	10.67	6.33	472 (33.24)	40.00	10.65	6.16
416 (29.30)	40.00	11.13	6.56	416 (29.30)	40.00	11.13	6.36
308 (21.69)	42.77	10.77	6.57	308 (21.69)	42.77	10.77	6.23
224 (15.77)	31.46	8.95	5.66	224 (15.77)	31.46	8.95	5.28

TABLE XVIII

SITES	1978				1979			
	a	b	c	d	a	b	c	d
A	312 (41.06)	22.87	7.81	5.25	312 (41.06)	22.87	7.77	5.08
	280 (36.84)	23.18	7.69	4.88	280 (36.84)	23.18	7.65	4.71
	60 (7.89)	6.29	1.92	1.25	60 (7.89)	6.29	1.89	1.19
	108 (14.21)	15.61	3.95	2.67	108 (14.21)	15.61	3.95	2.50
B	172 (35.25)	18.53	5.18	3.23	172 (35.25)	18.53	5.15	3.12
	72 (14.75)	10.40	2.72	1.64	72 (14.75)	10.40	2.72	1.56
	124 (25.41)	14.55	4.70	2.90	124 (25.41)	14.55	4.70	2.74
	120 (24.59)	14.49	5.58	3.34	120 (24.59)	14.49	5.56	3.13
C	208 (30.42)	18.98	5.29	3.23	208 (30.42)	18.98	5.29	3.14
	176 (25.73)	18.41	5.84	3.47	176 (25.73)	18.41	5.85	3.34
	196 (28.65)	21.40	6.95	4.30	196 (28.65)	21.40	6.96	4.10
	104 (15.20)	12.87	4.44	2.75	104 (15.20)	12.87	4.55	2.61
D	176 (31.21)	14.92	3.98	2.36	176 (31.21)	14.92	3.97	2.30
	216 (38.29)	20.77	5.78	2.40	216 (38.29)	20.77	5.78	3.30
	52 (9.22)	7.22	1.82	1.11	52 (9.22)	7.22	1.82	1.05
	120 (21.28)	16.85	4.79	3.03	120 (21.28)	16.85	4.79	2.83

rose as their numbers till the third layer, yet they continued to rise in the fourth layer though their actual numbers fell. Their percentage of abundance as of the total soil fauna when considered were seen to be similar to that of their percentages among total mesofauna (Table-XIX).

The largest family among Araneida was the family Clubionidae forming nearly 44 to 56% of Araneida. Their numbers in the different layers for both the years were nearly the same in different sites with very little differences, as in site B fourth layer recorded a little less than in first annual cycle, while in site D the first layer recorded a little more and second layer recorded a little less in the second annual cycle. The steady decrease in numbers was again seen to be in only site D. In sites A and C, they fell and rose in the alternate layers, while in site B they fell steadily till the third layer to rise though insignificantly in the fourth layer. When Clubionidae was seen as the percentage of abundance of Araneida, mesofauna or total soil fauna, it followed more or less the same trend as the sites except site D where the trend was in reverse. However, in site A, the first and second layer where the numbers were the same, yet a slight increase was recorded among those relative percentages (Table-XX).

The next family among Araneida was the Lycosidae which formed nearly 16-39% of Araneida. Here also their numbers in different layers were consistent for both the years in the various sites under consideration. The only site where there was a steady decrease from top to bottom layers was site A, while there was steady decrease till the third layer in site D with a sudden increase in the fourth. Site B recorded the increase in the second layer which fell thereafter till the fourth, while site C fell and rose alternatively. This pattern was also seen similar when

Table XIX : Showing the total number of Araneida and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total mesofauna.

c : Percentages in Total soil fauna.

Table XX : Showing the total number of Family Clubionidae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in Araneida.

c : Percentages in total mesofauna

d : Percentages in Total soil fauna.

TABLE XIX

1978			1979			SITES
a	b	c	a	b	c	
532 (27.77)	13.31	8.94	532 (27.77)	13.25	8.66	
488 (25.47)	13.41	8.51	488 (25.47)	13.33	8.20	A
492 (25.68)	15.72	10.23	492 (25.68)	15.50	9.73	
404 (21.08)	14.79	9.99	404 (21.08)	14.78	9.36	
572 (26.93)	17.23	10.75	572 (27.24)	17.13	10.37	
596 (78.11)	22.51	13.57	596 (28.38)	22.51	12.89	B
500 (23.58)	18.97	11.69	500 (23.81)	18.97	11.86	
452 (21.33)	21.00	12.57	432 (20.57)	20.00	11.25	
772 (32.78)	19.63	11.57	773 (32.17)	19.63	11.64	
528 (22.07)	17.51	10.42	528 (22.00)	17.55	10.00	C
576 (24.08)	20.43	12.64	576 (24.00)	20.45	12.04	
516 (21.57)	22.05	13.62	524 (21.83)	22.94	13.15	
936 (33.14)	22.16	12.55	948 (33.42)	21.39	12.38	
768 (27.20)	20.56	12.11	768 (27.08)	20.56	11.74	D
596 (21.10)	20.84	12.71	596 (21.02)	20.84	12.06	
524 (18.56)	20.93	13.25	524 (18.48)	20.93	12.35	

TABLE XX

1978				1979			
a	b	c	d	a	b	c	d
248 (25.94)	46.62	6.21	4.17	248 (25.94)	46.62	6.18	4.04
248 (25.94)	50.82	6.81	4.32	248 (25.94)	50.82	6.78	4.17
256 (26.78)	52.03	8.18	5.32	256 (26.78)	52.03	8.07	5.06
204 (21.34)	50.50	7.47	5.04	204 (21.34)	50.50	7.47	4.73
308 (28.10)	53.85	9.28	5.79	308 (28.41)	53.85	9.22	5.58
288 (26.28)	48.32	10.88	6.56	288 (26.57)	48.32	10.88	6.23
244 (22.26)	48.80	9.26	5.71	244 (22.51)	48.80	9.26	5.40
256 (23.36)	56.64	11.90	7.12	244 (22.51)	56.48	11.30	6.35
388 (32.33)	50.26	9.87	6.02	388 (32.33)	50.26	9.87	5.85
248 (20.67)	46.97	8.22	4.89	248 (20.67)	46.97	8.24	4.70
320 (26.67)	55.56	11.35	7.02	320 (26.67)	55.56	11.36	6.69
244 (20.33)	47.29	10.43	6.44	244 (20.33)	46.56	10.68	6.12
412 (30.56)	44.02	9.31	5.52	420 (30.98)	44.30	9.48	5.48
372 (27.60)	48.44	9.96	5.86	364 (27.43)	47.39	9.96	5.69
296 (21.96)	49.66	10.35	6.31	296 (21.83)	49.66	10.35	5.99
268 (19.88)	51.15	10.70	6.77	268 (19.16)	51.15	10.70	6.31

Lyco idae was considered as the percentage of Araneida. However when it was taken as the percentage of either total mesofauna or total soil fauna, it followed a trend of its own in both the cases though similar to each other in sites A and D, the third layer in sites B and C, the fourth recorded an increase while actually their numbers and their relative percentages of Araneida decreased (Table-XXI).

The third and last family under Araneida was Linyphidae which comprised of nearly 13 to 35% of Araneida. As in earlier cases the numbers in different layers for both the annual cycles were nearly consistent for various sites, except that it recorded a negligible decrease in the second annual cycle for the fourth layer at site B and an increase in the second layer for site D. The decrease from top to the bottom layers in numbers was again seen in site D only, while in site C there was a steady decrease till the third layer which rose by 4% in the fourth layer. Sites A and B had a significant rise in the second layer and fell steadily till the fourth layer. However, while the relative percentages of abundance in Araneida was considered, they seemed to follow the trend as their vertical distribution numbers only in sites C and D. The fourth layer in site A and the third layer in site B recorded a significant increase in their relative percentages of Araneida when actual numbers decreased. A similar trend was also seen as in the case of relative percentage of abundance in Araneida, total mesofauna and total soil fauna in sites A, C and D. n site B however, the relative percentages of abundance in total mesofauna and in total soil fauna followed a pattern of the family's own vertical distributional numbers (Table-XXII).

The remaining four groups under total mesofauna in the present investigation were with very little percentages of abundance.

Table XXI : Showing the total number of family Lycosidae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XXII : Showing the total number of family Linyphidae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in Araneida

c : Percentages in total mesofauna.

d : Percentages in Total soil fauna.

TABLE XXI.

1978				1979			
a	b	c	d	a	b	c	d
212 (43.80)	39.85	5.31	3.56	212 (43.80)	39.85	5.28	3.45
104 (21.49)	21.31	2.86	1.81	104 (21.49)	21.31	2.84	1.75
100 (20.66)	20.33	3.19	2.08	100 (20.66)	20.33	3.15	1.98
68 (14.05)	16.83	2.49	1.68	68 (14.05)	16.83	2.49	1.58
104 (26.80)	18.18	3.13	1.95	104 (27.08)	18.18	8.77	3.11
128 (32.99)	21.48	4.83	2.91	128 (33.33)	21.48	4.83	2.77
84 (21.65)	16.80	3.19	1.96	84 (21.88)	16.80	3.19	1.86
72 (18.56)	15.93	3.35	2.00	68 (17.71)	15.71	3.15	1.77
168 (36.84)	21.76	4.27	2.61	168 (36.84)	21.76	4.27	2.53
92 (20.18)	17.42	3.05	1.82	92 (20.18)	17.42	3.06	1.74
104 (22.80)	18.06	3.69	2.28	104 (22.80)	18.06	3.69	2.17
92 (20.18)	17.83	3.93	2.43	92 (20.18)	17.56	4.03	2.31
200 (37.59)	21.37	4.52	2.68	204 (38.06)	21.52	4.60	2.66
128 (24.06)	16.67	3.32	1.95	128 (23.88)	16.67	3.43	1.96
96 (18.05)	16.11	3.36	2.05	96 (17.91)	16.11	3.36	1.94
108 (20.30)	20.61	4.31	2.73	108 (20.15)	20.61	4.31	2.54

TABLE XXII

SITES	1978				1979			
	a	b	c	d	a	b	c	d
A	72 (15.13)	13.53	1.80	1.21	72 (15.13)	13.53	1.79	1.17
	136 (28.57)	27.87	3.74	2.37	136 (28.57)	27.87	3.72	2.29
	136 (28.57)	27.64	4.35	2.83	136 (28.57)	27.64	4.28	2.69
	132 (27.73)	32.67	4.83	3.27	132 (27.73)	32.67	4.83	3.06
B	160 (25.16)	27.97	4.82	3.01	160 (25.32)	27.97	4.79	2.90
	180 (28.30)	30.20	6.80	4.10	180 (28.48)	30.20	6.80	3.89
	172 (27.04)	34.40	6.53	4.02	172 (27.22)	34.40	6.53	3.81
	124 (19.50)	27.43	5.76	3.45	120 (18.98)	27.78	5.56	3.13
C	216 (29.35)	27.98	5.49	3.35	216 (29.03)	27.98	5.49	3.26
	188 (25.54)	35.61	6.23	3.71	188 (25.27)	35.61	6.25	3.56
	152 (20.65)	26.39	5.39	3.34	152 (20.43)	26.39	5.40	3.18
	180 (24.46)	34.88	7.69	4.75	188 (25.27)	35.88	8.23	4.72
D	324 (36.99)	34.62	7.32	4.34	324 (36.69)	34.18	8.21	4.23
	268 (27.24)	34.90	7.17	4.22	276 (27.83)	35.94	7.39	4.22
	204 (20.73)	34.23	7.13	4.35	204 (20.56)	34.23	7.13	4.13
	148 (15.04)	28.24	5.91	3.74	140 (14.92)	28.24	5.91	3.49

They were Protura, Diplura, Chelonethi and Isopoda in that order of dominance.

The group Protura formed nearly 2.5 to 7% of the total mesofauna. The consistency of their numbers for both the annual cycles in different layers was seen if at all in sites B and D only. The steady decrease in numbers from top to the bottom layers was seen in sites A and C, while in site D though there was a decrease till the third layer, with an insignificant increase in fourth. In site B there was a slight increase in second layer which fell thereafter in subsequent layers. When the group Protura was considered as the percentage of either mesofauna or the soil fauna, it was seen that both followed a trend similar to the vertical distributional numbers only in site B. In site A however, though the trend was similar to the third layer, there was an increase in the fourth layer in the first annual cycle while in the third layer in the second annual cycle. In site C, though a steady decrease in numbers was observed from top to the bottom layers, yet Protura percentage of either the mesofauna or total soil fauna recorded an increase in the second and fourth layer in contrast to the first and third layer where the actual numbers were more (Table-XXIII).

The group Diplura comprised of nearly 2.5 to 6% of the total mesofauna, their numbers recorded in different layers in various sites for the two annual cycles were not consistent except in the case of the fourth layer site A, the second and third layer in site B, first, second and third layer in site C and second, third and fourth layer in site D. However this group revealed a decrease in numbers from top to the bottom layers in all the sites in both the years of study. This trend of decrease from top to bottom layers was also seen when Diplura was taken as percentages of either the total mesofauna or total soil fauna in sites C and D

for both annual cycles and in site A for second annual cycle only. The first annual cycle in site A revealed a sudden increase in the third layer, while in site B the increase was seen in the second layer though in both the cases only very insignificantly (Table-XXIV).

The last two groups under mesofauna comprised of Chelonethi and Isopoda. The former formed nearly 2%, while the latter only 1%, of the total mesofauna respectively. The numbers of Chelonethi were more or less similar for all the layers in all the sites. So also it was true for the group Isopoda. As their percentage of abundance either among total mesofauna or total soil fauna was very negligible, nothing further can be said about them (Tables-XXV, XXVI).

The third and last major group under total soil fauna was macrofauna, the possible large sub-divisions under this group were total insecta, total myriapoda, Annelida and Mollusca. The total insecta was categorised into its major orders namely, Coleoptera, Diptera, Hemiptera, Hymenoptera, Trichoptera, Thysanoptera, Dermaptera, Lepidoptera and Orthoptera. The order Hymenoptera excludes the total ants which is presented not only separately but also upto family levels.

The total insecta, their numbers when considered in the vertical distribution of different soil layers for the two annual cycles, was found to be always more in the second annual cycle not only in the different layers but also in different sites. Further there was a steady decrease in their numbers from top to the bottom layers in all the sites during both the annual cycles except in site A where they rose by nearly 3% in the second layer but fell steadily thereafter. The total insects formed nearly 70 to 80% of the total macrofauna. This percentage of macrofauna was however seen to be nearly the same for different layers at

Table XXIII : Showing the total number of Protura *and its relative percentages for* the total study period in the four different sites at four different depths for each annual cycle.

Table XXIV : Showing the total number of *Diplura and its relative percentages* for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in mesofauna.

c : Percentages in Total soil fauna.

TABLE XXIII

1978			1979			SITES
a	b	c	a	b	c	
176 (34.11)	4.40	2.96	180 (33.33)	4.48	2.93	
152 (29.46)	4.18	2.65	152 (27.60)	4.15	2,56	A
100 (19.38)	3.19	2.08	140 (20.83)	4.41	2.77	
88 (17.05)	3.22	2.18	88 (18.35)	3.22	2.04	
160 (32.61)	5.42	3.38	180 (31.69)	5.39	3.26	
184 (33.33)	6.95	4.19	184 (32.39)	6.95	3.98	B
136 (24.69)	5.16	3.18	136 (23.94)	5.16	3.01	
52 (9.42)	2.42	1.45	68 (11.98)	3.15	1.77	
220 (40.44)	5.60	3.41	220 (41.46)	5.60	3.32	
124 (22.79)	4.11	2.45	116 (21.80)	3.86	2.20	C
120 (22.06)	4.26	2.63	116 (21.80)	4.12	2.42	
80 (14.71)	3.42	2.11	56 (15.04)	2.45	1.41	
308 (38.12)	6.96	4.13	308 (38.12)	6.95	4.02	
264 (32.67)	7.07	4.16	264 (32.67)	7.07	4.04	D
116 (14.36)	4.06	2.47	116 (14.36)	4.06	2.35	
120 (14.85)	4.79	3.03	120 (14.85)	4.79	2.83	

TABLE XXIV

1978			1979		
a	b	c	a	b	c
140 (33.65)	3.50	2.35	156 (42.39)	3.08	2.54
108 (25.96)	2.97	1.88	128 (34.98)	3.49	2.15
100 (24.04)	3.19	2.08	104 (28.26)	3.28	2.06
68 (16.35)	2.49	1.68	68 (18.48)	2.49	1.58
164 (31.54)	4.94	3.08	168 (31.58)	5.03	3.05
148 (28.46)	5.59	3.37	148 (27.82)	5.59	3.20
144 (27.69)	5.46	3.37	144 (27.07)	5.46	3.19
64 (12.31)	2.97	1.78	72 (13.53)	3.33	1.88
180 (35.72)	4.58	2.79	180 (35.72)	4.58	2.71
136 (26.98)	4.51	2.68	136 (26.98)	4.52	2.58
120 (23.81)	4.26	2.63	120 (23.81)	4.26	2.51
68 (13.49)	2.91	1.80	48 (13.40)	2.10	1.20
256 (36.36)	5.79	3.43	252 (36.00)	5.69	3.29
216 (30.68)	5.78	3.40	216 (30.86)	5.78	3.30
136 (19.32)	4.76	2.90	136 (19.43)	4.76	2.75
96 (13.64)	3.83	2.43	96 (13.71)	3.83	2.26

TABLE XXV : Showing the total number of Chelonethii and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XXVI : Showing the total number of Isopoda and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in mesofauna.

c : Percentages in Total soil fauna.

TABLE XXV

1978			1979			SITES
a	b	c	a	b	c	
60 (25.42)	1.52	1.01	60 (25.42)	1.49	0.98	A
56 (23.74)	1.54	0.98	56 (23.74)	1.53	0.94	A
60 (25.42)	1.92	1.25	60 (25.42)	1.89	1.19	A
60 (25.42)	2.20	1.48	60 (25.42)	2.20	1.39	A
60 (24.19)	1.81	1.13	60 (23.81)	1.80	1.09	B
64 (25.81)	2.42	1.46	64 (25.40)	2.42	1.38	B
64 (25.81)	2.43	1.50	64 (25.40)	2.43	1.42	B
60 (24.19)	2.79	1.67	64 (25.40)	2.96	1.67	B
60 (25.86)	1.53	0.93	60 (25.86)	1.53	0.90	C
56 (24.13)	1.86	1.10	60 (25.86)	1.99	1.14	C
56 (24.14)	1.99	1.23	56 (24.14)	1.99	1.17	C
60 (25.86)	2.56	1.58	56 (24.14)	2.45	1.41	C
60 (25.00)	1.36	0.80	60 (25.00)	1.35	0.78	D
60 (25.00)	1.61	0.95	60 (25.00)	1.61	0.92	D
60 (25.00)	2.10	1.28	60 (25.00)	2.10	1.21	D
60 (25.00)	2.40	1.52	60 (25.00)	2.40	1.41	D

TABLE XXVI

1978			1979		
a	b	c	a	b	c
24 (25.00)	0.60	0.40	24 (25.00)	0.60	0.39
24 (25.00)	0.66	0.42	24 (25.00)	0.66	0.40
24 (25.00)	0.77	0.50	24 (25.00)	0.76	0.47
24 (25.00)	0.88	0.59	24 (25.00)	0.88	0.56
24 (25.00)	0.72	0.45	24 (25.00)	0.72	0.44
24 (25.00)	0.91	0.55	24 (25.00)	0.91	0.52
24 (25.00)	0.91	0.56	24 (25.00)	0.91	0.53
24 (25.00)	1.12	0.67	24 (25.00)	1.11	0.63
24 (25.00)	0.61	0.37	24 (30.00)	0.61	0.36
24 (25.00)	0.80	0.47	24 (30.00)	0.80	0.45
24 (25.00)	0.85	0.53	24 (30.00)	0.85	0.50
24 (25.00)	1.03	0.63	8 (10.00)	0.35	0.20
20 (26.30)	0.45	0.27	20 (26.30)	0.45	0.26
20 (26.30)	0.54	0.32	20 (26.30)	0.54	0.31
20 (26.32)	0.70	0.43	20 (26.32)	0.70	0.40
16 (21.05)	0.64	0.40	16 (21.05)	0.64	0.38

different sites, even though as mentioned above, the actual numbers of the total insects present increased in the second annual cycle in the different layers of the soil in all the sites studied. Their relative percentages of the total macrofauna was seen to be in the reverse in site D in relation to the actual numbers, though in the second annual cycle they decreased at the fourth layer very insignificantly. In site A the third layer registered the maximum percentage and though it decreased in the fourth layer the levels were much greater than the first. In sites B and C there was an increase in the third and fourth layer for both the annual cycles. When the total insecta was considered as the percentage of the total soil fauna, it revealed a pattern very similar to those of the percentages as in macro-fauna (Table-XXVII).

Among the total insects the major group was the order Hymenoptera. However for the sake of convenience we separated the total ants from this order Hymenoptera as it formed a major portion. When so considered the total ant numbers for the different layers in both the annual cycles were nearly the same in all the sites. The decrease in numbers from top to the bottom layers was seen only in sites C and D, while in sites A and B they fell and rose alternatively in different layers. The total ants comprised of nearly 45 to 62% of the total insects and 30 to 50% of the total macrofauna and when these percentages were considered for different layers in different sites during two annual cycles, the trend was in reverse again in site D, in relation to the vertical distribution to their actual numbers. They however followed a similar trend in sites A and B, but in site C they registered an increase in third layer. When total ants as percentages of total soil fauna was calculated, the percentage distributional pattern in the different layers for different sites during the period of

Table XXVII : Showing the total number of insecta and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total macrofauna.

c : Percentages in total soil fauna.

Table XXVIII : Showing the total number of ants and its relative percentages for the total study period in the four differeent sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total insecta.

c : Percentages in macrofauna.

d : Percentages in total soil fauna.

TABLE XXVII

1978			1979		
a	b	c	a	b	c
1168 (25.17)	74.68	19.64	1230 (25.22)	73.73	20.85
1324 (28.53)	76.44	23.08	1380 (27.19)	71.73	23.20
1260 (27.16)	82.25	26.20	1344 (26.48)	77.42	26.57
888 (19.14)	78.45	21.96	1072 (21.12)	76.35	24.84
1300 (29.44)	73.70	24.44	1420 (28.06)	73.20	25.74
1140 (25.82)	73.08	25.96	1316 (26.01)	73.44	28.46
1060 (24.00)	74.65	24.79	1240 (24.51)	74.70	27.43
916 (20.74)	73.63	25.47	1084 (21.42)	73.24	28.23
1680 (32.92)	77.35	26.05	1828 (31.47)	77.59	27.56
1324 (25.94)	75.92	26.12	1496 (25.76)	76.33	28.35
1132 (22.18)	75.67	24.85	1132 (22.59)	75.93	27.42
968 (18.97)	77.56	25.55	1172 (20.18)	78.13	29.42
2048 (33.20)	77.58	27.45	2184 (32.04)	77.12	28.51
1732 (28.08)	77.74	27.30	1872 (27.46)	77.23	28.62
1312 (21.27)	80.99	27.99	1512 (22.18)	80.94	30.61
1076 (17.44)	82.77	27.20	1248 (18.31)	78.59	29.41

TABLE XXVIII

SITES	1978				1979			
	a	b	c	d	a	b	c	d
A	632 (27.15)	54.11	40.41	10.63	636 (27.04)	49.69	36.64	10.36
	628 (26.98)	47.43	36.26	10.95	612 (26.02)	44.35	31.81	10.29
	704 (30.24)	55.87	45.95	14.64	692 (29.42)	51.49	39.86	13.68
	364 (15.63)	40.99	32.16	9.00	412 (17.52)	38.43	29.34	9.55
B	640 (29.63)	49.23	36.28	12.03	640 (27.30)	45.07	32.99	11.60
	532 (24.63)	46.67	34.10	12.11	596 (25.43)	45.29	33.26	12.89
	572 (26.48)	53.96	40.28	13.38	632 (26.96)	50.97	38.07	13.98
	416 (19.26)	45.41	33.44	11.57	476 (20.31)	43.91	32.16	12.40
C	972 (33.20)	57.86	44.75	15.07	964 (31.06)	52.74	40.92	14.54
	716 (24.45)	54.08	41.06	14.12	780 (25.13)	52.14	39.80	14.78
	692 (23.63)	61.13	46.26	15.19	740 (23.04)	56.40	42.82	15.47
	548 (18.72)	56.61	43.91	14.47	620 (19.17)	52.90	41.33	15.56
D	1196 (32.60)	58.40	45.30	16.03	1176 (31.14)	53.85	41.53	15.35
	1024 (27.92)	59.12	45.96	16.14	1044 (27.65)	55.77	43.07	15.96
	772 (21.05)	58.85	47.65	16.47	840 (22.25)	55.56	44.97	17.00
	676 (18.43)	62.83	52.00	17.08	716 (18.96)	57.37	45.09	16.87

study followed nearly a very similar trend as for the relative percentage of total ants under insects and macrofauna (Table - XXVIII).

The ants were subdivided further into its families, Myrmicinae, Ponerinae, Pseudomyrmicinae, Dorylinae and Dolichoderinae in that order of abundance. The family Myrmicinae was nearly 30 to 40% of the total ants. Their numbers for the different layers in the different sites were consistent during the second annual cycle. Their actual numbers present in different layers decreased steadily for both the annual cycles from top to the bottom only in sites C and D. In site A there was a sudden increase in the second layer which fell thereafter till the bottom layer, while in site B there was an increase in third layer to levels as for the first layer. As the percentage of their occurrence in total ants they were seen to follow as in earlier cases a trend in the reverse with increasing percentages from top to the bottom layers in site D during both the annual cycles. In case of sites A,B and C these percentages were seen to be on the increased side at the bottom most fourth layer for both annual cycles when in all the sites the number registered were the least. When the family Myrmicinae was considered as the percentage of either the total insecta, macrofauna or the total soil fauna, it was seen that they followed a trend in different layers as the family's own vertical distributional number for both the annual cycles in sites A,B and C. As usual in site D, these percentages were in reverse trend of increase from top to the bottom layers (Table-XXIX).

The next family in terms of abundance among ants was the family Ponerinae. This family also revealed a consistency of the number present in different layers for both the annual cycles in all the sites undertaken. In their vertical distribution, it was

Table XXIX : Showing the total number of family Myrmicinae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total Ants.

c : Percentages in total Insecta.

d : Percentages in total Macrofauna.

e : Percentages in total Soil fauna.

TABLE XXIX

SITES	1979					1979				
	a	b	c	d	e	a	b	c	d	e
A	228 (25.79)	36.08	19.52	14.58	3.83	228 (25.79)	35.85	17.81	13.13	3.71
	276 (31.22)	43.95	20.85	15.94	4.81	276 (31.22)	45.10	20.00	14.35	4.64
	236 (26.70)	33.52	18.73	15.40	4.91	236 (26.70)	34.10	17.56	13.59	4.67
	114 (16.29)	39.56	16.22	12.72	3.56	114 (16.29)	34.95	13.43	10.26	3.34
B	240 (27.91)	37.50	18.46	13.61	2.71	240 (27.91)	37.50	16.90	12.37	4.35
	192 (22.33)	36.09	16.84	12.31	4.37	192 (22.33)	32.21	14.59	10.71	4.15
	244 (28.37)	42.66	23.02	17.18	5.71	244 (28.37)	38.61	19.68	14.70	5.40
	184 (21.39)	44.23	20.09	14.79	5.12	184 (21.39)	38.66	16.97	12.43	4.79
C	364 (33.09)	37.45	21.67	16.76	5.65	364 (32.85)	37.76	19.91	15.45	5.49
	296 (26.91)	41.34	22.36	16.97	5.84	296 (26.71)	37.95	19.79	15.10	5.61
	240 (21.82)	34.68	21.20	16.04	5.27	240 (21.66)	32.43	18.29	13.89	5.02
	200 (18.18)	36.50	20.66	16.03	5.28	208 (18.77)	33.55	17.75	13.87	5.22
D	376 (30.13)	31.44	18.36	14.24	5.04	376 (30.13)	31.97	17.22	13.28	4.91
	344 (27.56)	33.59	19.86	15.44	5.42	344 (27.56)	32.95	18.38	14.19	5.26
	280 (22.44)	36.27	21.34	17.28	5.97	280 (22.44)	33.33	18.52	14.99	5.67
	248 (19.87)	36.69	23.05	19.08	6.27	248 (19.87)	34.64	19.87	15.62	5.84

seen that in sites A and C the numbers fell and rose alternatively, while in site B there was a steady increase till the third layer with a drastic fall in the fourth. In site D there was an increase in the second layer though insignificant, it fell steadily thereafter. Ponerinae formed nearly 7-14% of the total insecta and 20 to 30% of the total ants. These percentages when considered for different layers was seen to follow a trend similar to the actual numbers only in site B. In sites A and C a significant increase in the percentages was seen in the fourth layer only in case of their abundance in total macrofauna for both the annual cycles when their numbers actually were the least. In site D there was slight increase in percentage for the third layer when their actual numbers were less than nearly 6% from the second layer. When this family Ponerinae was considered either as percentages of total insects, macrofauna and total soil fauna the trend in different layers in the different sites for both the annual cycles followed nearly a similar pattern to the vertical distributional numbers in all the sites except in site D as usual, where the trend was in the reverse (Table-XXX).

The third family of abundance among ants was the family Pseudomyrmicinae which comprised nearly 5-18% of the total insecta and 12-28% of the total ants. Their numbers in different layers were consistent for the second annual cycle as the first annual cycle at the various sites except for sites A and C, where there was a fall and rise in the alternate layers in the vertical distribution of their numbers, the remaining two sites B and D showed a steady decrease from top to bottom layers for both the annual cycles. A trend similar to their vertical distributional numbers was also seen for relative percentage of this family either for total ants, total insects, macrofauna or total soil

Table XXX : Showing the total number of family Ponerinae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total Ants.

c : Percentages in total Insecta.

d : Percentages in total Macrofauna.

e : Percentages in total Soil fauna.

TABLE XXX

SITES	1978					1979				
	a	b	c	d	e	a	b	c	d	e
A	140 (25.93)	22.15	11.99	8.95	2.35	140 (25.93)	22.01	10.94	8.06	2.28
	120 (22.22)	19.11	9.06	6.93	2.09	120 (22.22)	19.61	8.70	6.24	2.02
	164 (30.37)	23.20	13.02	10.70	3.41	164 (30.37)	23.70	12.20	9.45	3.24
	116 (21.48)	31.87	13.06	10.25	2.87	116 (21.48)	28.16	10.82	8.26	2.69
B	144 (25.71)	22.50	11.08	8.16	2.71	144 (25.71)	22.50	10.14	7.42	2.61
	164 (29.29)	30.83	14.39	10.50	3.73	164 (29.29)	27.52	12.46	9.15	3.55
	172 (30.71)	30.07	16.23	12.11	4.02	172 (30.71)	27.22	13.87	10.36	3.81
	80 (14.29)	19.23	8.73	6.43	2.22	80 (14.29)	16.81	7.38	5.41	2.08
C	228 (31.49)	23.46	13.57	10.50	3.54	228 (32.02)	23.65	12.47	9.68	3.44
	168 (23.21)	23.46	12.69	9.63	3.31	168 (23.60)	21.54	11.23	8.57	3.18
	180 (24.86)	26.01	15.90	12.03	3.95	168 (23.60)	22.70	12.80	9.72	3.51
	148 (20.44)	27.00	15.29	11.86	3.91	148 (20.79)	23.87	12.63	9.87	3.71
D	240 (29.13)	20.07	11.72	9.09	3.22	240 (29.13)	20.41	10.99	8.47	3.13
	244 (29.61)	23.83	14.09	10.95	3.85	244 (29.61)	23.37	13.03	10.07	3.73
	192 (23.30)	24.87	14.63	11.85	4.10	192 (23.30)	22.86	12.70	10.28	3.88
	148 (17.96)	21.89	13.75	11.38	3.74	148 (17.96)	20.67	11.86	9.32	3.45

fauna in sites A and C only for both the annual cycles. In site B all these relative percentages showed an increase in the second layer and the fourth layer when the actual numbers were either less or same respectively in both the annual cycles. In site D, there was a usual trend in the reverse though significant after the second layer (Table-XXXI).

The family Dorylinae came next in importance after the family Pseudomyrmicinae and comprised of nearly 3 to 8% of the insects and 3 to 4% of the total ants. The steady decrease in their numbers from top to the bottom layers in both the annual cycles were seen only in sites C and D. Site A showed an increase in second layer, which fell steadily thereafter while site B showed a fall and rise till the fourth layer. The relative percentages of this family Dorylinae either among total insects, total ants, macrofauna or total soil fauna revealed a trend in different layers similar to actual numbers present in all the sites except for the fourth layer of sites B,C and D where they registered a slight increase when the actual numbers were the same as in the third layer (Table-XXXII).

The family Dolichoderinae came last in importance among the ants and comprised of nearly 3 to 10% of the total ants and 2 to 5% of the total insects. The numbers in the different soil layers fell steadily from top to the bottom layers in both the annual cycles only in site D, while so in site C for the first annual cycle only. The increase in the second and third layers and a fall in the fourth layer was seen in the first annual cycle in site A and for the second annual cycle in site C. The fall and rise in the alternate layers was seen for both the annual cycles in site B and for the second annual cycle in site A. When this family relative percentage of the total ants were considered, it

Table XXXI : Showing the total number of family Pseudomyrmicinae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total Ants.

c : Percentages in total Insects.

d : Percentages in total Macrofauna.

e : Percentages in total Soil fauna.

TABLE XXXI

SITES	1978					1979				
	a	b	c	d	e	a	b	c	d	e
A	124 (29.52)	19.62	10.62	7.93	2.08	124 (29.52)	19.50	9.69	7.14	2.02
	76 (18.10)	12.10	5.74	4.39	1.32	76 (18.10)	12.40	5.51	3.95	1.28
	164 (39.05)	23.30	13.02	10.70	3.41	164 (39.05)	23.70	12.20	9.45	3.24
	56 (13.33)	15.38	6.31	4.95	1.39	56 (13.33)	13.59	5.22	3.09	1.30
B	148 (29.13)	23.13	11.38	8.39	2.78	152 (29.69)	23.75	10.70	7.84	2.76
	144 (28.35)	27.07	12.63	9.23	3.28	144 (28.13)	24.16	10.94	8.04	3.11
	108 (21.26)	18.08	10.19	7.61	2.53	108 (21.09)	17.09	8.71	6.51	2.39
	108 (21.26)	25.96	11.79	8.68	3.00	108 (21.00)	22.69	9.96	7.30	2.81
C	204 (29.31)	20.99	12.14	9.39	3.16	204 (29.48)	21.16	11.16	8.66	3.08
	168 (24.14)	23.46	12.69	9.63	3.31	168 (24.28)	21.54	11.23	8.57	3.18
	188 (27.01)	27.17	16.61	12.57	4.13	184 (26.59)	24.86	14.04	10.65	3.85
	136 (19.54)	24.82	14.05	10.90	3.59	136 (19.65)	21.94	11.60	9.07	3.41
D	308 (32.22)	25.75	15.04	11.67	4.13	308 (31.83)	26.19	14.10	10.88	4.02
	252 (26.36)	24.61	14.55	11.31	3.97	252 (26.03)	24.14	13.46	10.40	3.85
	212 (21.34)	27.46	16.16	13.09	4.52	216 (22.31)	25.71	14.29	11.56	4.37
	192 (20.08)	28.40	17.84	14.77	4.85	192 (19.83)	26.82	15.38	12.09	4.52

Table XXXII : Showing the total number of family Dorylinae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total Ants.

c : Percentages in total Insects.

d : Percentages in total Macrofauna.

e : Percentages in total Soil Fauna.

TABLE XXXII

SITES	1978					1979				
	a	b	c	d	e	a	b	c	d	e
A	76 (29.23)	12.03	2.51	4.86	1.28	76 (26.76)	11.95	5.94	4.38	1.24
	88 (33.85)	14.01	6.65	5.08	1.53	88 (30.99)	14.38	6.38	4.57	1.48
	72 (27.69)	10.23	5.71	4.70	1.50	72 (25.35)	10.40	5.36	4.15	1.42
	24 (9.23)	6.59	2.70	2.12	0.59	48 (16.90)	11.65	4.48	3.42	1.11
B	56 (46.66)	8.75	4.31	3.17	1.05	52 (25.00)	8.13	3.66	2.68	0.94
	16 (13.33)	3.01	1.40	1.03	0.36	48 (23.08)	8.05	3.65	2.68	1.04
	24 (20.00)	4.20	2.26	1.69	0.56	52 (25.00)	8.23	4.19	3.13	1.15
	24 (20.00)	5.77	2.62	1.93	0.67	56 (26.92)	11.76	5.17	3.78	1.46
C	112 (45.16)	11.52	6.67	5.16	1.74	112 (32.56)	11.62	6.13	4.75	1.69
	48 (19.36)	6.70	3.63	2.75	0.95	80 (23.26)	10.26	5.35	4.08	1.52
	48 (19.36)	6.94	4.24	3.21	1.05	80 (23.26)	10.81	6.10	4.63	1.67
	40 (16.13)	7.30	4.13	3.21	1.06	72 (20.93)	11.61	6.14	4.80	1.81
D	160 (43.96)	13.38	7.81	6.06	2.14	140 (38.83)	11.90	6.41	4.94	1.83
	104 (29.67)	10.16	6.00	4.67	1.64	108 (26.21)	10.34	5.77	4.46	1.65
	48 (13.18)	6.22	3.66	2.96	1.02	80 (19.42)	9.52	5.29	4.28	1.62
	48 (13.19)	7.10	4.46	3.69	1.21	64 (15.53)	8.94	5.13	4.03	1.51

was seen that they followed a trend of their vertical distributional numbers for the first annual cycle in all the four sites and in the second annual cycle only in sites C and D. In site A the fourth layer registered the maximum percentage as also in site B except that in the latter, the total trend was in the reverse for the second annual cycle. A trend similar to these relative percentages was also nearly the same when Dolichoderinae relative percentage among macrofauna and total soil fauna was considered, except in site D where they revealed a trend in the reverse as usual. However when the relative percentage was seen among the total insecta they showed the same trend as the other percentages in the first annual cycle and for the second annual cycle only in sites B and C, while in site A they followed the pattern as of the vertical distribution (Table-XXXIII).

Among the orders of insects, the order Coleoptera, comprised of 4 to 12%. The numbers in the different layers were found to be the same in the second annual cycle for the various sites. Further, there was a steady decrease in numbers from top to the bottom layers in all the sites. When their relative percentage of abundance in total insects, macrofauna and total soil fauna was considered the phenomenon of steady decrease in the different layers was seen only in second annual cycle in site B. In site A though there was a steady decrease till the third layer, there was a slight increase in the fourth layer, in their percentages for both the annual cycles, while in site D the trend was more or less in the reverse for these three percentages of abundance except in fourth layer which revealed a rise and fall in the alternative layers (Table-XXXIV).

The order Diptera came next in terms of abundance to Coleoptera, forming nearly 6-10% of the total insects. The steady

Table XXXIII: Showing the total number of family Dolichoderinae and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XXXIV : Showing the total number of Coleoptera and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total Ants.

c : Percentages in total Insecta.

d : Percentages in total Macrofauna.

e : Percentages in total Soil fauna.

TABLE XXXIII

1978					1979				
a	b	c	d	e	a	b	c	d	e
64 (28.57)	10.13	5.48	4.09	1.08	68 (30.36)	10.69	5.31	3.92	1.11
68 (30.36)	10.83	5.14	3.93	1.19	52 (23.21)	8.50	3.77	2.70	0.87
68 (30.36)	9.66	5.40	4.44	1.41	56 (25.00)	8.09	4.17	3.23	1.11
24 (10.71)	6.59	2.70	2.12	0.59	48 (21.43)	11.65	4.48	3.42	1.11
52 (46.43)	8.13	4.00	2.95	0.98	52 (25.49)	8.13	3.66	2.68	0.94
16 (14.29)	3.01	1.40	1.03	0.36	48 (23.53)	8.05	3.05	2.68	1.04
24 (21.43)	4.20	2.26	1.69	0.56	56 (27.45)	8.86	4.52	3.37	1.24
20 (17.85)	4.81	2.13	1.61	0.56	48 (23.53)	10.08	4.43	3.24	1.25
64 (41.02)	6.58	3.81	2.95	0.99	56 (22.58)	5.81	3.06	2.38	0.84
36 (23.08)	5.03	2.72	2.06	0.71	68 (27.42)	8.72	4.55	3.47	1.29
36 (23.08)	5.20	3.18	2.41	0.79	68 (27.42)	9.10	5.18	3.94	1.42
24 (12.82)	4.38	2.48	1.92	0.63	56 (22.58)	9.03	4.78	3.73	1.41
112 (42.43)	9.36	5.47	4.24	1.50	112 (32.56)	9.52	5.13	3.95	1.46
80 (30.30)	7.81	4.62	3.59	1.26	96 (27.91)	9.20	5.13	3.96	1.47
40 (15.15)	5.18	3.05	2.47	0.85	72 (20.93)	8.57	4.76	3.85	1.47
40 (12.12)	5.92	3.72	3.08	1.01	64 (18.60)	8.94	5.13	4.03	1.51

TABLE XXXIV

SITES	1978				1979			
	a	b	c	d	a	b	c	d
A	140 (35.00)	11.99	8.95	2.33	128 (34.78)	10.00	7.37	2.08
	108 (27.00)	8.16	6.24	1.88	88 (23.91)	6.38	4.57	1.48
	76 (19.00)	6.03	4.96	1.58	76 (20.65)	5.65	4.38	1.50
	76 (19.00)	8.56	6.71	1.88	76 (20.65)	7.09	5.41	1.76
B	140 (29.66)	10.77	7.94	2.63	140 (29.66)	9.86	7.22	2.54
	128 (27.12)	11.23	8.21	2.91	128 (27.12)	9.73	7.14	2.77
	108 (22.88)	10.19	7.61	2.53	108 (22.88)	8.71	6.51	2.39
	96 (20.34)	10.48	7.72	2.67	96 (20.34)	8.86	6.49	2.50
C	136 (30.09)	8.10	6.26	2.11	136 (30.09)	7.44	5.77	2.05
	124 (27.43)	9.37	7.11	2.45	124 (27.43)	8.29	6.33	2.35
	96 (21.24)	8.48	6.42	2.11	96 (21.24)	7.32	5.56	2.01
	96 (21.24)	9.92	7.69	2.53	96 (21.24)	8.19	6.40	2.41
D	188 (36.72)	9.18	7.12	2.52	188 (35.61)	8.61	6.64	2.45
	140 (27.34)	8.08	6.28	2.21	140 (26.52)	7.48	5.78	2.14
	140 (27.34)	10.67	8.64	2.99	140 (26.52)	9.26	7.49	2.83
	44 (8.59)	4.09	3.38	1.11	60 (11.36)	4.81	3.78	1.41

decrease in numbers from top to the bottom layers was seen for all the sites for both the annual cycles except for the first annual cycle in site A. Further, again with the exception of the first annual cycle in site A, all the other sites revealed nearly the same numbers for the top two layers and also similar numbers for next two bottom layers. However, the relative percentage of the abundance of Diptera in the total insects, macrofauna and total soil fauna always registered an increase in percentage in the second layer in all the sites for both the annual cycles, though the actual numbers present were nearly the same. This phenomenon was also true for the fourth layer when compared with the third and in most cases registering nearly the same or more than the first layer (Table-XXXV).

The order Hemiptera comprised 2 to 11% of the total insects. All the sites showed a decrease in numbers from top to the bottom layers for both the annual cycles except site A where there was a drastic increase in the second layer which though decreased steadily till the fourth, maintained a level far higher than the first layer. Moreover, the first and second layers for both the annual cycles registered nearly the same numbers in sites A,B and C. When the order Hemiptera was observed as the relative percentage abundance among total insects, macrofauna and total soil fauna, it was seen that they followed a trend similar to actual vertical distributional numbers except in the second and third layer in both the annual cycles in all the sites where they revealed an increase (Table-XXXVI).

The order Hymenoptera presented, are those present under this order except the ants. If so they formed nearly 2 to 10% of the total insects. A steady decrease in their numbers from top to the bottom layers was seen for both the annual cycles, only in

Table XXXV : Showing the total number of Diptera and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XXXVI : Showing the total number of Hemiptera and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total insecta.

c : Percentages in macrofauna.

d : Percentages in total soil fauna.

TABLE XXXV

1978				1979				SITES
a	b	c	d	a	b	c	d	
80 (24.69)	6.85	5.12	1.34	100 (27.77)	7.81	5.76	1.63	
100 (30.86)	7.55	5.77	1.74	100 (37.77)	7.25	5.20	1.68	
80 (24.69)	6.35	5.22	1.66	80 (22.22)	5.95	4.61	1.58	A
64 (19.75)	7.21	5.65	1.58	80 (22.22)	7.46	5.70	1.85	
112 (31.11)	8.62	6.35	2.11	132 (29.46)	9.30	6.80	2.39	
112 (31.11)	9.82	7.18	2.55	132 (29.46)	10.03	7.37	2.85	
68 (18.89)	6.42	4.79	1.59	92 (20.54)	7.42	5.54	2.04	B
68 (18.89)	7.42	5.47,	1.89	92 (20.54)	8.49	6.22	2.40	
108 (30.00)	6.43	4.97	1.67	128 (29.09)	7.00	5.43	1.93	
108 (30.00)	8.16	6.19	2.13	128 (29.09)	8.56	6.53	2.43	
76 (21.11)	6.71	5.08	1.67	96 (21.82)	7.32	5.56	2.01	C
68 (18.89)	7.02	5.45	1.81	88 (20.00)	7.51	5.87	2.21	
136 (30.09)	6.64	5.15	1.82	156 (29.32)	7.14	5.51	2.04	
136 (30.09)	7.85	6.10	2.14	156 (29.32)	8.33	6.44	2.39	
92 (20.35)	7.01	5.68	2.14	112 (21.05)	7.41	6.00	2.27	D
88 (19.47)	8.18	6.77	2.22	108 (20.30)	8.65	6.80	2.54	

TABLE XXXVI

1978				1979			
a	b	c	d	a	b	c	d
80 (18.87)	6.85	5.12	1.34	48 (12.24)	3.75	2.76	0.78
132 (31.13)	9.97	7.62	2.30	132 (23.67)	9.57	6.86	2.22
108 (25.47)	8.57	7.05	2.25	108 (27.55)	8.04	6.22	2.14
104 (24.53)	11.71	9.19	2.57	104 (26.53)	9.70	7.41	2.41
80 (27.77)	6.15	4.54	1.50	52 (29.55)	3.66	2.68	0.94
80 (27.77)	7.02	5.13	1.82	52 (29.55)	3.95	2.90	1.12
64 (22.23)	6.04	4.50	1.50	36 (20.45)	2.90	2.17	0.80
64 (22.23)	6.99	5.14	1.78	36 (20.45)	3.32	2.43	0.94
84 (28.38)	5.00	3.87	1.30	60 (30.00)	3.28	2.56	0.90
84 (28.38)	6.34	4.82	1.66	60 (30.00)	4.01	3.06	1.14
64 (21.62)	5.65	4.28	1.40	40 (20.00)	3.05	2.31	0.84
64 (21.62)	6.61	5.13	1.69	40 (20.00)	3.41	2.67	1.00
120 (36.14)	5.86	4.55	1.61	84 (36.21)	3.85	2.97	1.10
100 (30.12)	5.77	4.49	1.58	72 (31.03)	3.85	2.97	1.10
56 (16.87)	4.27	3.46	0.98	40 (17.24)	2.65	2.14	0.81
56 (16.87)	5.20	4.31	1.42	36 (15.51)	2.88	2.27	0.85

sites C and D while they increased in the second layer to fall in subsequent layers in sites A and B for both the annual cycles. When the relative percentage of abundance among total insects, macrofauna and total soil fauna were considered, it was seen that they followed a pattern similar to the distributional numbers except in the fourth layer for sites A, B and C, where they registered an increase for both the annual cycles. Moreover they showed an increase in the second layer for site B for both the annual cycles also (Table-XXXVII).

The order Thysanoptera comprised of nearly 3 to 7% of total insects. There was a steady decrease in their vertical numbers from top to the bottom in all the sites for both the annual cycles. However, when their relative percentages of abundance in total insects, macrofauna and total soil fauna were considered, it was seen that they revealed an increase in the fourth layer in all the sites for both the annual cycles and an increase in second layer in sites A, B and C. Further there was a steady decrease in the percentage from top to the bottom layers in contrast to their actual numbers (Table-XXXVIII).

The order Lepidoptera comprised of nearly 2 to 7% of the total insects. The steady decrease in numbers from top to the bottom layers was seen only in site D. In sites A and B, though there was a decrease till the third layer for the first annual cycle in the former and for both the annual cycles in the latter, there was a sudden increase in the fourth layer. In site A during the second annual cycle the increase was seen from third layer onward, while in site C there was an increase for the second layer which fell thereafter till the fourth layer in the second annual cycle, but showed a slight increase in the fourth layer

Table XXXVII : Showing the total number of Hymenoptera and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XXXVIII : Showing the total number of Thysanoptera and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total insecta.

c : Percentages in macrofauna.

d : Percentages in total soil fauna.

TABLE XXXVII

1978				1979				SITES
a	b	c	d	a	b	c	d	
24 (7.06)	2.05	1.53	0.40	56 (15.22)	4.38	3.23	0.91	
136 (40.00)	10.27	7.85	2.37	132 (35.87)	9.57	6.86	2.22	A
92 (27.06)	7.30	6.01	1.91	92 (25.00)	6.85	5.30	1.82	
88 (25.88)	9.91	7.77	2.18	88 (23.91)	8.21	6.27	2.04	
48 (26.09)	3.69	2.72	0.90	80 (26.32)	5.63	4.12	1.45	
56 (30.43)	4.91	3.59	1.28	88 (28.95)	6.69	4.91	1.90	B
40 (21.74)	3.77	2.82	0.94	72 (23.68)	5.81	4.34	1.59	
40 (21.74)	4.37	3.22	1.11	64 (21.05)	5.90	4.32	1.67	
76 (37.25)	4.52	3.50	1.18	100 (33.34)	5.47	4.24	1.51	
64 (31.37)	4.83	3.67	1.26	88 (29.33)	5.88	4.49	1.67	C
32 (15.69)	2.83	2.14	0.70	56 (18.66)	4.27	3.24	1.17	
32 (15.69)	3.31	2.56	0.85	56 (18.66)	4.78	3.73	1.41	
100 (34.72)	4.88	3.79	1.34	116 (31.02)	5.31	4.10	1.51	
84 (29.17)	4.85	3.77	1.32	108 (28.88)	5.77	4.46	1.65	D
64 (22.22)	4.88	3.95	1.37	88 (23.53)	5.82	4.71	1.78	
40 (13.89)	3.72	3.08	1.01	64 (17.11)	5.13	4.03	1.51	

TABLE XXXVIII

1978				1979			
a	b	c	d	a	b	c	d
64 (32.00)	5.48	4.09	1.08	88 (29.33)	6.88	5.07	1.43
64 (32.00)	4.83	3.70	1.12	84 (28.00)	6.09	4.37	1.41
36 (18.00)	2.86	2.35	0.75	64 (21.33)	4.76	3.69	1.27
36 (18.00)	4.05	3.18	0.89	64 (21.33)	5.97	4.56	1.48
64 (26.66)	4.92	3.63	1.20	84 (26.25)	5.92	4.33	1.52
64 (26.66)	5.61	4.10	1.46	84 (26.25)	6.38	4.69	1.82
60 (25.00)	5.66	4.23	1.40	80 (25.00)	6.45	4.82	1.77
52 (21.68)	5.68	4.18	1.45	72 (22.50)	6.64	4.86	1.88
64 (34.04)	3.81	2.95	0.99	84 (31.34)	4.60	3.57	1.27
52 (27.66)	3.93	2.98	1.03	72 (26.87)	4.81	3.67	1.36
40 (21.28)	3.53	2.67	0.88	60 (22.39)	4.57	3.47	1.25
32 (17.02)	3.31	2.56	0.84	52 (19.40)	4.44	3.47	1.31
64 (32.65)	3.13	2.42	0.86	84 (31.34)	3.85	2.97	1.10
52 (26.53)	3.00	2.33	0.82	72 (26.87)	3.85	2.97	1.10
40 (20.41)	3.05	2.47	0.85	60 (22.39)	3.97	3.21	1.21
40 (20.41)	3.72	3.08	1.01	52 (19.40)	4.17	3.27	1.23

during the first annual cycle. When the relative percentage of this order Lepidoptera was considered among the total insects, macrofauna and total soil fauna, they followed a trend similar to their actual numbers only in site A, while an increase was seen for the second layer in sites B and D for both the annual cycles and in the fourth layer in site D (Table-XXXIX).

Trichoptera came next in importance to Lepidoptera, comprising of nearly 3 to 6% to the total insects. The steady decrease in numbers from top to the bottom layers was seen only in sites C and D for both the annual cycles. Site A showed an increase in second layer which fell after, while in site B there was an increase in the fourth layer. When their relative percentage of abundance as in total insects, macrofauna and total soil fauna was seen, they followed a trend similar to the vertical distributional numbers except for the fourth layer in all the sites in both annual cycles. While they registered an increase in third layer in sites B, C and D their numbers were more or less the same as for the second layer in both the annual cycles (Table-XL).

The order Orthoptera comprised of 1.5 to 6% of the total insects. The steady decrease or similar numbers from top to bottom layers as the vertical distributional numbers was seen for the first annual cycle in sites B, C and D, while an increase from top to the bottom layers was seen for both the annual cycles in site A, while there was a fall and rise in alternate layers during the second annual cycle in sites C and D. When the order Orthoptera was compared as the percentages of total insects, macrofauna or the total soil fauna, it was seen that there was a steady increase in their percentages from top to the bottom layers in all the sites for both the years (Table-XLI).

Table XXXIX : Showing the total number of Lepidoptera and itsrrelative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XL : Showing the total number of Trichoptera and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total insecta.

c : Percentages in macrofauna.

d : Percentages in total soil fauna.

TABLE XXXIX

1978				1979				SITES
a	b	c	d	a	b	c	d	
40 (23.81)	3.42	2.56	0.67	64 (24.62)	5.00	3.69	1.04	
36 (21.43)	2.72	2.08	0.63	60 (23.08)	4.35	3.12	1.01	A
44 (26.19)	5.41	4.24	1.19	64 (24.62)	6.72	5.13	1.67	
48 (28.57)	5.41	4.24	1.19	72 (27.69)	6.72	5.13	1.67	
60 (28.30)	4.62	3.40	1.13	84 (26.92)	5.92	4.32	1.52	
60 (28.30)	5.26	3.85	1.37	84 (26.92)	6.38	4.69	1.82	B
44 (20.75)	4.15	3.10	1.03	68 (21.79)	5.48	4.10	1.50	
48 (22.64)	5.24	3.86	1.33	72 (23.08)	6.64	4.96	1.88	
48 (29.27)	2.86	2.21	0.74	80 (28.99)	4.38	3.30	1.21	
56 (34.15)	4.23	3.21	1.10	84 (30.43)	5.61	4.29	1.59	C
28 (17.07)	2.47	1.87	0.61	56 (20.29)	4.27	3.24	1.17	
32 (19.51)	3.31	2.56	0.84	56 (20.29)	4.78	3.73	1.41	
64 (37.21)	3.13	2.42	0.86	132 (39.29)	6.04	4.66	1.72	
60 (34.88)	3.46	2.69	0.95	92 (27.38)	4.91	3.80	1.41	D
24 (13.95)	1.83	1.48	0.53	56 (16.66)	3.70	3.00	1.13	
24 (13.95)	2.23	1.85	0.63	56 (16.66)	4.49	3.53	1.32	

TABLE XL

1978				1979			
a	b	c	d	a	b	c	d
52 (23.21)	4.45	3.32	0.87	52 (23.21)	4.06	3.00	0.85
60 (26.79)	4.53	3.46	1.05	60 (26.79)	4.35	3.12	1.01
56 (25.00)	4.44	3.66	1.16	56 (25.00)	4.17	3.23	1.11
56 (25.00)	6.31	4.95	1.39	56 (25.00)	5.22	3.99	1.30
72 (31.58)	5.54	4.08	1.35	72 (31.58)	5.07	3.71	1.31
48 (21.05)	4.21	3.08	1.09	48 (21.05)	3.65	2.68	1.04
48 (21.05)	4.53	3.38	1.12	48 (21.05)	3.87	2.89	1.06
60 (26.32)	6.55	4.82	1.67	60 (26.32)	5.54	4.05	1.56
108 (39.13)	6.43	4.97	1.67	108 (39.13)	5.91	4.58	1.63
56 (20.29)	4.23	3.21	1.10	56 (20.29)	3.74	2.86	1.06
56 (20.29)	4.95	3.74	1.23	56 (20.29)	4.27	3.24	1.17
56 (20.29)	5.79	4.49	1.48	56 (20.29)	4.78	3.73	1.41
96 (34.78)	4.69	3.64	1.29	96 (34.78)	4.40	3.39	1.25
68 (24.64)	3.93	3.05	1.07	68 (24.64)	3.63	2.81	1.04
60 (21.74)	4.57	3.70	1.28	60 (21.74)	3.97	3.21	1.21
52 (18.84)	4.83	4.00	1.31	52 (18.84)	4.17	3.27	1.23

Order Dermaptera came last, comprising of 2 to 5% of the total insect. A steady decrease in their numbers from top to the bottom layers for both the annual cycles was seen only in sites C and D. In site A they showed an increase in second layer maintained it in third layer and fell in fourth, while in site B though there was a steady decrease till the third layer, an increase was registered in the fourth in both the annual cycles. When their relative percentage among total insects, macrofauna and total soil fauna was considered, it was seen that they followed a trend similar to their vertical distributional numbers, only in site B and that too quite obvious in the first annual cycle. These percentages registered an increase in the third layer for both the annual cycles in sites A, C and D and for the second annual cycle in site B. Further, the fourth layer in sites B and D showed an increase in the second annual cycle (Table-XLII).

The major sub-division after insecta under macrofauna was made up of total myriapoda and comprised of 12 to 22% of the total macrofauna. This group Myriapoda was further divided into Diplopoda, Symphyla and Chilopoda in that order of abundance. When considering total myriapoda, it was seen that their numbers in different soil layers at different sites decreased steadily from top to the bottom layers for both the annual cycles in all the sites except in site A. In site A, the second layer registered an increase which fell thereafter. The same trend as their vertical distribution numbers was seen for the relative percentages of Myriapoda in macrofauna and in the total soil fauna in sites C and D for both the annual cycles and for the second annual cycle in site A. The latter site showed an increase in the fourth layer for the first annual cycle as also was seen for the fourth layer for both the annual cycles for site C (Table-XLIII).

Table XLI : Showing the total number of Orthoptera and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XLII : Showing the total number of Dermaptera and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in total insecta.

c : Percentages in macrofauna.

d : Percentages in total soil fauna.

TABLE XLI

1978				1979			
a	b	c	d	a	b	c	d
24 (23.08)	2.05	1.53	0.40	56 (24.14)	4.38	3.23	0.91
24 (23.08)	1.81	1.39	0.42	56 (24.14)	4.06	2.91	0.94
28 (26.92)	2.22	1.83	0.58	56 (24.14)	4.17	3.23	1.11
28 (26.92)	3.15	2.47	0.69	64 (27.59)	5.97	4.56	1.48
36 (7.27)	2.77	2.04	0.68	64 (27.59)	4.51	3.30	1.16
32 (4.24)	2.81	2.05	0.73	56 (24.14)	4.26	3.13	1.21
32 (24.24)	3.02	2.25	0.75	56 (24.14)	4.52	3.37	1.24
32 (24.24)	3.49	2.57	0.89	56 (24.14)	5.17	3.78	1.46
32 (33.33)	1.90	1.47	0.50	60 (27.77)	3.28	2.55	0.90
32 (33.33)	2.42	1.83	0.63	48 (22.22)	3.21	2.45	0.91
16 (16.16)	1.41	1.07	0.35	56 (25.93)	4.27	3.24	1.17
16 (16.16)	1.65	1.28	0.42	52 (24.07)	4.44	3.47	1.31
28 (25.00)	1.37	1.06	0.38	56 (25.93)	2.56	1.98	0.73
28 (25.00)	1.62	1.26	0.44	52 (24.07)	2.78	2.15	0.80
28 (25.00)	2.13	1.73	0.60	56 (25.93)	3.70	3.00	1.13
28 (25.00)	2.60	2.15	0.71	52 (24.07)	4.17	3.27	1.23

TABLE XLII

SITES	1978				1979			
	a	b	c	d	a	b	c	d
A	32 (25.81)	2.74	2.05	0.54	52 (23.64)	4.06	3.00	0.85
	36 (29.03)	2.72	2.08	0.63	56 (25.45)	4.06	2.87	0.94
	36 (25.81)	2,86	2.35	0.75	56 (25.45)	4.17	3.23	1.11
	24 (19.35)	2.70	2.12	0.59	56 (25.45)	5.22	3.99	1.30
B	48 (34.29)	3.69	2.72	0.90	72 (31.58)	5.07	3.71	1.31
	28 (20.00)	2.46	1.79	0.64	48 (21.05)	3.65	2.68	1.04
	24 (17.14)	2.26	1.69	0.56	48 (21.05)	3.87	2.89	1.06
	40 (28.57)	4.37	3.22	1.11	60 (26.32)	5.54	4.05	1.56
C	52 (37.14)	3.00	2.39	0.81	108 (39.13)	5.91	4.58	1.63
	32 (22.86)	2.42	1.83	0.63	56 (20.29)	3.74	2.86	1.06
	32 (22.86)	2.83	2.14	0.70	56 (20.29)	4.27	3.24	1.17
	24 (17.14)	2.48	1.92	0.63	56 (20.29)	4.78	3.73	1.41
D	56 (35.00)	2.73	2.12	0.75	96 (34.78)	4.40	3.39	1.25
	40 (25.00)	2.31	1.80	0.63	68 (24.64)	3.63	2.81	1.04
	36 (22.50)	2.74	2.22	0.77	60 (21.74)	3.97	3.21	1.21
	28 (17.50)	2.60	2.15	0.71	52 (18.82)	4.17	3.27	1.23

The major group under Myriapoda was Diplopoda which formed nearly 30-50% of the total Myriapoda. The numbers in the different layers steadily decreased from top to the bottom layers for both the annual cycles in all the sites studied. When looked at as percentages of total Myriapoda, it was seen that they had a similar vertical distribution only for first annual cycle in site C. In the remaining sites the third layer was much more during both the annual cycles in sites A, B and D and for the second annual cycle in site C, the increase was seen in second layer. However, when the relative percentage abundance of this group Diplopoda among either macrofauna or total soil fauna was considered, they seemed to follow a similar trend as for their vertical distributional numbers, only in sites A and D for both the annual cycles. In case of sites B and C these relative percentages were seem to be on the increase during both the annual cycles for the fourth and the second layers respectively (Table-XLIV).

The next group of importance under Myriapoda was Chilopoda which was 23 to 48% of the total Myriapoda. The steady decrease in numbers from top to the bottom layers was seen in all the sites except in site A, where in the latter case there was a two-fold increase in the second layer which dropped thereafter but still the third layer registering more than the first layer. When the relative percentage of this group under Myriapoda was considered it was seen that the fourth layer of sites A and B and the third layer of sites C and D increased when the actual numbers decreased during both the annual cycles. This trend was also true for the relative percentages of this group Chilopoda either among mesofauna or total soil fauna for sites A, B and C. However for site D during second annual cycle the fourth layer registered an increase for these relative percentages of abundance (Table-XLV).

Table XLIII : Showing the total number of Myriapoda and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in macrofauna.

c : Percentages in total soil fauna.

Table XLIV : Showing the total number of Diplopoda and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in total myriapoda.

c : Percentages in macrofauna.

d : Percentages in total soil fauna.

TABLE XLIII

1978			1979			SITES
a	b	c	a	b	c	
316 (29.92)	20.20	5.31	316 (26.00)	18.20	5.15	
344 (32.58)	19.86	6.00	424 (35.00)	22.04	7.13	A
212 (20.08)	13.84	4.41	272 (22.00)	15.67	5.38	
184 (17.42)	16.25	4.55	208 (17.00)	14.81	4.82	
388 (30.41)	22.00	7.29	388 (30.03)	22.00	7.03	
344 (26.96)	22.05	7.83	344 (26.63)	19.20	7.44	B
288 (22.57)	20.28	6.74	292 (22.60)	17.59	6.46	
256 (20.06)	20.58	7.12	268 (20.74)	18.11	6.98	
432 (33.13)	19.89	6.70	412 (32.29)	17.49	6.21	
356 (27.30)	20.41	7.02	348 (27.27)	17.76	6.60	C
296 (22.70)	19.79	6.50	296 (23.20)	17.13	6.19	
220 (16.87)	17.63	5.81	220 (17.24)	14.66	5.52	
532 (38.66)	20.15	7.13	532 (36.84)	18.79	6.95	
436 (31.69)	19.57	6.87	436 (30.82)	17.99	6.67	D
240 (17.44)	14.81	5.12	240 (16.62)	12.85	4.86	
168 (12.21)	12.92	4.25	236 (16.34)	14.86	5.56	

TABLE XLIV

1978				1979			SITES
a	b	c	d	a	b	c	d
132 (33.00)	41.77	8.44	2.22	132 (33.00)	41.77	7.60	2.15
124 (31.00)	36.05	7.16	2.16	124 (31.00)	29.25	6.44	2.08
84 (21.00)	39.62	5.48	1.75	84 (21.00)	30.88	4.84	1 66
60 (15.00)	32.61	5.30	1.49	60 (15.00)	28.85	4.27	1.39
152 (29.92)	39.18	8.62	2.86	152 (29.92)	39.18	7.84	2.76
128 (25.20)	37.21	8.21	2.91	128 (25.20)	37.21	7.14	2.77
116 (22.83)	40.27	8.17	2.71	116 (22.83)	39.73	6.99	2.57
112 (22.05)	43.75	9.00	3.11	112 (22.05)	41.79	7.57	2.92
172 (34.13)	39.81	7.92	2.67	164 (33.64)	39.81	6.96	2.47
140 (27.78)	39.33	8.03	2.76	140 (28.23)	40.23	7.14	2.65
112 (22.22)	37.84	7.49	2.46	112 (22.58)	37.84	6.48	2.34
80 (15.87)	36.36	6.41	2.11	80 (16.13)	36.36	5.33	2.00
208 (37.14)	39.10	7.88	2.79	208 (36.11)	39.10	7.34	2.72
168 (30.00)	38.53	7.54	2.65	168 (29.17)	38.53	6.93	2.57
120 (21.43)	50.00	7.41	2.56	120 (20.83)	50.00	6.42	2.43
64 (11.43)	38.10	4.92	1.62	80 (13.89)	33.90	5.04	1.87

The last group under Myriapoda was Symphyla which was nearly 20 to 42% of the total Myriapods. There was a steady decrease in numbers for both the annual cycles in sites B and C. Site D registered a fall and rise in alternate layers for both annual cycles, while in site A there was a slight increase in the fourth layer during the first annual cycle, rise in the second layer during the second annual cycle. The steady decrease from top to the bottom layers was also seen for the relative percentage of abundance of this group either among total myriapods, macrofauna or total soil fauna only in site B for both the annual cycles, while in site C, there was an increase in the second and fourth layer. This latter phenomenon was also seen in site D for both the annual cycles. In site A it followed a trend similar to their vertical distributional numbers, except for the third layer where the relative percentage abundance in total myriapods showed an increase (Table-XLVI).

Annelida formed a very minor portion of the macrofauna, comprised of nearly 1 to 5% of the total macrofauna. Either the steady decrease in numbers from top to the bottom layers or the similar numbers with a decrease till the bottom layer was seen for the second annual cycle in site D and both the annual cycles in sites A and C. Site B registered an increase after the third layer which maintained so till the fourth, while site D in the first annual cycle showed an increase in the third layer. The trend for the relative percentage of abundance of this groupp either among the macrofauna or total soil fauna was seen to be only in site B, while they were in the reverse trend for site D for both the annual cycles. In site A this latter trend was seen from the second layer till the fourth layer for both the annual cycles (Table-XLVII).

Table XLV : Showing the total number of Chilopoda and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XLVI : Showing the total number of Symphyla and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Number and percentages among themselves.

b : Percentages in total myriapoda.

c : Percentages in macrofauna.

d : Percentages in total soil fauna.

TABLE XLV

1978				1979				SITES
a	b	c	d	a	b	c	d	
84 (20.19)	26.58	5.37	1.41	84 (20.19)	26.58	4.84	1.37	
168 (40.38)	48.84	9.70	2.93	168 (40.38)	39.62	8.73	2.82	A
88 (21.15)	41.51	5.74	1.83	88 (21.15)	32.35	5.07	1.74	
76 (18.27)	41.30	6.71	1.88	76 (18.27)	36.54	5.41	1.76	
112 (27.72)	28.87	6.35	2.11	112 (27.18)	28.87	5.77	2.03	
108 (26.73)	31.40	6.92	2.46	108 (26.21)	31.40	6.03	2.34	B
92 (22.77)	31.94	6.48	2.15	96 (23.30)	32.87	5.78	2.12	
92 (22.77)	35.94	7.40	2.56	96 (23.30)	35.82	6.49	2.51	
144 (31.58)	33.33	6.33	2.33	144 (31.58)	34.95	6.11	2.17	
116 (25.44)	32.58	6.65	2.29	116 (25.44)	33.33	5.92	2.20	C
116 (25.44)	39.19	7.75	2.55	116 (25.44)	39.19	6.71	2.42	
80 (17.54)	36.36	6.41	2.11	80 (17.54)	36.36	5.33	2.00	
132 (42.22)	28.57	5.76	2.04	152 (40.43)	28.57	5.37	1.98	
108 (30.00)	24.77	4.85	1.70	108 (28.72)	24.77	4.46	1.65	D
60 (16.66)	25.00	3.70	1.28	60 (15.96)	25.00	3.21	1.21	
40 (11.11)	23.81	2.08	1.01	56 (14.89)	23.73	3.53	1.32	

TABLE XLVI

1978				1979			
a	b	c	d	a	b	c	d
100 (41.67)	31.65	6.39	1.68	100 (24.75)	31.65	5.76	1.63
52 (21.67)	15.11	3.00	0.91	132 (32.67)	31.13	6.86	2.22
40 (16.66)	18.87	2.61	0.83	100 (24.75)	36.76	5.76	1.98
48 (20.00)	26.09	4.24	1.19	72 (17.82)	34.62	5.13	1.67
124 (33.70)	31.96	7.03	2.33	124 (33.33)	31.96	6.39	2.25
108 (29.35)	31.40	6.92	2.46	108 (29.03)	31.40	6.03	2.34
80 (21.74)	27.78	5.63	1.87	80 (21.50)	27.40	4.82	1.77
52 (15.21)	20.31	4.18	1.45	60 (16.13)	22.39	4.05	1.56
116 (34.12)	26.85	5.34	1.80	104 (32.10)	25.24	4.41	1.57
96 (28.23)	26.96	5.50	1.89	92 (28.40)	26.44	4.69	1.74
68 (20.00)	22.97	4.55	1.49	68 (20.99)	22.97	3.94	1.42
60 (17.65)	27.27	4.81	1.58	60 (18.52)	27.27	4.00	1.51
172 (37.72)	32.33	6.52	2.31	172 (34.96)	32.33	6.07	2.25
160 (35.09)	36.70	7.18	2.52	160 (32.52)	36.70	6.60	2.45
60 (13.16)	25.00	3.70	1.28	60 (12.20)	25.00	3.21	1.21
64 (14.04)	38.10	4.92	1.62	100 (20.33)	42.37	6.30	2.36

Table XLVII: Showing the total number of Earthworm and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

Table XLVIII: Showing the total number of Mollusca and its relative percentages for the total study period in the four different sites at four different depths for each annual cycle.

a : Numbers and percentages among themselves.

b : Percentages in macrofauna.

c : Percentages in total soil fauna.

TABLE XLVII

1978			1979			SITES
a	b	c	a	b	c	
56 (40.00)	3.58	0.94	88 (32.84)	5.07	1.43	
32 (22.86)	1.85	0.56	60 (22.39)	3.12	1.01	
28 (20.00)	1.83	0.58	60 (22.39)	3.46	1.19	A
24 (17.16)	2.12	0.59	60 (22.39)	4.27	1.39	
32 (23.53)	1.81	0.60	60 (24.19)	3.09	1.09	
32 (23.53)	2.05	0.73	60 (24.19)	3.35	1.30	
36 (26.07)	2.54	0.84	64 (25.81)	3.86	1.42	B
36 (26.07)	2.89	1.00	64 (25.81)	4.32	1.67	
32 (26.66)	1.47	0.50	60 (25.86)	2.55	0.90	
32 (26.66)	1.83	0.63	60 (25.86)	3.06	1.14	
28 (23.33)	1.87	0.61	56 (24.14)	3.24	1.17	C
28 (23.33	2.24	0.74	56 (24.14)	3.73	1.41	
32 (24.24)	1.21	0.43	60 (25.86)	2.12	0.78	
32 (24.24)	1.44	0.50	60 (25.86)	2.48	0.92	
40 (30.30)	2.47	0.85	60 (25.86)	3.21	1.21	D
28 (21.21)	2.15	0.71	52 (22.41)	3.27	1.23	

TABLE XLVIII

1978			1979		
a	b	c	a	b	c
24 (19.35)	1.53	0.40	52 (22.03)	3.00	0.85
32 (25.81)	1.85	0.56	60 (25.42)	3.12	1.01
32 (25.81)	2.09	0.67	60 (25.42)	3.46	1.19
36 (29.03)	3.18	0.89	64 (27.12)	4.56	1.48
44 (27.50)	2.49	0.83	72 (26.47)	3.71	1.31
44 (27.50)	2.82	1.00	72 (26.47)	4.02	1.56
36 (22.50)	2.54	0.84	64 (23.53)	3.86	1.42
36 (22.50)	2.89	1.00	64 (23.53)	4.32	1.67
28 (21.21)	1.29	0.43	56 (24.56)	2.38	0.84
32 (24.24)	1.83	0.63	56 (24.56)	2.86	1.06
40 (30.30)	2.67	0.88	64 (28.07)	3.70	1.34
32 (24.24)	2.56	0.84	52 (22.81)	3.47	1.31
28 (25.00)	1.06	0.38	56 (25.45)	1.98	0.73
28 (25.00)	1.26	0.44	56 (25.45)	2.31	0.86
28 (25.00)	1.73	0.60	56 (25.45)	3.00	1.13
28 (25.00)	2.15	0.71	52 (23.67)	3.27	1.23

The group Mollusca came last in terms of abundance under macrofauna, comprising of nearly 0.5 to 4% of the total macrofauna. Here again as the annelida vertical distributional numbers either remained constant or decreased from top to bottom layers for both the annual cycles in sites B and D. In site A, the trend was in reverse while in site C there was a fall and rise in alternate layers during both the annual cycles. A trend similar to their vertical distributional numbers was seen only in sites A and C. When their relative percentage among macrofauna or total soil fauna was considered, site B showed an increase in the second layer for their relative percentages as well as the fourth layer, while in site D, a trend in the reverse was seen in these relative percentages of abundance which increased from top to the bottom soil layers (Table-XLVIII).

SEASONAL FLUCTUATIONS

When a seasonal analysis of total soil fauna was done, it was observed that they ranged from 900 to nearly $2,900X10^2/m^2$, when all the sites were considered. The minimum was seen for the month of June in sites A and B, while the maximum was recorded in the month of December in site D. The range in the different soil layers when considered was nearly between 200 to $950X10^2/m^2$. The interesting observation moreover was that when each site was considered, the maximum and minimum for the years of study was in June and December respectively for all the sites except site A where the minimum occurred in the month of January during both the years of study. This phenomenon was also true when the individual layers in different sites (A,B,C,D) was also considered (Fig. 2).

A similar seasonal study when done for microfauna, it was seen to follow the same patterns as the total soil fauna not only in different sites but also in different soil layers during the entire study period. It ranged from nearly 20 to $170X10^2/m^2$, the minimum in site B in the month of June and the maximum in sites C and D in the month of December. While the individual soil layers were considered the microfauna ranged from a minima of 4 to a maxima of $60X10^2/m^2$ (Fig. 3).

Under the major sub-groups of microfauna, it was seen that the prostigmatid mites followed exactly the same trend as it was seen either for total soil fauna or for total microfauna. In any case they ranged from a minima of $24X10^2/m^2$ to a maxima of $168X10^2/m^2$. When all the sites were considered the minima occurred in January in site A while the maxima occurred in December in site C. In the different layers the Prostigmatid mites ranged

Fig. 2 : Showing the seasonal fluctuation of total soil fauna as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

 : total soil fauna in site A.

 : total soil fauna in site B.

 : total soil fauna in site C.

 : total soil fauna in site D.

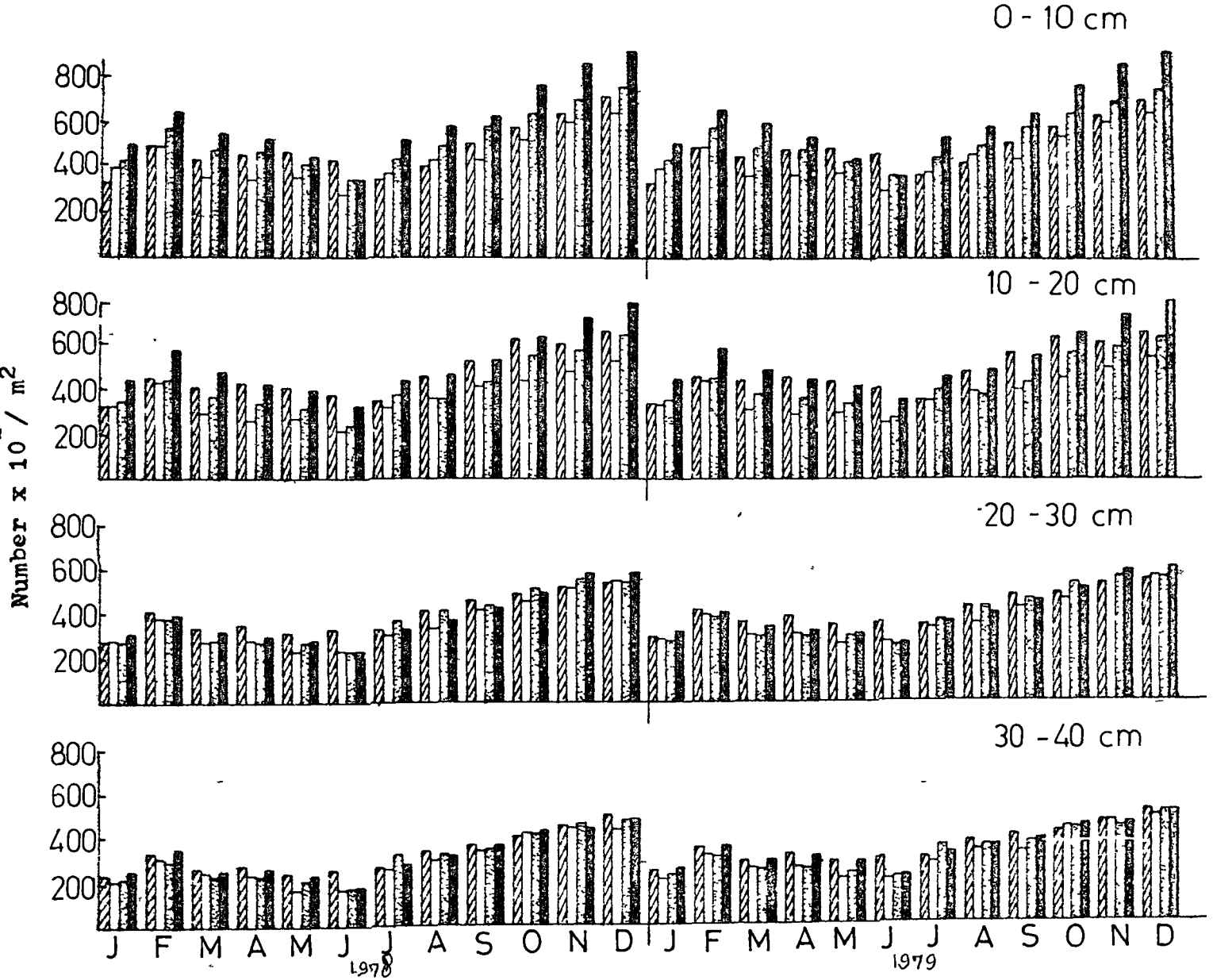

0 - 10 cm
10 - 20 cm
20 - 30 cm
30 - 40 cm
800
600
400
200
Number x 10 / m
J F M A M J J A S O N D J F M A M J J A S O N D
1978
1979

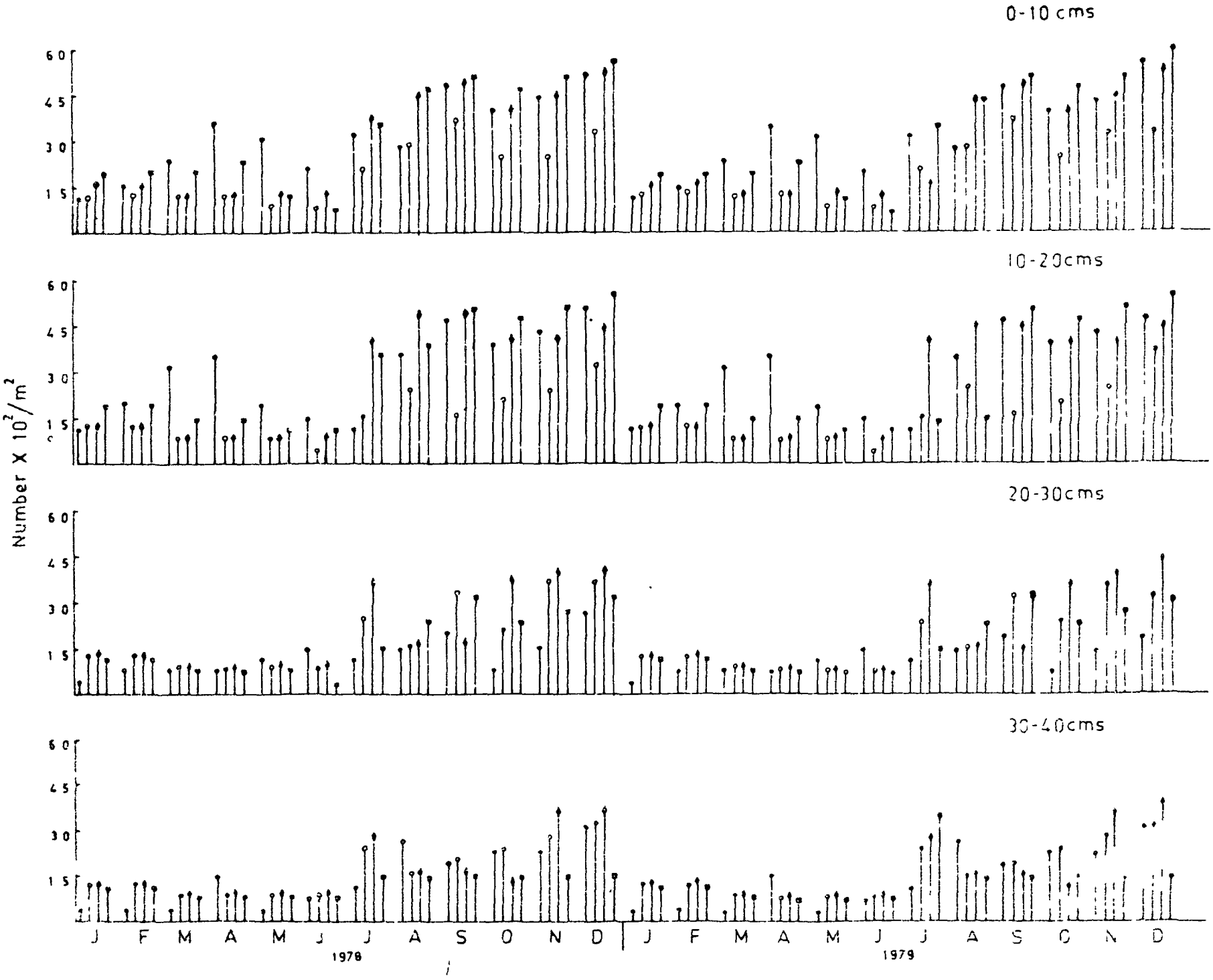
Fig. 3 : Showing the seasonal fluctuation of total microfauna as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

: Total microfauna in site A.

: Total microfauna in site B.

: Total microfauna in site C.

: Total microfauna in site D.


0-10 cms
10-20cms
20-30cms
30-40cms
Number X $10^2/m^2$
60
45
30
15
J F M A M J J A S O N D J F M A M J J A S O N D
1978
1979

from a minimum of $4X10^2/m^2$ to a maximum of nearly $60X10^2/m^2$, the minimum occurring in summer months and maxima in winter months (Fig. 4). The next was Protozoa which ranged from a minimum of total absence to a maximum of nearly $50X10^2/m^2$. A similar phenomenon as for total microfauna in that minimum occurred in summer months (April, May, June) and the maximum in the winter season (November, December) (Fig. 4).

When the group Protozoa was broken up for lower levels like flagellata, cilliata and amoebae a similar trend of fluctuation was observed and maximum of more than $4X10^2/m^2$ was never recorded in any of these groups in any soil layer in different sites during both the years of study (Fig. 5).

After microfauna the next major group comprised of mesofauna which was seen to follow a nearly similar pattern in their seasonal fluctuations as for the microfauna or total soil fauna during the entire study period. However, the total mesofauna ranged from a minimum of $524X10^2/m^2$ to maximum of $1,788X10^2/m^2$, the former in the month of June in site B and the latter in the month of December in site D. All the sites did show the minima and maxima in June and December respectively during both the years of study except in site A, where the minima was recorded in July. The range in the individual layers at different sites of mesofauna was between 108 and $576X10^2/m^2$ during the entire study period in different sites (A,B,C,D) (Fig. 6).

Among the major subdivisions under soil-mesofauna, Collembola revealed a pattern of seasonal abundance and fluctuations, quite contrast to all the others described so far, in that the minimum was always recorded in all the sites and in all the soil layers in the month of January for both the years of study,

Fig. 4 : Showing the seasonal fluctuation of Prostigmata and Total Protozoa as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

— : Total Prostigmata.

: Total Protozoa.

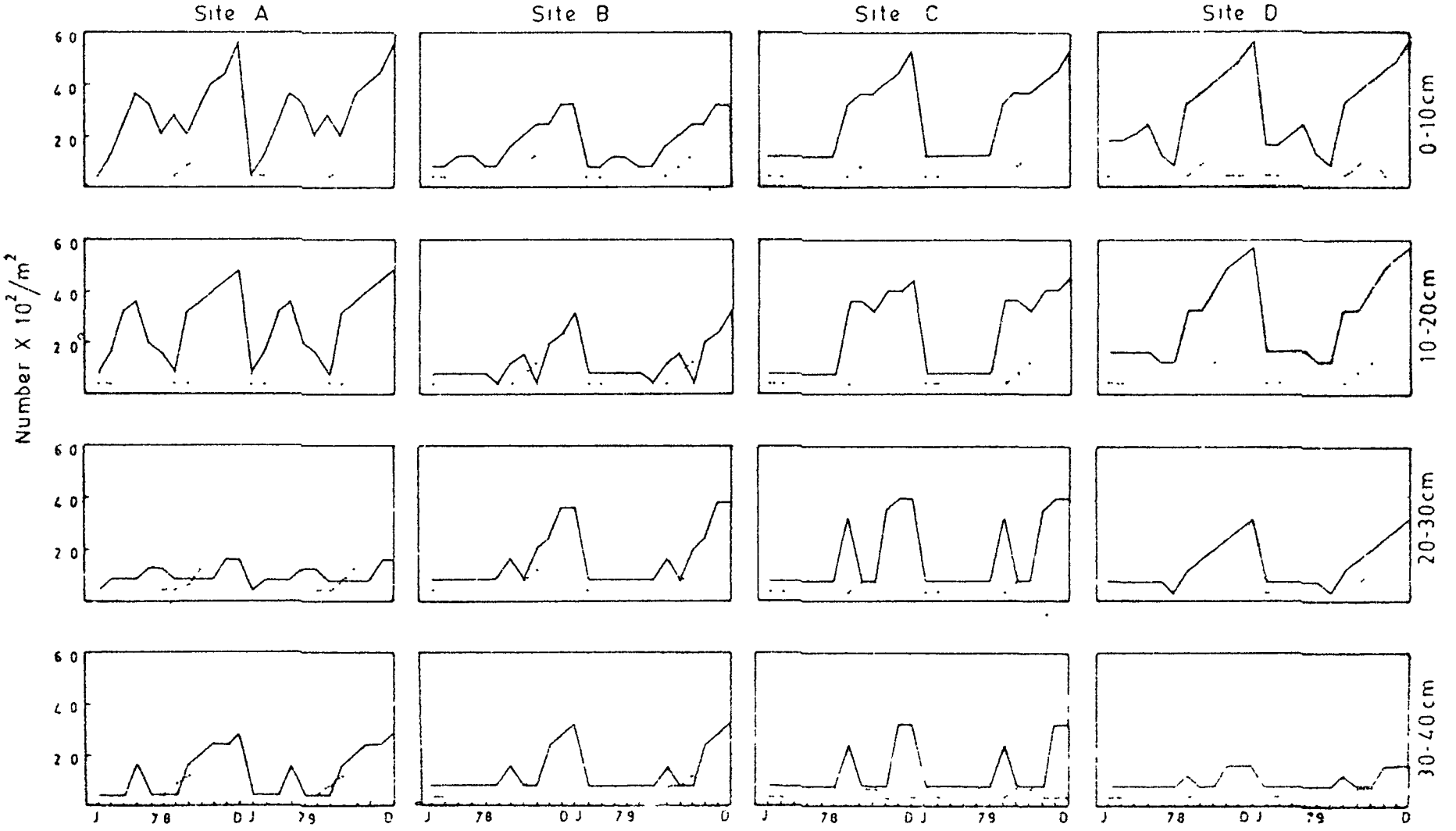

Site A
Site B
Site C
Site D
Number X $10^2/m^2$
60
40
20
0-10cm
10-20cm
20-30cm
30-40cm
J
78
D J
79
D

Fig. 5 : Showing the seasonal fluctuation of Flagellata, Ciliata and Amoebae as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

— : Flagellata

···· : Ciliata

×—× : Amoebae

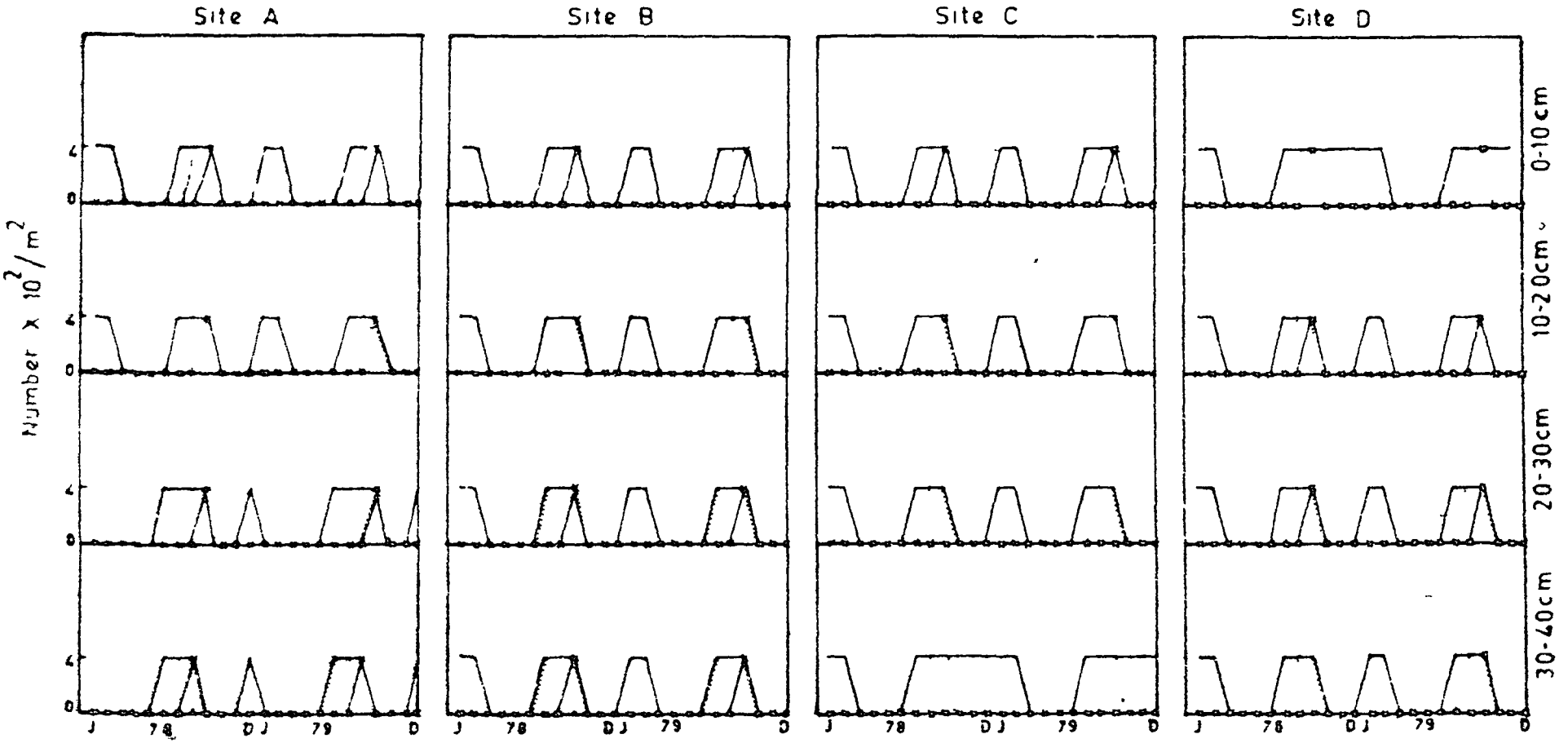

Site A
Site B
Site C
Site D
Number x $10^2/m^2$
4
0
J
78
DJ
79
D
0-10 cm
10-20cm
20-30cm
30-40cm

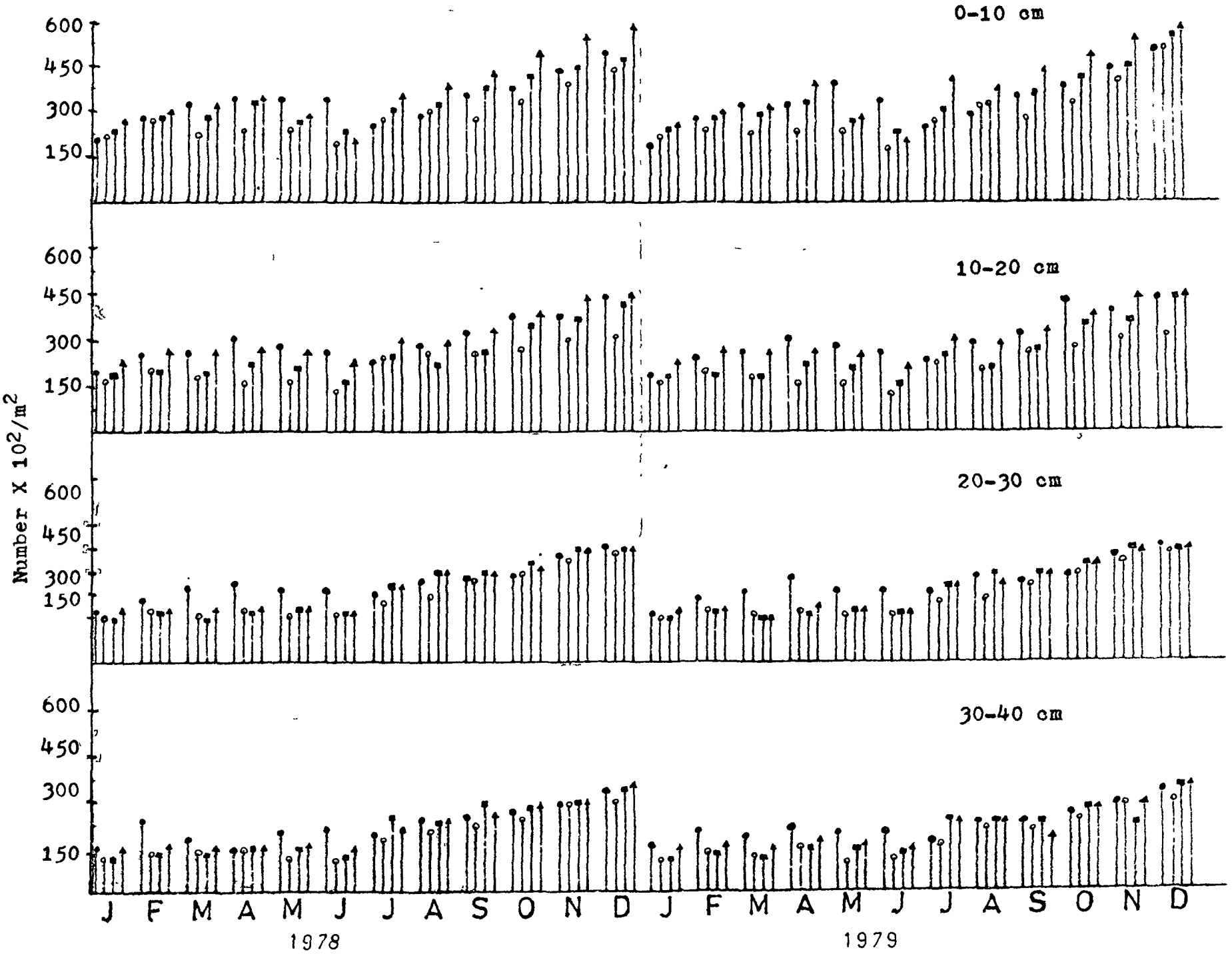
Fig. 6 : Showing the seasonal fluctuation of total mesofauna as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

 : Total mesofauna in site A.

 : Total mesofauna in site B.

 : Total mesofauna in site C.

 : Total mesofauna in site D.


0-10 cm
10-20 cm
20-30 cm
30-40 cm
600
450
300
150
Number X $10^2/m^2$
J F M A M J J A S O N D J F M A M J J A S O N D
1978
1979

though the maximum continued to be in December. Collembola ranged from a minimum of nearly $240X10^2/m^2$ to a maximum of $628X10^2/m^2$ at the different sites during the entire study period. The range in the individual soil layers were between 40 and $200X10^2/m^2$ (Fig.7).

When the different families of Collembola were considered for their seasonal fluctuations, all of them more or less followed the similar pattern as for Collembola, especially the families Entomobryidae and Hypogastruridae with a slight deviation in families Sminthuridae and Isotomidae where the minimum though not very significant, was recorded in the month of March (Fig. 8). The number in families Entomobryidae, Hypogastruridae, Sminthuridae and Isotomidae ranged from 88 to $304X10^2/m^2$ in the months of March and December; 72 to $200X10^2/m^2$ in the months of January and December; 44 to $120X10^2/m^2$ in the months of April, June and December and 20 to $84X10^2/m^2$ in the months of March and December respectively. The range in the individual layers ranged from 4 to $84X10^2/m^2$, in all the families (Fig. 8).

The next major group after Collembola in total mesofauna was Acarina, which seemed to follow the same pattern as for Collembola in all the sites except in site D which recorded a summer minima as was seen for total soil fauna or microfauna. This phenomenon was also true when Acarina was looked at its sub-order levels as mesostigmata, cryptostigmata and astigmata. They ranged as a whole from 108 to $624X10^2/m^2$ in different sites. In mesostigmata, cryptostigmata and astigmata the ranges were as 52 to 280 $X10^2/m^2$ in the months of January and December; 40 to $212X10^2/m^2$ and 16 to $132X10^2/m^2$ respectively. The Acarina population in the individual soil layers ranged from 4 to $80X10^2/m^2$ (Figs. 7 & 9).

Araneida, which comes next in importance after Acarina in

Fig. 7 : Showing the seasonal fluctuation of total Collembola and total Acarina as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

— : Total Collembola

····· : Total Acarina

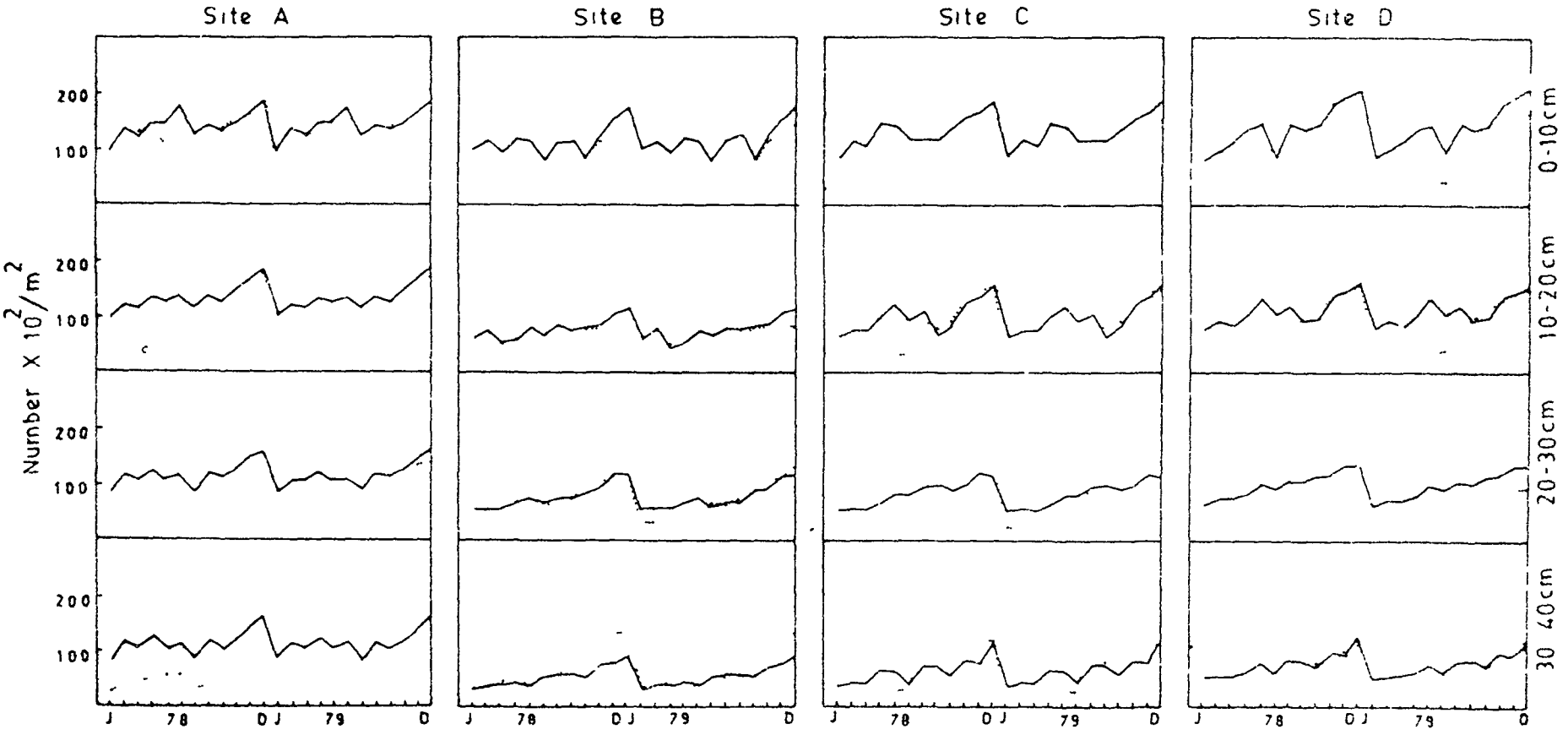

Site A
Site B
Site C
Site D
Number X 10²/m²
200
100
0-10cm
10-20cm
20-30cm
30 40cm
J
78
D J
79
D

Fig. 8 : Showing the seasonal fluctuation of families of Collembola as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

— : Entomobryidae

—·— : Hypogastruidae

—···— : Sminthuridae

····· : Isotomidae

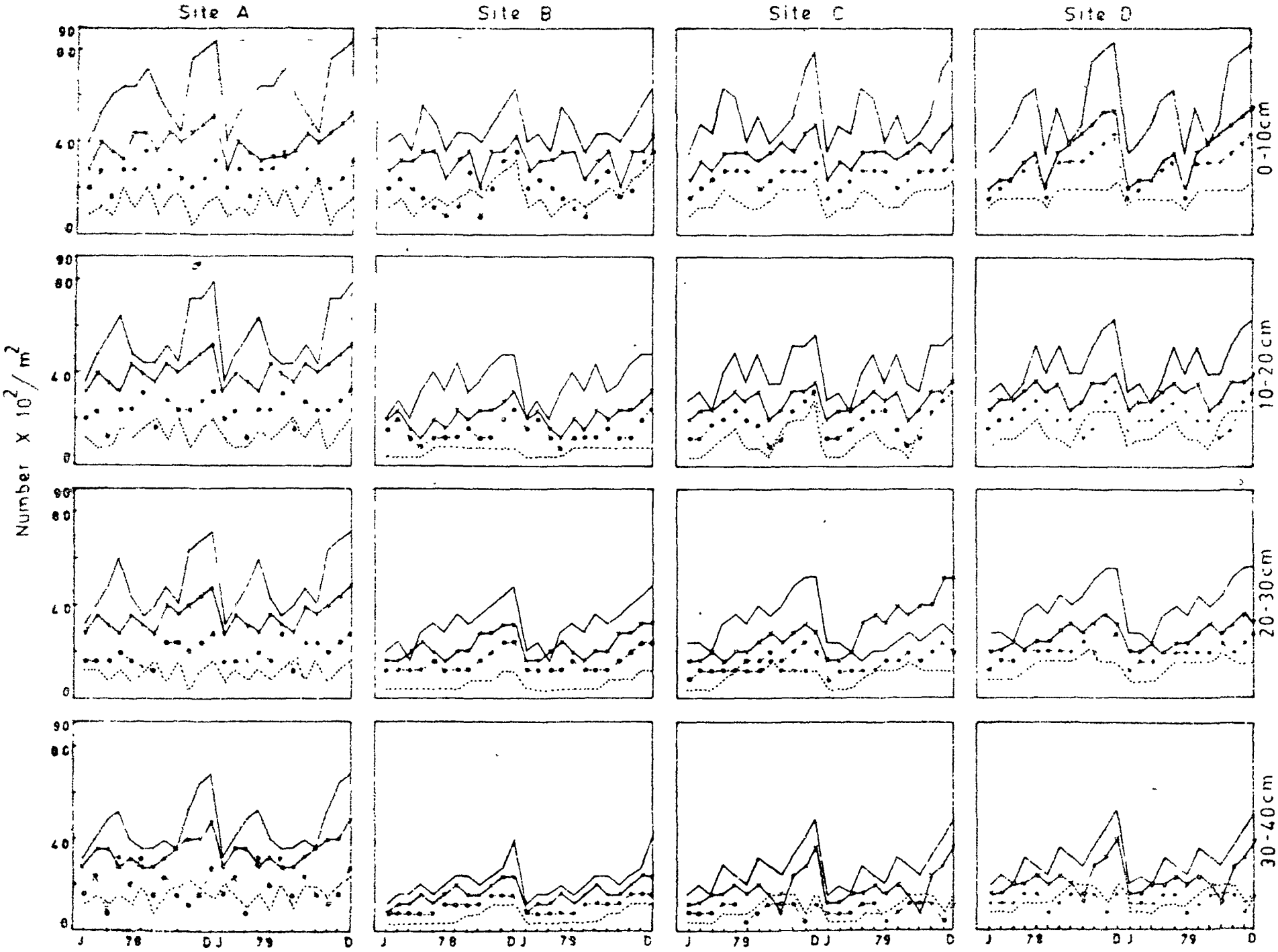
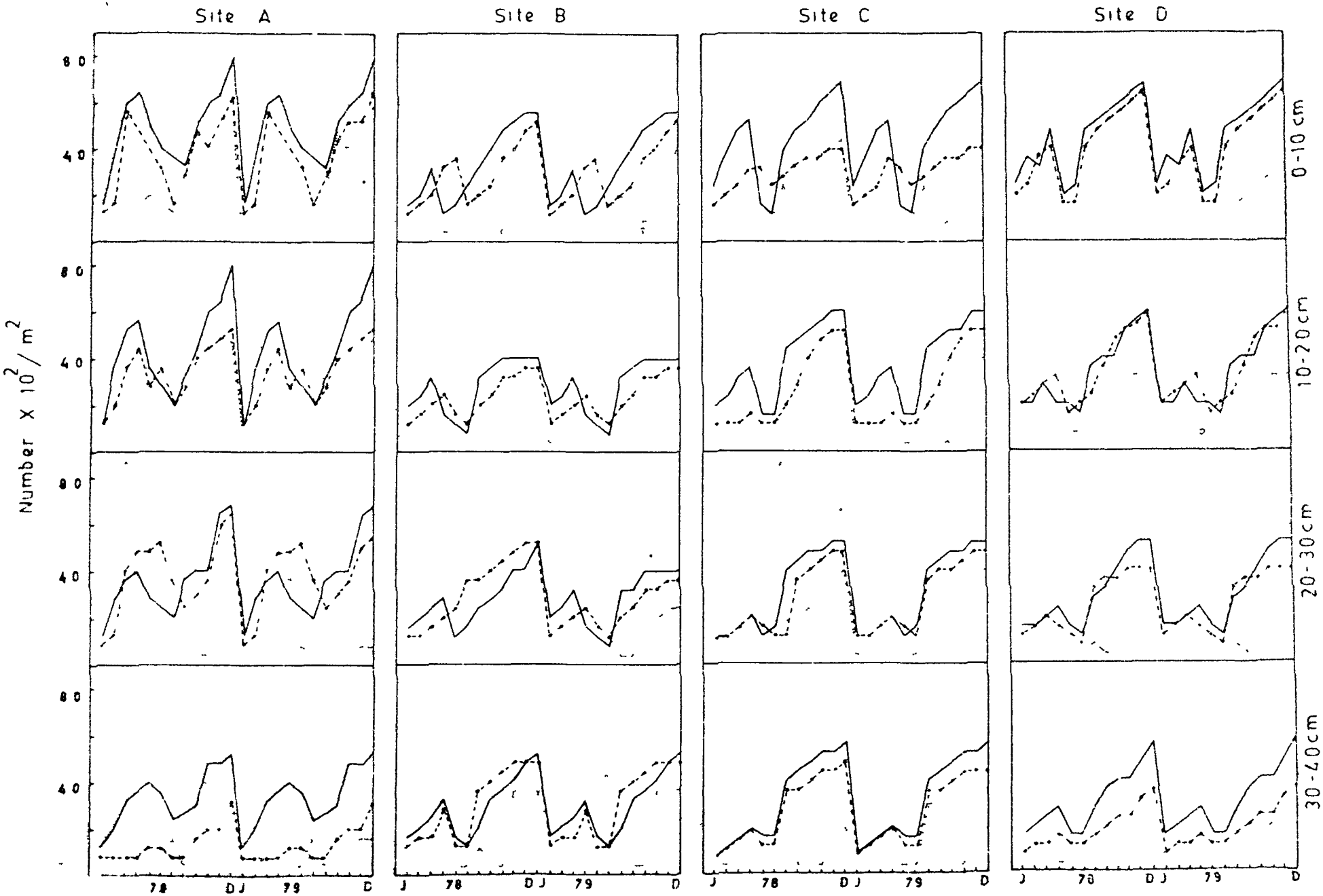

Site A
Site B
Site C
Site D
0-10cm
10-20cm
20-30cm
30-40cm
Number X $10^2/m^2$
90
80
40
0
J
78
DJ
79
D

Fig. 9 : Showing the seasonal fluctuation of sub-orders of Acarina as present in the four different sites at four different depths for both the annual cycles (1978 to 1979).

— : Mesostigmata

--- : Cryptostigmata

: Astigmata


Site A
Site B
Site C
Site D
Number X 10² / m²
80
40
0-10 cm
10-20cm
20-30cm
30-40cm
J
78
DJ
79
D

terms of abundance under mesofauna seemed to follow a similar pattern of seasonal fluctuation as has been observed for Collembola. The population ranged from 92 to 408X10^2/m^2 in the months of January and December respectively. In individual soil layers they ranged from 20 to 128X10^2/m^2. This pattern of seasonal fluctuation was also true when Araneida was seen at its family level and especially in family Clubionidae and Lycosidae, while in Linyphiidae in site D, the first cycle showed a summer minima, though it was true for second annual cycle. The population ranged from 28 to 184X10^2/m^2 in the months of January, February and December respectively. When the individual layers were considered the ranges were from 4 to 56X10^2/m^2 in the same months in all the families of Araneida (Fig. 10).

The remaining groups under mesofauna being Protura, Diplura, Isopoda and Chelonethi which had a common seasonal fluctuation pattern in the first three groups, in that they revealed a summer minima and winter maxima while in the last group namely Chelonethi the minimum was always in January and maximum in December. The population in all the groups ranged from 16 to 108X10^2/m^2 in the months of January and December respectively. When the individuals soil layers were considered the range were 4 to 36X10^2/m^2 (Fig. 11).

The third major group in the total soil fauna was macrofauna which revealed a seasonal fluctuation with a maximum peak of occurrence in February and minimum in June, July. This was true not only in different sites under consideration but also when the individual soil layers were looked at. The range of population were from 300 to 908X10^2/m^2 in the months of June and February, December for both the annual cycles of study. The range was from 44 to 300X10^2/m^2 at the individual soil layers (Fig. 12).

Fig. 10 : Showing the seasonal fluctuation of families of Araneida as present in the four different sites at four different depths for both the annual cycles (1978 to 1979).

·—· : Clubionidae

···· : Lycosidae

— : Linyphidae

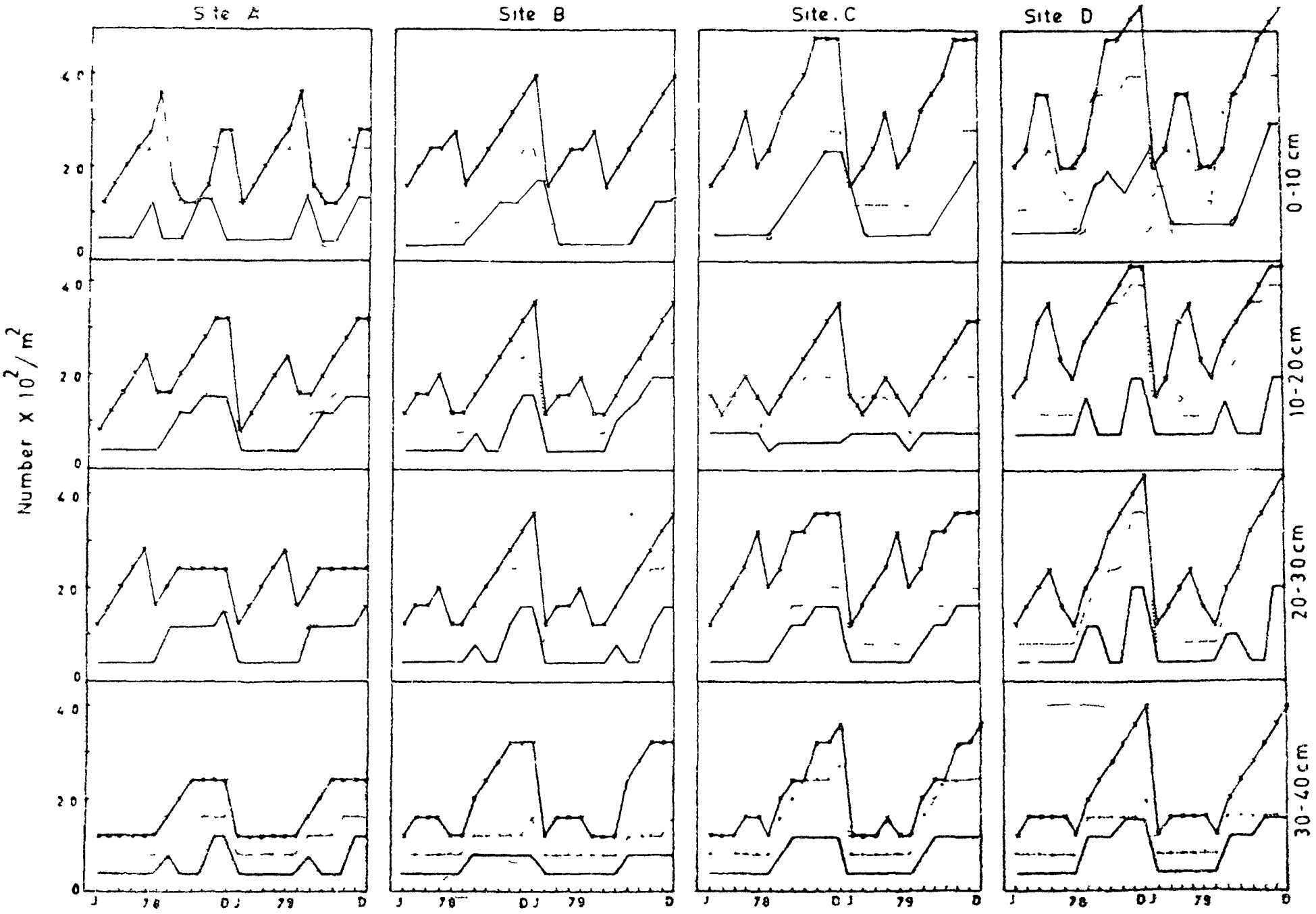

Site A
Site B
Site C
Site D
Number X $10^2/m^2$
0-10 cm
10-20cm
20-30cm
30-40cm
40
20
0
J
78
DJ
79
D

Fig. 11 : Showing the seasonal fluctuation of Chelonethii, Diplura, Protura and Isopoda as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

— : Chelonethii

····· : Diplura

— : Protura

– : Isopoda

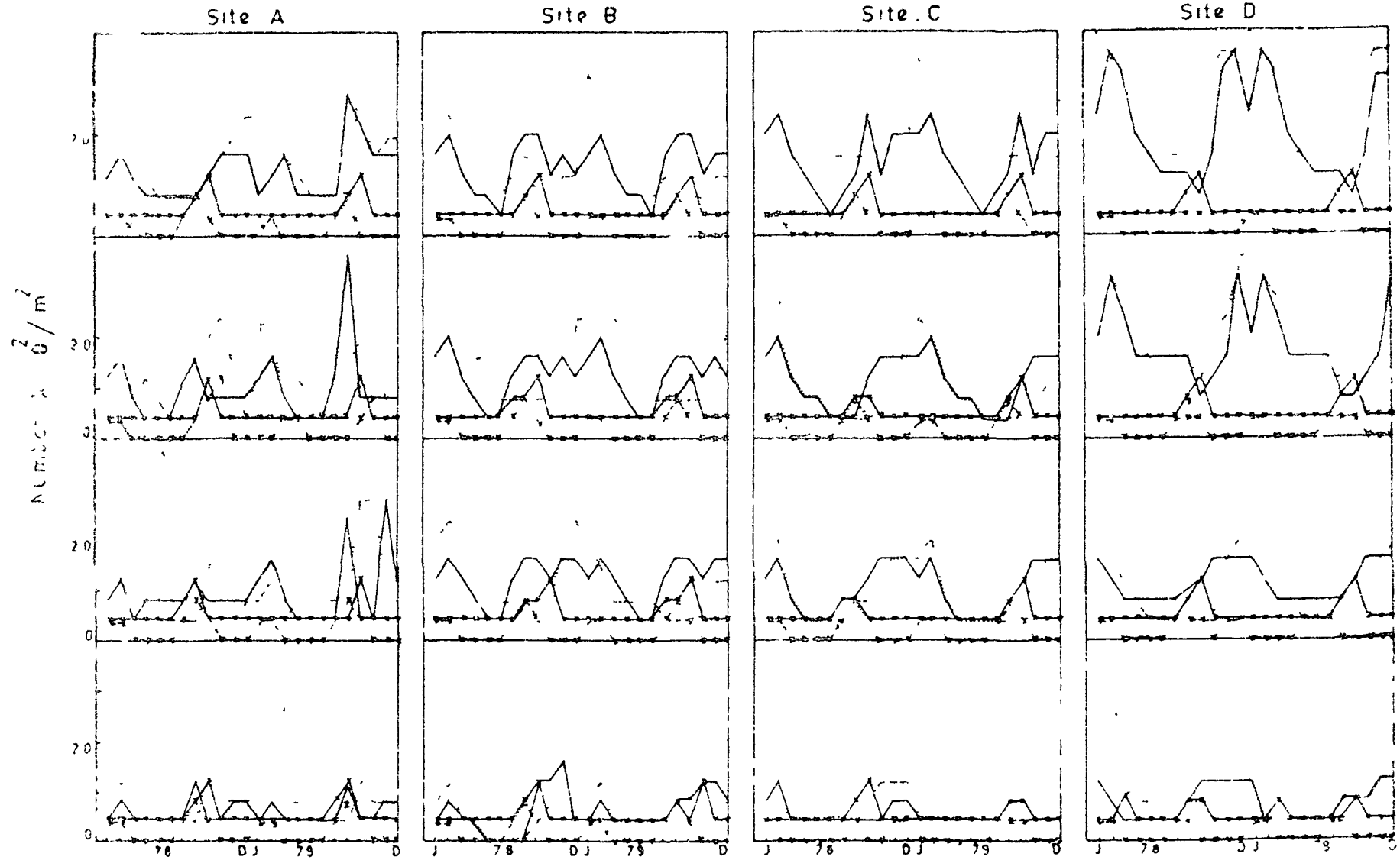
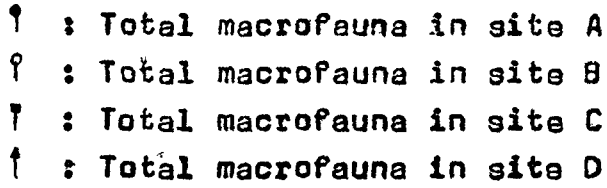
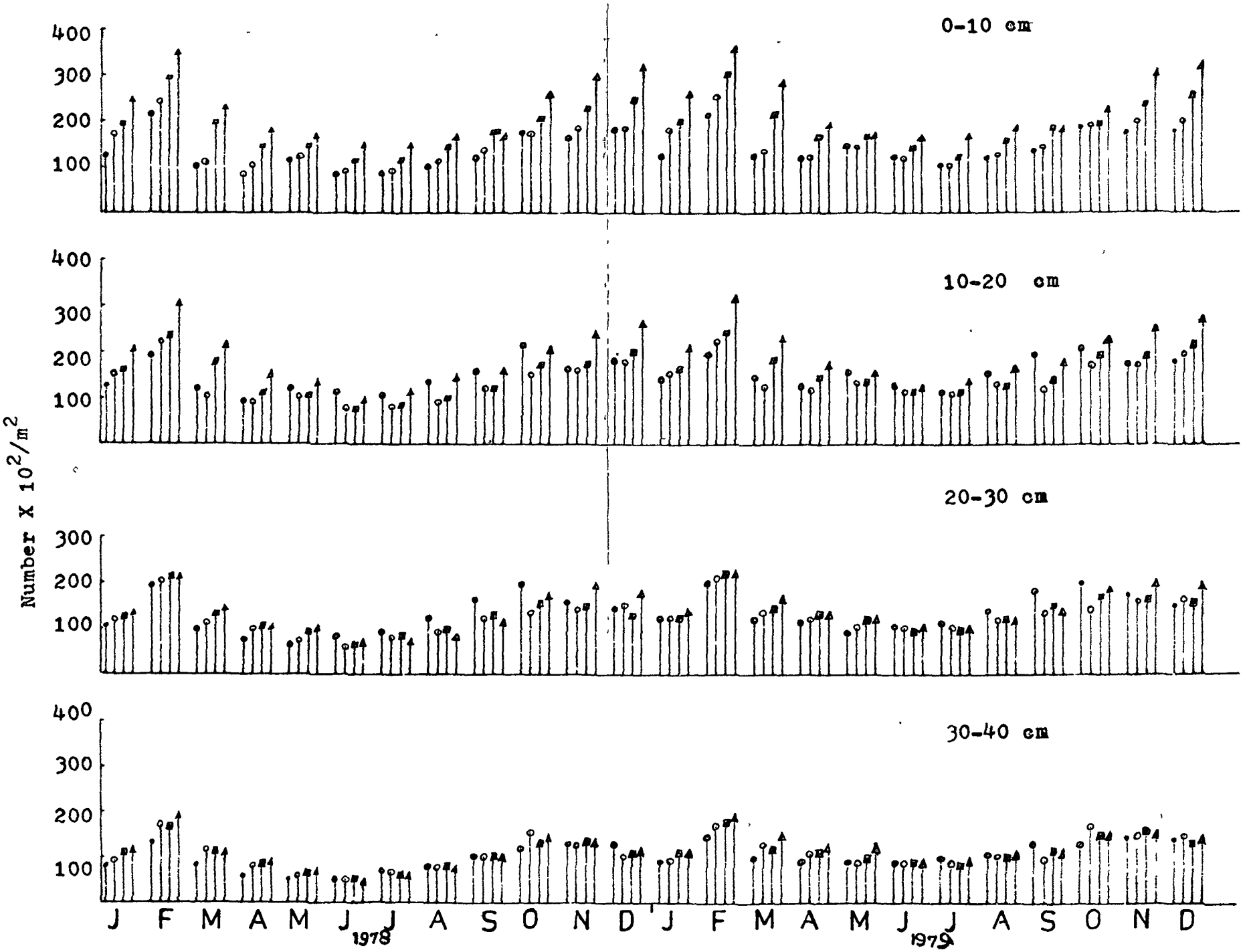

Site A
Site B
Site C
Site D
78
DJ
79
D

Fig. 12 : Showing the seasonal fluctuation of macrofauna as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).




0-10 cm
10-20 cm
20-30 cm
30-40 cm
400
300
200
100
Number X $10^2/m^2$
J F M A M J J A S O N D J F M A M J J A S O N D
1978
1979

The most abundant group in macrofauna was total insects, which showed a more or less similar pattern in their seasonal fluctuation as macrofauna which is quite understandable because the fluctuation pattern depended upon insects. They ranged from 224 to $732X10^2/m^2$ in the months of June and December respectively. The range of individual soil layers was from 36 to $280X10^2/m^2$ for both the annual cycles of study (Fig. 13).

When total insects was sub-divided into its major categories, it was seen that ants were the most dominant group and recorded a maxima in February in site A, but in October for the other sites, while the minimum was recorded during May-June. It was true when all the sites as well as all the layers were also considered. The range of population were from 128 to $496X10^2/m^2$. The range in individual soil layers were from 20 to $148X10^2/m^2$ (Fig. 13).

The ants when looked at its family levels in the present investigation where 5 families were present, all the families revealed a more or less similar picture as was seen for the total ants, in that the maximum occurred in February in all the sites and October in site A, while the minimum was observed in May-June in all the sites at all the depths. The range of population in different families of ants like (Myrmicinae, Ponerinae, Dorylinae, Pseudomyrimicinae and Dolichoderinae) ranged from 44 to $148X10^2/m^2$ in the months of April and October; 24 to $96X10^2/m^2$ in the months of May and October; 12 to $68X10^2/m^2$ in the months of April and October; 20 to $124X10^2/m^2$ in the months of April and October; and 12 to $56X10^2/m^2$ in the months of August and October respectively. While the individual layers were considered, the ranges were from 4 to $44X10^2/m^2$ in all the sites for both the annual cycles (Fig. 14).

Fig. 13 : Showing the seasonal fluctuation of total insecta, total myriapoda and total ants as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

— : Total Insecta

⟷ : Total Myriapoda

: Total Ants

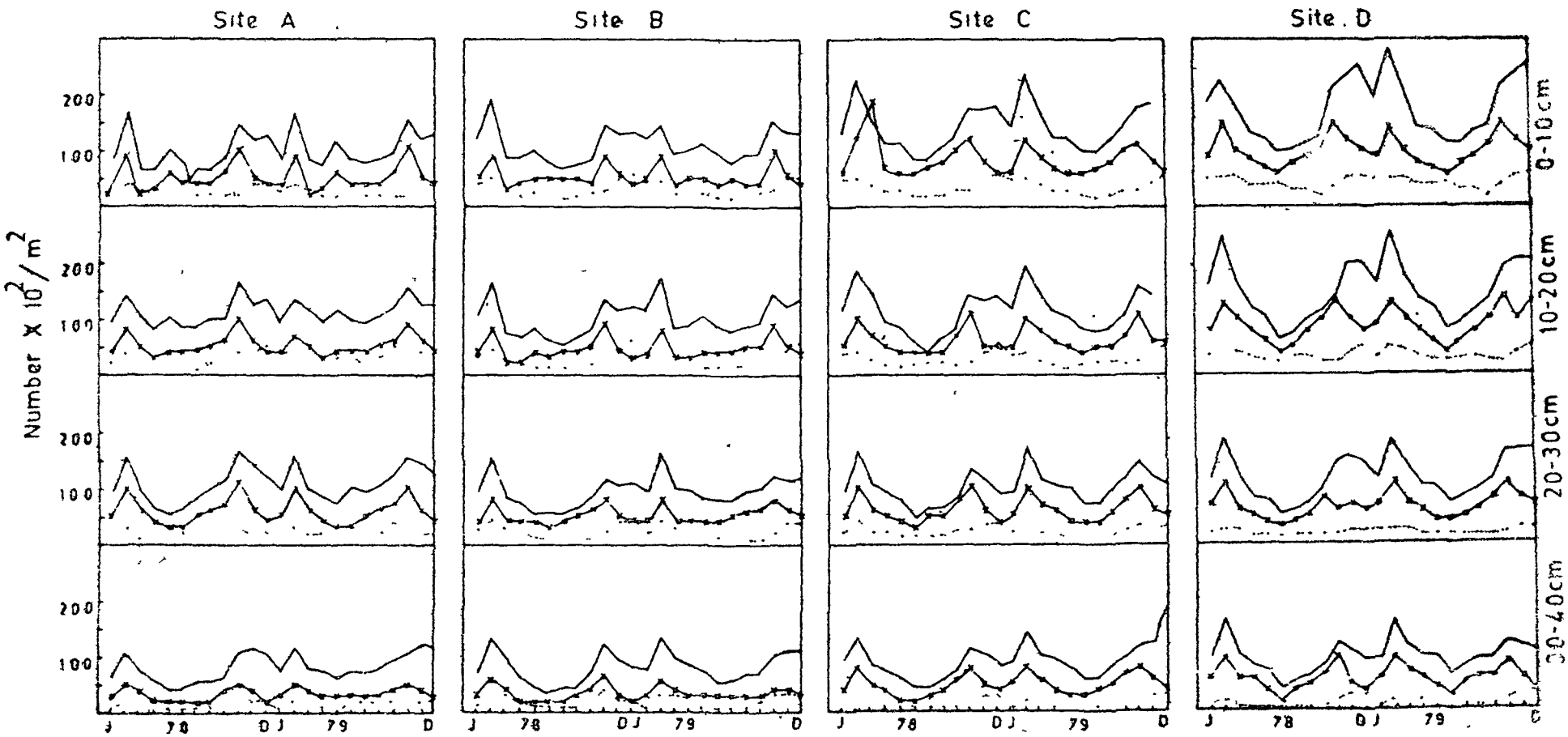

Site A
Site B
Site C
Site D
Number X $10^2/m^2$
200
100
0-10cm
10-20cm
20-30cm
30-40cm
J
78
DJ
79
D

Fig. 14 : Showing the seasonal fluctuation of families of ants as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

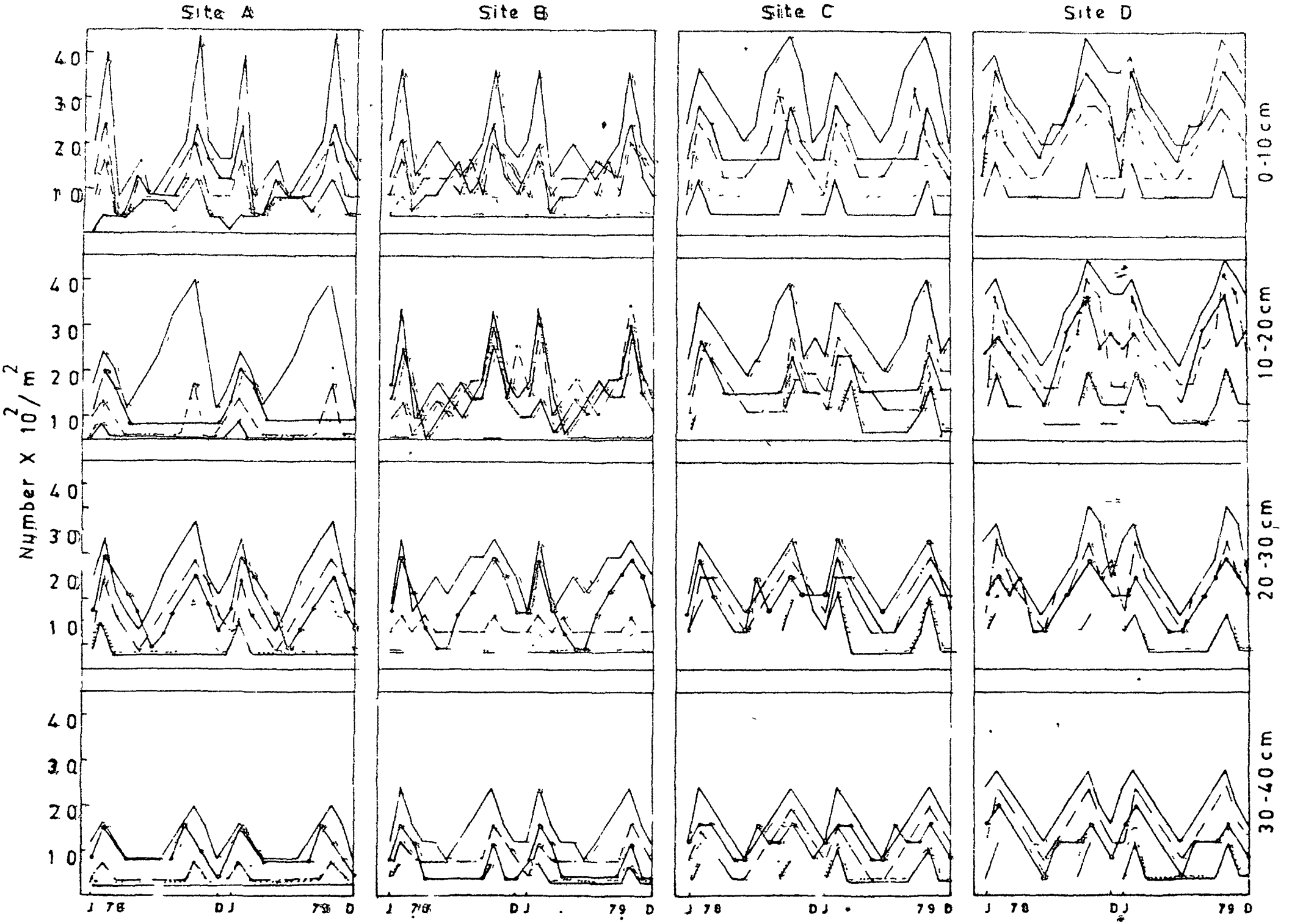
— :Myrmicinae

—• :Pseudomyrmicinae

—•• :Ponerinae

··· :Dorylinae

— :Dolichoderinae


Site A
Site B
Site C
Site D
Number X 10 2 / m 2
0-10 cm
10-20 cm
20-30 cm
30-40 cm
40
30
20
10
J 78
DJ
79 D

Among the other sub-divisions of total insects, which included orders like Coleoptera, Diptera, Hemiptera, Hymenoptera, Thysanoptera, Lepidoptera, Trichoptera, Orthoptera and Dermaptera, all of them revealed a winter maxima and a summer minima (Fig.15). The range in the insect orders to their dominant abundance, were 16 to $72X10^2/m^2$ in the months of July and December; 8 to $80X10^2/m^2$ in the months of June and December; 16 to $52X10^2/m^2$ in the same months; 0 to $60X10^2/m^2$ in the same months; 0 to $48X10^2/m^2$ in the months of January, February and December; 0 to $54X10^2/m^2$ in the months of March, April and December; 16 to $40X10^2/m^2$ in the months of April, May, June and December; 0 to $32X10^2/m^2$ in the months of March, April and August; and 0 to $40X10^2/m^2$ in the months of April, May, June and December. The range of population in individual layers were 0 to $24X10^2/m^2$ in the months of April and November-December respectively (Figs. 15 & 16).

Macrofauna which predominantly contained insect had as the second major group Myriapoda. This group was further divided into Symphyla, Chilopoda and Diplopoda. However when either Myriapoda or different sub-groups were observed for the seasonal fluctuations during the entire period of investigation it was observed that a winter maxima particularly in December existed, and a summer minima between April to June was observed. The total Myriapoda ranged from 48 to $196X10^2/m^2$ in the months of July and December respectively. The range in individual layers was 4 to $60X10^2/m^2$. The different three sub-groups ranged from 4 to $64X10^2/m^2$ in the months of June, July, August and December; 16 to $64X10^2/m^2$ in the months of June and December and 20 to $76X10^2/m^2$ in the months of July and December respectively in terms of dominance. The population when seen in each soil layers ranged from 4 to $36X10^2/m^2$ (Fig. 13 & 17).

Fig. 15 : Showing the seasonal fluctuation of endopterygote insects as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

— : Coleoptera

····· : Lepidoptera

— : Trichoptera

---- : Diptera

—x— : Hymenoptera

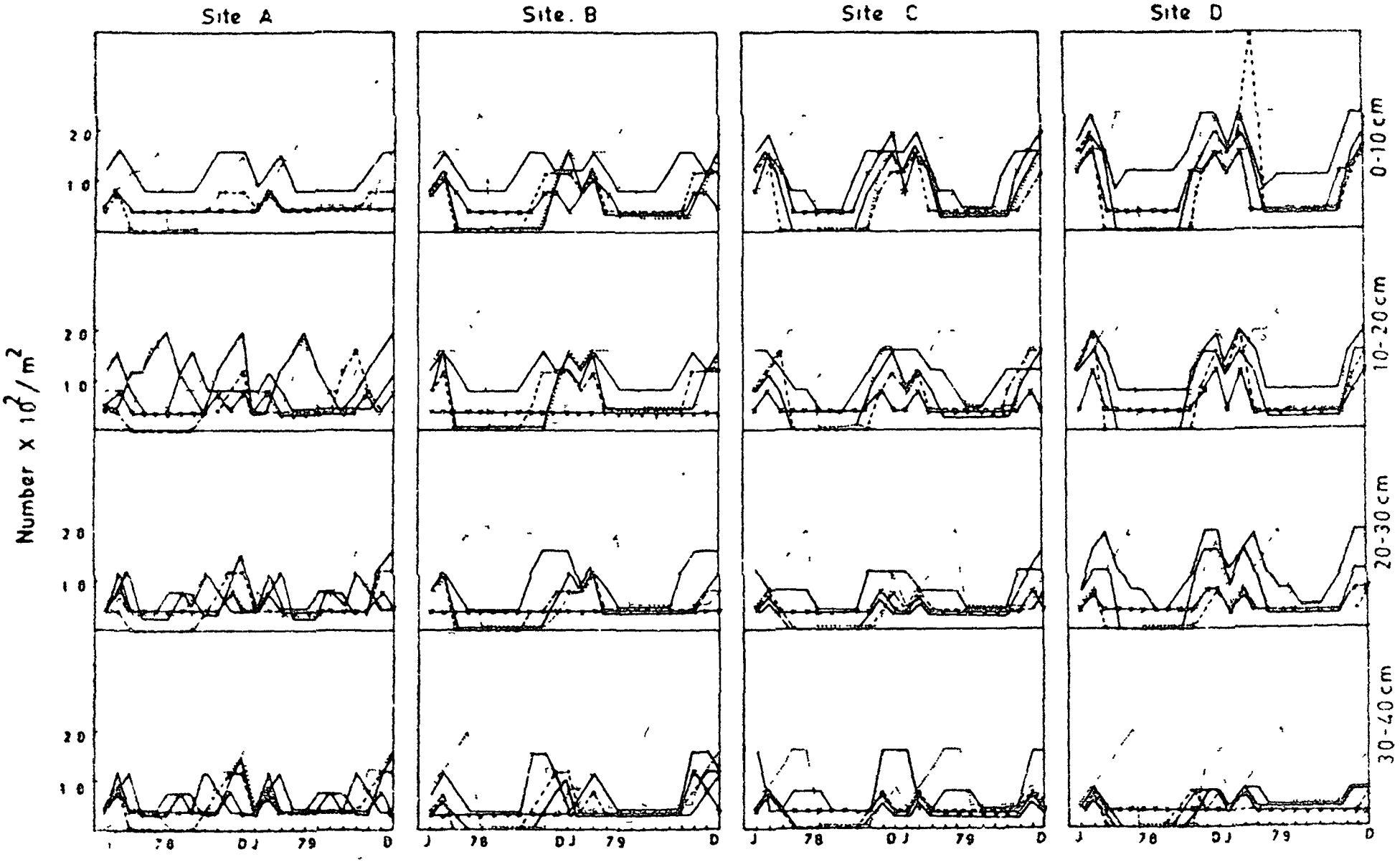

Site A
Site. B
Site C
Site D
Number X $10^2/m^2$
20
10
0-10 cm
10-20 cm
20-30 cm
30-40 cm
J
78
DJ
79
D

Fig. 16 : Showing the seasonal fluctuation of exopterygote insects as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

: Orthoptera

: Dermaptera

: Hemiptera


: Thysanoptera

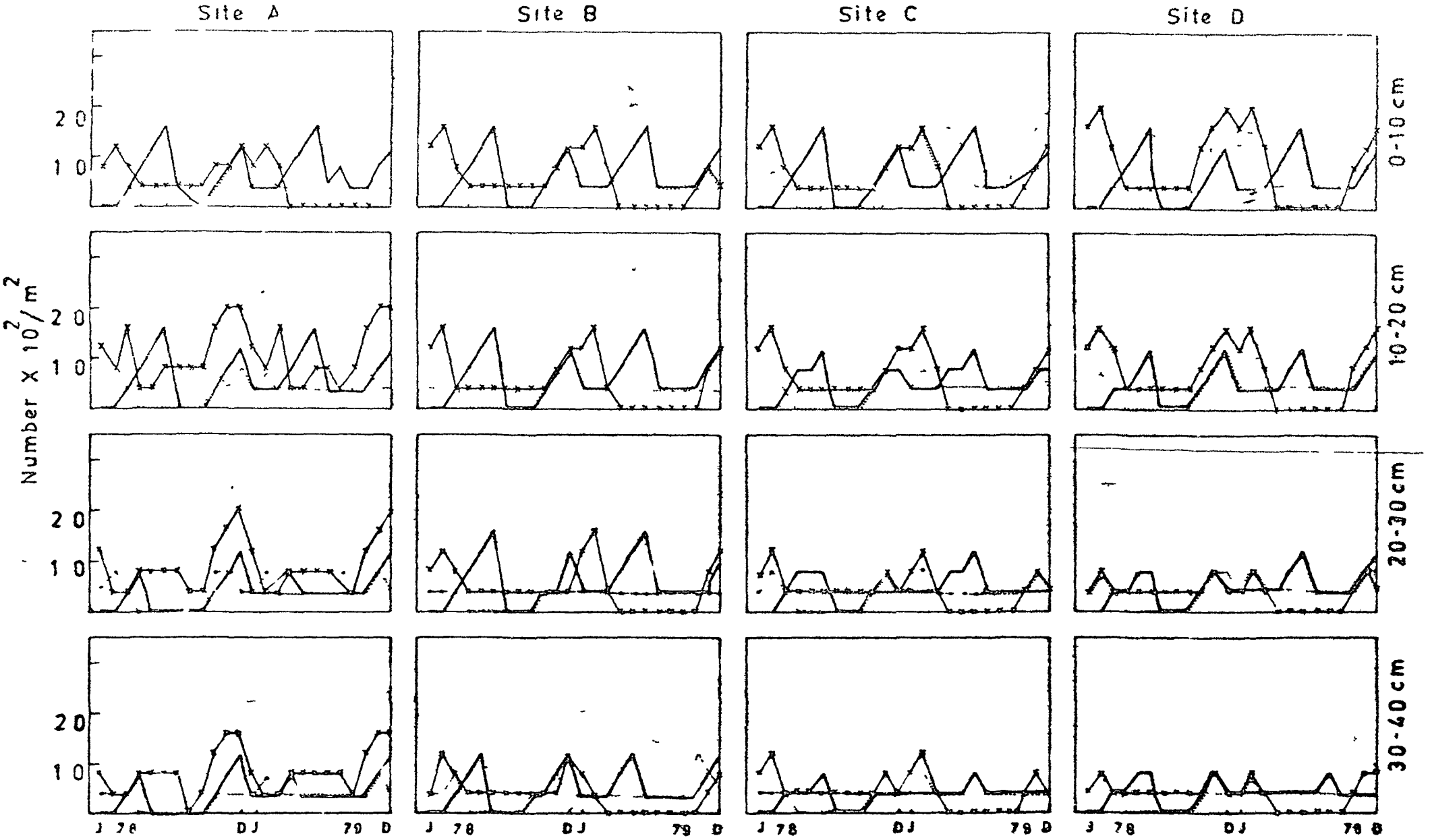
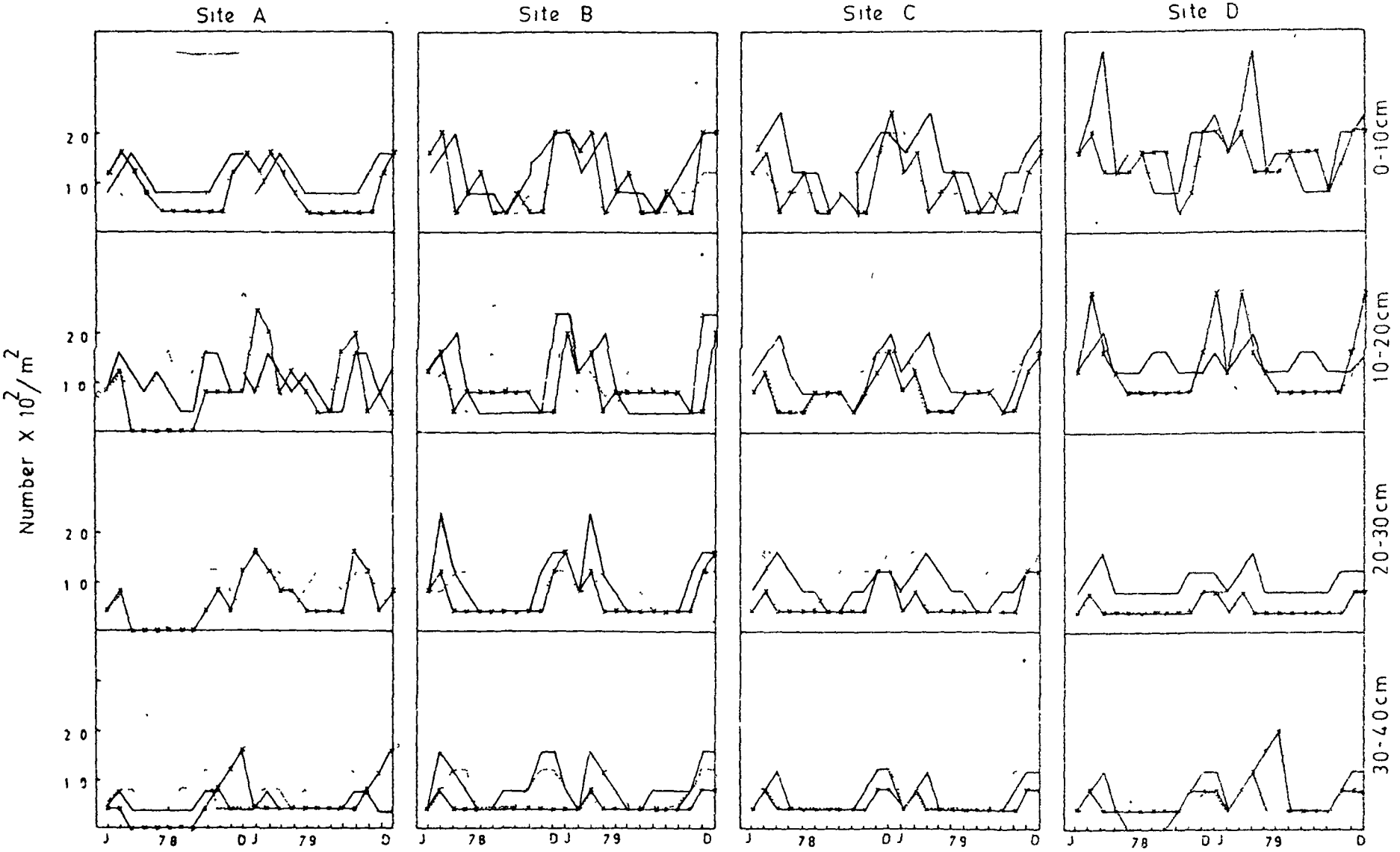

Site A
Site B
Site C
Site D
0-10 cm
10-20 cm
20-30 cm
30-40 cm
Number X 10² / m²
2 0
1 0
J 78
DJ
79 D

Fig. 17 : Showing the seasonal fluctuation of sub-orders of Myriapoda as present in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

×—×: Total Chilopoda

— : Total Symphyla

····: Total Diplopoda


Site A
Site B
Site C
Site D
Number X 10²/m²
0-10cm
10-20cm
20-30cm
30-40cm
20
10
J
78
DJ
79
D

Mollusca and Earthworms formed the least abundant among the macrofauna, their seasonal pattern of fluctuation showed a maxima in Autumn (August and September) and a minima during both Summer and Winter in Mollusca, while in Earthworms it was only in Summer. The population ranged from nil to $28X10^2/m^2$ and nil to $40X10^2/m^2$ respectively. These ranged again nil to $12X10^2/m^2$ when the individual soil layers was considered (Fig. 18).

Physico-Chemical factors

The various physico-chemical factors undertaken in the present study was broadly chosen as under three major categories (1) physical (environmental), (2) Physical and (3) Chemical. Under Physical (environmental), Soil Temperature, Air Temperature, Moisture content and Rainfall was included, while the second physical incorporated pH, Conductivity, Bulk-density and Porosity of the soil, while the chemical factors were organic carbon, Nitrogen, Phosphorus and Potassium.

The soil and air temperature at the different layers and different sites was seen to reach a peak in September while the minimum was in March in soil and in November in air for both the annual cycles. The range of soil and air temperature were from 30 to 35°C and 24 to 38°C respectively (Fig. 19).

Rainfall had a summer maxima and winter minima true for all the sites. It ranged from nil to 308.18 cm during the first annual cycle, while in second annual cycle it was from 1.3 to 355.3 cm. The moisture content of the soil however unlike rainfall showed a bimodal peak of maxima, one in summer and one in winter in all the sites, while the minimum observed was between the months of February and April (Fig. 20). The range of moisture

Fig. 18 : Showing the seasonal fluctuation of Mollusca and Earthworm as present in the four different study sites at four different sites for both the annual cycles (1978 to 1979).

— : Total Mollusca

····· : Total earthworm

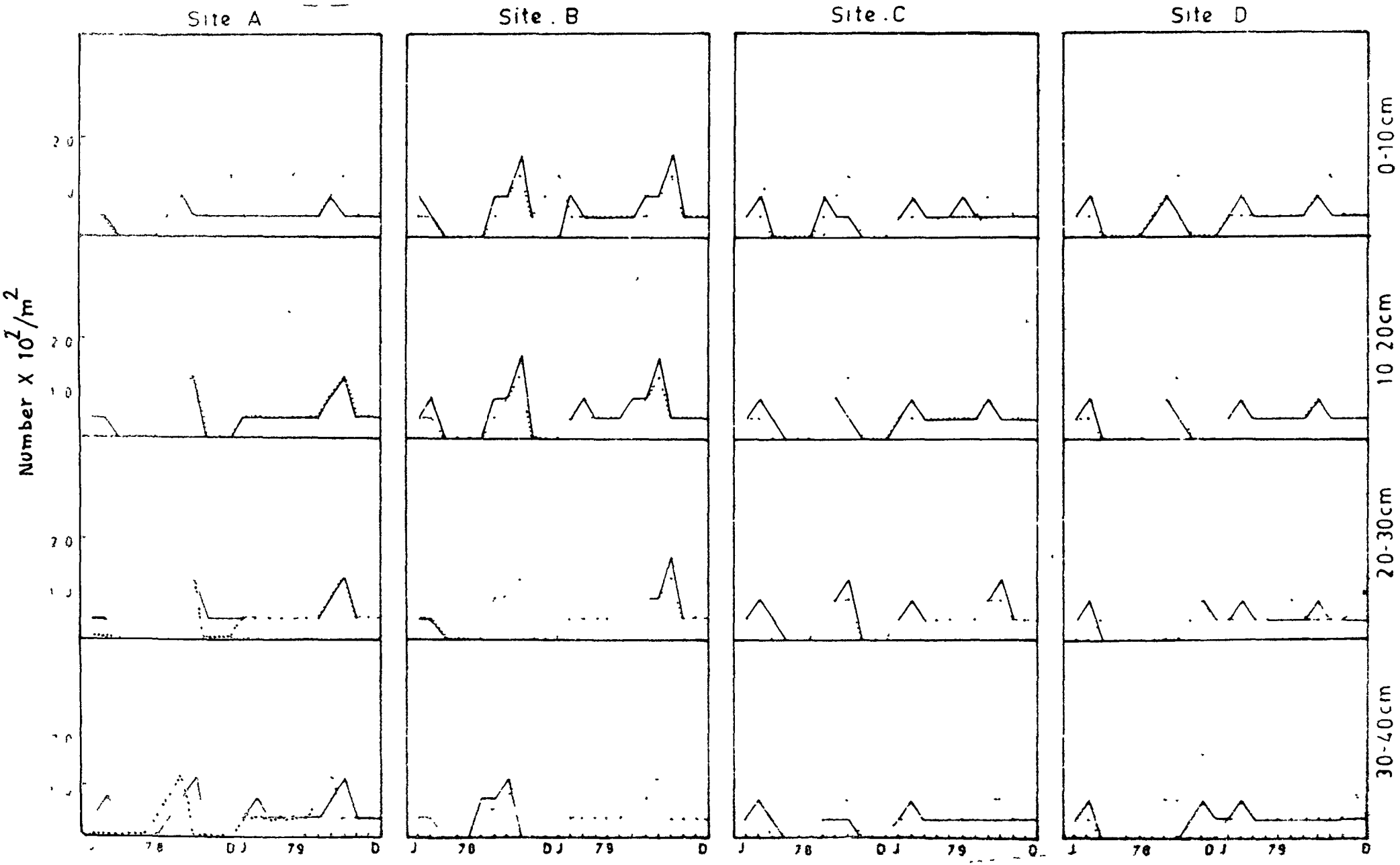

Site A
Site . B
Site . C
Site D
0-10 cm
10 20cm
20-30cm
30-40cm
Number X $10^2/m^2$
J 78 DJ 79 D

Fig. 19 : Showing the seasonal fluctuations of Air temperature in the study area and soil temperature in the four different sites at four different depths for both the annual cycles (1978 to 1979).

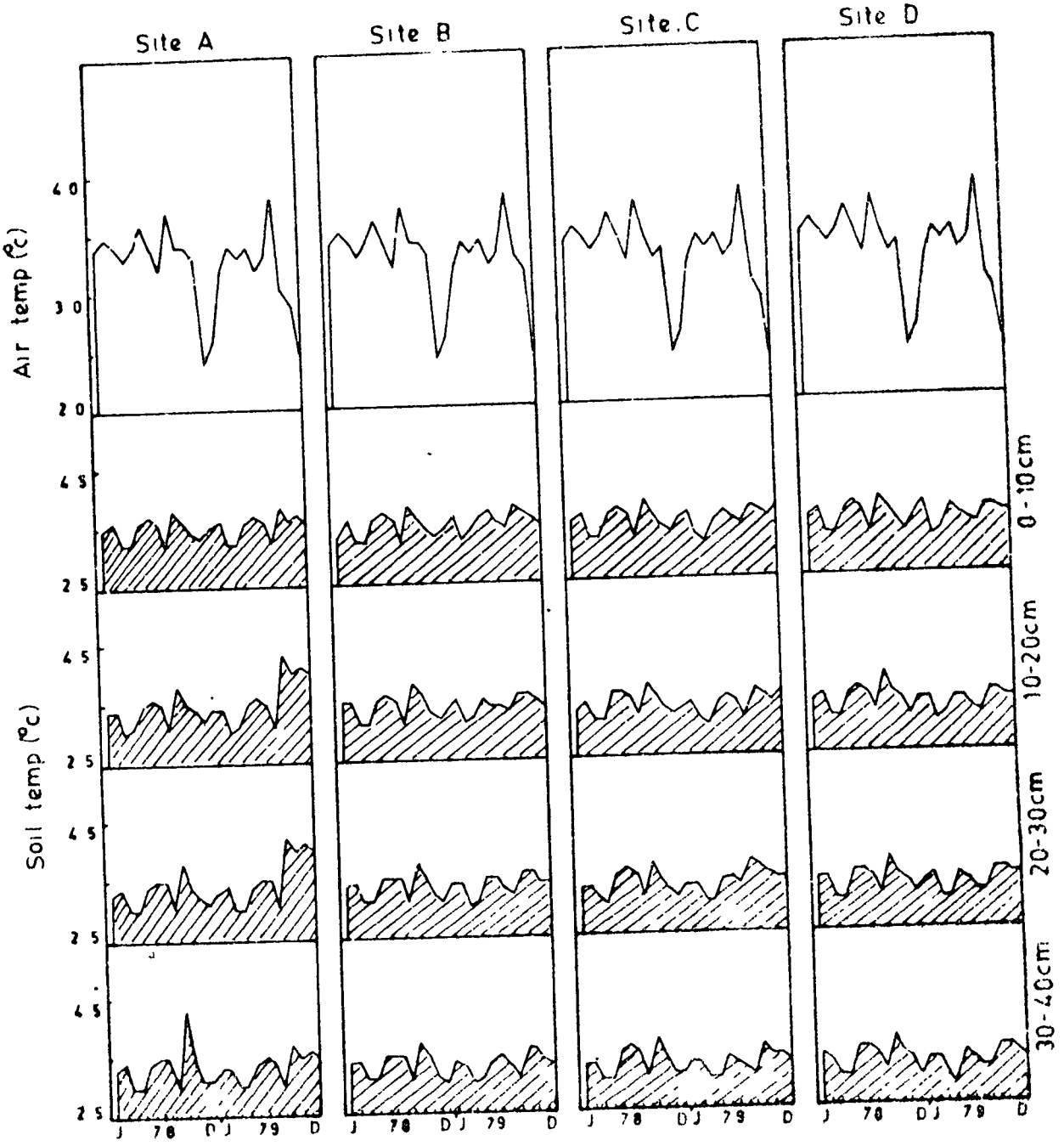
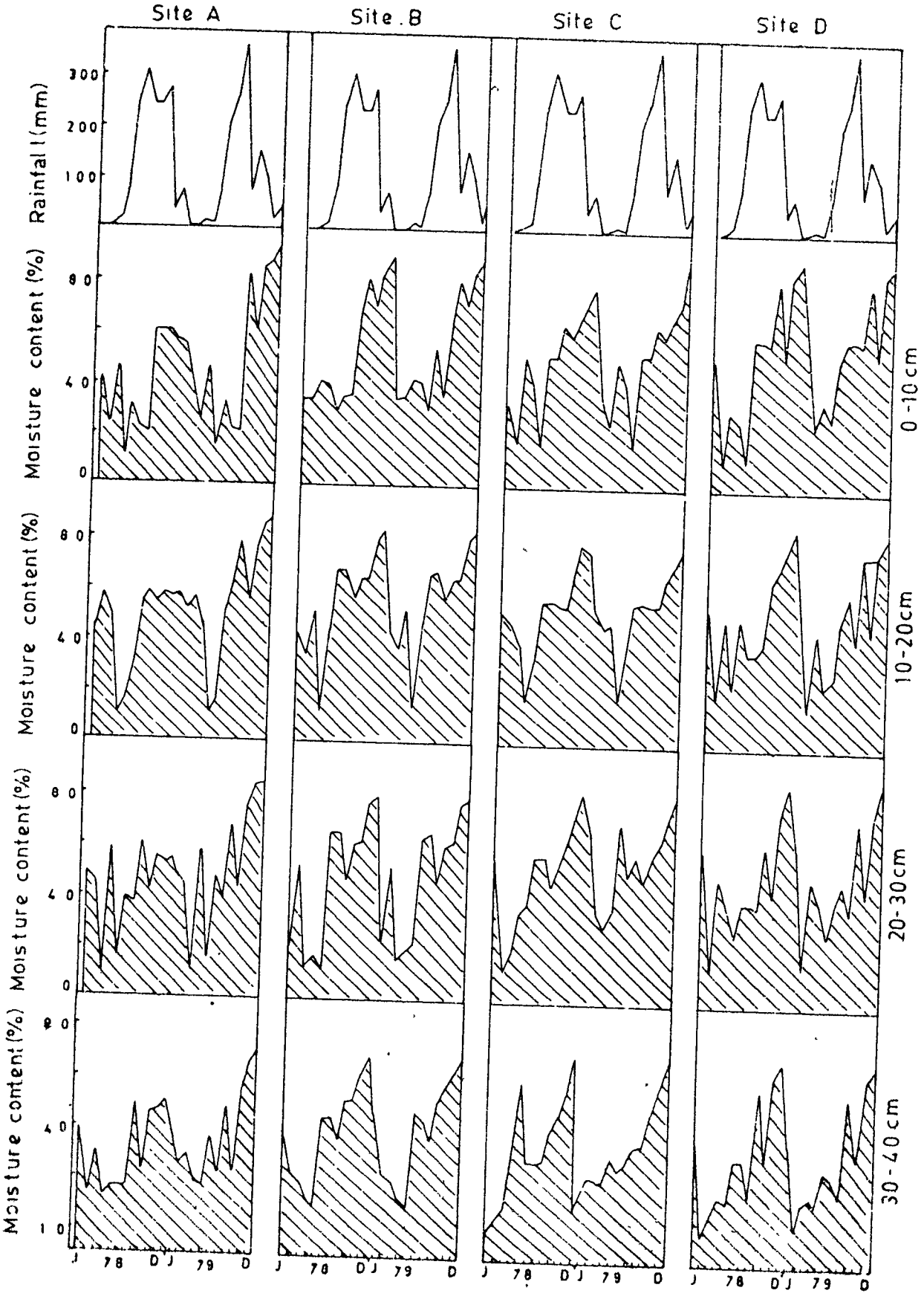

Site A
Site B
Site C
Site D
Air temp (°C)
40
30
20
Soil temp (°C)
45
25
0-10cm
10-20cm
20-30cm
30-40cm
J 78 DJ 79 D

Fig. 20 : Showing the seasonal fluctuation of Rainfall in the study area and moisture content of the soil in different study sites at different depths for both the annual cycles (1978 to 1979).


Site A
Site B
Site C
Site D
Rainfall (mm)
300
200
100
Moisture content (%)
80
40
0
0-10 cm
10-20cm
20-30cm
30-40 cm
J
78
D
J
79
D

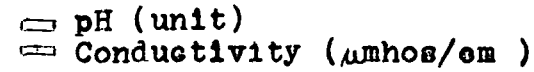
content was 10 and 89% approximately in all the sites for both the years of study (Fig. 20).

The pH of soil had a general trend of summer minima and winter maxima in both years for most of the sites and most of the soil layers, in that, though July figured in all the sites as maximum, the minimum was in November for site A and September and December for the remaining sites. pH ranged from 5.0 to 7.4 during the entire study period (Fig. 21). The specific conductance of soil was seen to follow a reverse trend as that of pH in general for the different sites. However the upper soil layers showed a maxima in the winter months and in summer in the bottom two layers. The specific conductance of soil ranged from 5.25 to 60.06 µmhos/cm in upper soil layers while in lower layers it was from 9.45 to 58.20 µmhos/cm (Fig. 21).

The bulk density of the soil in both the annual cycles in sites A and B was maximum in the summer months and minimum in October, while it was maximum in December in sites C and D, though the minimum was the same. The bulk density ranged from 1.30 to 1.48 units in the first annual cycle and 1.24 to 1.43 units in the second annual cycle. The porosity of the soil followed the same pattern more or less as that of pH in all the sites, and ranged from 22.03 to 48.9% in all the sites during the entire study period (Fig. 22).

All the chemical factors (C,N,P and K) also revealed the summer maxima and winter minima in all the sites in all the soil layers. The ranges of C,N, P and K were 1.45 to 2.1%; 0.12 to 0.18%; 0.06 to 0.28 ppm and 0.9 to 2.0 ppm respectively (Figs. 23 & 24).

Fig. 21 : Showing the seasonal fluctuation of pH and conductivity of the soil in the four different study sites at four different depths for both the annual cycles (1978 to 1979).



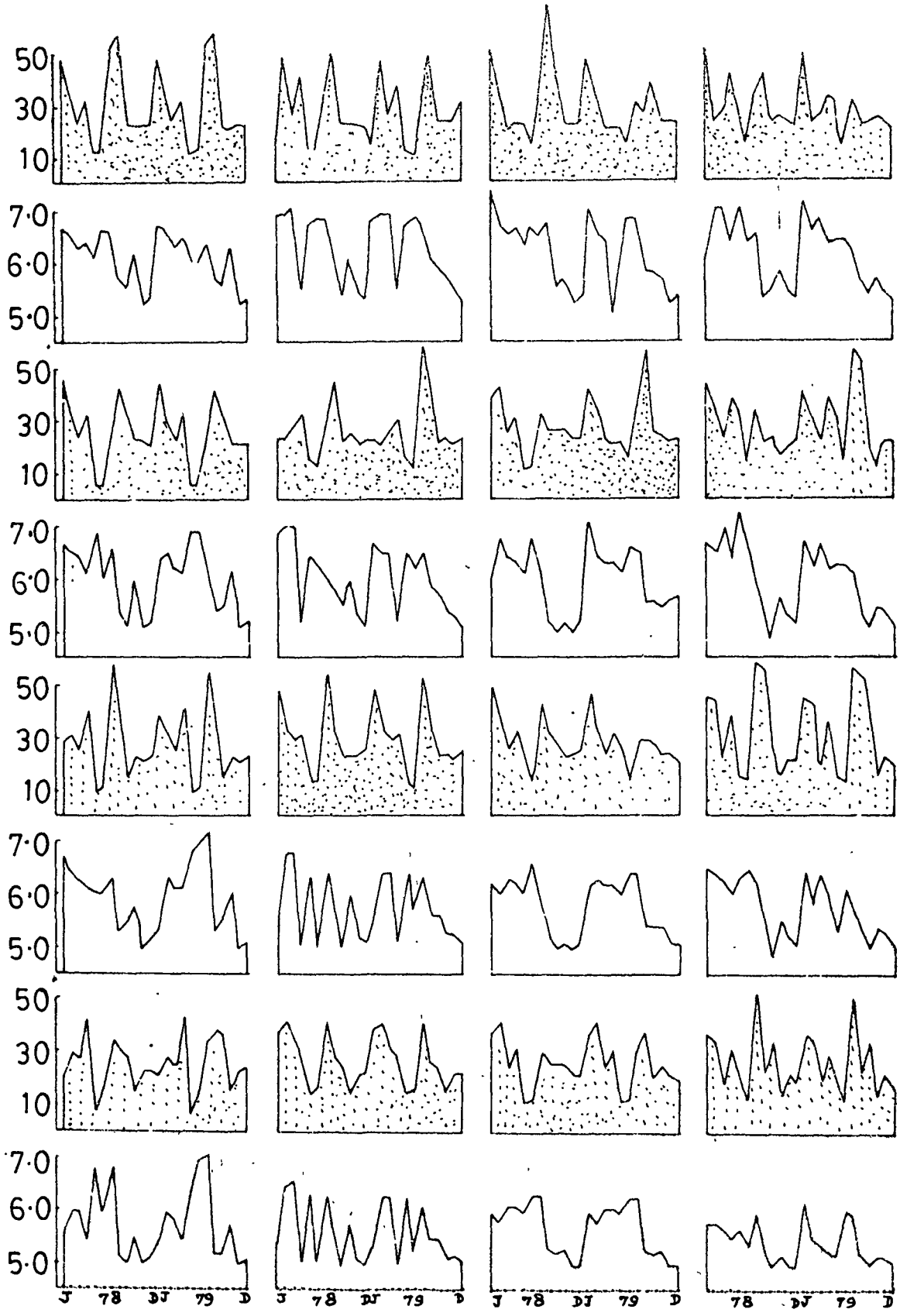

50
30
10
7·0
6·0
5·0
J
78
DJ
79
D

Fig. 22 : Showing the seasonal fluctuation of Bulk-density and porosity of the soil in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

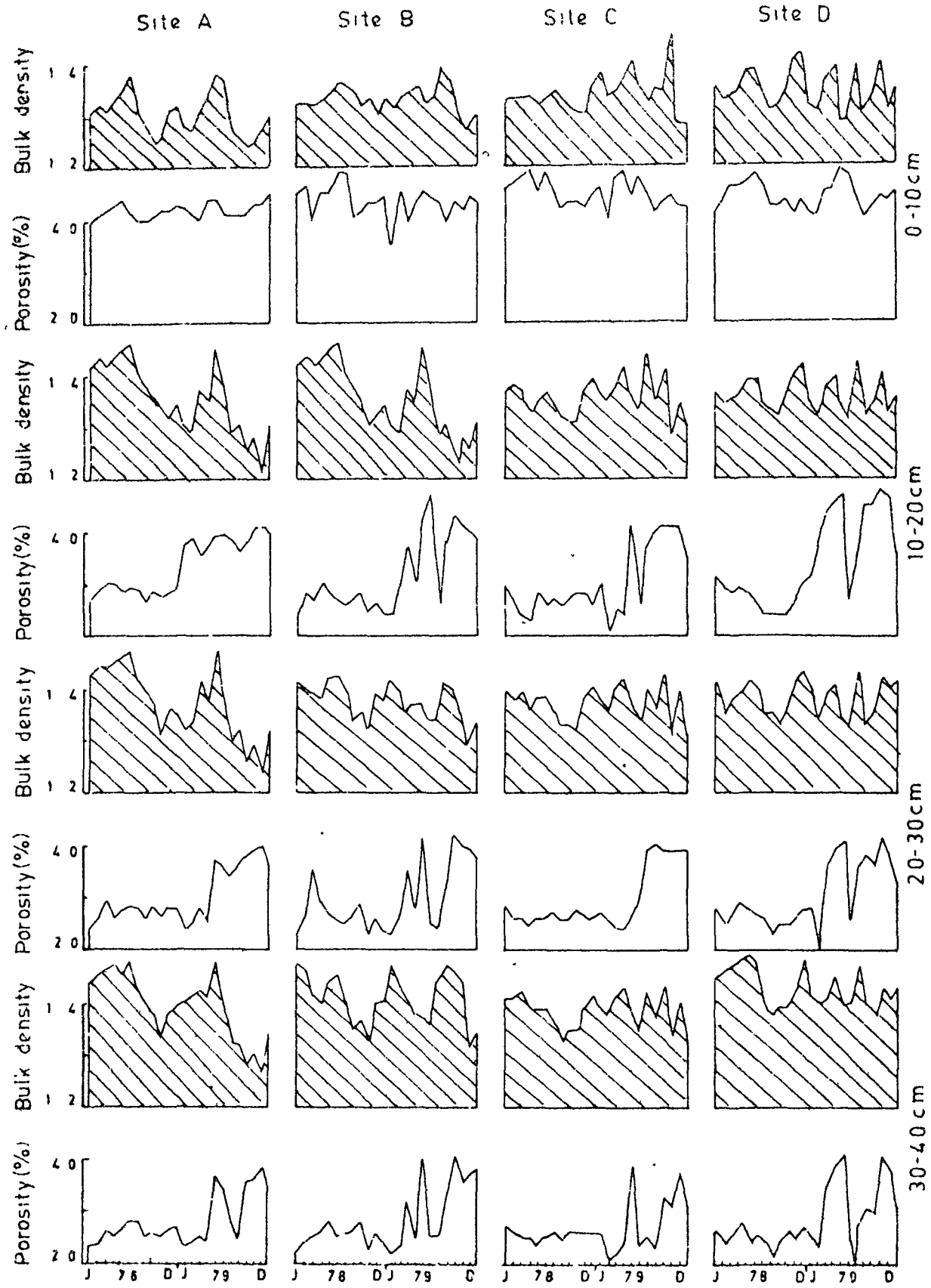

Site A
Site B
Site C
Site D
Bulk density
Porosity(%)
1.4
1.2
4.0
2.0
0-10cm
10-20cm
20-30cm
30-40cm
J 78 D J 79 D

Fig. 23 : Showing the seasonal fluctuation of Carbon and Nitrogen of the soil in the four different study sites at four different depths for both the annual cycles (1978 to 1979).

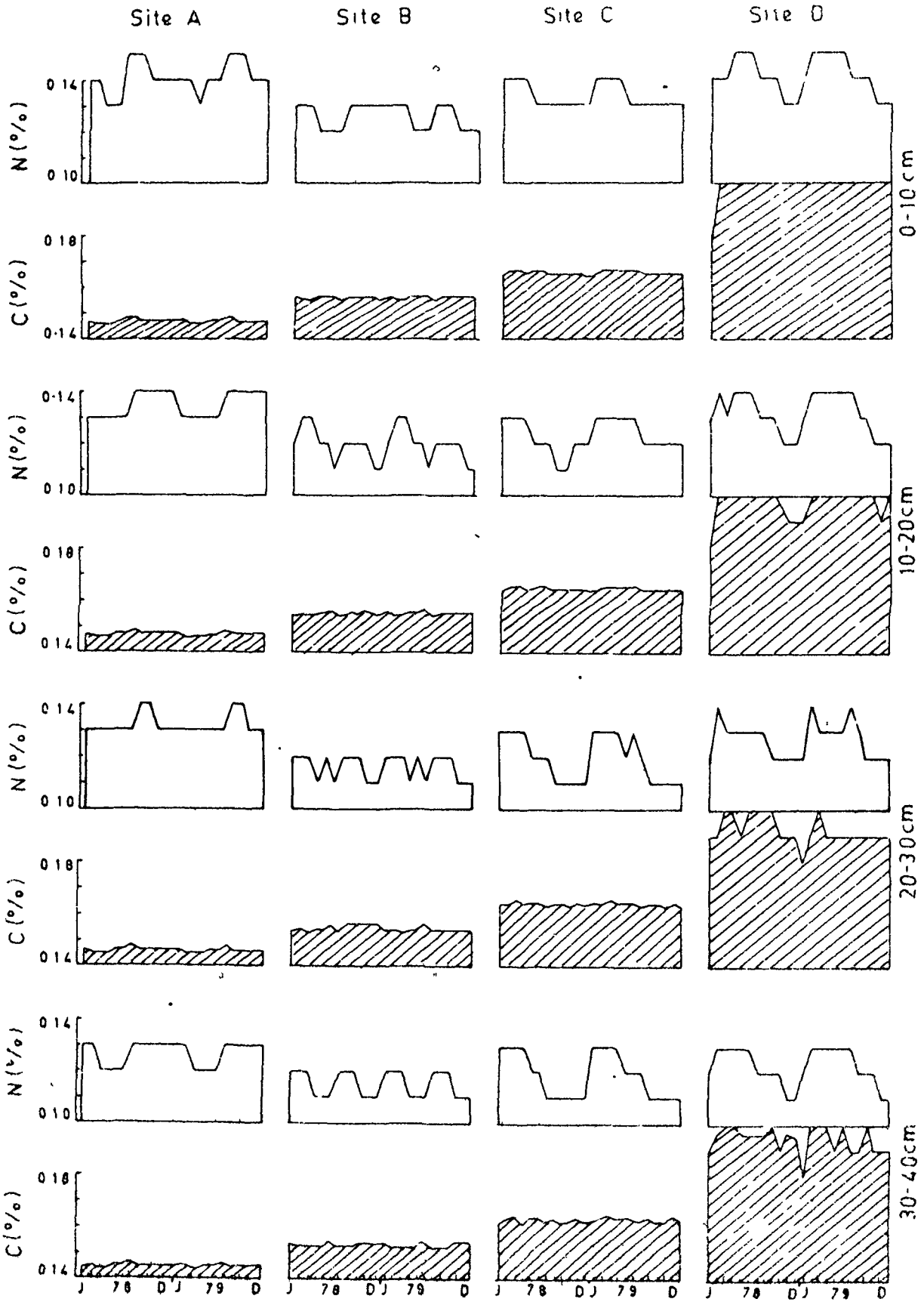
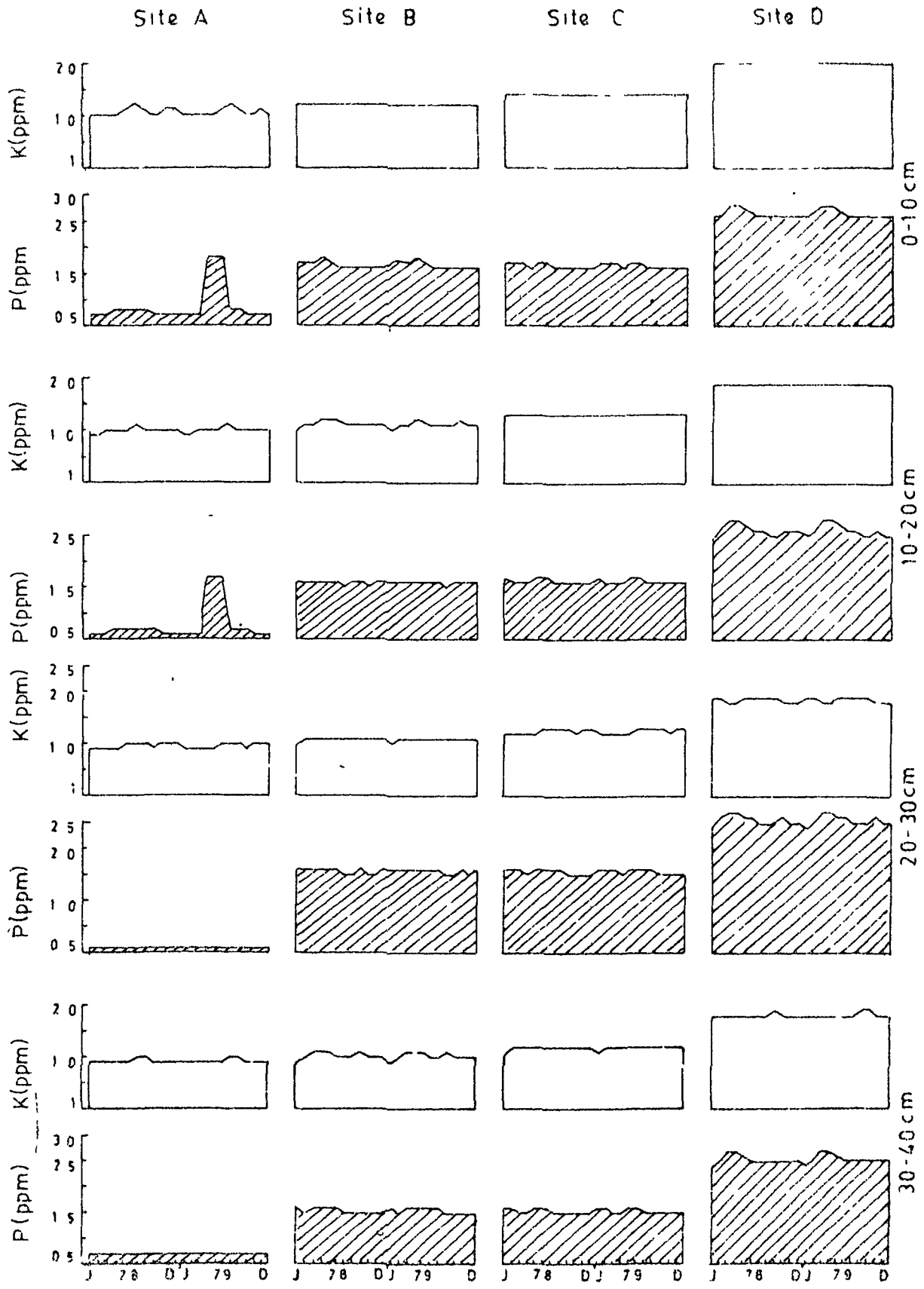

Site A
Site B
Site C
Site D
N (%)
C (%)
0 14
0 10
0 18
0·14
0-10 cm
10-20cm
20-30cm
30-40cm
J 78 D J 79 D

Fig. 24 : Showing the seasonal fluctuation of Potassium and Phosphorus of the soil in the four different study sites at four different depths for both the annual cycles (1978 to 1979).


Site A
Site B
Site C
Site D
K(ppm)
P(ppm)
0-10cm
10-20cm
20-30cm
30-40cm
J 78 D J 79 D

DISCUSSION

The present work is unique, as mentioned in the introduction, that though the immediate effects on soil fauna after either burning or other stress factors considerable literature exist, yet very little is available on land abandoned after cultivation. Moreover, the work incorporated not only the study of cultivated land abandoned from 1 to 20 years, but also that this land was cultivated after the logging and burning processes had taken place and then left fallow. It is known that the length of a fallow period depends to a large extent on the vigour of several secondary successions, which is a complex ecological mechanism, we therefore confined ourselves only to the restoration of fertility of soil in such abandoned fallows by a comparative study of only the soil fauna in the different age groups of the fallows enabling identification of the actual period of recolonization to the original levels of soil fauna.

It was seen that in general, the oldest fallow (20 years) had the maximum number of either total soil fauna or when broken up into micro, meso and macrofauna levels. This clearly indicated that a build up of soil fauna in older fallows exists. However, it was also observed from the results that the least abundance of the groups was seen in site B (5 years old), when one should have expected the lowest numbers in site A (1 year old), being the youngest fallow and the most recently abandoned after cultivation. This could be explained by the fact that immediately after cultivation any soil left untouched would attract heavy density of soil fauna which would start colonizing, but unfavourable mineral conditions and other non suitable edaphic factors, results in decrease in numbers as can be observed in site B. These

results agree with those of Karpinen (1958), Huhta et. al. (1967; 1969) and Moritz (1965) where they have clearly indicated a temporary increase in the numbers of soil fauna in particular Oribatids, immediately after clear cutting. However, reports also exist of the populations falling to half the original values (Kuhnelt, 1950) for Collembola. This immediate increase and later stabilizing effects primarily depends on succession of soil developments, which depends on the development of soil types (Rosek, 1978). Further, soil animal groups which occur in the later successional stages cannot live in less developed earlier stages probably for eco-physiological reasons, as they are not passive components of succession, hence they change the soil micro structure and are capable of pushing succession actively forward.

This is very true as seen from the results that micro, meso, macro and total soil fauna which dropped from the youngest fallow to the five year old fallow thereafter increased steadily till all of them recorded maximum in the oldest, which presumably could be the last stage of succession and total recolonization. This last aspect was very true in particular for mesofauna which recorded an abundance in the oldest fallow (site D) at a level equivalent to that in the youngest fallow (site A), which proves that stabilization had taken place and the density being reached to threshold levels, in addition to the species diversity. This was supported by the fact that in the present study a clear phenomena of succession and stabilization is seen. The numbers of either meso, micro or macrofauna when considered as a percentage of the total soil fauna in different sites, there was a drop in mesofauna, more or less equal levels in microfauna and an increased percentage abundance of the total fauna in macrofauna as one goes from the youngest (site A) to the oldest fallow (site D).

One clear observation from the present study was that in the vertical distribution of the total soil fauna, there was a steady decrease from the top to the bottom soil layers regardless of the age of the fallow. This was true also when seen from either micro, meso or macrofaunal divisions, with minor variations at certain groups. Though the present study has been done on abandoned fallows after cultivation, yet the common phenomenon of soil inhabiting fauna abundant near the soil surface was observed, characteristic of any soil condition due to adequate living space, favourable moisture aeration rates and accumulation of organic debris (Weis-fogh (1948), Murphy (1953), Haarlov (1960), Hale (1967) and Wallwork (1970). Similarly, there are exceptions to this general rule, for certain taxa which are deep soil inhabitants like Symphyla, Protura, Paurōpoda, some mites and collembola as can also be seen from the present study when there were slight fluctuations in the study, decrease phenomenon from the top to bottom soil layers, revealing at certain times increase in the second layer, a rise and fall in alternate layers or an increase in the bottom-most layer, as has also been shown by early workers for general soil studies like Glasgow (1939), Salt et. al. (1948), Sheals (1957), Edwards (1959a,b), Poole (1961), Evans et. al. (1961) and Price (1975). This was also very true when the percentage of the total of either individual major groups or the larger broader divisions of micro, meso and macrofauna levels as in the present study, was observed. The study area no doubt though modified considerably by the effects of cultivation, fallowing and other habital disturbances associated with agricultural practices, the actual numbers or the percentages of the totals in the deeper soils for certain groups could be attributed to the result of surface impoverishment, favouring in the devel-

opment of sub-surface fauna (Price, 1973; Price and Benham,1977). This depth distribution is known to be governed by a complexity of factors, of which feeding habits, size of the individuals and microclimate conditions are some of the important ones. The reaction of these soil communities to such factors is different for groups or species and hence it would be difficult to generalize and assess the most important factor or factors determining their depth distribution (Pande and Berthet, 1975). However, the nearest correlation for depth distribution could be attributed to the larger climatic conditions of the area in operation at that given period of time.

To be more certain, one has to see the seasonal variations in the different groups as shown in the graphs (Figs. 2 to 18) for the present study. If so observed it was seen that there was a clear regularity in the seasonal fluctuations of not only the soil fauna but also in all its major sub-divisions and groups during both the annual cycles in all the sites. Invariably there was a clear rising of population to form the maximal peaks in most cases during the winter months and especially in the months of November and December which is the onset of a cold period if at all in these humid tropics. This phenomenon was seen for all the major groups including total soil fauna like microfauna, mesofauna and macrofauna, except that in the latter the maximum though still in cold wintersmonths occurred in the month of February and not in the months of November and December as in the other cases.

Further, the minimum recorded for these major groups was observed to be confined to the summer months and in most cases just before the onset of the monsoons, in the months of June and July. Such a regularity of a seasonal trend of fluctuation, where

the maximum is in the winter and minimum in summer months was also seen in all the sub-divisions in the present study except in the case of Protozoa and its sub-groups, Chelonethi, Diplura, Isopoda, Mollusca and Earthworms. Here the maximum was seen to occur in the Autumn months of August, September, while the minimum was still in the Summer months as in the other cases. One exception was seen in the order Diptera where the summer month of May recorded maximum and minimum in September, where one cannot draw conclusions to the possibilities of such an occurrence for only this group, though later some light is thrown when they are correlated with different abiotic and edaphic factors. Groups like Collembola, Cryptostigmata, Astigmata, Araneida and its two families, Clubionidae and Lycosidae were maximum in the winter month of December, minimum in the succeeding month of January. This seasonal trend of fluctuations has been seen to be observed in all the sites undertaken in the present study with very minor variations if at all among themselves.

Though the above have been the general observations in regard to maximum and minimum population in the various groups of soil fauna studied, it was seen that in most cases there is a bimodal peak of abundance, where the magnitude of one is much less than the other. These peaks of abundance whether occurring during the winter months or autumn months was always alternated with the summer or post-monsoon months of very low abundances. This phenomenon was true for the minor subdivisions of the soil fauna also as shown in the present study (Figs. 2 to 18). Various authors have reported different peaks of abundance, as Bellinger (1954) recorded as spring peak, while Poole (1961) a summer maxima with small winter peak, while Joosse (1969) spring and autumn for some species and summer for others. The work in tropical soils which

is confined to Southeast Asia and Japan, where Ogino et. al., (1965) showed a collembola increase from August to March while Takeda (1973) recorded two peaks one in winter and other in summer. Niijima (1975) showed three peaks for the dominant species of Collembola studied. All these reveal that our own study also show affinities with one or more of the above reports, yet no definite trend of fluctuations can be seen to be similar in any two studies. Different climatic conditions prevailing in different regions always has an effect on the pattern of fluctuation disallowing any true comparison between any two regions. In the present study, it was also seen in particular for Collembola though December was the maximum, the immediate succeeding months records the minimum in both the annual cycles which further builds up slowly, indicative of an over-wintering populations (Wallwork, 1959; Evans et. al., 1961, Madge, 1969). The next major group being Acarina also revealed the trend similar to Collembola in the first year of study in sites A, B and C and for the second year in all the sites and for the first year in site D where it recorded a minimum in June. Such peaks of abundance in winter is not unusual (Curry, 1971). All the other groups followed one of these.

The pattern of seasonal fluctuations as mentioned above, was seen not to differ much between the different sites. However, while the vertical distribution of the different groups were undertaken and their seasonal fluctuations in relation to the different soil layers at the different sites in the present study, there does seem to be variations between the sites. The total soil fauna, microfauna and mesofauna revealed an increase in abundance from August to October-November in the second layer during both the years of study only in site A. Further in site D

in the first two layers, microfauna is more or less constant, while in the remaining sites as in the case of macrofauna for all sites, the trend of a top to bottom layer decrease in numbers was seen throughout the study period irrespective of abundance or fall. This phenomenon of the second layer recording more in some months or were the same as related to the top surface layers was seen usually in site A even at minor sub-division levels like Prostigmata, Collembola, Hypogastruridae, Sminthuridae, Astigmata, and Family Clubionidae. The only groups which showed a constant decrease from top to the bottom soil layers without the effect of any season was Protozoa, Isotomidae, Acarina, Lycosidae, Chelonethi, Diplura, Protura, Isopoda and most of the macrofaunal groups. The group Prostigmata, Sminthuridae, Cryptostigmata, Linyphidae revealed in site D for certain months and specially during the autumn months of August to October-November an increase in the second layer or more or less equal to the surface layer. The vertical distribution phenomenon as seen in site A where there was definitely migration to the second layer on the onset of winter could have been due to the non-stabilizing effect of the soil in the youngest fallow (site A) in contrast to the remaining fallows, where a clear separation of species in relation to primarily the pore space could have taken place. Further, in site A the surface layer has very little of litter cover in relation to other sites and this being exposed to cold temperature (winter) and dessiccation (summer) of the soil surface would probably be responsible for such migration from the top to the second layer. Moreover, it was only observed in certain groups though we see them to be the most dominant groups in the present study (Van der Drift, 1951 and Usher, 1964). In site D a similar phenomenon as seen in site A for certain groups could be attributed to the fact that as

reported earlier by many soil workers even in untouched forest soils, presence of a definite vertical migration in some species was in relation to their feeding behaviour. As only major subdivisions were taken into consideration in the study, it was not possible therefore to pinpoint the actual mechanism responsible for vertical migration in the oldest abandoned fallow (site D) though the effect of some abiotic factors and edaphic factors on these groups cannot be ruled out. Further as has been recorded earlier, Acarina had a much evener vertical distribution than Collembola when one considered the major dominant groups in the present study. Such high populations in some strata and low populations in the other without any evidence of seasonal changes in vertical distribution have also been noted by many workers such as Glasgow (1939), Strickland (1945, 1947) and Stockli (1957).

The concent of vertical distribution of Collembola was outlined by Usher (1970a) and Hale (1966), who feel that seasonal changes in vertical distribution are not necessarily caused by differential mortality in Collembola. In groups where the maximum density irrespective of the season was seen in the top layer could be attributed to the attraction to the top humus layer where there exist very small amplitudes of the humidity and temperature and the presence of rich contents of organic substances (Imdate,1974). Moreover, the annual pattern of seasonal incidence of any group in relation to their vertical distribution would closely be related to their specific life history and ecoclimate of their habitat (Nosek, 1977). Therefore, unless the actual recruitment pattern of species was examined, the interpretion of seasonal density and its fluctuations in the vertical distribution can give very little concreate information. Populations are known with short generation times (r - strategists) to feed on labile organic

substrates and exhibit marked fluctuations while those with long generation times (K-strategists) are expected to consume non-labile substrates and hence show lower density fluctuations. Hence it is primarily dependent upon the opportunity for the individual species in any community for developing apt life history strategies adapted to the mosaic of the physical, environmental and food resources of the soil (Mitchell, 1977). The above phenomenon though not possible to be identified from the present study, clearly indicates as seen in the life history chapter at least that the stability of the tropical fauna in the present study as one goes from the youngest abandoned fallow (site A) to the oldest abandoned fallow (site D) might be a consequence of their birth rate in conjunction with teoparity (Cole, 1954). All these suggest that the vertical distribution is closely related with the habitat character and is determined and dependent by the response of the individuals to these characters (Takeda, 1973).

It is for this reason that the seasonal vertical distribution of soil fauna and its various groups in the different sites have been correlated with the various physico-chemical factors both of the atmosphere and the soil. When so considered it was seen that pH was usually maximum in the summer and minimum in winter in all the soil layers in different sites undertaken in the present study for both the annual cycles. However, in most of the cases, pH was negatively correlated to the various groups which was highly significant. Moreover it was seen that for total soil fauna, mesofauna, Collembola and Acarina it was not significant while positively significant at $P < 0.01$ in the first layer at site A and negatively significant for the microfauna and prostigmata. This factor may also have some bearing for the vertical distribution of these groups showing maxima in the second layer

during certain months. A similar phenomenon was also observed for Prostigmata in site D. pH was totally non-significant in the groups like Protozoa and Total Insecta. There was no clear cut correlation variation in the soil layers at different sites except A that in most of these major groups there was a highly significant negative correlation in the second and third layer for most sites. In the present study, pH was mostly in the acidic side therefore most of the groups were related to acidity (Hale, 1966; Nosek, 1957). Still further reports do exist of pH having no effect (Agrell, 1941; Bellinger, 1954; Paclt, 1956; Cassagnau, 1961, 1964; and Christiansen, 1964) (Tables XLIX to LXIV).

The next factor, conductivity revealed two peaks of increase in most of the sites one during the monsoon and the other during winter. However, this factor was seen to be mostly non-significant and does not seem to play any major role except in Protozoa and Araneida. In these groups probably there was a negative correlation for the vertical distribution in various sites.

After pH, the next important factor which seem to affect the soil faunal levels was observed to be the soil moisture content. In this, the correlation for most of the groups in the various levels at the different sites for both the annual cycles revealed a highly significant positive correlation, in particular for major subgroups and for those groups mentioned earlier where a vertical distribution pattern seasonally occurs the correlationship was at $P < 0.01$ level. However, many investigations have shown no relationship between soil moisture and various groups of soilfauna (Macfadyen, 1952, 1954; Huther, 1961; Marcuzzi,1967, 1968, 1973), while others reported definite negative correlation (Hammer, 1934, 1937, 1953 and Stebaeua, 1962), yet it is known

Table XLIX : Showing the correlation coefficient between the different abiotic factors and the major groups of soil fauna for the total study period at study site A and at the soil depth 0-10 cm.

Cond. : Conductivity; Moi. : Moisture content; S.T. : Soil temperature; A.T. : Air temperature; R.F. : Rainfall; B.D.: Bulk-density; Por. : Porosity;

TSF : Total soil fauna; MiF : Microfauna; Pros : Prostigmata; Pro : Protozoa; MeF : Mesofauna; Col : Collembola; Aca : Acarina; Ara : Araneida; MaF : Macrofauna; Ins : Insecta; Ant : Ants; Myr : *Myriapoda*.

TABLE XLIX

	TF	MiF	Pro	Pros	Mef	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH .	0.348	0.764**	0.149	0.691**	0.268	0.153	-0.045	-0.566**	-0.268	-0.153	-0.045	-0.348
Con.	-0.094	0.330	-0.470*	0.451*	0.243	0.280	0.169	-0.697**	-0.243	-0.280	-0.169	0.094
Moi.	-0.433*	-0.499*	-0.295	-0.395	-0.328	-0.243	-0.216	0.066	0.328	0.243	0.216	0.433*
ST.	0.311	-0.110	-0.219	-0.437*	-0.263	-0.338	-0.516*	-0.094	0.263	0.338	0.516*	-0.311
AT.	0.472*	-0.071	-0.246	0.161	0.386	0.325	0.190	-0.011	-0.386	-0.325	-0.190	-0.472*
RF.	0.626**	-0.032	-0.246	0.040	0.533*	0.415	0.047	0.070	-0.533*	-0.415	-0.047	-0.626**
BD	-0.132	0.304	0.486*	0.153	0.286	0.234	0.184	0.316	-0.286	-0.234	-0.184	0.132
Por.	-0.053	-0.440*	0.543**	-0.578**	0.197	-0.215	0.180	0.597**	0.198	0.215	0.180	0.053
C	0.369	-0.159	-0.147	-0.110	0.287	0.224	0.182	0.115	-0.287	-0.224	0.182	-0.369
N	0.090	-0.038	-0.529*	0.115	0.292	0.297	0.032	-0.223	-0.292	-0.297	0.032	-0.090
P	0.390	0.108	0.257	0.031	0.192	0.190	0.219	0.261	-0.192	-0.190	-0.219	-0.390
K	0.038	-0.183	0.000	-0.176	0.229	0.259	0.184	0.224	-0.229	-0.259	-0.184	-0.038

* = $P < 0.05$
** = $P < 0.01$

Table 4 : Showing the correlation coefficient between the different abiotic factors and the major groups of soil fauna for the total study period at study site A and at the soil depth 10-20 cms.

Cond : Conductivity; Moi : Moisture content; S.T. : Soil temperature; A.T. : Air temperature; R.F. : Rainfall; B.D. : Bulk-density; Por : Porosity.

TSF : Total soil fauna; MiF : Microfauna; Pros : Prostigmata; Pro : Protozoa; Maf : MeF : Mesofauna; Col : Collembola; Aca : Acarina; Ara : Araneida; MaF : Macrofauna; Ins : Insecta; Ant : Ants; Myr : Myriapoda.

TABLE L

	TF	MiF	Pro	Pros	MaF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.688**	-0.321	-0.070	-0.753**	-0.677**	-0.670**	-0.581*	-0.749**	-0.335	-0.075	-0.121	-0.360
Con	-0.125	0.065	0.454*	-0.035	-0.296	-0.257	-0.387	-0.160	0.006	-0.103	-0.040	-0.019
Moi	0.340	0.166	0.304	0.084	0.206	0.153	0.009	0.346	0.546**	0.409	0.454*	0.432*
ST	0.135	-0.228	0.090	-0.150	0.108	0.071	0.007	0.234	0.313	0.307	0.149	0.373
AT	-0.137	-0.223	0.160	-0.040	-0.142	-0.195	-0.081	-0.065	-0.203	-0.230	0.186	0.255
RF	-0.339	-0.290	0.091	-0.346	-0.224	-0.149	-0.232	-0.054	-0.443*	-0.394	-0.185	0.476*
BD	-0.536*	-0.412	-0.085	-0.393	-0.406	-0.318	0.062	-0.147	-0.254	-0.060	-0.519*	-0.256
Por	0.056	-0.076	0.123	-0.088	0.137	0.172	-0.008	0.170	0.252	0.340	0.460*	0.240
C	-0.065	0.157	-0.099	0.403	0.351	0.337	0.322	0.240	0.382	0.252	0.521*	0.176
N	0.620**	0.585*	-0.097	0.503*	0.627**	0.038	-0.014	0.131	0.097	0.060	0.433*	0.055
P	-0.316	-0.321	-0.087	-0.284	-0.243	-0.132	-0.141	-0.235	-0.329	-0.207	-0.588*	-0.315
K	0.063	0.133	0.073	0.153	0.211	0.227	0.262	0.364	-0.327	-0.890**	-0.519*	-0.457*

* = $P < 0.05$

** = $P < 0.01$

Table LI : Showing the correlation coefficient between the different abiotic factors and the major groups of soil fauna for the total study - period at study site A at the soil depth 20-30 cms.

Con : Conductivity; Moi : Moisture content; S.T. : Soil temperature; A.T. : Air temperature; R.F. : Rainfall; B.D. : Bulk-density; Por : Porosity.

T.F : Total soil fauna; MiF : Microfauna; Pros : Prostigmata; Pro : Protozoa; MeF : Mesofauna; Col : Collembola; Aca : Acarina; Ara : Araneida; MaF : Macrofauna; Ins : Insecta; Ant : Ants; Myr : Myriapoda.

TABLE LI

	TF	MiF	Pro	Pros	MeF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.694**	-0.549**	-0.271	-0.504*	-0.720**	-0.646**	-0.533*	-0.600**	-0.271	-0.252	-0.109	-0.194
Con	-0.309	-0.425*	-0.112	-0.497	-0.310	-0.345	-0.334	-0.103	-0.140	-0.062	0.195	-0.397
Moi	0.471*	0.192	0.221	0.038	0.338	0.467*	0.141	0.371	0.412	0.389	0.274	0.068
ST	0.212	0.361	0.362	0.130	0.021	-0.005	-0.042	0.234	0.348	0.221	0.190	0.447*
AT	-0.153	0.222	0.392	-0.106	0.113	-0.198	-0.056	0.008	-0.179	-0.251	-0.061	-0.059
RF	-0.271	0.300	0.471*	0.053	-0.139	-0.240	-0.079	0.041	-0.398	-0.501*	-0.378	-0.256
BD	-0.650**	-0.256	-0.256	-0.094	-0.429*	-0.423*	-0.204	-0.429	-0.672**	-0.687**	-0.459*	-0.570*
Por	0.440*	0.479*	0.238	0.436*	0.379	0.268	0.353	0.283	0.[illegible]09	-0.042	-0.155	-0.041
C	0.049	0.380	0.373	0.007	0.226	0.065	0.143	0.475*	-0.041	-0.012	-0.030	-0.134
N	0.203	0.505*	0.860**	-0.175	0.110	0.124	0.051	0.355	0.428*	0.464*	0.432*	0.258
P	0.000	0.000	0.000	-0.383	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K	0.462*	0.465*	0.177	0.483*	0.527*	0.482*	0.445*	0.558**	0.143	0.216	0.007	-0.058

* = $P < 0.05$

** = $P < 0.01$

Table LII : Showing the correlation coefficient between the different abiotic factors and the major groups of soil fauna for the total study - period at study site A at the soil depth 30-40 cms.

Con : Conductivity; Moi : Moisture content; S.T. : Soil temperature; A.T. : Air temperature; R.F. : Rainfall; B.D. : Bulk-density; Por : Porosity.

T.F : Total soil fauna; MiF : Microfauna; Pros : Prostigmata; Pro : Protozoa; MeF : Mesofauna; Col : Collembola; Aca : Acarina; Ara : Araneida; MaF : Macrofauna; Ins : Insecta; Ant : Ants; Myr : Myriapoda.

TABLE LII

	TF	MiF	Pro	Pros	MeF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.581**	-0.633**	0.125	-0.735**	-0.582**	-0.505*	-0.415	-0.216	0.008	-0.389	-0.430*	-0.426*
Con	0.232	0.182	0.241	-0.023	-0.095	0.013	-0.052	-0.120	0.256	-0.203	0.004	-0.073
Moi	0.584**	0.655**	0.258	0.602**	0.555**	0.654	0.510*	0.186	0.272	0.485*	0.404	0.391
ST	0.073	-0.012	-0.200	0.090	0.114	0.240	0.130	0.183	0.030	0.266	0.203	0.396
AT	-0.196	-0.080	0.014	-0.103	-0.156	-0.176	-0.378	-0.028	-0.357	-0.079	-0.342	-0.107
RF	-0.332	-0.078	0.414	-0.257	-0.211	-0.094	-0.578**	-0.442*	0.210	-0.048	-0.465*	-0.249
BD	-0.664**	-0.649**	-0.162	-0.663**	-0.643**	-0.448*	-0.123	-0.302	-0.216	-0.472*	-0.081	-0.415
Por	-0.081	0.221	-0.039	0.255	0.358	0.416	0.342	0.031	0.037	0.434*	0.345	0.243
C	0.052	-0.058	0.136	-0.078	-0.076	0.242	0.055	-0.067	0.210	-0.024	0.080	0.313
N	0.567**	0.497*	0.049	-0.082	-0.023	0.101	0.364	0.063	0.101	-0.099	0.256	0.299
P	-0.668**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K	-0.668**	0.225	0.899**	-0.129	-0.160	0.097	-0.295	-0.304	0.402	-0.211	-0.151	-0.208

* = $P < 0.05$

** = $P < 0.01$

Table LIII : Showing the correlation coefficient between the different abiotic factors and the major groups of soil fauna for the total study period at study site B at the soil depth 0-10 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

T.F = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LIII

	TF	MiF	Pro	Pros	MaF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.597**	-0.645**	-0.221	-0.598**	0.178	0.141	-0.091	-0.971**	-0.271	-0.183	0.098	-0.353
Con	0.074	0.124	0.236	0.248	0.039	0.081	0.168	-0.691**	-0.253	-0.291	-0.163	0.096
Moi	0.771**	0.801***	0.548**	0.641***	0.623**	0.481*	0.211	0.112	0.318	0.348	0.281	0.438*
ST	0.045	0.049	0.128	0.321	0.114	0.234	0.638**	-0.084	0.274	-0.391	0.581**	-0.319
AT	-0.325	0.291	0.284	0.164	0.392	0.374	0.182	-0.018	-0.392	-0.312	-0.196	-0.481*
RT	-0.489*	-0.121	-0.214	-0.013	0.423	0.384	0.087	0.071	-0.541**	-0.423*	-0.097	-0.631**
BD	-0.334	0.297	0.212	0.148	0.281	0.272	0.192	0.321	-0.291	-0.335	-0.188	0.152
Por	-0.202	-0.069	0.418	-0.435*	0.114	0.295	0.183	0.581**	0.197	0.291	0.189	0.081
C	0.004	-0.296	-0.212	-0.189	0.256	0.241	0.191	0.123	-0.293	-0.312	0.183	-0.381
N	0.176	0.399	0.414	0.119	0.281	0.298	0.071	-0.281	-0.281	-0.119	0.041	-0.098
P	-0.412	0.285	0.313	0.113	0.212	0.181	0.292	0.251	-0.181	-0.181	-0.220	-0.391
K	0.000	0.297	0.000	0.181	0.238	0.274	0.174	0.242	-0.234	-0.291	-0.183	-0.081

* = $P < 0.05$

** = $P < 0.01$

Table LIV : Showing the correlation coefficient between the different abiotic factors and the major groups of soil fauna for the total study period at study site B at the soil depth 10-20 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk-density; Por = Porosity.

TSF = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LIV

	TF	MiF	Pro	Pros	MeF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.475*	-0.547**	-0.082	-0.641**	-0.612**	-0.612**	-0.571**	-0.723	-0.312	-0.041	-0.112	-0.312
Con	-0.049	0.235	-0.462*	-0.081	-0.316	-0.281	-0.313	-0.112	0.007	-0.109	-0.081	-0.016
Moi	0.548**	0.680**	0.308	0.091	0.282	0.183	0.008	0.348	0.587**	0.419	0.481*	0.442*
ST	0.190	-0.021	0.081	-0.154	0.118	0.082	0.009	0.332	0.318	0.309	0.153	0.381
AT	-0.399	-0.333	0.186	-0.081	-0.192	-0.181	-0.092	-0.081	-0.281	-0.241	0.191	0.259
RF	-0.449*	-0.258	0.041	-0.414	-0.284	-0.181	-0.258	-0.069	-0.479*	-0.381	-0.191	0.482*
BD	0.496*	-0.254	-0.091	-0.312	-0.491*	-0.398	0.092	-0.187	-0.212	-0.091	-0.512*	-0.281
Por	0.094	-0.029	0.191	-0.091	0.181	0.182	-0.009	0.117	0.281	0.346	0.412	0.281
C	-0.240	-0.156	0.081	0.402	0.350	0.363	0.328	0.261	0.391	0.257	0.581**	0.196
N	-0.264	-0.403	0.091	0.508*	0.612**	0.051	-0.081	0.182	0.091	0.081	0.481*	0.057
P	0.023	-0.126	-0.091	-0.281	-0.256	-0.181	-0.143	-0.241	-0.331	-0.281	-0.591**	-0.323
K	-0.279	-0.277	-0.173	0.158	0.281	0.231	0.281	0.381	-0.338	-0.818**	-0.512*	-0.461*

* = $P < 0.05$

** = $P < 0.01$

Table LV : Showing the correlation coefficient between the different abiotic factors and the major groups of soil fauna for the total study period at study site B at the soil depth 20-30 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

T.F = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LV

	TF	MiF	Pro	Pros	MeF	Col	Aca	Ara	Maf	Ins	Ant	Myr
pH	-0.457*	-0.418	0.068	-0.456*	-0.502**	-0.505*	-0.553**	-0.482*	0.130	0.083	0.136	-0.031
Con	-0.162	-0.020	0.438*	-0.191	-0.240	-0.333	-0.328	-0.216	0.056	-0.019	-0.015	-0.055
Moi	0.580**	0.789**	0.173	0.743**	0.757**	0.701**	0.790**	0.714**	0.234	0.269	0.376	0.202
ST	0.021	0.202	0.285	0.097	0.059	0.131	0.111	0.016	-0.033	0.028	0.294	-0.305
AT	0.010	-0.128	0.275	-0.238	-0.185	-0.140	-0.093	-0.232	-0.306	-0.436*	-0.178	-0.467*
RF	-0.194	-0.031	0.360	-0.173	-0.189	-0.071	-0.047	-0.250	-0.628**	-0.652**	-0.309	-0.721**
BD	-0.488*	-0.432*	0.159	-0.337	-0.428*	-0.417	-0.453*	-0.438*	0.428*	0.419	0.276	0.306
Por	0.319	0.265	-0.016	0.272	0.284	0.349	0.291	0.281	0.071	0.160	0.179	0.000
C	0.005	0.004	-0.560*	0.153	0.140	0.185	0.162	0.151	0.017	0.020	-0.205	0.204
N	-0.474*	-0.277	0.627**	-0.528*	-0.544**	-0.483*	-0.557**	-0.505*	0.016	-0.077	-0.067	-0.223
P	-0.349	-0.433*	-0.340	-0.313	-0.407	-0.389	-0.407	-0.338	0.009	0.047	-0.240	0.114
K	0.160	0.183	-0.075	0.217	0.301	0.347	0.365	0.279	0.001	0.021	0.199	0.004

* = $P < 0.05$

** = $P < 0.01$

Table LVI : Showing the correlation coefficient between the different abiotic factors and the major groups of soil fauna for the total study period at study site B at the soil depth 30-40 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

TSF = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LVI

	TF	MiF	Pro	Pros	MaF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.316	-0.319	0.010	-0.616**	-0.582**	-0.583**	-0.413	-0.219	0.001	-0.381	-0.440**	-0.448*
Con	-0.198	0.109	0.245	-0.083	-0.094	0.023	-0.081	-0.131	0.284	-0.281	0.008	-0.081
Moi	0.707**	0.867**	0.453*	0.643**	0.554**	0.681**	0.581**	0.192	0.281	0.494*	0.481*	0.394
ST	-0.474	-0.058	0.242	0.094	0.124	0.341	0.138	0.194	0.041	0.284	0.208	0.382
AT	-0.310	-0.245	0.141	-0.113	-0.191	-0.192	-0.384	-0.112	-0.367	-0.083	-0.352	-0.187
RF	-0.393	-0.093	0.412	-0.253	-0.210	-0.084	-0.572**	-0.414	0.208	-0.084	-0.336	-0.242
BD	-0.023	0.453*	-0.460*	-0.632**	-0.613**	-0.448*	-0.101	-0.301	-0.214	-0.471*	-0.071	-0.423*
Por	0.317	0.224	0.084	0.312	0.348	0.420	0.341	0.081	0.307	0.414	0.342	0.241
C	0.354	0.236	-0.433*	-0.071	-0.073	0.341	0.081	0.216	-0.034	0.091	0.313	0.341
N	-0.326	0.249	0.094	-0.091	-0.018	0.201	0.361	0.083	0.108	-0.091	0.354	0.281
P	-0.797**	-0.550**	0.183	0.193	0.485*	0.231	0.414	0.423*	0.493*	0.118	0.119	0.121
K	-0.136	-0.337	0.642**	-0.112	-0.140	0.023	-0.192	-0.301	0.201	-0.209	-0.151	-0.118

* = $P < 0.05$

** = $P < 0.01$

Table LVII: Showing the correlation coefficient between the different abiotic factors and the major groups of the soil fauna for total study period at study site C at the soil depth 0-10 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

TSF = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LVII

	TF	MiF	Pro	Pros	MaF	Col	Ara	Ara	MaF	Ins	Ant	Myr
pH	-0.601**	-0.402	-0.123	-0.581**	0.117	0.123	-0.080	-0.542**	-0.281	-0.181	0.081	-0.343
Con	0.018	0.196	0.248	0.298	0.084	0.091	0.193	-0.698**	-0.268	-0.299	-0.181	0.101
Moi	0.489*	0.674**	0.313	0.418	0.408	0.210	0.103	0.308	0.342	0.281	0.281	0.432*
ST	0.225	0.205	0.132	0.221	0.101	0.212	0.632**	-0.081	0.217	-0.381	0.580**	-0.309
AT	0.220	-0.033	0.212	0.438*	0.423*	0.371	0.114	-0.001	-0.382	-0.212	-0.116	-0.423*
RF	-0.240	0.220	-0.212	-0.023	0.428*	0.381	0.081	0.061	0.541**	-0.429*	-0.097	-0.648**
BD	-0.237	-0.292	0.418	0.142	0.292	0.273	0.191	0.328	-0.091	-0.241	-0.198	0.162
Por	-0.594**	-0.626**	0.448*	-0.440*	0.134	0.291	0.191	0.591**	0.196	0.282	0.191	0.093
C	-0.562**	-0.513*	-0.281	-0.191	0.212	0.241	0.191	0.128	-0.281	-0.212	0.183	-0.282
N	-0.366	-0.670**	0.720**	0.129	0.312	0.323	0.118	-0.313	-0.318	-0.214	0.121	-0.101
P	-0.680**	-0.693**	0.414	0.123	0.284	0.182	0.281	0.241	-0.181	-0.173	-0.232	-0.384
K	-0.672**	-0.095	0.113	0.191	0.332	0.281	0.182	0.243	-0.334	-0.280	-0.191	-0.071

* = $P < 0.05$

** = $P < 0.01$

Table LVIII : Showing the correlation coefficient between the different abiotic factors and the major groups of the soil fauna for total study period at study site C at the soil depth 10-20 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

T.F = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LVIII

	TF	MiF	Pro	Pros	MaF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.511*	-0.534*	-0.091	-0.713**	-0.703**	0.613**	-0.818**	-0.423*	-0.151	-0.223	-0.123	-0.433*
Con	0.091	0.241	0.558**	-0.153	-0.421	-0.371	-0.423*	-0.223	0.117	-0.208	-0.191	-0.123
Moi	0.582**	0.601**	0.302	0.191	0.372	0.194	0.119	0.342	0.512*	0.423*	0.581**	0.413
ST	0.167	-0.081	0.091	-0.584**	0.123	0.112	0.119	0.342	0.391	0.373	0.184	0.391
AT	-0.603**	-0.581**	0.191	-0.091	-0.182	-0.191	-0.113	-0.112	-0.373	-0.253	-0.181	0.253
RF	-0.059	0.448*	-0.123	-0.414	0.391	0.188	-0.212	-0.081	-0.471*	-0.381	-0.192	0.523*
BD	-0.547**	0.254	-0.113	-0.332	-0.481*	-0.339	0.091	-0.181	-0.281	0.381	0.442*	0.291
Por	0.590**	-0.212	0.182	-0.118	0.191	0.198	-0.008	0.118	0.298	0.391	0.513*	0.372
C	0.487*	0.181	0.123	0.414	0.381	0.373	0.381	0.281	0.383	0.357	0.581**	0.21
N	-0.822**	-0.616**	0.098	0.616**	0.681**	0.068	-0.019	0.192	0.098	0.088	0.582**	0.158
P	-0.554**	-0.118	-0.098	-0.381	-0.266	-0.183	-0.188	-0.258	-0.388	-0.291	-0.588**	-0.584**
K	-0.544**	-0.288	-0.181	0.168	0.384	0.241	0.288	0.388	-0.393	-0.761**	-0.551**	-0.468*

* = $P < 0.05$

** = $P < 0.01$

Table LIX : Showing the correlation coefficient between the different abiotic factors and the major groups of the soil fauna for total study period at study site C at the soil depth 20-30 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

TaF = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LIX

	TF	MiF	Pro	Pros	MaF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.504*	-0.483*	0.032	-0.492*	-0.544**	-0.599**	-0.489*	-0.424*	0.142	0.092	0.135	-0.044
Con	-0.196	-0.081	0.449*	-0.214	-0.341	-0.383	-0.323	-0.255	0.081	-0.290	-0.025	-0.025
Moi	0.375	0.577**	0.123	0.362**	0.574**	0.604**	0.678**	0.634**	0.241	0.248	0.365	0.198
ST	-0.117	0.284	0.314	0.113	0.108	0.235	0.247	0.082	-0.710	0.020	0.345	-0.434*
AT	-0.313	-0.334	0.281	-0.313	-0.191	-0.141	-0.091	-0.238	-0.391	-0.448	-0.183	-0.488*
RF	-0.674**	-0.505*	0.274	-0.310	-0.181	-0.074	-0.078	-0.241	-0.341	-0.431*	-0.172	-0.473*
BD	-0.605**	-0.612**	0.184	-0.383	-0.448*	-0.434*	-0.461*	-0.442*	0.437*	0.408	0.273	0.304
Por	0.469*	0.385	-0.181	0.291	0.273	0.348	0.282	0.274	0.081	0.118	0.181	0.117
C	0.596**	0.014	-0.432*	0.123	0.114	0.174	0.143	0.145	0.023	0.014	-0.241	0.208
N	-0.779**	-0.544**	0.817**	-0.732**	-0.561**	-0.441**	-0.581**	-0.501**	0.081	-0.018	-0.083	-0.313
P	-0.609**	-0.642**	-0.314	-0.343	-0.412	-0.383	-0.409	-0.333	-0.007	0.043	-0.243	0.118
K	-0.606**	-0.183	0.174	0.313	0.408	0.434*	0.361	0.278	0.058	0.084	0.123	0.011

* = $P < 0.05$

** = $P < 0.01$

Table LX : Showing the correlation coefficient between the different abiotic factors and the major groups of the soil fauna for total study periodsat site C at the soil depth 30-40 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

TsF = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembole; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LX

	TF	MiF	Pro	Pros	MaF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.130	-0.181	0.081	-0.514*	-0.572**	-0.414	-0.403	-0.292	0.008	-0.317	-0.423*	-0.434*
Con	0.059	0.043	0.212	-0.071	-0.081	0.033	-0.070	-0.121	0.273	-0.273	-0.007	-0.071
Moi	-0.043	-0.134	0.414	0.523*	0.551**	0.613**	0.571**	0.119	0.273	0.481*	0.471*	0.333
ST	0.139	0.114	0.212	0.081	0.131	0.339	0.157	0.181	0.071	0.271	0.207	0.379
AT	-0.513*	-0.431*	0.318	-0.303	-0.343	-0.113	-0.481*	-0.182	-0.313	-0.091	-0.342	-0.158
RF	-0.291	-0.084	0.431*	-0.241	-0.223	-0.073	-0.581**	-0.492*	0.248	-0.086	-0.341	-0.281
BD	-0.624**	0.515*	-0.414	-0.682**	-0.653**	-0.471*	-0.118	-0.371	-0.216	-0.462*	-0.013	-0.464*
Por	0.830**	0.616**	0.221	0.431*	0.412	0.515*	0.347	0.118	0.372	0.423*	0.351	0.272
C	-0.338	0.247	-0.431*	-0.113	-0.084	0.381	0.112	0.438*	-0.081	0.081	0.323	0.439*
N	-0.472*	0.340	0.081	-0.084	-0.023	0.243	0.354	0.072	0.107	-0.073	0.343	0.273
P	-0.637**	-0.447*	0.172	0.182	0.472*	0.234	0.404	0.427*	0.482*	0.127	0.123	0.137
K	-0.634**	-0.527*	0.342	-0.172	-0.170	0.053	-0.118	-0.352	0.242	-0.281	-0.141	-0.124

* = $P < 0.05$

** = $P < 0.01$

Table LXI : Showing the correlation coefficient between the different abiotic factors and the major groups of the soil fauna for total study period at study site D at the soil depth 0-10 cms.

Con. = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

TsF = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LXI

	TF	MiF	Pro	Pros	MaF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.871**	0.313	0.140	0.541**	0.261	0.121	-0.081	-0.551**	-0.112	-0.253	-0.184	-0.114
Con	-0.226	0.414	-0.464*	0.414	0.253	0.281	0.172	-0.543**	-0.281	-0.275	-0.112	0.121
Moi	0.530*	0.539**	0.313	0.212	0.851**	0.213	0.218	-0.066	-0.313	-0.241	-0.212	-0.428*
ST	0.116	-0.121	-0.281	-0.414	-0.261	-0.332	-0.501*	-0.801**	-0.011	0.269	0.414	0.213
AT	-0.249	0.171	-0.243	0.191	0.382	0.339	0.190	-0.121	-0.384	-0.313	-0.119	-0.481*
RF	-0.257	0.081	-0.241	0.091	0.515*	0.412	0.213	0.036	-0.534*	-0.413	-0.043	-0.616**
BD	-0.294	0.541**	0.396	0.112	0.313	0.241	0.196	0.312	-0.283	-0.241	-0.191	0.145
Por	0.452*	0.112	0.414	0.131	-0.113	0.313	-0.118	-0.515*	-0.192	-0.212	-0.113	-0.093
C	-0.601**	0.142	-0.113	-0.181	0.296	0.234	0.172	0.134	-0.251	-0.251	0.172	-0.313
N	-0.802**	0.541**	0.526*	-0.192	0.281	0.279	-0.081	0.212	-0.182	-0.184	-0.212	-0.381
P	-0.588**	-0.318	-0.243	0.031	0.181	0.179	0.215	0.243	-0.114	-0.173	-0.215	-0.319
K	0.409	-0.173	0.000	-0.118	0.232	0.212	0.184	0.231	-0.218	-0.214	-0.313	-0.089

* = $P < 0.05$

** = $P < 0.01$

Table LXII : Showing the correlation coefficient between the different abiotic factors and the major groups of the soil fauna for total study period at study site D at the soil depth 10-20 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

T.F = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Anta; Myr = Myriapoda.

TABLE LXII

	TF	MiF	Pro	Pros	MeF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.032	-0.348	-0.131	-0.643**	-0.680**	-0.681**	-0.570**	-0.637**	-0.374	-0.073	-0.131	-0.370
Con	-0.318	0.142	0.494*	-0.081	-0.284	-0.246	-0.356	-0.119	0.008	-0.119	-0.040	-0.116
Moi	-0.076	-0.116	0.302	0.094	0.305	0.243	0.008	0.045	0.580**	0.402	0.476*	0.431*
ST	0.204	-0.341	0.081	-0.144	0.209	0.061	0.008	0.235	0.316	0.317	0.152	0.383
AT	-0.220	-0.331	0.186	-0.083	-0.173	-0.198	-0.112	-0.072	-0.303	-0.418*	0.424*	0.112
RF	-0.439*	-0.294	0.098	-0.351	-0.231	-0.152	-0.233	-0.080	-0.481*	-0.391	-0.183	0.474*
BD	-0.530*	-0.444*	-0.088	-0.380	-0.440*	-0.313	0.061	-0.141	-0.267	0.347	0.461*	0.243
Por	0.502*	-0.072	0.112	-0.113	0.351	0.182	-0.009	0.117	0.256	0.341	0.462	0.081
C	0.523*	-0.056	0.424*	0.387	0.381	0.333	0.245	0.389	0.281	0.597***	0.193	-0.061
N	0.576**	0.481	-0.097	0.504*	0.616**	0.038	-0.015	0.132	0.093	0.081	-0.318	0.317
P	0.797**	0.313	-0.097	-0.225	-0.247	-0.142	-0.181	-0.241	-0.336	-0.271	-0.581**	-0.324
K	0.771**	-0.135	0.072	0.143	0.223	0.228	0.217	0.394	-0.317	0.760**	-0.460*	-0.444

* = $P < 0.05$

** = $P < 0.01$

Table LXIII : Showing the correlation coefficient between the different abiotic factors and the major groups of the soil fauna for total study period at study site D at the soil depth 20-30 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

T.F = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LXIII

	TF	MiF	Pro	Pros	MeF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.607**	-0.580**	-0.284	-0.481*	-0.610**	-0.641**	-0.530*	-0.537**	-0.580**	-0.212	-0.107	-0.191
Con	-0.319	-0.415	-0.102	-0.487*	-0.300	-0.335	-0.324	-0.097	-0.130	-0.052	0.185	-0.387
Moi	0.492*	0.172	0.201	0.018	0.318	0.447*	0.121	0.350	0.400	0.370	0.273	0.058
ST	0.089	0.350	0.352	0.100	0.011	-0.004	-0.041	0.314	0.341	0.211	0.180	0.440*
AT	-0.269	0.281	0.412	-0.136	0.153	-0.202	-0.156	0.008	-0.162	-0.241	-0.041	-0.051
RF	-0.593**	-0.117	0.412	0.481*	0.083	-0.141	-0.250	-0.083	0.051	-0.372	-0.508*	0.246
BD	-0.595**	-0.550**	-0.213	-0.093	-0.419	-0.413	-0.219	-0.419	-0.616**	-0.636**	-0.452*	-0.561**
Por	0.536*	0.436*	0.231	0.426*	0.373	0.258	0.251	0.293	0.112	-0.080	-0.181	-0.081
C	0.541**	0.081	0.391	0.351	0.008	0.285	0.081	0.152	0.489*	-0.083	-0.024	-0.035
N	-0.682**	0.671*	0.861**	-0.181	0.230	0.134	0.067	0.385	0.518*	0.536*	0.481*	0.368
P	-0.601**	0.000	0.000	-0.443*	0.000	0.000	0.000	0.113	0.442*	0.818**	0.123	0.143
K	-0.596**	0.515*	0.178	0.196	0.639**	0.518*	0.442*	0.608**	0.153	0.219	0.000	-0.098

* = $P < 0.05$

** = $P < 0.01$

Table LXIV : Showing the correlation coefficient between the different abiotic factors and the major groups of the soil fauna for total study period at study site D at the soil depth 30-40 cms.

Con = Conductivity; Moi = Moisture content; S.T. = Soil temperature; A.T. = Air temperature; R.F. = Rainfall; B.D. = Bulk density; Por = Porosity.

TaF = Total soil fauna; MiF = Microfauna; Pros = Prostigmata; Pro = Protozoa; MeF = Mesofauna; Col = Collembola; Aca = Acarina; Ara = Araneida; MaF = Macrofauna; Ins = Insecta; Ant = Ants; Myr = Myriapoda.

TABLE LXIV

	TF	MiF	Pro	Pros	MeF	Col	Aca	Ara	MaF	Ins	Ant	Myr
pH	-0.618**	0.727**	0.136	-0.616**	-0.481*	-0.504*	-0.413	-0.213	0.009	-0.414	-0.431*	0.516*
Con	-0.172	-0.113	0.281	-0.081	-0.112	0.118	-0.063	-0.186	0.286	-0.304	-0.007	-0.421
Moi	0.586**	0.658**	0.268	0.616**	0.565**	0.636**	0.523*	0.196	0.272	0.473*	0.414	0.381
ST	0.252	-0.018	-0.200	0.098	0.124	0.241	0.136	0.173	0.081	0.281	0.303	0.393
AT	-0.344	-0.090	0.018	-0.113	-0.186	-0.181	-0.373	-0.038	-0.342	-0.081	-0.341	-0.108
RF	-0.439*	-0.091	0.424*	-0.353	-0.224	-0.088	-0.588**	-0.452*	0.216	-0.053	-0.481	-0.251
BD	-0.130	-0.639**	-0.181	-0.652**	-0.640**	-0.441*	-0.228	-0.313	-0.316	-0.461	-0.091	-0.419
Por	0.255	0.281	-0.041	0.254	0.388	0.406	0.341	0.081	0.309	0.414*	0.348	0.258
C	-0.047	-0.068	0.186	-0.173	-0.081	0.240	0.053	-0.081	0.281	-0.031	0.083	0.391
N	-0.754**	0.688**	0.053	-0.181	-0.038	0.111	0.361	0.083	0.109	-0.091	0.281	0.277
P	-0.247	0.000	0.113	0.118	0.141	0.138	0.113	0.124	0.218	0.418	0.110	0.139
K	-0.021	0.238	0.713**	-0.186	-0.166	0.088	-0.286	-0.306	0.504*	-0.218	-0.161	-0.281

* = $P < 0.05$

** = $P < 0.01$

Acari and Collembola require high humidity (Kuhnelt, 1950; Christiansen, 1964), other reports that the period of prolonged drought seem to have serious effects on the survival of the individual (Nielsen, 1955a, 1955b) and that Collembola has been reported to be relatively resistant to short duration flooding and capable of not only living in the submerged conditions but also laying and hatching of eggs has been carried out. This therefore confirms from the present study that primarily it is the moisture gradient in the soil which was responsible for not only the vertical distribution but also for seasonal fluctuations in particular to total soil fauna, microfauna, mesofauna, prostigmata, acarina, collembola, aranedida, total insecta, ants and total myriapoda which was directly correlated to the moisture content of the soil whereas, in the other groups it seemed to have very little effect (Tables-XLIX to LXIV).

Soil temperature and air temperature in the present study seemed to play a very negligible role in the abundance and vertical distribution, seasonally in all the sites for all the major groups. However air temperature, wherever observed significantly like Acarina, Total Insecta and Myriapoda were seen to affect primarily the surface layer and was significant negatively correlated at $P < 0.01$. In case of soil temperature a similar phenomenon was seen except that they were mostly positively significant at $P < 0.05$ level particularly in groups like total ants, acarina and myriapoda. Such a finding where the temperature either soil or atmosphere having very little effect on groups of soil fauna find very little support from the existing literature. Kevan (1965), Butcher et. al. (1971), Gupta and Dhooria (1974) showed a marked effect of soil and air temperature while Niijima (1971) attributed temperature effecting Collembola densities in winter.

However it is recorded that though temperature influences the metabolic rate, yet it is not considered ecologically important when soil fauna are capable of migrating to the deeper layers during high or low temperatures (Kuhnelt, 1950 and Christiansen, 1964). Reports exist for either winter or summer movements of many soil invertebrates moving down especially when temperature either rises or falls below a critical level (Dowdy, 1944; Pierrard *et. al.* 1963; Bocock and Heath, 1967 and Mitchell, 1978) (Tables-XLIX to LXIV).

Importance of rainfall as an abiotic factor affecting soil faunal groups in the present study seemed to be very negligible. There was no definite positive or negative correlation wherever they were significantly correlated either between layers of the same site or even between sites. These effects seem only as a negative correlation when the total soil fauna was considered and acarina for only the fourth layer and total insecta and myriapoda in particular, where in latter the first layer in all the sites and the third layer in sites B and C were highly significant (negatively correlated at $P < 0.01$ level), while for the second layer in the same groups for all the sites it was positively correlated at $P < 0.05$ level. Such statistically non-significant seasonal differences of precipitation affecting the soil moisture is reported earlier (Burns, 1952; Terraunt, 1956). However it is known that rainfall is the most important climatic element in these areas. Therefore with the increase in rainfall and the topography of the region and steepness of the slope, affects the soil fauna (Muir, 1955), which probably helps these animals to be adapted to such situations.

The bulk density of the soil in the present study which seem

to be a factor affecting soil fauna was observed to be a highly significant though negative in most of the groups at $P < 0.01$ level and in particular for the third and fourth layers. Further it was observed that in no case the animals in the first layer of any site was affected by the bulk density. The important groups affected by this factor in the third and fourth layer were Collembola, Total Mesofauna, Prostigmata, Acarina, Araneida, Insecta, Ants and Myriapoda. In addition, the total soil fauna showed a significant correlation in the second layer as was also true for Total Microfauna and ants. It seems to be that the third and the fourth layer of any site is the deciding fact for bulk density to operate as the factor on soil animals. From literature it seems that there are no reports of bulk density and soil faunal relationships either in forest soils, grassland or otherwise. The nearest could be that of physical characteristics of compacted soil (Gooderham, 1973; El-Karouri, 1974; Aritajat, 1975 and Aritajat et. al. 1977).

The porosity of the soil and its effects on the various groups in the different soil layers seem to play a very negligible role even in major groups like Collembola and Acarina and Total Insects. This factor seems to play a role if at all in the fourth layer in site C for which no definite reason can be attributed. The first layer showing significantly positive correlation with the soil fauna and porosity was seen in groups like Protozoa and Araneida, while a negative correlations in the same layer was seen in Prostigmata at $P < 0.05$. Porosity as a factor is known to be directly related to the drainage and therefore probably affects the reproductive capacity of the animals (Margalef, 1963; Pianka, 1970). Further it is known that with a soil moisture content of 30% the relative humidity of soil pore-spaces may not

fall below 90% (Thandrup, 1939). This excess water therefore creates competition for living space (Murphy, 1955). This phenomenon can also be seen in the present study when during the rainy months groups like Protozoa and Araneida while showing either more or less equal abundance in the top two layers, and Prostigmata shows a negative correlation proving its migration due to its predatorial habits to deeper layers.

In regard to the chemical factors undertaken in the present study it seems that only Nitrogen and Potassium seem to play a significant role if at all, while Carbon and Phosphorus showed no definite trends of correlations between layers nor between sites. It seems that the third layer especially in sites A and D was affected by the chemical factors such as Nitrogen and Potassium, the former negatively and latter positively significant at $P < 0.05$ levels. Phosphorus and Carbon wherever present and significantly correlated was only in the fourth layer mostly in site C. The earlier phenomenon was seen to be in groups like Collembola, Total Mesofauna, Prostigmata, Araneida and Acarina, while the latter was seen among the same groups and in addition in Protozoa. The negatively significant correlation of Potassium particularly in the second layer in most sites were observed to be in the groups of insects, Ants and Myriapods. The latter negative correlation was also seen for Phosphorus in the second layer in all the sites at $P < 0.05$. Such negative correlation particularly between the levels of Nitrogen and Phosphorus in the soil have been well documented and the positive correlations of Phosphorus to larger groups is similarly known (Edwards and Lofty, 1974). Similar relative correlations with carbon has also been shown by these workers. It is however difficult to see how the amount of Phosphorus would play any role as those of Carbon, Nitrogen and Potassium. Work

also exist on the levels of Phosphorus, positively correlated at least at specific levels of spiders and Collembola while at latter total numbers was much less affected by Potassium as was seen in the present study (Edwards et. al. 1975). Soil animals are known to return the elements to soil in the chemical forms quite different from plants and further their moults and faeces contribute chemicals like Phosphorus, while Earthworms and Ants are known to excavate chemicals from deeper layers and bring it to the surface (Byzova, 1970; Koklovskaja, 1965; Dimo, 1958; Lee and Wood, 1971). In any case other than the importance of Potassium and Nitrogen which also not very dominant and deciding chemical factors, the others do not seem to play any significant role in either the abundance or vertical distribution seasonally of the different soil groups in the various sites during the present investigation.

In conclusion some of the major aspects which has been observed from the present study has shown that the immediate abandonment of land after agriculture shows an increase in the soil animal population level and in particular mesofaunal levels as seen in site A. There was a drop however in the subsequent aged sites (B and C) while again in the oldest abandoned fallow (site D) it reached to the level of site A. Moreover, a definite successional pattern was seen in the case of macrofaunal levels where the maximum recorded in site D, indicating thereby that the colonization of macrofauna is the deciding factor for relating to soil fertility in such abandoned fallows after agricultural practices. Literature reveals that macrofauna is dependent on the litter layer for an increase in population density (Nakamura and Yamauchi, 1970 and Nakamura, 1971). Further, it is recorded that though some animals get destroyed after shifting cultivation, the species density decreases within 4 to 5 year and stabilizes

after 25 years (McColl, 1974). Moreover from the present study it appears that the environment for vertical migration is the moisture gradient of the soil, while temperature is only secondary, thereby permitting the annual cycle to be partitioned by different faunal groups. It is also known that the physical property of the climate within the soil was less variable than that of the air above, proving thereby that animals are committed to survive than the manipulation of ecosystems for benefit of human ends. The result of the present study revealed that mobility of the population seem to be a regulating factor of ecological production and that particular tophic groups of soil invertebrates reflects better than their population density in successional trends of the ecosystem studied (Kaczmarek, 1978).

The clearing of forest and cultivation of land in tropics results in harsher environment with extremes of temperature, moisture and direct impact of heavy rain. These changes therefore would have a greater effect on smaller organisms than on larger ones as seen in the present study. In particular Collembola and Acarina can be seen to increase in numbers and then stabilize being the dominant groups, while Prostigmata was seen to be directly related to porosity and hence more in the youngest site (Wallwork, 1976). Such reports were also seen in Nigeria and some humid tropics (Lasebikan, 1975). Next in importance, acidity, salinity and differences of Nitrogen being common limiting factors for animal colonization takes nearly 50 years for breaking down the elements to allow any colonization (Molyneux, 1963). Further, acidity is always known to increase with weathering (Luxton, 1976b). With all these criteria, the density increases of mesofaunal groups which affects the total soil fauna could be attributed to three main reasons, (1) apart from active migration,

wind aids dispersal (Freeman, 1952; Buahin and Edwards, 1963), (2) the life cycle being relatively short, therefore adapted for colonization, the production being more than one generation per year (Sheals, 1956) and lastly (3) low initial population of predatory pressure (Dunger, 1968a). All this can be very clearly observed from the present study and is in confirmation with earlier workers like Bruning et. al. 1965 who find density to be increasing after 8 years of reclaimed site and in particular humidity being one factor and soil moisture content affecting the densities (Hale, 1963; Ashraf, 1971 and Hutson, 1974). Similarly, Neumann (1973) has shown surface fauna colonizes especially Coleoptera after a 3 year period. All this revealed that land within a year of reclaimation does support a larger and varied soil fauna while it may take several years for larger groups like macrofauna to become established. This confirmed from the present study that the youngest site has still increasing density numbers, more or less stabilizing in the oldest fallow (Hutson, 1980). The study therefore could probably support the view of Hutchinson (1953) who defined co-active patterns as resulting from competitive interaction, where the stochaistic influences of the soil acting on its microenvironments is balanced.

All the above conclusions could be effectively significant as the density of the soil fauna in the present study seem to be in concordance with earlier workers from tropical situations. Moreover the present estimates can be seen to approach even much more than those recorded for temperate densities (Greenslade and Greenslade, 1968), and it would be premature therefore to make any definite statements, as tropical work is still in a relatively early stage and more so in India.

REFERENCES

ABe, T. 1971 On the food sharing among four species of ants in a sandy grassland. 1. Food and foraging behaviour. Jap. J. Ecol. 20, 219-230.

Agrell, L. 1941 Zur Okologie der Collembolan untersuchungen in Schwedischen Lappland opurcula. Entomol. Suppl. III : 1-236.

Ahlgren, I.F. & C.E. Ahlgren. 1960 Ecological effects of forest fires. Bot. Rev. 26 : 483-533.

Aitchison, C.W. 1979 Winter active subnivean invertebrates in Southern Canada. I. Collembola Pedobiologia 19, 113-120. II. Coleoptera. Pedobiologia 19, 121-128.

Alexander, F.E.S. & R.M. Jackson. 1955 Preparation of sections for study of soil micro-organisms. p 433-440. In D.K. McE. Kevan (ed.), Soil Zoology, Butterworths. Scientific Publications, London, Academic Press, New York.

Altmuller, R. 1979 Untersuchungen uber den Energieumsatz Von Dipterenpopulationen in Buchenwald (Luzulo-Fagetum). Pedobiologia 19, 245-278.

Anderson, J.M. 1971 Observations on the vertical distribution of oribatei (Acarina) in two woodland soils. In C.R. IVe Coll. Int. Zool. Soc., pp. 257-272 (ed. I.N.R.A.) I.N.R.A. Publ. 71-77, Paris 590 pp.

Aritajat, U. 1975 The effects of compaction of agricultural soils on soil fauna. M. Phil Thesis, University of London.

_____, D.S. Madge & P. Gooderham. 1977 The effects of compaction of agricultural soils on soil fauna. Pedobiologia, 17, 283-291. I. Field investigations, 262-282. Pedobiologia, 17, 262-282. II. Laboratory investigations. 283-291.

Ashraf, M. 1971 Influence of environmental factors on Collembola. Rev. Ecol. Biol. Sol. 8, 243-252.

Aucamp, J.L. & P.A.J. Ryke 1965 The efficiency of an improved film extractor in stratification studies of soil microarthropods. S. Afr. J. Sci. 61: 276-279.

Auetbach, S.I. & D.A. Crossley. 1960 A sampling devive for soil arthropods. Acarologia, 2, 279-287.

Baduri, A.K. & D.N. Raychoudhuri. 1968 Studies on the oribatid mites of Calcutta and subarbs. 1 Oriental Insect, 2(2) : 195-200.

Baker, E.W., J.H. Camin, F. Cunliffe, T.A. Woolley & C.E. Yunker. 1958 Guide to the families of mites. Contrib. Inst. Acarology, Dept. Zool. Univ. Maryland, No. 3, 242 p. College Park, Maryland.

Baker, E.W. & G.W. Wharton. 1952 An introduction to Acarology, Macmillan, New York, 465 pp.

Balogh, J. 1958 Lebensgemeinschaften der Landtiere ihre. Erforschung unter besonderer Berucksichtigung der Zoologischen Arbeitsmethoden. Verlag der ungarischen Akademie der wissenschaften Budapest, Akademie Verlag, Berlin. 560 p.

——————— 1963 Identification keys tof Holarctic oribatid mites (Acari) families and genera, Acta, Zool, hung. 9, 1-60,

Baroni-Urbani,C. 1965 Sull,'attivita' di foraggiamento del Camponotus nylanderi E.M.- Insectes Scioaux 12, 253-264.

——————— 1969 Ant communities of the high altitude, Appennine grasslands. Ecology 50, 488-492,

Bauhin,G.K.A. & C.A. Edwards. 1963 The colonization of sterilized soil by invertebrates. Report of Rothamsted Experimental station, 1963 pp. 149-150.

Beebe, W. 1916 Fauna of four square feet of jungle debris, Zoologica, 2, 107-119,

Belfield, W. 1956 The arthropods of the soil in a West African pasture, J, Anim, Ecol, 25 : 275-287,

——————— 1967 The effects of overhead watering on the meiofauna in a West African pasture. P. 192-210. In O.Graff and J.E. Satchell (eds), Progress in soil Biology. Academic Press, London.

Bennett, W.D. 1960 The reduction of forest fire hazard created by logging slash. A literature review. Pulp and Paper Research Institute of Canada. Technical Reports. Series 175. 56 p.

Berlese, A. 1905 Apparechio per raccogliere presto ed. in gran. numero picoli arthropodi. Redia, 2, 85-90.

Berthet, P. 1963 Mesure de la consommation d'oxygen des oribatides (Acariens) de la litiere des forets, p. 18-21. In. J. Doeksen and J.Van der Drift (eds), Soil organisms. North-Holland Publ. Co. Amsterdam, 453 p.

Blower, J.G. 1955 Millipedes and centipedes as soil animals. p. 138-151. In. D.K. McE. Kevan (ed). Soil Zoology. Butterworths Scientific Publications London, Academic Press, New York.

Bocock, K.L. & J. Heath. 1967 Feeding activity of the millipede Glomeris marginata (Villers) in relation to its vertical distribution in the soil. In: O. Graff and J.E. Satchell eds. Progress in soil zoology. Braunschweig. Amsterdam, pp. 233-240.

Bornebusch, C.H. 1930 The fauna of forest soil (Skovbundens Dipreuerden). Forsth. Forsogsv. Danm. 11 : 1-224 pp.

Brauns, A. 1954 Terricole Dipterenlarven untersuchungen Zur angewandte Bodenbiologie Musterschmidt, Wissenschaftlicher Verlag, Gottingen, Frankfurt, Berlin, Vol. 1, 179 p.

———— 1955 Puppen terricoler Dipterenlarven. Untersuchungen Zur angewandte Bodenbiologie Musterschmidt Wissenschaftlieher Verlag, Gottingen, Frankfurt, Berlin, Vol. 2,156 p.

Brenchley, W.E. 1935 Park grass plots. Rothamsted experimental station. Report for 1934, 138-159.

———— 1969 The park Grass plots at Rothamsted, 1856-1949. Harpenden - Rothamsted Experimental Station. 144 pp.

Bruning, E., H. Unger & W. Dunger. 1965 Untersuchungen Zur frage der biologischen Aktivierung alttertiarer Rohbodenkippen des Braunkohlentagebanes in Abhangigkeit Von Bodenmelioration und Rokultivierung. Zeitschrift fur Landeskultur, 6, 9-38.

Buffington, J.D. 1967 Soil arthropod populations of the New Jersey pine barrens as affected by fire. Entomol. Soc. Am. 60 : 530-535.

Burges, N.A. 1967 The decomposition of organic matter in the soil in Burges, N.A. and Raw, F., eds., Soil biology, 479-492.

Burges, A. & F. Raw. 1967 eds. Soil biology. Academic Press London and New York.

Burn, P.Y. 1952 Effects of fire on forest soils in the pine barren region of New Jersey. Yale Univ. School of forestry. Bull. 57. 50 p.

Butcher, J.W., R. Snider & R.J. Snider. 1971 Bioecology of edaphic collembola and Acarina. Ann. Rev. Entomol., 16 : 249-288.

Byzova, Ju. B. 1970 Ob Ocenke roli Diplopoda V Krugovorote Kaleija. Zool. 2. 49, 11, 1640-1643.

Carpenter, G.H. 1897 The Collembola of Mitchelstown cave. Ir. Nat. 6, 225-233.

——————— 1906 On two new Irish species of Collembola. Scient. Proc. R. Dubl. Soc. 11, 39-42.

——————— 1907 The natural history of Lambay Island, Co. Dublin (Apterygota). Ir. Nat. 16, 54-56.

——————— 1908 On two Collembola new to the Britannic fauna. Ir. Nat. 17, 174-179.

——————— 1911 New Irish Apterygota - Collembola. Ir. Nat. 20, 83-85.

——————— 1913 Clare Island survey. Apterygota. pt. 32, Proc. R. Ir. Acad. 31, 5-12.

Cassagnau, P. 1961 Ecologie du sol dans les pyrenees centrales les biocenoses des Collemboles. Hermann, Paris, 235 pp.

——————— 1964 Ecologie et biologie des Symphypleones epiges de la haute vallee d. Aure. Hautes Pyrenee's). Rev. Ecol. Biol. Sol. 1, 451-500.

Choudhuri, D.K. & S. Roy. 1967 Qualitative composition of the Collembola fauna of some uncultivated fields in Nadia district (West Bengal) with a correlation between monthly population and individual soil factor. Rev. Ecol. Biol. Soc. IV.(3): 507-515.

——————— 1970 Interaction between soil Collembola and other Sub-terranean arthropods. Sci. & Cult. 36(5) : 280-282.

Christiansen,K. 1964 Bionomics of Collembola and other subterrarean arthropods. Sci. & Cult. 36(5) : 280-282.

Coiffait, H. 1958 Les. Coleopteres du sol. Vie et Milieu. Suppl. 7, 204 p.

Cole, L.C. 1954 The population consequences of life history phenomena. 62. Rev. Biol. 29, 103-157.

Critchley, B.R., A.G. Cook, U. Critchley, T.J. Perfect, A.R. Smith & Y. Yeadon. 1979 Effects of bush clearing and soil cultivation on the invertebrate fauna of a forest soil in the humid tropics. Pedobiologia. 19, 425-438.

Curry, J.P. 1971 Seasonal and vertical distribution of the arthropod fauna of an old grassland. Soil Sci. Proc. Royal Dublin Soc. Series B, Vol. 3 : 49-71.

Dammerman, K.W. 1937 Second contribution to a study of the tropical soil and surface fauna, Treubia, 16, 121°-147.

Darlong, V.T. & J.R.B. Alfred. 1981 Differences in arthropod structure in soils of forest and jhum sites of North-East India. Pedobiologia (in press).

Darwin, C.R. 1840 On the formation of mould. Trans. Geol. Soc. (London) (2), 5 : 505-509.

——————— 1881 The formation of vegetable mould through the action of worms, with observations on their habits. J. Murray, London. 326 p.

Davidson, S.J. 1979 Mesofaunal response to cattle dung with particular reference to Collembola. Pedobiologia, 19, 402-407.

Delamare Deboutteville, C. 1951 Microfauna du Sol der pays temperes et. tropicaux. Vie et. Milieu, Suppl. 1,360 p.

——————— & E.Rapoport. (ed.) 1962 - 63 Biologie de l'Amerique australe. 2 Vols. Etude sur faune de sol. Editions du centre National de la Recherche Scientifique, Paris.

Den Heyer, J.,& P.A.J. Ryke 1966 Mesofaunal investigation of the soil in a thorn tree (Acacia karroo) biotope. Revista de Biologia 5; 309-364.

Dicastri, F. 1973 Soil animals in latitudinal and topographical gradients of Mediterranean ecosystems. P. 171-190. In F. Dicastri and H.A. Mooney (eds.) Mediterranean type Ecosystems: Origins and structure. Springer-Verlag, Berlin.

Diem, K. 1903 Untersuchungen uber die Bodenfauna in den Alpen. Jahrb. Naturwiss. Ges. st. Galen, 1901-1902 : 1-234.

Dimo, P.A. 1958 Nabljudenija i issledovanija po faune pocv. Kisihev.

Doeksen, J. & J.Van der Drift. 1963 Soil organisms proceedings of the Colloquium on soil fauna, soil microflora and their relationships. Oosterbeck, the Netherlands, September 10-16, North Holland Publishing Company Amsterdam, 453 p.

Dowdy, W.W. 1944 The influence of temperature on vertical migration of invertebrates inhabiting different soil types. Ecology 25 : 449-460.

Drift, J. Vander 1951 Analysis of the animal community of a beech forest floor, Tijdschr. Ent., 94 : 1-68.

Drift, J.Van der. 1963 A comparative study of the soil fauna in forests and cultivated land on sandy soils in Suriname. Studies on the fauna of Suriname and other Guyanas, Vol. VI. Uitg. Naturw. Studkring. Suriname, No. 32 : 1-42.

Dunger, W. 1956 Untersuchungen uber Laubstreuzersetzung durch Collembola Zool. Jahrb., Abt, Syst, 84 : 75-98.

——— 1958 Uber die Zersetzung der Laubstreu durch die Boden-Makrofauna in Auenwald; Zool, Jb (Syst.). 86 : 139-180,

——— 1964 Tiere im Boden Neue Boehm-Bucherei No,327, A Ziemsen Verlag, Wittenberg Lutherstadt, 265 p.

Eason, E.H. 1964 Centipedes of the British Isles, Warne, London X +294 p.

Edney, E.B. 1953 The woodlice of Great Britain and Ireland, Proc. Linn. Soc. Lond., 164 : 49-98 p.

——— 1968 Transition from water to land in isopod crustaceans, Am. Zool. 8 : 309-326.

Edwards, C.A.T. 1959a The ecology of Symphyla. II. Seasonal soil migrations. Ent. ex. appl. 2 : 257-267.

——— 1959b Keys to the genera of Symphyla. J. Linn. Soc. Lond; 44 : 164-169.

Edwards, C.A. & G.W. Heath. 1963 The role of soil animals in breakdown of leaf material in Doeksen, J, and Drift J, Van der, eds., Soil organisms, 76-84 p.

——— & J.R. Lofty. 1974 The invertebrate fauna of the Park Grass plots, Rothamsted Report for 1974. Part 2 : 133-154.

——— C.G. Butler & J.R. Lafty. 1975 The invertebrate fauna of the Park Grass plots. II surface fauna, Rothamsted Report for 1975, Part 2.

Eglitis, V.K. 1954 Fauna Pochv. Latviiskoi SSR Akademiya Nauk Latviiskoi SSR, Riga, 261 p.

El-Karouri, M.O.H. 1974 Studies of soil compaction in relation to plant growth, Ph.D. Thesis, Univ. of London.

Engelmann, M.D. 1961 The role of soil arthropods in the energetics of an old field community. Ecol. Monograph. 31 : 221-238.

Evans, G.O., J.G. Sheals & D. Macfarlane. 1961 Terrestrial Acari of the British Isles. I. Introduction and biology. British Museum, London, 219 p.

Farb, P. 1959 Living earth. Harper and Brothers, New York. 178 p.

Ford, J. 1937 Fluctuations in natural populations of Collembola and Acarina. J. Anim. Ecol. 6 : 98-111.

Forsslund, K.H. 1945 Studier over det lagre djurlivet i nordsvensk skogsmark. Medd. Skogsforsoksanot. 34(1) : 1-283 pp.

Frankel, B. 1979 The juvenile stadia of the diploid and triploid subspecies of Trichoniscus pusillus. Brandt (Crustacea: Isopoda). J. nat. Hist. 13 : 195-210.

Franz, J.M. 1950 Bodenzoologie als Grundlage der Bodenplege, Akademie Verlag, Berlin, 316 p.

Freeman, J.D. 1952 Occurrence of Collembola in the air. Proc. Roy. Entomol. Soc. Lond. Series A : 27-28.

Freeman, B.E. 1967 Studies on the ecology of larval Tipulinae (Diptera, Tipulidae). J. Anim. Ecol. 36 : 123-146.

Frenzel, G. 1936 Untersuchungen uber die Tierwelt des Wiesenbodens. G. Fischer, Jena, 130 p.

Fujikawa, T. 1970a Relation between oribatid fauna and some environments of Nopporo. National forest in Hokkaido (Acarina: Cryptostigmata). II. Oribatid fauna in soils under four different vegetations. Appl. Ent. Zool. 5 : 69-83.

———— 1970b Notes on the efficiency of a modified Tullgren apparatus for extracting oribatid mites. Appl. Ent. Zool. 5 : 42-44.

———— 1970c Distribution of soil animals in three forests of Northern Hokkaido. II. Horizontal and vertical distribution of oribatid mites (Acarina : Cryptostigmata). Appl. Ent. Zool. 5 : 208-212.

Gabbutt, P.D. 1967 Quantitative sampling of the Pseudoscorpion Chthonius ischnocheles from beech litter. J. Zool. Lond. 151 : 469-478.

———— & M. Vachon. 1963 The external morphology and life history of the Pseudoscorpion Chthonius ischnocheles. Proc. Zool. Soc. Lond. 140 : 75-98.

———— 1965 The external morphology and life history of the Pseudoscorpion Neobisium muscorum. Proc. Soc. Lond. 145 : 335-358.

———— 1967 The external morphology and life history of the Pseudoscorpion Roncus lubricus. J. Zool. Lond. 153 : 475-498.

Galle, L. Jr. 1972 Study of ant populations in various grassland ecosystems. Acta. Biol. Szeged. 18 : 159-164.

Gerard, B.M. 1964 The Linnean society of London synopsis of the British fauna, No. 6, Lumbricidae (Annelida).

——— 1967 Factors affecting earthworms in pastures, J. Anim. Ecol. 36 : 235-252.

Gilyarov, M.S. 1949 Osobenosti pochvy kak sredy obitaniya i ee Znachemie V evolutzii nasekomykh, Akademiya. Nauk SSSR, Moskva, Leningrad, 279 p.

Gisin, H. 1943 Okologie und Lebensgemeinschaften der collembola in Schweizerischen Excursionsgebiot Basels. Rev, Suisse Zool, 50 : 131-224.

——— 1952 Die Okologische forschung und die Lebensgeminschaften, Scientia, 6 : 151-155.

——— 1960 Collembolenfauna europas, Mus. Hist, Nat,, Geneva, 312 p.

Glasgow, J.P. 1939 A population study of subterranean soil collembola. J. Anim. Ecol. 8 : 323-353.

Godfrey, R. 1910 The false scorpions of Scotland, Ann. Scott. nat. Hist. 19 : 23-33.

Gooderham, P.T. 1973 Soil physical conditions and plant growth. Ph.D. Thesis, University of Reading.

Graff, O. & J.E. Satchell. 1967 Progress in soil Biology, North Holland, Amsterdam.

Greenslade, P.J.M. 1969 Soil-fauna studies, Part II Ecology. Phil. Trans, Roy. Soc. B, 255 : 313-320.

——— & P. Greenslade. 1968 Soil and litter fauna densities in the Solomon Islands. Pedobiologia, 7 :362-370.

Gupta, S.K. & M.S. Dhooria. 1970 Addition to the plant mite fauna of Punjab and Himachal Pradesh. Proc. Indian Sci, Congr, 61-69.

Gupta, S.K. & S.P. Mukharjee. 1976a Microarthropods in some cultivated soil at Varanasi. Indian J. Ent. 38(3) : 272-280.

——— 1976b Qualitative composition of the fauna of cultivated and uncultivated soil. Indian J. Ent. 38(4) : 313-324.

Haarlov, N. & T. Weis-fogh. 1953 A microscopical technique for studying the undisturbed texture of soils. Oikos. 4 : 44-57.

Haarlov, N. 1960 Microarthropod from Danish soils, ecology and phenology. Oikos. Suppl. 3 : 1-165.

Halbert, J.N. 1915 Clare Island survey, pt. 39, Acarinida Sec. II. Terrestrial and marine Acarina. Proc. R. Ir. Acad. 31 : 45-136.

——— 1920 The Acarina of the seashore. Proc. R. Ir. Acad. 35 : 106-152.

——— 1923 Notes on Acari with descriptions of new species. J. Linn. Soc. 35 : 363-392.

Hale, W.G. 1966a A population study of moorland Collembola, Pedobiologia. 6 : 65-99.

——— 1966b The Collembola of the Moor-house National Nature Reserve, West Moorland a habitat, Rev. d. Ecologie et. de Biol. du Sol. 3 : 97-122.

——— 1967 Collembola. Soil Biology (ed. by A.Burges & F. Raw). 397-411. Acad. Press, London.

Hammer, M.A. 1934 Quantitative investigation of the microfauna communities of the soil in East Greenland, (Preliminary Report), Medd. Greenland. 100 : 1-39.

——— 1937 Quantitative and qualitative investigation of the soil at Angmagssolik and in Mikis fjord. Med. Greenland. 108-153.

——— 1953 Investigations of the microfauna of North Canada. II. Collembola Acta, Artica, 6 : 1-108.

Handley, W.R. 1954 Mull and mor formation in relation to forest soils. Forest Commiss. Bull. (London), 23-115 p.

Hartmann, F. 1951 Der waldboden, Humus, Bodenund Wurzeltypen als Standortsauzeiger, Osterreiches Produktivatata Zentrum, Wien, 151 p.

Hemmingsen, A.M. 1973 Npcturnal weaving on nest surface and division of labour in weaver ants (Oecophylla smaragdina) (Fabricus, 1775), Vidensk. Meddr. dansk. naturh. Foren. 136 : 49-56.

Hermosilla, W. & R Murua 1966 Estudio ecologico-cuantitativo de la fauna hipogea en las dunas de concon-quintero. Bol. Proc. anim. (Chille), 4: 69-102.

Hatchett, S.P. 1947 'Biology of the Isopoda of Michigan', Ecol. Monograph. 17 : 47-79.

Heydemann, B. 1958 Erfassungsmethoden fur die Biozonosen der Kulturbiotop in Balogh. J. Lebensgemeinschaften der Landtiere (Budapest).

Heyward, F. & A.N. Tissot. 1936 Some changes in the soil fauna associated with forest fires in the longleaf pine region. Ecology. 17 : 659-666.

Hirschmann, W. (ed.) 1957 Gangsystematik der Parasitiformes. Acarologie. Furth. Bayern (6 parts in 5 folgen published upto date).

Holt, S.J. 1955 On the foraging activity of the wood ant. J. Anim. Ecol. 24 : 1-34.

Hughes, T.E. 1959 Mites or the Acari. Athlone press, University of London, London. 225 p.

Huhta, V. 1979 Effects of liming and deciduous litter on earthworm (Lumbricidae) populations of a spruce forest with an innoculation experiment on Allolobophora caliginosa. Pedobiologia. 19 : 340-345.

_____, E. Karppinen, M. Nurminen & A. Valpar. 1967 Effect of silvicultural practices upon arthropod, annelid and nematode populations in coniferous forest soil. Ann. Zool. Fennici. 4 : 87-143.

_____ 1969 Further notes on the effect of silvicultural practices upon the fauna of coniferous forest soil. Annu. Zool. Fenn. 6 : 327-334.

Hunt, J.H. 1974 Temporal activity patterns in two competing ant species (Hymenoptera : Formicidae). Psyche. 81 : 237-242.

Hutchinson, G.E. 1953 The concept of pattern in ecology. Proc. Acad. Nat. Sci. Philadelphia. 105 : 1-12.

Huther, W. 1961 Okologische untersuchungen uber die fauna pfalzischer weinbergsboden mit besonderer Berucksichtigung der Collembola und Miben. Zool. Jahr. Abt. Systemat. Okol. Geograph. Tiere. 89 : 243-368.

Hutson, B.R. 1974 The invertebrate fauna influencing soil development on industrial reclamation sites. Ph.D. Thesis. Univ. of Newcastle upon Tyne.

_____ 1980 Colonization of industrial reclamation sites by Acari, Collembola and other invertebrates. J. Appl. Ecol. 17 : 255-275.

Imadate, G. 1974 Protura. Fauna Japonica. Tokyo Keigaku Publishing Co. Ltd., 351 p.

Janus, H. 1965 Land and freshwater molluscs, Burke, London.

Joffe, J.S. 1936 Pedology. Rutgers University Press, New Brunswick, New Jersey, 575 p.

Joosse, E.N.G. 1960 Some observations on the biology of Anurida maritima (Guerin) collembola. J. Morph. Ökol. Tiere. 57 : 320-328.

——————— 1969 Population structure of some surface dwelling Collembola in a coniferous forest soil. Neth. J. Zool. 19 : 621-634.

Kaczmarek, M. 1973 Collembola in the biotopes of the Kampinos National part distinguished according to the natural succession. Pedobiologia. 13 : 257-272.

——————— 1978 Die lokomotorische Aktivitat der Bodenfauna als parameter der trophischen Struktur und der Sukzession Von Wald Okosystemen. Pedobiologia. 18 : 434-441.

Karg, W. 1968 Bodenbiologisch untersuchungen uber die Eignung Von Milben, insbesondre von parasitiformen Raubmilben als. Indikatoren. Pedobiologia. 8 : 30-44.

Karppinen, E. 1955 Ecological and transect survey studies on Finnish camisiids (Acari : Oribatei), Ann, Zool. Soc. Vanaimo. 17 : 1-80.

Keen, B.A. 1931 The physical properties of the soil, Longmans Green and Company, London.

Kevan, D.K.McE. 1955a Proceedings of the University of Nottingham second Easter School in Agricultural Science. Butterworths Scientific Publications, London, Academic Press, New York, [illegible] 512 p.

——————— 1960 Soil entomology. Ann. Soc. Entomol. Quebec 4 : 33-46.

——————— 1961 Soil entomology in Canada - a review of recent and current work. Ann. Soc. Entomol. Quebec 6 : 19-45.

——————— 1962 Soil animals. H.F. and G. Witherby, London Philosophical Library, New York. 237 p.

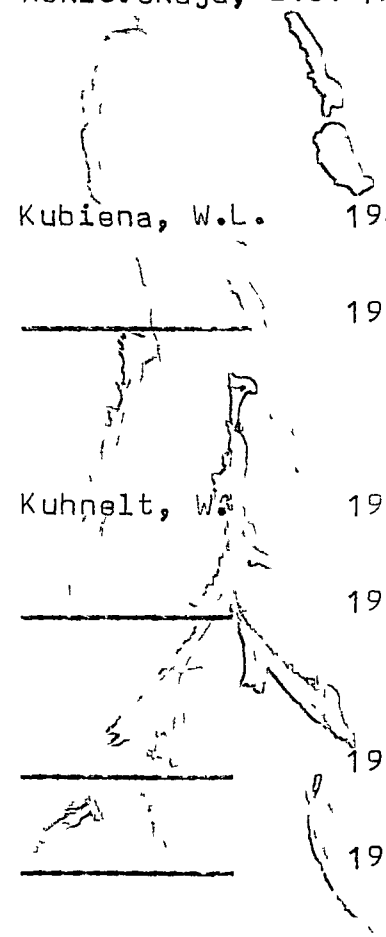
——————— 1965 The soil fauna- its nature and biology. "Ecology of soil borne plant pathogens Prelude to Biological control. Univ. of Calif. Press, Berkeley, Los Angeles and London.

Kipenvarlitz, A.F. 1961 Izmenenie pochvennoi fauny nizinnykh bolot pod Vliyaniem melioratzii i selskokhozyaistvennogo osboeniya: Sel'khozgiz, Belorusskoi SSR, Minsk; 199 p.

Kitazawa, Y. 1962 The ecological fluctuations of soil animals in Japanese land areas (in Japanese). Pedologist. 6 : 37-41.

Koklovskaja, L.S. 1965 Vlijanie bespozvonochych zivotnych na aktivizacuju azota, phosphora i Kalija V torfjanych pocvach. In: Osobennosti bolotoobrazovanija V nekotorych lesnych i predgornych rajonach sibiri i Dal nego. Vostoka, M., Nauka, 165-181 p.

Kubiena, W.L. 1948 Entwicklungslehre des Bodens springer Verlag, Wien, 215 p.



——— 1953 The soils of Europe. Illustrated diagnosis and systematics. Issued under the auspices of the consejo superior de Investigacione cientificas, Madrid. T. Mirby, London, 317 p.

Kuhnelt, W. 1957 An introduction to the study of the Soil animals. In D.K.Mc.E.Kevan (Eds) ,Soil Zoology, 3-22p. Academic Press , N.Y.

——— 1957 Biologia del suelo (Transl. E. Humbert) 2nd ed of Kuhnelt, 1950) consejo superior de investigaciones cientificas, Madrid. 267 p.

——— 1961 Soil Biology with special reference to the animal kingdom, London, 397 pp.

——— 1963 Soil inhabiting Arthropoda. Ann. Rev. Entomol. 8 : 115-136.

Lawrence, R.F. 1953 The biology of the crytic fauna of forests, Balkema, Cape Town and Amsterdam. 408 p.

——— 1961 A survey of the Collembola of the Burren Co. Clare, Ireland. Entomologists Gaz. 12 : 143-164.

Lebrun, P.H. 1965 Contribution a' letude ecologique des oribates de la litiere dans une foret de royenne Belgique. Mem. Int. roy. Sc. nat. de. Belgique. 153 : 1-96.

——— 1971 Ecologie et biocenotique de quelques peuplements d, arthropodes edaphiques. Mem. Inst. roy. Sc. Nat. de Belgique 165:1-203.

Lee, K.E. & T.G. Wood. 1971 Termites and Soils. Acad. Press. London. N.Y.

Loksina, I.E. & S.I. Golovatch. 1979 Diplopoda of the USSR fauna. Pedobiologia. 19 : 381-389.

Loots, G.E. & P.A. Ryke. 1967 The ratio oribatei: Trombidiformer with reference to organic matter contents in soils. Pedobiologia. 7 : 121-124.

Lozek, V. 1962 Soil conditions and their influence on terrestrial Gasteropoda in Central Europe in Murphy, P.W., ed. Progress in Soil Zoology, 334-342 p.

Luxton, M. 1967b The zonation of Saltmarsh Acarina, Pedobiologia. 7 : 55-66.

Macfadyen, A. 1952 The small arthropods of a Molinia fen at Cothill, J. Anim. Ecol. 21 : 87-117.

——————— 1953 Notes on methods for the extraction of small soil arthropods. J. Anim. Ecol. 22 : 65-77.

——————— 1954 The invertebrate fauna of Jan-Mayen island (East Greenland). J. Anim. Ecol. 23 : 261-297.

——————— 1955 In "Soil Zoology" (D.K. McE. Kevan ed.). Butterworth, London. A comparison of methods for extracting soil arthropods. 315-332 p.

——————— 1957 Animal Ecology - aims and methods. Sir Isaac Pitman and Sons Ltd., London and Toronto; Pitman Publishing Corporation, New York, 264 p.

——————— 1961 Improved funnel type extractors for soil arthropods. J. Anim. Ecol. 30 : 171-184.

——————— 1963 Animal Ecology - aimrs and methods. 2nd ed. Sir Isaac. Pitman and Sons. London and Toronto Pitman Publishing Corporation, New York, 344 p.

Madge, D.S. 1969 Field and Laboratory studies on the activities of two species of tropical earthworms. Pedobiologia. 9 : 188-214.

Manton, S.M. 1954 The evolution of arthropodan locomotory mechanisms, Part 4. The structure, habits and evolution of the Diplopoda. J. Linn. Soc. (Zool.). 42 : 299-368.

Marcuzzi, G. 1967 Osservazioni ecologische sulla fauna del suolocon portecolase refiremento al veneto alla Regione Trentiono-Alto Adige. Riv. Biol. 60-433.

——————— 1968 Osservazioni ecologische sulla fauna del suolc di alcune regioni forestali italiane. Ann. Contro.,Econ. Mont. Venezie. 7-209.

——————— 1973 Ecological considerations on the collembola of South-Eastern Alps and prealps. Rev. Ecol. Biol. Sol. 10(3) : 327-340.

———————, A.M. Lorenzoni & F. Di Castri 1970 La fauna del suolo di una regione della Prealpivenete (M. Spitz, Recoaro). Aspetti. autoecologici. Atti. Ist Ven. Sc. Lett. Arti. 128 : 411-567.

Margalef, R. 1963 On certain unifying principles of ecology. Amer. Nat. 97 : 357-374.

Maynard, E.A. 1951 A monograph of the collembola or springtail insects of New York State. Comstock. Pub. Co., Ithaca, New York, 333 p.

McColl, H.P. 1974 The arthropods of the floors of six forest types on the west coast, South Island. A preliminary report. Proc. N.Z. Ecol. Soc. 21 : 11-16.

Metz, L.J. & M.H. Farrier. 1971 Prescribed burning and soil mesofauna on the Santee Experimental Forest. In Proc. Prescribed burning Symp. USDA For. Ser. Southeastern Forest. Exp. Stn. Asheville, N.C. 100-106 p.

——————— 1973 Prescribed burning and populations of soil mesofauna. Environ. Entomol. 2 : 433-440.

Milne, S. 1962 Phenology of a natural population of soil collembola. Pedobiologia. 2 : 41-52.

Mitchell, M.J. 1977 Population dynamics of oribatid mites (Acari : Cryptostigmata) in an aspen woodland soil. Pedobiologia. 17 : 305-319.

Mina, V.N. 1962 Comparison of methods for determining the intensity of soil respiration. Soviet Soil. Science. 10 : 1188-1192.

Molyneux, J.K. 1963 Some ecological aspects of Colliery waste heaps around Wigan, S.Lancashire. J.Ecol. 51 : 315-321.

Moritz, M. 1965 Untersuchungen uber den Einfluss von Kahlschlagmassnahmen auf die Zusammensetzung Von Hornmilbengeneinschafter (Acari : Oribatei) horddeutscher Laub-und Kiefernmischwalder. Pedobiologia. 5 : 65-101.

Muir, J.W. 1955 The effect of soil forming factors over an area in the South of Scotland. J. Soil. Sci. 6(1) : 84-93.

Mukherji, S.P.& J. Singh. 1967 Some aspects of the study of soil arthropods in the wheat field and floral garden. J. Scientific Res. B.H.U. 2 : 177-185.

——————— 1970 Seasonal variations in densities of soil arthropod population in a rose garden at Varanasi (India). Pedobiologia. 10 : 442-446.

Muller, P.E. 1879 Studier over Skovjord, Som bidrag til 5 Skovdyrkingens theori. I. Om bogemuld og bogemor paa sand og ler. Tidsskv. Skovbr. 3 : 1-124.

Muller, P.E. 1884 Idem II. Om muld og mor i egeskove og paa heder. Tidsskr, Skovbr. 7 : 1-232.

Murphy, P.W. 1952 Soil faural investigations in forestry commission, London, Rept. Forest. Res. 130-134 p.

_____ 1955 Ecology of the fauna of forest soils. In. Kevan, D.K. McE. (Ed). Soil Zoology, Butterworths, London. 99-124 p.

_____ 1962 Phenology of a natural population of soil collembola. Pedobiologia. 2 : 41-52.

Naglitsch, E. 1966 Uber Veranderungen der Zusammensetzung der mesofauna wahrend der Rotte organischer substanzen im Boden. Pedobiologia. 6 : 178-194.

Nakamura, Y. & K. Yamauchi. 1970 Distribution of soil animals in three forests of northern Hokkaido. I. Description of surveyed area and soil macro animals. J. Jap. For. Soc. 52 : 269-273.

Neumann, U. 1973 Succession of soil fauna in afforested spoil banks of the brown coal mining district of Cologne. Ecology and Reclamation of Devastated land (ed. by R.J. Hutnik & G. Davis), Gordon and Breach. N.Y. 2 : 335-348.

Newell, P.F. 1967 'Mollusca' in Burges, N.A. and Raw, F. eds. Soil biology, 413-433 p.

Nielsen, C.O. 1955a Survey of a year's results obtained by a recent method for the extraction of soil inhabiting enchytracid worms in Kevan, D.K. McE, ed. Soil Zoology, 202-214 p.

_____ 1955b Studies on the Enchytralidae 2. Field studies. Natura Jutl. 4 : 1-58.

Nielsen, M.G. 1972 Aboveground activity of the ant Lasius alienus (Forst) (Hymenoptera: Formicidae). Natura. Jutl. 16 : 83-94.

Niijima, K. 1971 Seasonal change in collembolan populations in a warm temperate forest of Japan. Pedobiologia. 11 : 11-26.

_____ 1973 Experimental studies on the life history, fecundity and growth of Sinella curviseta (Apterygota : Collembola). Pedobiologia. 13 : 186-204.

Nosek, J. 1955 Pozhamky K ekologii pudny fauny S hlediska biologie pudy. Slovenskej Akademie Vied V Bratislava, 154 p.

O'Connor, F.B. 1957 An ecological study of the enchytraeid worm population of a coniferous forest soil. Oikos. 8 : 161-199.

Odum, E.P. & A.J. Pontin. 1961 Population density of the underground ant, Lasius flavus as determined by tugging with ^{32}P. Ecology. 42 : 186-188.

Ogino, K., P. Saichuae & G. Imadate. 1965 Seasonal changes of soil microarthropod populations in Central Thailand. Nature and life in South East Asia. 4 : 303-315.

Paclt, J. 1956 Biologie der primar flugellosen Insekten G. Fischer, Jena. 258 p.

Palmen, E. 1951 A survey of the Oniscoidea (Isopoda Terr.) of Newfoundland'. Ann. Zool. Soc. Vanamo. 14 : 1-27.

Pande, Y.D. & P. Berthet. 1975 Observations on the vertical distribution of soil oribatei in a woodland soil. Trans. R. ent. Soc. Lond. 127(3) : 259-275.

Peachey, J.E. 1962 A comparison of two techniques for extracting Enchytraeidae from moorland soils in Murphy, P.W. ed. Progress in soil Zoology. 286-293 p.

——— 1963 Studies on the Enchytraeidae (Oligochaeta) of moorland soil. Pedobiologia. 2 :81-95.

Pearse, A.S. 1943 Effects of burning over and raking off litter on certain soil animals in the Duke forest. Am. Midl. Nat. 29(2) : 406-424.

Petal, J. 1972 Methods of investigating the productivity of ants. Ekol. Pol. 20 : 9-22.

——— 1974 Analysis of a sheep pasture ecosystem in the Pieniny Mountains (the Carpathians) XV. The effect of pasture management of ant population. Ekol. Pol. 22 : 679-692.

Pianka, E.R. 1970 On r- and K selection. Am. Nat. 104: 592-597.

Pierrard, G. E. Bonte & R. Baurant. 1963 Observations sur l'hibernation de Blaniulus guttulatus. Bosc (Myriapoda-Diplopoda-Blaniulidae). Bull. Inst. agron. stns. Rech. Gembloux. 31 : 127-141.

Pitelka, F.A. 1964 The nutrient recovery hypothesis for arctic microtines. I. Introduction. In: Crisp, D.J. (ed.). Grazing in Terrestrial and marine Environments. Blackwell, Oxford. 55-56 p.

Poole, T.B. 1961 An ecological study of the Collembola in a coniferous forest soil. Pedobiologia. 1 : 113-137.

Poinsot, N. 1968 Cas d'anhydrobiose chez le Collembola Subisotoma variabilis Gisin. Rev. Ecol. Biol. Sol. 4 : 585-586.

Prabhoo, N.R. 1961 Studies on Indian Enchytraeidae (Oligochaeta). J. Zool. Soc. India. 12(2) : 125-132.

——————— 1964 Studies on Indian Enchytraeidae (Oligochaeta). J. Zool. Soc. India. 16(1 & 2) : 82-86.

——————— 1972 South Indian Protura. I. Two nes species and three new records of Acerentomoidae. Rev. Ecol. Biol. Sol. 9 : 711-718.

Price, D.W. 1973 Abundance and vertical distribution of microarthropods in the surface layers of a california pine forest soil. Hilgardia. 42 : 121-147.

——— ——————— 1975 Vertical distribution of small arthropods in a California pine forest soil. Ann. Entomol. Soc. Am. 68 : 174-180.

——————— & G.S. Benham, Jr. 1977 Vertical distribution of soil inhabiting microarthropods in a agricultural habitat in California. Environ. Entomol. 6(4) : 575-580.

Quick, H.E. 1960 'British slugs', Bull. Mus. Br. nat. Hist. 6 : 103-226.

Raw, F. 1956 The abundance and distribution of Protura in grassland. J. Anim. Ecol. 25 : 15-21.

——————— 1967 'Arthropoda' (except Acarina and Collembola) in Burges, N.A. and Raw, F. (eds.). Soil Biology, 323-362 p.

Reddy, M.V. & J.R.B. Alfred. 1978a Microarthropods associated in the decomposition process of pine litter of Meghalaya pine (Pinus kesiya Royle) forests. A preliminary report in Proc. 1st All Ind. Symp. Soil Biol. Ecol. Eds. C.A. Edwards and G.K. Veeresh, UAS Bangalore. 22 :31-35.

——————— 1978b Decomposition of pine (Pinus kesiya Royle) needles in a tropical pine forest ecosystem, North-Eastern India. Int. Cong. Ecol. Jerusalem, Israel.

Ressl, F. & M. Beier. 1958 'Zur Okologie, Biologie und Phanologie der heimischen Pseudoskorpione. Zool. Jb. (Syst). 80 : 407-450.

Riha, G. 1951 Zur Okologie der oribatiden in Kalkstein-boden. Zool. Jb. (Syst.). 80 : 407-450.

Rusek, J. 1978 Pedozootische Sukzessionen wahrend der Entwicklung Von Okosystemen. Pedobiologia. 18 : 426-433.

Russell, E.J. 1957 The world of the soil. Collins, London. 237 p.

Salmon, J.T. 1951 Keys and bibliography to the Collembola. Zool. Publ. Victoria Univ. Coll. Wellington 8, 82 p.

——————— 1956 Idem First Supplement. Ibid. 20-35 p.

Salt, G. 1952 The arthropod population of the soil in some East African pastures. Bull. Entom. Res. 43 : 203-220.

——————— 1955 The arthropod population of the soil under Elephant grass in Uganda. Bull. Entom. Res. 46 : 539-545.

———————, F.S.J. Hollick, F. Raw & M.V. Brian. 1948 The arthropod population of pasture soil. J. Anim. Ecol. 17 : 139-150.

Satchell, J.E. 1963 Nitrogen turnover by a woodland population of Lumbricus terrestris in Doeksen, J. and Drift, J. Van der. eds. Soil organisms. 60-66 p.

——————— 1967 'Lumbricidae' in Burges, N.A. and Raw, F., eds. Soil biology, 259-322 p.

Sharma, G.D. & D.K. McE Kevan. 1963b Observations on Folsomia similis (Collembola: Isotomidae) in Eastern Canada, Pedobiologia. 3 : 48-61.

——————— 1963c Observations on Pseudosinella petterseni and Pseudosinella alba (Collembola : Entomobryidae) in Eastern Canada. Pedobiologia. 3 : 62-74.

Schuster, R. 1956 Der Anteil der oribatiden an den Zersetzungsvorgangen im Boden. Z. Morphol. Okol. Tiere. 45 : 1-33.

——————— 1958 Okologischfaunistische untersuchungen an bodenwohnenden Kleinarthropoden (Speziell oribatiden) des Salzlachengebietes im Seewinkel. Sitzber Akad. Wiss. Wien (1) 168 : 27-78.

Schaller, F. 1962 Die unterwelt des Tierreiches verstandl wiss. Springer-Verlag, Berlin, Gottingen, Heidelberg, No. 78, 126 p.

Sheals, J.G. 1957 The Collembola and Acarina of uncultivated soil. J. Anim. Ecol. 26 : 125-134.

Singh, J. & U.R. Singh. 1975 An ecological study of soil microarthropods from soil and litter of Tropical deciduous forest of Varanasi (India). Trop. Ecol. 16(2) : 81-85.

_____ & K.S. Pillai. 1975a A study of soil microarthropods communities in some fields. Rev. Ecol. Biol. Sol. 12 : 579-590.

_____ & S.P. Mukherji. 1971 Quantitative composition of soil arthropods in some fields at Varanasi (India). Oriental Insects. 5(4) : 487-494.

_____ 1973 Population size of soil arthropods in some fields at Varanasi (India). Sci. and Cult. 39 : 498-500.

Smith, M.H. 1971 Food as limiting factors in the population ecology of Peromyscus polionotus (Wagner). Ann. Zool. Fenn. 8 : 109-112.

Snyder, T.E. 1949 Catalog of the termites (Isoptera) of the world. Smithson. Inst. Misc. Collections 112, 490 p.

_____ 1956 Annotated subject heading bibliography of termites 1350 B.C. to A.D. 1954. Smithson Inst. Misc. Collections. 130, 306 p.

_____ 1961 Supplement to the annotated subject heading bibliography of termites 1958 to 1960. Smithson. Inst. Misc. Collections. 143(3), 137 p.

Stach, J. 1947 The apterygotan fauna of Poland in relation to the world fauna of this group of insects. Family Isotomidae (Krakow) 488 p.

Stammer, H.J. 1957 Tyroglyphidae und Tarsonemini. In H.J. Stammer (ed.). Beitrage Zur Systematik und Okologie Mitteleuropaischer Acarina. Akademische Verlagsgesellschaft, Geest und Portig K-G. 1 : 1-384.

_____ 1959 Tyroglyphidae und Tarsonemini. 2(1) : 385-389 p.

_____ 1963 Mesostigmata 1(2), 804 p.

Stebayev, I.V. 1962 Zoological characteristics of tundra soils Zool. J. Soviet. Acad. Sci. 41 : 816-825.

Strenzke, K. 1949a Die biozonotischen Grundlagen der Bodenzoologie. Z. Pflanzenernahr. Dung. Bodenk. 45 : 245-262.

_____ 1949b Okologische studien uber die Collembola gesellschaften fouchter Boden Ost-Holsteins. Arct. Hydrobiol. 42 : 201-303.

Stockli, A. 1957 Die Metazoenfauna von Wiesen-und Aekerboden aus der ungebung Zurich, Landw. Jb. Schweiz. 6 : 571-595.

Strickland,A.H. 1945 A survey of the soil litter fauna of some forest reserves and cacao estates in Trinidad, British west Indies. J. Anim. Ecol. 14 : 1-11.

——————— 1947 The soil fauna in two contrasted plots of land in Trinidad, British West Indies. J. Anim. Ecol. 16 : 1-10.

Sturm, H. 1959 Die Nanrung der Proturen. Naturwissenschaften. 46 : 90-97.

Takeda, H. 1979 On the extraction process and efficiency of Macfadyen's high gradient extractor. Pedobiologia. 19 : 106-112.

Tarras-Wahlberg, N. 1961 The oribatei of a Central Swedish bog and their environment. Oikos. Suppl. 4, 56 p.

Tarrant, R.F. 1956 Effect of slash burning on some physical soil properties. Forest. Sci. 2 : 18-22.

Thandrup, H.M. 1939 Studier uber jydske Heders Okologi. 1. Hedebundens fugtighedsdsfohold. Acta. Jutl. 11 (Suppl.) : 1-82.

Theron, P.D. & P.A.J. Ryke. 1969 The family Nanorchestidae Grandjean (Acari: Prostigmata) with descriptions of new species from South African soils. J. ent. Soc. 5th Afr. 32 : 31-60.

Thiele, H.U. 1959 Experimentelle untersuchungen uber de Abhangigkeit bodenbewahnender. Tierarten Vom kalkgehalt, des Standortes. Z. Angew. Entomol. 44 : 1-21.

Tischler, W. 1955 Zynokologie der Landtiere Fischer, Stuttgart. 414 p.

Torne, E. Von. 1965 Experimentelle untersuchungen uber den Einflub der Lebenstatigkeit von Mikroorganismen und Bodentieren auf den abbau von Zellulose I Pedobiologia. 5 : 211-227.

Trehan, K.N. 1945 Some observations of the soil fauna of cotton fields at Lyallpur. Proc. Indian. Acad. Science. 21(B) : 191-201.

Tullgren, A.H. 1918 Ein sehr einfacher Ausleseáp-parat Fur terricole-Tierfaunen. Z. Angew. Ent. 4 : 149-150.

Tribe, H.T. 1960 - 61 Microbiology of cellulose decomposition in soil. Soil. Sci. 92 : 61-77.

Tuxen, S.L. 1949 Uber den Lebenszyklus und die postembryonale Entwicklung Zweier danischer Proturengattungen', Biol. Skr. 6 : 1-50.

Usher, M.B. 1967 Studies on population ecology, with particular reference to soil Collembola. Ph.D. Thesis University of Edinburgh.

_____ 1975 Seasonal and vertical distribution of a population of soil arthropods. Cryptostigmata. Pedobiologia. 15 : 364-374.

_____, B.C. Longstaff & D.R. Southall. 1970 Studies on populations of Folsomia candida (Insecta: Collembola). The productivity of populations in relation to food and exploitation. Oecologia (Berl.). 7: 68-79.

Van den Berg, R.A. & P.A.J. Ryke. 1967 - 68 A systematic ecological investigation of the acrofauna of the forest floor in Magoebaskloef (South Africa) with special reference to the Mesostigmata. Revista de Biologia. 6 : 157-234.

Vatsauliya,P.K. & J.R.B. Alfred. 1980 Quantitative study of the soil arthropods in jhum ecosystems of North-Eastern India. Ind. Zool. 4 : (1 & 2): 153-160 p.

Veeresh, G.K. 1974 War against white grubs. Curr. Res. 3 : 87-88.

_____ 1977 Studies on the Root-grubs in Karnataka. UAS. Monograph series No. 2, 87 p.

_____ 1979 Influence of Agriculture on the outbreak of white grubs in India. Proc. VII Intern. Coll. Sol. Zool. In Soil Biology as related to land use practices. 301-309 p.

Verhoeff, K.W. 1928 Diplopoda I in Bronn, H.G. (ed.). Klassen und ordnungen des Tierreiches. 5 : 1-1072.

_____ 1932 Diplopoda II in Bronn, H.G. (ed.). Klassen und ordnungen des Tierreiches. 5 : 1073-2084.

_____ 1934a Diplopoda, Symphyla, Pauropoda, Chilopoda in Bronner, P., Ehrmann, P. and Ulmer, G. eds., Tierwelt Mitteleur. 2 : 1-120 p.

Vlug, H. & J.H. Borden. 1973 Soil acari and Collembola populations affected by logging and slash burning in a coastal British Columbia coniferous forest Environ. Entomol. 2(6) : 1016-1023.

Walkley, A. & I.A. Black. 1934 An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil. Sci. 37 : 29-38.

Wallwork, J.A. 1958 Notes on the feeding behaviour of some forest mites. Oikos. 9 : 260-271.

_____ 1959 The distribution and dynamics of some forest soil mites. Ecology. 40 : 557-563.

_____ 1967 Acari in soil biology (A. Burges & F. Raw, eds.). Acad. Press London. and New York. 363-395 p.

_____ 1970 Ecology of soil animals, McGraw-Hill, London, New York, Sydney, Toronto, Mexico, Johannesburg, Panama.

Webb, N.R. 1977 Observations on Steganacarus magnus : General biology and life cycle. Acarologia 19 : 686-697.

_____ & G.W. Eimes. 1972 Energy budget for adult Steganacarus magnus (Acari). Oikos. 23 : 359-365.

_____ 1973 The structure of an adult population of Steganacarus magnus (MIC) Cryptostigmata. Proc. 3rd international Congress of Acarology. Prague. 135-137 p.

_____ 1979 Variations between populations of Steganacarus magnus (Acari : Cryptostigmata) in Great Britain. Pedobiologia. 19 : 390-401.

Weis-Fogh, T. 1948 Ecological investigations on mites and collembolas in the soil. Nat. Jult. 11 : 139-270.

White, G. 1789 The natural history and antiquities of Selborne (various editions). B. White & Son, London.

Wiggins, E.A., E.A. Curl & J.D. Harper. 1979 Effects of soil fertility and cotton rhizosphere on populations of Collembola. Pedobiologia. 19 : 75-82.

Wilde, S.A. 1954 Forest humus: its genetic classification. Trans. Wisconsin. Acad. Sci. 43 : 137-167.

Williams, E.C. 1941 An ecological study of the floor fauna of the Panama rain forests. Bull. Chicago, Acad. Sci. 6 : 63-124.

Williams, E.D. 1974 Changes in yield and botanical composition caused by the new liming scheme on Park Grass Rothamsted Experimental Station. Report, 2, 67-73 p.

Williams, D.E. 1966 Slash burning research. British Columbia. Lumberman. 32-41 p.

Wise, K.A.J. 1967 Collembola (Springtails). Antarctic Research Series. 10 : 123-148.

Witkamp, M. & D.A. Crossley. 1966 The role of arthropods and microflora in breakdown of white oak litter. Pedobiologia. 6 : 293-303.

Wood, T.G. 1970 Microarthropods from soils in the arid zones in Southern Australia. Search 1, 75 p.

LIFE HISTORY

INTRODUCTION

Most works available on collembola have primarily been directed to their abundance in relation to various environmental factors under field conditions. Moreover, field studies on collembola species have included age-structure, respiration, birth and mortality figures. However, very little is available on the life history of collembola species under laboratory conditions in relation to various environmental factors.

The earliest report available was that of Maclagen (1932) who showed that soil pH had a profound effect on the oviposition of Sminthurus viridis (L.), and that it was optimum at pH 6.5. Later, Davidson (1934) showed that pH 5.5-7.0 was favourable for the same species oviposition. This found support even in field studies as Gisin (1943) showed for Odontella armata (Axelson), typically basophilic and Odontella lamellifera (Axelson), as acidophilic. Britt (1951) working on the life history of Achorutes armatus attributed high mortality due to the varying concentrations of charcoal and plaster of Paris used as culture media. He however did not give any idea in regard to physicochemical factors affecting the life history pattern of that species. Milne (1960) suggested that quantity of food and moisture content rapidly changed the oviposition, fecundity and mortality in various species of Arthropleone collembola. The use of activated charcoal as a substrate for life-history studies have been well documented by Choudhuri (1960) and Goto (1960a).

The earliest work on environmental factors on the development of collembola is that of Choudhuri (1960, 1963) who had shown the effect of temperature on three species of the genus

Onychiurus. Marshall and Kevan (1962) also showed the effect of temperature on the oviposition of Folsomia candida (Willem), where an increase in temperature simultaneously increased the oviposition rate and also reduced the time of hatching. Sharma and Kevan (1963a) also showed the influence of temperature on the development, mortality and fecundity of individual species of collembola.

Green (1964a, 1964b) revealed moisture as one factor in the reduction of mortality and the other as crowding affecting the fecundity, which was highly reciprocal to the density of the culture media. Vail (1965) showed that activated charcoal and its pH had an effect on collembola species. A linear relationship between the reciprocal of egg-developmental time and temperature was revealed by Hale (1965a, 1965b). Ashraf (1969) while working on the fecundity of Onychiurus bhattii Yosii showed that they differed considerably with pH and that most individuals survived around slight alkaline pH but died at pH beyond 9.7. Studies on food and the speed of establishment of a population (Folsomia candida) (Usher et al., 1971) revealed that it was proportional to the rate at which the food was supplied. When this was independent of density and became limiting, the stable population size got reduced. He also concluded that effect of exploitation must have been to reduce the competition for space. Snider (1971) has shown in culture-experiments that type and quality of diet can influence collembola growth and fecundity. This is attributed to pH which can have a great effect on the population of adventitous bacteria and fungi.

Snider (1973) and Snider and Butcher (1973) showed that reproductive cycles observed between field and laboratory condi-

tions cannot be correlated, because, in cultures the period between hatching to end of oviposition was extended to more than three times. Niijima (1973) while working on Sinella curuiseta showed that with increase in temperature, early maturity was obtained. This she correlated with the field, the growth rate being lower, owing probably to adverse environmental conditions like low-moisture, wide fluctuations in the temperature and food supply. Hutson (1974, 1978) was the latest record of various environmental factors like pH, conductivity and salinity who showed that either one or all three factors did play a significant role in the reproduction of some species of collembola.

The aim of the present study therefore was to at least take up some important species of the dominant groups, to identify the reproductive strategies and to show further their importance in the population-dynamics. It was therefore done on two sites (Site A and Site D) on four dominant species of collembola available. Their life histories in relation to some environmental factors like pH, temperature and salinity under laboratory culture conditions were done. These sites, were chosen as the youngest abandoned fallow (Site A) and the oldest abandoned fallow (Site D), to reveal any significant differences in the individual species life histories.

MATERIAL AND METHODS

The top surface layers of soil from site A and site D were taken for these experiments. The specimens from the soil samples were extracted in the usual way with the help of modified Tullgren funnel series. The collecting tubes for this extraction contained triple distilled water. The species were then identified, removed and kept separately. All four species belonged to Family Entomobryidae. These were, (1) Seira indica Yosii, 1962 (2) Seira lateralis Yosii, 1966 (3) Salina Yosii Salmon, 1964 and (4) Entomobrya kali Imms, 1912, the former two from site A and the latter two from site D were used in these experiments. The substrate preparation was done by the plaster-charcoal method followed after Hutson (1978), using charcoal in variable quantities for the differing ph values. These were placed in small glass vivaria, which consisted of heat resistant glass containers 3 cm. deep and 5 cm. in diameter. After the substrate was poured into these vivaria, they were covered with a thin sheet of plastic to prevent growth of fungi and also to render the vivaria more or less air-tight. The various concentrations of salinity was made with the help of Sodium chloride solutions. These solutions were prepared by dissolving Analar Sodium chloride in triple distilled water in the quantities required, as given by Richards (1954). However, when the moisture content of the substrate kept lowering only drops of triple distilled water was added to culture-media and not the salt solution.

Experiments were conducted at temperatures, 20º, 25° and 30°C in temperature controlled incubators. The fourth experiments was conducted under ambient temperatures in the laboratory which served as the control. The pH used were 6.2, 5.2 and 4.2 for 20°,

25° and 30°C respeetively while it was 4.2 for the room temperature (control). Salinity concentrations were used at 1%, 2% and 3% levels accordingly. In this respect the experiments were in the form of a randomized block-design where the first set comprised of 20°C, 6.2 pH and 1% salinity, the second set was at 25°C, 5.2 pH and 2% salinity, while the third was with 30°C, 4.2 pH and 3% salinity. The controls were at room temperature and 4.2pH. Foods of different kinds were used though however they were not calculated in the present experiments as a limiting factor. Yeast in agar and boiled banana was given as food, both in sterilized forms. For each experimental set, five replicates were conducted for all the four species undertaken.

In each treatment 2 individuals of each species, small enough not to have previously oviposited were introduced into the replicates of each culture. Males and females were identified by the presence of Aedaegus and heavy cilia on the abdomen of the male in contrast to female in all the four species. Daily cultures were examined twice, once in the morning hours (1000 hrs.) and the other in the evening hours (1600 hrs.).

Triple distilled water was added to the culture media usually in the morning to keep the culture media constantly moist. Food was administered just before sun set. Egg development time was calculated from the day of oviposition to when more than 50% of the eggs in a single batch had hatched. The significant differences between the results for fecundity and mortality at the various temperature, pH and salinity levels were tested statistically, but as no significant differences were found between the replicates of mean number of eggs per batch, the results at each treatment were pooled and only the treatment mean square was used

to compare the residual mean square and incorporation of Standard Error and Standard Deviation. This was done for all the experimental designs in replicates for each species. The measurements in terms of length was taken twice daily till the next higher was observed after a moult and measurements continued again. At every stage the count of the population was recorded and the experiments were continued for each of the four species in all experiments designed upto the sexually matured stage, which in the present case was upto the 6th instar.

RESULTS

The present experiments incorporated the fecundity and mortality of four species of collembola under different experimental conditions and with control at ambient temperature.

In Seira indica Yosii, 1966 which was collected from the surface layers of the youngest abandoned fallow (Site A) it was seen that the oviposition definitely decreased (60 eggs), with increased pH and reduced temperature and salinity. This was clearly seen from Table-LXV, that the number of eggs laid was seen to be maximum (78 eggs) under ambient conditions, even though the pH was low. But in the next stage, that is, immediately after hatching (Ist instar), there was a sudden drop (50 individuals) in the hatchability under lab-conditions, though it was not so, under the remaining three experimental conditions (70, 65 and 57 individuals). In the subsequent instars in this species from second to sixth instar, though there was a steady drop in numbers, yet they more or less stabilized at the last instar stage (28 to 30 individuals) irrespective of the fecundity.

While considering the number of days for the hatchability or for the growth of the different instars, it was seen that again temperature played a role. Under maximum conditions (30°C) and at ambient temperature which was also around that, it was seen that the maximum number of days (10 to 12 days) for the hatching of the egg into the first instar, and the least number of days in the lowest temperature regime (7 to 8 days). However, for the growth of subsequent instars, there was hardly any difference under the different experimental conditions and also in the control.

The third aspect which was taken into consideration was either the diameter of the eggs or the length measurements of the

different instars, which under all these experimental designs and control, were more or less similar. Yet, the largest individuals of the species was definitely recorded at higher temperature, though the increase in the length measurement was never more than 0,05 mm. (Table-LXV) and hence thought to be negligible.

In the next species namely Seira lateralis Yosii, 1966 it was seen that oviposition depended on temperature as in S. indica. However in this species the number of eggs laid was much more and in fact nearly one and half times (90-100 eggs) than that of S. indica. In this species it was seen that the survival of the individuals steadily felt and were more or less stabilized at the sixth instar stage when they were sexually mature under the different experimental setups. In regard to the duration of days taken, either for hatching or for the development of the instars; it was observed that it was maximum under maximum temperature regimes. However, the development of the different stages from first to sixth instar, there was negligible difference in the number of days between two moults under any experimental conditions (Table-LXVI). Similarly when the measurements of either the diameter of the egg or the length of the different instars were taken it was seen that the maximum sizes (0,21 to 0,22 mm) were obtained at experiments with maximum temperature and lowest pH values and highest salinity, while the lowest (0,19 to 0.20 mm) were recorded in just the reverse experimental conditions.

The third species Salina yosii Salmon, 1964 was obtained from the surface layers of the oldest abandoned fallow (Site). This species also showed a trend of oviposition and development similar to that of S. indica and S. lateralis from Site A. The important points, however, observed were the number of eggs laid in this species was nearly double that of S. indica and one and

Table LXV : Showing the fecundity, mortality, egg diameter, instar length, period of days of development for Seira indica at the different experimental set up and control.

TABLE LXV

EXPERIMENT NO.		HATCHING	I	II	III	IV	V	VI
I	a.	60 ± 1.0	57 ± 1.0	50 ± 1.0	45 ± 1.0	40 ± 1.0	25 ± 1.0	25 ± 1.0
	b.	7 ± 2.74	7 ± 2.35	3 ± 1.41	4 ± 1.73	6 ± 1.0	6 ± 1.0	6 ± 1.0
	c.	0.13 ± 0.01	0.25 ± 0.01	0.32 ± 0.01	0.58 ± 0.01	0.58 ± 0.01	0.69 ± 0.01	0.85 ± 0.01
II	a.	70 ± 1.0	65 ± 1.0	53 ± 1.0	40 ± 1.0	35 ± 1.0	30 ± 1.0	30 ± 1.0
	b.	8 ± 1.41	9 ± 1.87	4 ± 1.73	5 ± 1.58	6 ± 2.0	7 ± 1.58	7 ± 1.58
	c.	0.14 ± 0.01	0.30 ± 0.01	0.45 ± 0.01	0.56 ± 0.01	0.60 ± 0.01	0.71 ± 0.01	0.88 ± 0.01
III	a.	72 ± 1.0	70 ± 1.0	60 ± 1.0	50 ± 1.0	40 ± 1.0	30 ± 1.0	30 ± 1.0
	b.	10 ± 1.87	10 ± 1.87	5 ± 1.58	6 ± 2.00	7 ± 2.74	8 ± 2.55	8 ± 2.35
	c.	0.16 ± 0.01	0.31 ± 0.01	0.47 ± 0.01	0.57 ± 0.01	0.63 ± 0.01	0.72 ± 0.01	0.90 ± 0.01
IV	a.	78 ± 1.0	50 ± 1.0	45 ± 1.0	40 ± 1.0	35 ± 1.0	30 ± 1.0	28 ± 1.0
	b.	12 ± 3.87	6 ± 2.24	3 ± 1.73	5 ± 2.45	5 ± 2.35	7 ± 2.74	6 ± 2.24
	c.	0.14 ± 0.01	0.34 ± 0.01	0.42 ± 0.01	0.51 ± 0.01	0.60 ± 0.01	0.71 ± 0.01	0.91 ± 0.01

Table LXVI : Showing the fecundity, mortality, egg diameter, instar length, period of days of development for Seira lateralis at the different experimental set up and control.

TABLE LXVI

EXPERIMENT NO.		HATCHING	I	II	III	IV	V	VI
I	a.	90 ± 1.0	81 ± 1.0	71 ± 1.0	70 ± 1.0	65 ± 1.0	60 ± 1.0	55 ± 1.0
	b.	15 ± 2.92	10 ± 1.87	5 ± 1.58	7 ± 1.87	6 ± 1.41	7 ± 1.41	7 ± 2.74
	c.	0.91 ± 0.01	0.35 ± 0.01	0.48 ± 0.01	0.60 ± 0.01	0.70 ± 0.01	0.86 ± 0.01	0.94 ± 0.01
II	a.	96 ± 1.0	90 ± 1.0	80 ± 1.0	72 ± 1.0	64 ± 1.0	62 ± 1.0	61 ± 1.0
	b.	10 ± 3.0	11 ± 2.55	7 ± 2.40	8 ± 2.74	8 ± 1.12	8 ± 2.35	8 ± 2.83
	c.	0.20 ± 0.01	0.45 ± 0.01	0.55 ± 0.01	0.63 ± 0.01	0.71 ± 0.01	0.88 ± 0.01	0.98 ± 0.01
III	a.	102 ± 1.0	98 ± 1.0	82 ± 1.0	70 ± 1.0	60 ± 1.0	55 ± 1.0	50 ± 1.0
	b.	16 ± 8.94	12 ± 2.83	8 ± 2.74	7 ± 2.69	8 ± 2.24	9 ± 2.55	9 ± 3.32
	c.	0.21 ± 0.01	0.46 ± 0.01	0.60 ± 0.01	0.70 ± 0.01	0.74 ± 0.01	0.90 ± 0.01	1.15 ± 0.01
IV	a.	110 ± 1.0	100 ± 1.0	90 ± 1.0	79 ± 1.0	71 ± 1.0	67 ± 1.0	59 ± 1.0
	b.	17 ± 4.95	9 ± 1.73	6 ± 1.22	6 ± 2.24	7 ± 1.22	8 ± 2.74	7 ± 2.45
	c.	0.22 ± 0.02	0.41 ± 0.01	0.56 ± 0.00	0.61 ± 0.01	0.68 ± 0.00	0.83 ± 0.02	0.93 ± 0.01

half times that of S. lateralis. In any case the maximum eggs laid (130-132) was seen under the maximum temperature regimes and salinity and minimum pH values. The subsequent survival figures in the different instars though steadily fell under all the experimental conditions, like the two previous species, yet they did not stabilize at the sexually mature stage. In fact, the ambient temperature which recorded the maximum fecundity (130 eggs) showed the least survival (100 individuals) in the sixth instar, while even the least eggs (120 eggs) laid at the lowest temperature and salinity and highest pH values recorded (103 individuals) and the maximum was seen to be (108) individuals at 30°C and 3% salinity, 4.2 pH when the eggs was only 10 less than the highest recorded.

This species also, revealed that the duration of days taken either for the hatching of the eggs or for the development of the different instars, there was no significant difference between the different experimental conditions. One further observation in contrast to S. indica and in concordance with S. lateralis is that the diameter of the eggs laid or the length measurements obtained in the different instars, there was hardly any significant difference (Table-LXVII), under the different experiments.

The last species, Entomobrya kali Imms, 1912 had the lowest oviposition rate and was nearly half of S. indica (40 to 48 eggs). However, it was seen, that at the experimental conditions with maximum temperatures and highest salinity but with lowest pH not only the maximum eggs were laid but proportionally the survival was also maximum in the 6th instar stage, and as in all the other species the duration of days taken either for hatching or for the different stages between moults, was also observed here. Further the maximum sizes were also recorded under these experimental conditions.

Table LXVII : Showing the fecundity, mortality, egg diameter, instar length, period of development in Salina vagli at the different experimental set up and control.

TABLE LXVII

EXPERIMENT NO.		HATCHING	I	II	III	IV	V	VI
	a.	120 ± 1.0	110 ± 1.0	107 ± 1.0	105 ± 1.0	104 ± 1.0	103 ± 1.0	103 ± 1.0
I	b.	10 ± 2.92	11 ± 3.0	5 ± 2.0	6 ± 1.0	7 ± 2.74	7 ± 2.74	7 ± 2.06
	c.	0.24 ± 0.01	0.55 ± 0.01	0.70 ± 0.01	0.80 ± 0.01	0.92 ± 0.01	1.15 ± 0.01	2.05 ± 0.01
	a.	126 ± 1.0	124 ± 1.0	114 ± 1.0	113 ± 1.0	108 ± 1.0	106 ± 1.0	10_4 ± 1.0
II	b.	11 ± 4.1	12 ± 2.74	7 ± 2.74	7 ± 2.74	9 ± 2.83	8 ± 2.45	8 ± 2.45
	c.	0.27 ± 0.01	0.58 ± 0.01	0.74 ± 0.01	0.94 ± 0.01	1.10 ± 0.01	1.18 ± 0.01	2.50 ± 0.01
	a.	130 ± 1.0	128 ± 1.0	120 ± 1.0	118 ± 1.0	115 ± 1.0	111 ± 1.0	108 ± 1.0
III	b.	12 ± 3.46	14 ± 3.74	8 ± 2.24	9 ± 2.24	10 ± 2.29	9 ± 4.03	9 ± 3.74
	c.	0.28 ± 0.01	0.59 ± 0.01	0.76 ± 0.02	0.98 ± 0.00	1.12 ± 0.01	1.22 ± 0.01	2.52 ± 0.01
	a.	132 ± 1.0	130 ± 1.0	110 ± 1.0	108 ± 1.0	106 ± 1.0	104 ± 1.0	100 ± 1.0
IV	b.	10 ± 1.41	6 ± 1.0	7 ± 1.58	8 ± 2.0	8 ± 2.35	8 ± 2.35	9 ± 2.83
	c.	0.27 ± 0.02	0.56 ± 0.01	0.65 ± 0.01	0.71 ± 0.01	0.85 ± 0.0	0.98 ± 0.01	1.80 ± 0.01

One peculiarity which deviated from the earlier three species is that in this species, the duration of days for either hatching or for the different moulting stages of the instars, was seen to be minimum under the control conditions as also for either the diameter of the eggs or for the different instar lengths, (Table-LXVIII).

Though all the above mentioned, for the four species were the general observations, it was felt to work out the percentages of hatching and mortality in the different instars, and the percentage of survival in the adult sexually matured stage. When so done, it was seen that the maximum percentage (97%) of eggs hatched in the first species - Seira indica at the highest temperature series and the lowest (64%) was seen under the control experiments. Moreover, a similar trend between these two conditions was in the mortality percentage for the I instar, where in the third experimental series the mortality seen in the first instar was only nearly 3%, while the control showed nearly 49% mortality. However, under maximum temperatures it revealed thereafter for subsequent instars from second to fifth instar an increased mortality percentage. The second instar mortality was more or less similar in all the experiments under all the conditions while in the third instar highest (25%) in medium temperature and the highest mortality for the fourth instar was again under maximum temperature series (20%) and for V instar in the lowest temperature experiments, (38%). The VI instar revealed no mortality at all under the different experimental set ups while the control showed nearly 7% mortality. The percentage of adult finally observed was more or less the same under all the experimental conditions with a fall of only 4% under the control experiments.

Table LXVIII : Showing the fecundity, mortality, egg diameter, instar length, period of development in *Entomo-Krya kali* at the different experimental set up and control.

TABLE LXVIII

EXPERIMENT NO.		HATCHING	I	II	III	IV	V	VI
I	a.	40 ± 1.0	35 ± 1.0	34 ± 0.56	32 ± 1.0	31 ± 1.0	28 ± 1.0	27 ± 1.0
	b.	2 ± 0.71	5 ± 1.22	6 ± 1.29	7 ± 1.74	8 ± 2.74	8 ± 2.24	8 ± 2.83
	c.	0.47 ± 0.02	0.70 ± 0.01	0.85 ± 0.01	0.96 ± 0.00	1.10 ± 0.01	1.40 ± 0.01	3.25 ± 0.01
II	a.	42 ± 1.0	30 ± 1.0	28 ± 1.0	26 ± 1.0	24 ± 1.0	22 ± 1.0	20 ± 1.0
	b.	3 ± 1.41	6 ± 1.41	7 ± 2.0	8 ± 2.83	10 ± 3.0	9 ± 3.54	9 ± 1.0
	c.	0.47 ± 0.01	0.75 ± 0.02	0.91 ± 0.01	0.99 ± 0.01	1.14 ± 0.01	1.60 ± 0.01	3.60 ± 0.01
III	a.	48 ± 1.0	40 ± 1.0	38 ± 1.0	36 ± 1.0	35 ± 1.0	33 ± 1.0	30 ± 1.0
	b.	4 ± 1.41	7 ± 2.0	8 ± 2.0	9 ± 2.0	11 ± 3.67	10 ± 3.67	10 ± 1.23
	c.	0.48 ± 0.01	0.78 ± 0.01	0.98 ± 0.01	1.10 ± 0.01	1.30 ± 0.01	1.90 ± 0.01	3.70 ± 0.01
IV	a.	44 ± 1.0	36 ± 1.0	32 ± 1.0	31 ± 1.0	30 ± 1.0	28 ± 1.0	26 ± 1.0
	b.	2 ± 0.71	4 ± 1.0	5 ± 2.0	6 ± 2.83	7 ± 2.0	8 ± 2.74	8 ± 2.74
	c.	0.43 ± 0.02	0.68 ± 0.01	0.72 ± 0.01	0.85 ± 0.01	1.06 ± 0.01	1.20 ± 0.01	3.10 ± 0.01

Seira lateralis as in Seira indica revealed the highest percent of hatchability under maximum temperature series and also the lowest mortality in the first instar. In this species the subsequent mortality percentage for instars II to VI, was seen to be more or less same under all experimental set ups except for the 3 instar where approximately 1.5% only was seen as mortality as under medium temperature series. The maximum adult of survival was seen to be in conditions of minimum and medium temperature series of nearly 60-64% while the least was observed under maximum temperature series (50%).

In Salina Yosii, the percentage of hatching was seen to be nearly the same (98.5%) in medium, maximum and ambient temperatures, while the minimum (92%) was seen in minimum temperature. However, the reverse trend was observed in the mortality percentage of Ist instar where the maximum was recorded under low temperatures (8%) and the minimum in all remaining experimental conditions of nearly 1.5%. The 2nd instar again revealed a reverse trend to the first instar in that in the control experiments, the maximum percentage of mortality of nearly 15% was observed while the minimum was seen in low temperature (2.7%). The third instar showed more or less similar percentage mortality under all experimental conditions, while in the 4th, 5th and 6th instars, the lowest percentage mortality was seen in low temperatures, while maximum mortality in medium temperatures (4.4%), maximum temperatures (3.5%) and control (3.4%), respectively. The percentage of adult survival at the end of the experiment, was seen to be maximum under maximum temperature (nearly 86%), while the lowest was observed in the control (76%). In the other two experimental conditions, the percentage survival was very near to the maximum recording 83%.

The last Entomobrya kali in contrast to all the other three species, recorded the maximum percentage of hatchability under low temperatures (nearly 88%), while the lowest (71%) was seen under medium temperature series. The percentage of mortality from the first to sixth instar, was nearly the same under the different experimental set ups except that significant maximum mortality was seen for the first instar in medium temperatures (28%). Similarly the least mortality was observed to be more or less under the first experimental set up. The percentage of adult survival at the end of the experiment in this species was seen to be maximum under low temperature conditions (nearly 68%) and the lowest under medium temperature conditions (nearly 48%). In the other two set ups of, it was around 60% $\pm$ 2 (Table-LXIX).

Lastly, it was felt that among the survival of adults in different experimental series in the different species the ratio of male and female was to be worked out. When so done it was seen that for all the species, the maximum number of males in relation to females was seen to be under medium temperatures. This was significantly shown for Seira indica and Seira lateralis. However, Salina Yosii and Entomobrya kali, the male-female ratio was more or less the same under the different experimental conditions (Table-LXX).

Though all the above were direct observations made under different experimental set ups, yet we wanted to see whether the factors undertaken like pH and salinity had really any statistically significant relationships with the fecundity or development of the various stages. In this connection a multivariate regression analysis was performed between the three major environmental factors as used in the different experiments and the fecundity, survival numbers of different instars, the egg-diameter and

Table LXIX : Showing the mortality and natality percentages in all the four species.

A = Seira indica

B = Seira lateralis

C = Salina yosii

D = Entomobrya kali

TABLE LXIX

EXPERIMENT NO.		% HATCHA-BILITY.	I	II	III	IV	V	VI	% SURVIVAL OF ADULT
I	(A)	95.00	5.00	12.28	10.00	11.11	37.50	00.00	41.67
	(B)	90.00	10.000	12.35	1.41	7.14	7.69	8.33	61.11
	(C)	91.67	8.33	2.73	1.87	0.95	0.96	0.00	85.83
	(D)	87.50	12.50	2.86	5.88	3.13	6.45	3.57	67.50
II	(A)	92.86	7.14	18.46	24.53	12.50	14.29	0.00	42.86
	(B)	93.75	6.25	11.11	10.00	11.11	3.13	1.61	63.54
	(C)	98.41	1.59	8.06	0.88	4.42	1.85	1.87	82.54
	(D)	71.43	28.57	6.67	7.14	7.69	8.33	9.09	47.62
III	(A)	97.22	2.78	14.29	16.67	20.00	25.00	0.00	41.67
	(B)	96.08	3.92	10.20	14.63	14.29	8.33	9.09	49.02
	(C)	98.46	1.54	6.25	1.67	1.69	3.48	2.70	83.08
	(D)	83.33	16.67	5.00	5.26	2.78	5.71	9.09	62.50
IV	(A)	64.10	48.72	10.00	11.11	12.50	11.42	6.67	35.90
	(B)	90.97	9.09	10.00	12.22	10.13	5.63	11.94	53.64
	(C)	98.48	1.52	15.38	1.82	1.85	1.89	3.85	75.76
	(D)	81.82	18.18	11.11	3.13	3.23	6.67	7.14	59.09

Table LXX : Showing the male-female ratio in the different species.

A = Seira indica
B = Seira lateralis
C = Salina yosii
D = Entomobrya kali

TABLE LXX

EXPERIMENT NO.	A	B	C	D
I	1.5:1	1.5:1	1.42:1	2.9:1
II	4.6:1	1.9:1	1.36:1	3.0:1
III	2.4:1	1.5:1	1.30:1	1.9:1
IV	2.8:1	1.0:1	1.43:1	2.2:1

instar length measurements and the number of days for the development at each stage and in the final analysis. When so done, as seen in Table-LXXI, it was seen that for Seira indica fecundity was highly positively significant, $P < 0.01$, while no significance at all was seen between temperature and the numbers in each instar. Temperature and the number of days was significant only in the egg (hatching) and in the V and VI instar, all positively significant, the former at $P < 0.05$ and the latter two at $P < 0.01$ level. Temperature with either the egg-diameter or with the length of individual instars when correlated was shown to be not significant in the former. It was significant for the I, III, IV and VI instars all at $P < 0.01$ level. When pH was so correlated, it had the same correlation like temperature except that it was negatively correlated. Similarly when salinity was correlated with all the different life history aspects in Seira indica, a more or less similar phenomenon as temperature was seen except that in addition to all the significant correlations as for temperature, salinity showed a positive correlation significant at $P < 0.05$ level. In addition to these individual correlations a multivariate analysis revealed high significance for all the stages of life history and that too highly significant at $P < 0.01$ levels in all cases except for the egg stage and the V instar where the level of significance was $P < 0.05$ (Table-LXXI).

In Seira lateralis temperature with either egg-numbers or number of instars showed no significance at all, except in the second instar stage where positive at $P < 0.05$ level. Between temperature and number of days involved in the life history it was seen to be significant for hatching and in instars I, II, positively significant at $P < 0.01$ in all cases wherever it was significant except the egg and the IV. Finally temperature with

Table LXXI : Showing the correlation coefficient between the various environmental factors like Temperature, pH and Salinity and the different life history stages of *Seira indica*.

TABLE LXXI

	EGGS	I	II	III	IV	V	VI
Temp./Egg No.	0.850**	0.233	0.302	0.307	0.272	0.344	0.262
Temp./Days	0.521*	0.285	0.293	0.210	-0.192	0.808**	0.713**
Temp./Egg Dia.	0.217	0.857**	-0.041	0.819**	0.790**	-0.350	0.843**
pH/Egg No.	-0.956**	-0.082	-0.191	-0.301	-0.154	-0.286	-0.171
pH/Days	-0.579**	-0.031	-0.023	0.010	0.380	-0.826**	-0.640**
pH/Egg Dia.	-0.363	-0.951**	0.042	-0.741**	-0.658**	0.355	-0.811**
Sal./Egg No.	0.957**	-0.091	0.067	0.236	0.054	0.224	0.060
Sal./Days	0.624**	-0.233	-0.217	-0.132	-0.421	0.716	0.451
Sal./Egg Dia.	0.473**	0.954**	-0.099	0.545*	0.472*	-0.308	0.674**
Mult. Cor.	0.503*	0.968**	0.500*	0.987**	0.873**	0.500*	0.947**

* = $p < 0.05$

** = $p < 0.01$

egg-diameter or length of the various instars it was seen to be positively significant in all the cases except V instar and at a level of $P < 0.01$ except the egg and the fourth instar stage where it was at $P < 0.05$. The next factor, pH when correlated was seen to be non-significant either for the egg-number and the number of different instars, but it was negatively significant when correlated with either the number of days or the measurements of the various stages at $P < 0.01$ level in the egg stage and in I, II and III instar except for IV instar where correlation with measurement which was significant at $P < 0.05$ level. The third factor, salinity was similar to pH except that there was a non-significance for the third instar and number of days, while for the first instar for the length measurement, where though significant which was at only $P \leq 0.05$ level. The multiple correlation values were all positively significant at $P \leq 0.01$ (Table-LXXII).

In Salina Yosii the various environmental factors seem to follow a similar pattern of significant correlations in that whether it was temperature, pH or salinity, it was seen only for temperature and the number of II instars at $P \leq 0.01$ level while in all other it was not significant. Similarly, the number of days when correlated with these three environmental factors, it was seen that temperature and pH were similar to each other, except that it was in former positively significant and latter negatively significant at $P < 0.01$ level either for egg-hatchability or for the development of the I, II, IV and V instars, while salinity showed a positive relationship at $P < 0.01$ level for the length of days only for the eggs and the first instar. Temperature and pH with the measurements again were similar except the former was positive and latter was negative at $P < 0.01$ level, for the egg-diameter only. It was also so for salinity except that it was at

Table LXXII : Showing the correlation coefficient between the various environmental factors like Temperature, pH and Salinity and the different life history stages of Seira lateralis.

TABLE LXXII

	EGGS	I	II	III	IV	V	VI
Temp./Egg No.	0.101	0.195	0.444	-0.073	0.369	0.275	0.194
Temp./Days	0.732**	0.904**	0.726**	0.213	-0.293	-0.263	-0.311
Temp./Egg Dia.	0.529*	0.838**	0.975**	0.780**	0.446*	0.308	0.711**
pH/Egg No.	-0.156	-0.029	-0.335	0.128	-0.312	-0.261	-0.118
pH/Days	-0.934**	-0.991**	-0.935**	-0.574**	-0.094	-0.109	0.006
pH/Egg Dia.	-0.692**	-0.708**	-0.885**	-0.487*	-0.080	0.076	-0.348
Sal./Egg No.	0.208	-0.095	0.212	0.059	0.200	0.204	0.042
Sal./Days	0.990**	0.963**	0.967**	-0.082	0.324	0.292	0.041
Sal./Egg Dia.	0.713**	0.498*	0.738**	0.465*	-0.146	-0.320	0.176
Mult. Cor.	0.663**	0.979**	0.984**	0.966**	0.934**	0.967**	0.991**

* = $P < 0.05$

** = $P < 0.01$

$P < 0.05$ levels. All the othere were non-significant for any of the three environmental factors undertaken. The multiple correlation showed a positive significance in all cases at $P < 0.01$ level except for the V instar where the level was $P < 0.05$ and for the Ist it was not significant (Table-LXXIII).

In Entomobrya kali when the correlations were made, it was seen that the various environmental factors with either the number of eggs or number of instars had no significance except when pH showed a negative significance only for the I instar at $P \leq 0.01$ level. Similarly when the number of days were undertaken the eggs hatching period was shown to be significant with all environmental factors at $P \leq 0.05$ level except that pH was negatively significant. Temperature showed a positive significance also for the first instar at $P < 0.05$ and for salinity at $P \leq 0.01$ level for the second instar. The measurements when correlated, it was seen that both temperature and pH showed non-significants for the eggs while salinity showed negative significance at $P \leq 0.05$ level, while pH and salinity showed non-significance for all instars and temperature only for IV instar at $P < 0.01$ level. Multiple correlation again, was seen to be highly positively significant at $P < 0.01$ level except for the first instar where they were not significant (Table-LXXIV).

Table LXXIII : Showing the correlation coefficient between the various environmental factors like temperature, pH and Salinity and the different life history stages of *Salina yosii*.

TABLE LXXIII

	EGGS	I	II	III	IV	V	VI
Temp./Egg No.	0.177	-0.040	0.880**	0.402	0.290	0.283	0.305
Temp./Days	0.890**	0.911**	0.750**	0.116	0.746**	0.686**	0.206
Temp./Egg Dia.	0.762**	0.193	0.176	0.302	0.335	0.038	0.193
pH/Egg No.	-0.109	-0.135	-0.324	-0.361	-0.264	-0.215	-0.354
pH/Days	-0.980**	-0.975**	-0.568**	0.114	-0.573**	-0.493	0.039
pH/Egg Dia	-0.663**	-0.232	0.082	-0.033	-0.103	-0.230	0.058
Sal./Egg No.	0.038	0.245	0.205	0.267	0.171	0.168	0.034
Sal./Days	0.958**	0.910**	0.339	-0.234	0.347	0.279	-0.257
Sal./Egg Dia.	0.532*	0.308	-0.338	-0.237	-0.184	0.306	-0.326
Mult. Cor.	0.732**	0.397	0.978**	0.996**	0.983**	0.456*	0.999**

* = $P < 0.05$

** = $P < 0.01$

Table LXXIV : Showing the correlation coefficient between the various environmental factors like temperature, pH and salinity and the different life history stages of Entomobrya kali.

TABLE LXXIV

	EGGS	I	II	III	IV	V	VI
Temp./Egg No.	0.428	0.188	0.182	0.146	0.330	0.226	0.235
Temp./Days	0.881**	0.489*	0.250	0.204	0.324	0.422	0.232
Temp/Egg Dia.	-0.166	0.166	0.119	0.206	0.460*	0.365	0.319
pH/Egg No.	-0.306	-0.892**	-0.034	-0.026	-0.166	-0.150	-0.154
pH/Days	-0.773**	-0.389	-0.103	-0.084	-0.208	-0.307	-0.153
pH/Egg Dia.	0.361	-0.096	0.123	0.037	-0.231	-0.123	-0.113
Sal./Egg No.	0.148	-0.130	-0.113	-0.086	0.000	0.119	0.054
Sal./Days	0.651**	0.396	0.837**	0.098	0.226	0.308	0.201
Sal./Egg Dia.	-0.553**	0.069	-0.373	-0.273	0.000	-0.130	-0.169
Mult. Cor.	0.882**	0.139	0.993**	0.986**	0.985**	0.996**	0.999**

* = $P < 0.05$

** = $P < 0.01$

DISCUSSION

The present study incorporated the life history of four dominant species of collembola of the family Entomobryidae from jhum sites, two species from the youngest and two from the oldest abandoned fallow. The primary aim was to identify from these life history studies, whether the population dynamics could be correlated and hence the experiments were conducted under laboratory conditions. It is known that in many collembola the length of life-cycle varies with the species and the time of year when eggs are laid, but usually the development stages till the attainment of adults or sexual mature state, occurs within the period of year at the higher latitudes. However, in most cases two or more generations may be produced within a year.

In these experiments, it was seen that though the species undertaken were different from each other and also inhabiting different soil conditions, yet they revealed similarities of many aspects in their life-history strategies Seira indica revealed maximum production of eggs, maximum percentage of hatching and maximum size either of the egg diameter or the instar length to be always in the experiment of higher temperature and salinity and lower pH. A similar situation like Seira indica was also seen in Seira lateralis except that the number of eggs laid and the size of the eggs and different instars were more. Salina yosii also revealed a similar trend as for Seira indica and Seira lateralis except that the eggs were nearly double that of S. indica and one and half times that of S. lateralis. The measurements (egg diameter or the instar lengths) were further increased this species. All other aspects like percentage hatching etc. was similar to S. indica and S. lateralis. The last Entomobrya kali showed the lowest oviposition in comparison to all others. All

the other aspects were similar to S. indica. Percentage hatching was however maximum at the lower temperatures for this species.

The percentage of mortality in various instars was minimum in S. indica under maximum temperature and salinity and with low pH conditions only for the first instar unlike from II to VI instars it was maximum. In case of S. lateralis it was more or less similar to S. indica. In Salina yosii the maximum percentage mortality was seen in first instar under low temperature and salinity with high pH in contrast to S. indica and S. lateralis. The second instar, however, showed a reverse trend, while the subsequent instars did not reveal any significant increases in mortality under the different experimental set ups. In Entomobrya kali, the percentage of mortality in various instars was more or less similar under different experimental set ups.

While considering the percentage of adults, it was more or less the same under all experimental set ups while the maximum, male-female ratio was seen under medium temperature and it was more or less like this phenomenon also in S. lateralis. In Salina yosii, the maximum percentage of adults was seen under low temperature series, while the ratio (male-female) remained constant under all experiments, as also from E. kali.

From the above, it was seen that it was primarily the relation of temperature which was related to either egg-development, duration of each instar, total life span of species and the production of males and females. It seems that the higher the temperature, the more rapid were their developments. Further it looked that salinity also which was maximum at these higher temperatures might have played some role along with low pH. Green (1964a) revealed that limited reproductive period observed in laboratory conditions, will be different from field because the period of

development was seen to be nearly three times under culture conditions in contrast to field. This was supported by Snider (1973) who got maximum eggs of Folsomia candida and also that the maximum longivity was attained. These are further supported by Marshall and Kevan (1962). The greatest fecundity in the present study was seen for Salina yosii where the longivity was also maximum in comparison to the others. The fecundity being less or the development period being enhanced may be attributed to the accumulation of excretory products which might contaminate the surface of cultures. Christiansen (1967) found a depression of reproduction in non-cultures of several species of collembola, It was for this, that Snider (1973) transferred her animals to fresh cultures whenever it was found to be contaminated. Moreover the attribution of density could have played another important role in the growth and rate of development. Green (1964b) showed that fecundity was increased by reducing the density of overcrowded cultures.

However, it was seen from the present study that the higher temperature and salinity did show a definite relationship to fecundity and rate of development in all the species studied. At high temperatures, it is known that there is a general increase in the metabolic rate, which has a greater utilization of food. Further as Agrell (1941) pointed out that the tolerance for the temperatures is greater in adults than the young ones. The optimum temperature for hatching was shown to be (22-24°C) by Marshall and Kovan (1962); while Snider (1971) revealed that 21°C was the optimum. Choudhuri (1963) though states that temperature is one criteria for the percentage of egg to complete the development yet he could find no significant differences between the wide range of temperatures which he had used for Onychiurus.

As for pH there are very little reports. However, it was

known that the charcoal and plaster in the various ratios resulting in different pH values have had a profound effect on the fecundity and longivity of collembola species (Hutson, 1978). The substrate pH indirectly affects bacteria and fungi and this variations in food utilised in relation to type and quality of the diet influences collembola growth and fecundity (Snider, 1971). The pH in the present experiments though operating significantly was definitely coupled with their relationships and effects on fecundity and developmwnt with that of temperature and salinity. Hale (1965b; 1965c) had showed eggs being reduced at lower pH but simultaneously at optimum temperatures. Sharma and Kevan (1963a) found similar results as by Milne (1960) at very low temperatures. These results cannot be compared since they are rather low for the number of eggs per female per batch.

The factor of salinity again has very little comparison in earlier literature. However, it was seen that at higher salinity levels maximum growth and development had taken place. This is understandable as in the field conditions the conductance values have also been quite high during the high levels of population density. This is in confirmation of the study of Hutson (1974, 1978), who showed that at higher conductivity collembola species is able to survive and reproduce adequately. Such results are comparable with plant ecologists that the yield of crops is directly related to conductance, therefore to salinity.

Even though the above interpretation have been given between the main environmental factors and life history strategies it was generally seen that temperature as an environmental factor showed only positive significant for S. indica in relation to fecundity while all others were non-significant. Hence temperature does not really play a major role in oviposition. Similarly

except for the II instar for S. lateralis and Salina yosii where there was a positive significance, in all other cases it was not significant. Therefore it seems that the mortality was not affected by temperature. The length of days in relation to temperature was seen to be operative for the hatching in all the species and for Salina yosii in most of the instars, while in Seira indica in last two instars and for Seira lateralis the first two instars. In this case it does reveal that temperature played a role in the development time either for the hatching period or for the different molts. In relation to the size it was seen that temperature was significantly related only for Seira lateralis and Salina yosii for egg diameter, In Seira indica and Seira lateralis, for all other instars there was some significance, while for Salina yosii there was totally non-significance and for Entomobrya kali for only IVth instar, Therefore the size affected by temperature only for some, not for others. This sort of temperature variations in relation to different correlations show that for the species like Seira indica and Seira lateralis from the youngest abandoned fallow there is quite some significance while for older abandoned fallow species like Salina yosii and Entomobrya kali there was very little significance, with temperature. This proves that established species have very little variations with minor fluctuations of temperature.

pH as next environmental factor was seen to be significantly correlated in all cases wherever but negatively. Only in Seira indica fecundity was correlated with pH while in other species it was not significant. Therefore like temperature, pH also does not play any significant role in the oviposition rate. Similarly it did not show any significance for the mortality of all the instars in any of these species. In relation to length

of days of development and pH, it showed that there was significance in all the species for hatching, though negative. In Seira lateralis and Salina yosii the length of developmental days of earlier instars also showed significance negative relationships while for Seira indica it was for last two instars. This showed like temperature that there was some relationship except that it was in negative. For the measurements, also pH showed a similar correlation in the different species except that it was always negatively correlated.

Salinity also revealed a similar pattern like temperature for either fecundity or the number of instars as well as for the length of days of development and for different measurements.

It was further seen that in most cases for all the species the multiple correlation was highly significant. This therefore proves that temperature and salinity acts positively in that with increase in temperature and salinity, there is a definite relationship with the length of days and the size, while it is negatively significant for pH, hence higher the pH lower these possibilities.

REFERENCES

Agrell, L. 1941 Zur Okologie der collembolen. Untersuchungen im Schwedischen Lappland opuscula. Entomol. Suppl. III : 1-236.

Ashraf, M. 1969 Studies on the biology of Collembola. Rev. Ecol. Biol. Sol. 6 : 337-347.

Britt, N.W. 1951 Observations on the life history of the collembolan Achorutes armatus. Trans. Amer. Micr. Soc. 70 : 119-132.

Choudhuri, D.K. 1960 Influence of temperature on the development of Onychiurus furciferus (Borner) and its mathematical representation. Proc. Zool. Soc. Calcutta, 13 : 123-128.

——————— 1963 Temperature and its effect on the three species of the genus Onychiurus collembola. Proc. Zool. Soc., Calcutta, 16 : 97-117.

Christiansen, K. 1967 Competition between collembolan species in culture jars. Rev. Ecol. Biol. Sol. 4 : 439-462.

Davidson, J. 1934 The "Lucerneflea", Sminthurus viridis L. (Collembola) in Australia. Bull. Counc. Sci. ind. Res. (Aust). 79 : 1-66.

Gisin, H. 1943 Okologie und Lebensgemeinschaften der collembola im Schweizerischen Exkursionsgebiet Basels. Rev. Suisse. Zool. 50 : 131-224.

Goto, H.E. 1960a Simple techniques for the rearing of Collembola and a note on the use of a fungistatic substance in the cultures. Entomologists mon. Mag. 96 : 138-140.

Green, C.D. 1964a The life history and fecundity of Folsomia candida (Willem) var. distincta (Bagnall) (Collembola : Isotomidae). Proc. R. ent. Soc. Lond. (A) 39 : 125-128.

——————— 1964b The effect of crowding upon the fecundity of Folsomia candida (Willem) var. distincta (Bagnell) (Collembolla). Ent. exp. appl. 7 : 62-70.

Hale, W.G. 1965a Observations on the breeding biology of Collembola (I). Pedobiologia. 5 : 146-152.

——————— 1965b Observations on the breeding biology of Collembola (II).Pedobiologia. 5 : 161-177.

Hutson, B.R. 1974 Ph.D. Thesis, University of New Castle upon Tyne.

Hutson, B.R. 1978 Effects of variations of the plaster charcoal culture method on a collembolan, Folsomia candida. Pedobiologia, 18:138-144.

Maclagen, D.S. 1932 An ecological study of the "Lucerneflea" (Sminthurus viridis L.). Bull. ent. Res. 23 : 101-145.

Marshall, V.G. & D.K. McE Kevan. 1962 Preliminary observations on the biology of Folsomia candida Willem, 1902 (Collembola : Isotomidae). Can. Ent. 94 : 575-586.

Milne, S. 1960 Studies on the life histories of various species of arthropeone collembola. Proc. R. ent. Soc. Lond. (A) 35 : 133-140.

Niijima, K. 1973 Experimental studies on the life history, fecundity and growth of Sinella curviseta (Apterygota, Collembola). Pedobiologia. 13 : 186-204.

Richards, L.A. (Ed.) 1954 The diagnosis and improvement of saline and alkali soils. U.S. Dep. Agric. Handbook No. 60.

Sharma, G.D. & D.K. McE Kevan. 1963a Observations on Isotoma notabilis (Collembola : Isotomidae) in Eastern Canada. Pedobiologia. 3 : 34-47.

Snider, R.J. 1971 Dietary influence on the growth and fecundity of Onychiurus justi (Denis) (Onychiuridae : Collembola). Proc. IV Coll. Pedobiologia, 226-234.p.

Snider, R.M. 1973 Laboratory observations on the biology of Folsomia candida (Willem) (Collembola : Isotomidae). Rev. Ecol. Biol. Sol, 10 : 103-124.

_____ & J.W. Butcher. 1973 The life history of Folsomia candida (Willem) (Collembola : Isotomidae) relative to temperature. Great Lakes Entomol. 6 : 97-106.

Usher, M.B., B.C. Longstaff & D.R. Southall. 1971 Studies on populations of Folsomia candida (Insecta : Collembola). Oecologia (Berl.). 7 : 68-79.

Vail, P.V. 1965 Colonization of Hypogastrura manubrialis (Collembola : Poduridae) with notes on its biology. Ann. ent. Soc. Am. 58 : 555-561.

FOOD AND FEEDING

INTRODUCTION

The process of recycling of nutrients and the flow of energy between different trophic levels is greatly influenced by the soil organism and their biotic relationships. In spite of the importance of such studies, many aspects are still unknown either in relation to structural and functional phenomnon of the trophic relationships of arthropods living in the soil. This is very true especially among those groups of animals where attempts have been made and which dominate any soil ecosystem like collembola. Most studies exist on the aspects of ecology connected with nutrition biology of collembola in particular to litter decomposition and thereby formation of soil and very little on the natural feeding behaviour of these groups of animal in the field.

One of the earliest reports in relation to feeding biology of the collembola was by Agrell (1941) who showed the occurrenco of empty guts to dry condition in the soil and litter in Anurophorus laricis, Day (1950) showed during the studies of earthworm that bacteria does not get affected by passage through the gut. Hutchinson (1951) also showed the effect of physico-chemical instability of the litter and humus microhabitats for the incorporation of fugitive species. The type of vegetation in a region, was reported to be indirectly affected and exerted the influence of the microfloral composition in the soil (Bellinger, 1954). The increase to about two-thirds of the bacteria in the soil was attributed to the mixing of the organic and mineral particles by earthworms and millipedes (Kollmansperger, 1956). Such mixing is also attributed to the tranlocation of those fragments from the litter layer to lower horizon of the soil (Macfadyen, 1957). Periodic non-feeding phases associated with moulting in collembola population was well documented by Poole (1959). Certain micro-

flora are reported to be present as gut symbionts in collembola having an important role in the digestion of plant material (Torne, 1961). The distribution of collembola is directly proportional to the distribution of fungi on which they feed (Knight, 1961) and that they are greatly influenced by humidity conditions of the habitat (Poole, 1961), Individual preferences of certain plants by collembola species are known to be established (Dunger, 1962). Such populations when aggregated is known to play atleast a peripheral role in soil processes (Macfadyen, 1963). Under culture experiments of feeding, it was shown by Sharma and Kevan (1963b; 1963c) that populations of collembola fail to reproduce on a diet lacking in plant material and showed occassional cannibalistic behaviour, However, Christensen (1964) showed food preferences was quite a wide range, and that Bacillus sp, in the gut of collembola was capable of digesting chitin thereby further confirming the fact that collembola and micro- or macroflora are directly proportional, In any case the distinction between ingested and assimilated was shown by Healey (1965) that certain collembola species utilised only fats and carbohydrates in fungal hyphae without interferring with the reproductive structures of the fungus. Healey (1965) also showed that collembola species can survive upto eighteen months in a state of facultative diapause without feeding.

Knight and Angel (1967) showed that the average collembola spend an inactive or semiactive state for nearly 40-50% of its adults life. Von Torne (1967a; 1967b) had shown the activity of the collembola own gut-enzyme complement along with coprophagy could be responsible for the utilization of common resources. The bacterial contents of the soil and the migration of the collembola to higher densities of the former was shown to be reciprocal

by Stebaeva (1967). The lack of breaking down cellulose in collembola was reported by Zinkler (1969) and that the diminution of leaves after passing through guts is the initial step of the decomposition cycle (Tikhomirov, 1969). The action of fungi on much materials could be immediate as they are known to adapt physiologically to wide range of concentration of nitrogen (Levi and Cowling, 1969), for the growth and regulation of animal populations depended on the food quality (Watson, 1970). This is supported by the fact that the individuals of the same species differing in the gut contents from different habitats, is greater than in individuals of different species guts in the same habitats (Gilmore and Raftensperger, 1970; Bodvarsson, 1970). Further confirmation to this have been shown by McMillan and Healey (1971) where collembola species living together show gut contents very similar.

The nutritional differences between species of fungi with respect to feeding of collembola was shown by Mills and Sinha (1971) which was coupled with the infrequent feeding behaviour of collembola (Dewith and Joose, 1971). This is further supported by the fact that most collembola species are more or less unspecialized feeders (Petersen, 1971; Massoud, 1971; Luxton, 1972). Such low degree of specialization was associated with excess of food available (Anderson and Healey, 1972) and that scarcity of food was an important source of stability in reducing the amplitude of population fluctuations (Smith, 1972). Further, Jones (1972) showed the secretion of toxic substances from root system to control populations.

The importance of food available under field conditions was shown by Emlen (1973) as an adaptation to varied diet would only seem a selective advantage under laboratory conditions. A direct relationship between fauna and flora in agricultural tilled soil

was shown by Kines and Sinha (1973). Moreover, at any one time the greater part of a population does not take part in the utilization of food resources (McMillan, 1975).

Fungi from the onset of decay of plant remains incorporates a major protion of labile nutrients in microbial tissues which represents a high quality of food resources for soil invertebrates (Smith, 1976). This along with the nutritional values and physiological activities is helped by the wide adaptability to the nitrogen (Dowding, 1976; Parks, 1976). Causes of starvation leads to mass migration of the animals and is directly related to rainfall after a dry period in inducing high feeding activities among soil-lembola species (Joosse, 1976). In this respect Mitchell and Parkinson (1976) revealed the feeding attributes of a fauna in relation to its role to decomposition.

Joosse and Testrink (1977a; 1977b) attributed food scarcity to establishing populations and predation (Earnsting, 1977) and soil moisture (Verhoef, 1977) for the regulation and survival of some collembola populations.

Work on Indian collembola and their feeding behaviour does not exist by themselves except that of Singh (1969) and if at all present they are in relation with either the general studies or life history strategies. Hence the aim of present work was to identify among some dominant species of collembola present in the different abandoned fallows and especially the youngest and oldest and to see their feeding behaviour. This aspect was taken up also to find out whether the soil fertility was restored and nutrient recycling was done by these dominant species of collembola in such soils. All comparison of the feeding of the four species undertaken by what is present in their gut contents was therefore

coreelated with one major group of microflora namely fungi of the soil. Also their studies were carried out seasonally for a period of one annual cycle to identify the selectiveness or non-selectiveness of the food (fungi) as present in the soil correlated with that present in the gut.

MATERIAL AND METHODS

The four species undertaken were the same as for the life history studies. The extraction for these studies were also similarly done as shown earlier in that chapter. Every month replicates of 5 from each species collected and extracted from field were used for the studies..

Immediately after collection of the species the gut of the individual species were teased out from five individuals each. These guts were then placed in the dilution plate for culture and cut open and spread out on the media with the help of a spray of triple distilled water. Hence five plates were prepared for each species every month. The soil was taken from the two sites (A and B) where these species occurred and a similar soil dilution plate method was used to isolate the fungi. In this case 10 gm of soil from each site and replicate samples of five were placed in 100 ml of triple distilled water in a 250 ml. Erlenmayer flask and blended for 1 minute for each replicate sample (5) for both soil samples from both sites and hence a total of 10 plates were prepared every month. Final dilution of 1 to 10,000 were used for isolation. The media selected was Martin's rose $\pm$ Bengal Agar (Martin,1950).

Such plates both for the gut contents of the collembola s species and soil samples amounting to 20 (animals) and 10 soil replicates were incubated every month at 25 $\pm$ 1 for 5 days. After this period the plates were removed, the fungi identified upto species whereever possible or at least to genera and such identified colonies counted and expressed, as percentages of the total. The co-efficient of variation was calculated (Ivlev, 1961). All the above was done for a period of one year beginning January, 1978.

RESULTS

The present study was conducted on four species of dominant collembola species found in two abandoned fallows (Site A and Site D), the youngest and oldest respectively. One common finding in both the sites of the fungi from top soil layers in these abandoned fallows was that a total of 21 species of fungi were recorded, irrespective of the age of the fallow. Of these 21 species, when the total year was taken into consideration, it was seen that Trichoderma viride, Pers, ex. Gray was maximum in the soil (nearly 16%) followed by Penicillium chrysogenum, Thom. (15%), Aspergillus niger, Van Tiegham (14%) and Fusarium sp. (12%), in the soil of the youngest abandoned fallow (Site A). All the others recorded less than 10% with Penicillium nigricans, Bainier, Thom. (9%) and the least were Cladosporium sp., Acremonium sp. and Verticillium sp. all recording only 0.8% (Fig. 25).

A similar analysis of the soil in the oldest abandoned fallow (Site D) when seen for the whole year, revealed that the maximum occurrence of the surface layer of this site was that of Penicillium nigricans (13%). All the others recorded below 10% with only Aspergillus niger (nearly 10%). The least occurred species in this site were those of Actinomucor sp., Verticillium sp. and Scopullariopsis sp., all recording around 1.5% (Fig. 26).

As seen for the soil throughout the annual cycle, it was seen that in the gut of the various species undertaken that in Seira indica, the maximum occurrence of the fungi Trichoderma viride amounting nearly 24% followed by Fusarium sp. of nearly 23%. Hence these two species formed nearly 50% of those found in the gut while the ones not recorded at all throughout the year, though present in the soil were Cladosporium sp., Mucor hiemalis, Wehmer, Acremonium sp., Cunninghamella sp., Actinomucor sp.,

Verticillium sp., and Scopullariopsis sp. Hence out of 21 species of fungi found in the soil, only 14 species were recorded in the gut in this species (Fig. 25).

In Seira lateralis Yosii when so observed it was seen that Fusarium sp. formed nearly 25% in the gut when the whole year was taken into consideration, followed by Alternaria alternata (Fries) Keissler and Penicillium chrysogenum both around 12%. Hence in this species of Collembola these three groups of fungi occupied nearly 50% of the total fungi in the gut. Again in this species, it was seen that seven fungi were absent which were Pythium sp., Mucor hiemalis, Acremonium sp., Cunninghamella sp., Actinomucor sp., Verticillium sp. and Scopullariopsis sp. It was therefore observed in this species of Collembola Seira lateralis that again only 14 species of fungi were recorded in the gut, out of the 21 species available in soil (Fig.25).

In the oldest abandoned fallow when a similar observation was made for the two dominant species of Collembola undertaken, it was seen for Salina yosii Salmon, that Alternaria alternata was recorded maximum in the gut (18%) followed by Fusarium sp. (14%). All the others recorded less than 10% with only Trichoderma viride recording nearly 10%. Here again as in the earlier species some fungi species were totally absent in the gut. They were Mucor hiemalis, Acremonium sp., Cunninghamella sp., Actinomucor sp., Verticillium sp. and Scopullariopsis sp. Hence out of 21 species of fungi present in the soil only 15 were available in the gut of Salina yosii (Fig. 26).

In the fourth species of Collembola, Entomobrya kali, Imms, when a similar observation was made in the gut for the total year, it was seen that Alternaria alternata and Fusarium sp. occupied nearly 15% each as maximum records among the groups of fungi present in the gut. All others were below 10% with only Penicillium nigricans, showing 9.3% as third in order of dominance. Here again like Salina yosii in the same site the same six groups of fungi were totally absent in the gut (Fig. 26).

Fig. 25 : Showing the different species of fungi in the soil of study site A and in the guts of the two species of Collembola - Seira indica and Seira lateralis as percentages throughout the study period.

: Seira indica;	: Soil;	: Seira lateralis;
1) Trichoderma viride	11) Alternaria alternata	
2) Aspergillus niger	12) Fusarium sp.	
3) Penicillium chrysogenum	13) Cephalosporium sp.	
4) Penicillium nigricans	14) Cladosporium sp.	
5) Mycogone sp.	15) Doratomyces sp.	
6) Absidia spinosa	16) Pythium sp.	
7) Absidia sp.	17) Acremonium sp.	
8) Mucor racemosus	18) Cunninghamella sp.	
9) Mucor circinelloides	19) Actinomucor sp.	
10) Mucor hiemalis	20) Verticillium sp.	
	21) Scopulariopsis sp.	

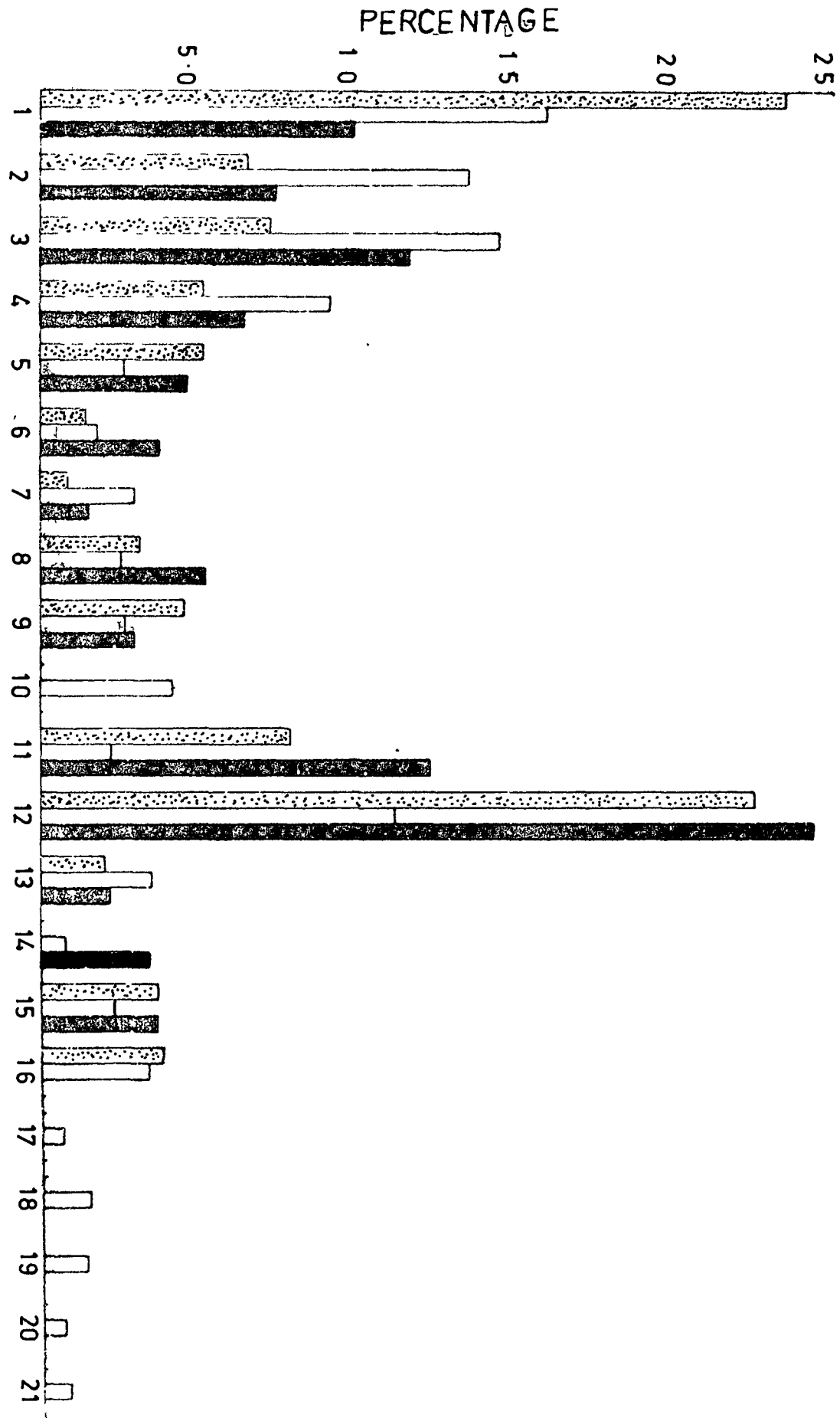
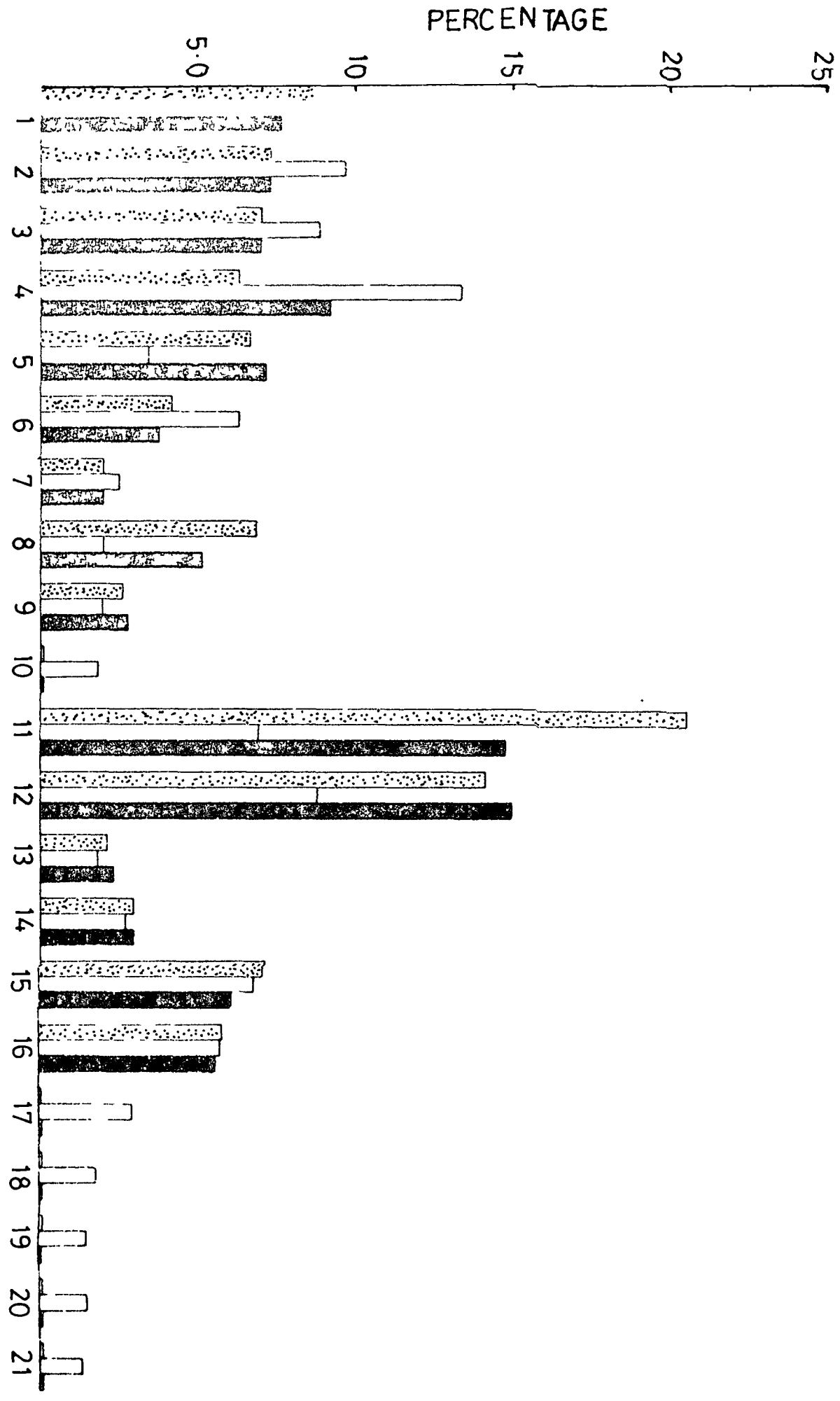

PERCENTAGE
5.0
10
15
20
25
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

Fig. 26 : Showing the different species of fungi in the soil of study site D and in the guts of the two species of Collembola - Salina yosii and Entomobrya kali as percentages throughout the study period.

: Salina yosii;	: Soil;	: Entomobrya kali;
1) Trichoderma viride		11) Alternaria alternata
2) Aspergillus niger		12) Fusarium sp.
3) Penicillium chrysogenum		13) Cephalosporium sp.
4) Penicillium nigricans		14) Cladosporium sp.
5) Mycogone sp.		15) Doratomyces sp.
6) Absidia spinosa		16) Pythium sp.
7) Absidia sp.		17) Acremonium sp.
8) Mucor racemosus		18) Cunninghamella sp.
9) Mucor circinelloides		19) Actinomucor sp.
10) Mucor hiemalis		20) Verticillium sp.
		21) Scopulariopsis sp.


PERCENTAGE
5·0
10
15
20
25
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

After the general observation for the whole year as shown above, it was now felt to see the seasonal fluctuations and their trends whethere in the soil or in the gut of the various species of Collembola undertaken in the present study. In site A, the fungi isolated from the surface layers revealed for those dominant species of fungi to have their peak period of abundance in the early spring to continue through the summer and decline, once monsoon sets in. In this respect Trichoderma viride recorded 45% in May, Penicillium chrysogenum, 25% in June. Aspergillus niger 31% in July, Fusarium sp. nearly 18% in March and Penicillium nigricans nearly 12% again in March. However, the same groups were seen to be minimum either during the early summer or late winter, like Trichoderma viride recorded nil in the month of April, Penicillium chrysogenum 5% in November, Aspergillus niger nil in January, Fusarium sp. nearly 2% in January, while Penicillium nigricans nil in May and June. In all other groups of fungi they were only around 10% or below (Table LXXV).

In site D, the seasonal trend when observed in the species of fungi present in different months on the surface layer of the soil revealed for the two dominant species, Penicillium nigricans and Aspergillus niger that the peak period of abundance was recorded in August and July respectively, while the minimum was seen in the month of January in both. It was also seen that there were five species which recorded at least 20% or more of the relative abundance at one or more months. These species were Absidia spinosa, Lendoner which recorded a maximum of 20% in the month of April, Alternaria alternata recorded 30%, maximum in the month of July and Fusarium sp., 30.1% again in July, while Doratomyces sp. recorded maximum of 20% in the month of May and finally Acremonium sp. again 20% in the month of January (Table-LXXV).

As seen for the soil in the two sites a seasonal trend in

Table XXXV : Showing the percentages of the various fungal species and their seasonal fluctuations in the soil of sites A and D.

1) *Trichoderma viride*
2) *Aspergillus niger*
3) *Penicillium chrysogenum*
4) *Penicillium nigricans*
5) *Mycone* sp.
6) *Absidia spinosa*
7) *Absidia* sp.
8) *Mucor racemosus*
9) *Mucor circinelloides*
10) *Mucor hiemalis*
11) *Alternaria alternata*
12) *Fusarium* sp.
13) *Cephalosporium* sp.
14) *Cladosporium* sp.
15) *Doratomyces* sp.
16) *Pythium* sp.
17) *Acremonium* sp.
18) *Cunninghamella* sp.
19) *Actinomucor* sp.
20) *Verticillium* sp.
21) *Scopulariopsis* sp.

TABLE LXXV

Site A

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
J	16.6	-	20.6	6.0	4.0	-	-	10.0	10.3	8.3	-	1.6	4.0	-	0.6	5.0	-	-	-	-	-
F	20.0	10.0	10.0	15.0	5.0	-	5.0	-	5.0	-	5.0	-	5.0	1.0	7.0	7.0	-	-	-	-	5.0
M	25.0	17.9	10.0	1.8	-	-	-	-	-	7.0	-	17.9	-	-	9.6	9.0	-	-	-	1.8	-
A	-	7.0	5.2	5.0	-	7.0	-	-	-	16.3	-	15.9	9.3	-	5.0	2.3	-	2.3	-	-	-
M	45.5	17.3	10.0	10.0	9.1	-	-	-	-	-	-	9.1	-	-	-	-	5.2	-	5.0	-	-
J	13.5	25.0	25.0	25.0	-	-	-	-	-	3.8	3.9	19.6	-	-	-	3.8	-	-	-	-	-
J	10.3	31.0	20.0	-	2.0	-	-	-	-	4.1	-	14.3	-	-	-	8.2	-	-	-	6.1	4.1
A	14.5	29.1	20.0	3.6	-	-	5.5	3.6	-	5.5	1.8	14.5	-	-	-	-	-	1.8	-	-	-
S	9.7	16.1	6.5	6.5	-	8.1	10.6	10.0	10.0	-	10.0	10.0	-	-	-	-	-	3.2	-	-	-
O	4.2	3.8	15.3	16.0	4.2	5.0	6.0	5.0	5.0	2.0	5.0	16.7	-	-	-	1.0	1.0	3.0	3.0	1.0	3.0
N	6.2	4.3	5.4	5.0	7.0	-	5.0	-	-	2.0	-	17.0	13.5	8.1	3.0	2.0	2.7	2.0	2.7	1.0	3.0
D	15.9	1.8	15.9	15.9	-	1.0	5.0	1.0	3.0	2.3	2.0	10.9	10.4	1.0	3.0	3.0	1.0	-	6.8	-	1.0

Site D

J	8.4	-	5.0	5.0	-	-	-	-	-	10.0	5.8	5.0	5.0	26.3	10.0	10.0	20.0	3.2	3.3	3.3	3.3
F	9.6	5.0	5.0	7.5	5.0	-	2.0	-	10.0	5.0	10.0	9.6	3.0	7.5	2.0	3.9	2.0	3.0	2.0	3.0	5.0
M	7.0	13.7	13.7	10.0	-	-	-	-	10.0	4.8	3.3	10.0	-	-	7.1	10.0	1.0	2.0	3.0	2.0	2.0
A	-	15.0	10.0	20.0	-	20.0	-	-	-	1.0	-	5.0	-	-	5.0	5.0	1.0	1.0	1.0	1.0	-
M	-	5.8	5.0	8.9	-	10.0	-	-	-	2.7	-	5.1	-	-	20.0	10.0	8.9	10.0	5.4	5.4	2.7
J	9.2	10.0	1.5	10.0	-	2.0	-	6.5	-	-	30.0	30.8	-	-	-	-	-	-	-	-	-
J	5.7	20.0	12.3	30.0	-	8.6	-	-	-	-	12.9	10.0	-	-	-	-	-	-	-	-	-
A	4.1	50.0	15.0	27.6	5.0	6.9	5.0	9.5	-	-	15.0	10.0	2.9	2.0	2.0	2.0	-	-	-	-	-
S	5.1	15.4	10.0	10.0	10.0	10.0	4.0	14.4	-	-	8.6	6.0	5.1	5.4	10.0	5.0	-	-	-	-	-
O	8.2	10.0	7.7	10.0	15.9	2.0	10.9	-	1.4	-	-	8.0	2.3	4.5	16.0	14.0	1.0	1.0	1.0	1.0	1.0
N	11.2	7.6	11.8	10.0	2.0	17.6	5.0	-	1.8	-	-	5.0	2.0	5.0	4.5	6.5	2.5	2.5	1.5	1.5	2.0
D	10.9	10.2	10.0	12.0	5.0	14.8	4.0	-	1.1	-	-	3.4	2.0	5.0	6.5	10.0	1.0	1.0	1.0	1.0	1.0

the gut contents for the various species of fungi in the four different species of collembola was recorded. In Seira indica the two major species which were found in the gut contents were Trichoderma viride and Fusarium sp. which showed a maximum peak in July (50%) and November (45%) respectively. In addition to these two species, it was felt to see the occurrence of any species of fungi in the gut contents occupying more than 20%, at least once throughout the study period. When so observed, it was seen that Aspergillus niger recorded above 20% in the months of July and Optober in the former 31% and latter 21%, Penicillium chrysogenum, nearly 20% or more in the months of April and August while Absidia spinosa showed 20% only in the month of April and Mucor racemosus in the month of August (21%). Alternaria alternata showed in June and August, 38% and 29% respectively. In Mucor circinelloides Van Tieghem showed only in the month of January just 20% and Mycogone sp. revealed nearly 22% in the months of May and October. (Table-LXXVI).

In Seira lateralis when a similar analysis was made for the gut contents during the seasen, it was seen for the dominant groups like Fusarium sp., a record of 100% in the month of July and nil in the month of February, Alternaria alternata showed a maximum of 57% in the month of June, while Penicillium chrysogenum showed a maximum of 28.5% in the months of April and November. The groups of fungi which recorded 20% or more in one or more months during the study period, was seen in 5 fungal species. These are, Trichoderma viride, 20% abundance in the month of May and 28.5% in the month of November, while Aspergillus niger was 28.5% only in November and 23% in September. In Absidia spinosa, 28.5% was recorded in the month of April while Mucor racemosus, Fresenius showed 40% in August and 23% in September and Mycogone sp. showed 30% in May (Table-LXXVI).

Table LXXVI : Showing the percentages of the various fungal species and their seasonal fluctuations in the guts of Seira indica & Seira lateralis.

1) Trichoderma viride
2) Aspergillus niger
3) Penicillium chrysogenum
4) Penicillium nigricans
5) Mycena sp.
6) Absidia spinosa
7) Absidia sp.
8) Mucor racemosus
9) Mucor circinelloides
10) Mucor hiemalis
11) Alternaria alternata
12) Fusarium sp.
13) Cephalosporium sp.
14) Cladosporium sp.
15) Doratomyces sp.
16) Pythium sp.
17) Acremonium sp.
18) Cunninghamella sp.
19) Actinomucor sp.
20) Verticillium sp.
21) Scopulariopsis sp.

TABLE LXXVI

Seira indica

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN	20.0	-	13.3	06.7	13.3	-	-	-	20.0	-	-	13.3	-	-	13.3
FEB	5.5	5.5	-	11.1	5.5	-	11.1	-	16.6	16.6	-	11.1	-	11.1	5.5
MAR	11.8	11.8	17.6	11.8	-	-	-	-	-	-	17.6	-	-	17.6	11.8
APR	-	10.0	20.0	10.0	-	20.0	-	-	-	-	20.0	-	-	10.0	10.0
MAY	33.3	-	-	-	22.2	-	-	-	-	-	44.4	-	-	-	-
JUN	25.0	-	-	-	-	-	-	-	-	37.5	37.5	-	-	-	-
JUL	50.0	-	-	-	-	-	-	-	-	-	50.0	-	-	-	-
AUG	7.1	14.3	21.4	7.1	-	-	-	21.4	-	28.5	-	-	-	-	-
SEP	33.3	16.7	8.3	8.3	-	-	-	16.0	-	-	16.7	-	-	-	-
OCT	21.4	21.4	7.1	7.1	21.4	-	-	-	-	-	21.4	-	-	-	-
NOV	50.0	-	-	-	-	-	-	-	-	-	50.0	-	-	-	-
DEC	25.0	-	-	-	-	18.8	-	-	18.8	12.5	12.5	-	-	6.3	6.3

Seira lateralis

JAN	9.1	-	18.2	9.1	-	-	-	-	-	-	27.3	18.2	-	18.2	-
FEB	9.1	4.5	-	9.1	9.1	-	9.1	-	18.2	13.5	-	9.1	13.6	4.5	-
MAR	15.0	10.0	20.0	10.0	-	-	-	-	-	-	20.0	-	15.0	10.0	-
APR	-	7.1	28.6	7.1	-	28.6	-	-	-	-	14.3	-	7.1	7.1	-
MAY	20.0	-	-	-	30.0	-	-	-	-	-	50.0	-	-	-	-
JUN	-	-	-	-	-	-	-	-	-	57.1	42.9	-	-	-	-
JUL	-	-	-	-	-	-	-	-	-	-	100.0	-	-	-	-
AUG	-	-	-	10.0	-	-	-	40.0	-	50.0	-	-	-	-	-
SEP	15.4	23.1	15.4	-	-	-	3.1	-	-	7.7	-	-	-	-	-
OCT	16.7	16.7	25.0	16.7	16.7	-	-	-	-	-	8.3	-	-	-	-
NOV	28.5	28.5	28.5	-	-	-	-	-	-	-	14.3	-	-	-	-
DEC.	4.5	-	4.5	-	-	18.2	9.1	-	18.2	27.2	9.1	-	4.5	4.5	-

In Salina yosii, when the dominant species were undertaken to see the seasonal fluctuations in the fungi present in the gut, it was seen that Fusarium sp. and Alternaria alternata occurred 50% in the month of July, while Trichoderma viride recorded a maximum of nearly 27% in the month of October. Those species which were 20% or more in any month was seen to be in Aspergillus niger and Penicillium chrysogenum which recorded 20% as maximum in the month of October, while in Absidia spinosa 33% in the month of August and in Mucor recemosus a peak of 67% was recorded in the month of August. The remaining species were Mycogone sp, which recorded a maximum of 50% in May, Doratomyces sp, maximum of 20% was seen in the month of October and Pythium sp, 23% in August (Table LXXVII).

In Entomobrya kali, the seasonal fluctuations of dominant groups when observed were seen as in the case of Alternaria alternata that a peak of nearly 70% was observed in the month of June with a slight drop to 60% in the month of July and reduced to nearly half (28%) in the month of August. Fusarium sp., maximum was seen in the month of May (45%) while it dropped to nearly 30% (29.5%) in the month of June, again increased to 40% in July, while Penicillium nigricans showed two peaks of abundance, one in August (27%) and the other in January (21%). Those species which recorded 20% or more in any month other than the dominant species above was in Aspergillus niger which recorded nearly 21% in the month of September as maximum peak, Absidia spinosa showed only 20% in the month of April as maximum, Mucor recemosus (45%) in the month of August, while in Mycogone sp. nearly 55% was recorded as maximum in the month of May, Doratomyces sp. recorded a peak of 25% in the month of October and Pythium sp. in the month of April with 20% (Table LXXVII).

Table LXXVII : Showing the percentages of the various fungal species and their seasonal fluctuations in the guts of the *Salina yoaii* and *Entomobrya kali*.

1) *Trichoderma viride*
2) *Asperoillus niger*
3) *Penicillium chrysogenum*
4) *Penicillium nigricans*
5) *Mycogone* sp.
6) *Absidia spinosa*
7) *Absidia* sp.
8) *Mucor racemosus*
9) *Mucor circinelloides*
10) *Mucor hiemalis*
11) *Alternaria alternata*
12) *Fusarium* sp.
13) *Cephalosporium* sp.
14) *Cladosporium* sp.
15) *Doratomyces* sp.
16) *Pythium* sp.
17) *Acremonium* sp.
18) *Cunninghamella* sp.
19) *Actinomucor* sp.
20) *Verticillium* sp.
21) *Scopullariopsis* sp.

TABLE LXXVII

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Salina yosii															
JAN	11.8	-	17.6	17.6	-	-	-	-	-	5.9	11.8	11.8	5.9	-	17.6
FEB	9.1	6.1	3.0	9.1	9.1	-	6.1	-	15.2	9.1	-	9.1	9.1	9.1	6.1
MAR	19.0	14.3	19.0	4.8	-	-	-	-	-	-	9.5	-	-	19.0	14.3
APR	-	15.4	7.7	17.7	-	23.1	-	-	-	-	7.7	-	-	15.4	23.1
MAY	-	-	-	-	50.0	-	-	-	-	40.0	10.0	-	-	-	-
JUN	-	-	-	-	-	-	-	-	-	84.0	16.0	-	-	-	-
JUL	-	-	-	-	-	-	-	-	-	50.0	50.0	-	-	-	-
AUG	-	-	-	16.7	-	-	-	66.7	-	16.7	-	-	-	-	-
SEP	17.6	17.6	11.8	11.8	11.8	-	-	17.6	-	5.9	5.9	-	-	-	-
OCT	26.7	20.0	20.0	6.7	-	-	-	-	-	-	6.7	-	-	20.0	-
NOV	16.7	12.5	4.2	-	-	16.7	12.5	-	14.7	-	4.2	-	4.2	8.3	4.2
DEC	4.7	2.3	2.3	2.3	9.3	11.6	7.0	-	2.3	-	4.7	11.6	18.6	16.3	7.0
Entomobrya kali															
JAN	2.5	-	16.7	20.8	-	-	-	-	-	8.3	8.3	8.3	8.3	-	16.7
FEB	7.3	7.3	4.9	9.8	9.8	-	4.9	-	14.6	7.3	-	9.8	12.2	4.9	7.3
MAR	14.3	9.5	19.0	9.5	-	-	-	-	-	-	14.3	-	-	19.0	14.3
APR	-	15.0	10.0	10.0	-	20.0	-	-	-	-	10.0	-	-	15.0	20.0
MAY	-	-	-	-	54.5	-	-	-	-	-	45.5	-	-	-	-
JUN	-	-	-	-	-	-	-	-	-	71.4	28.6	-	-	-	-
JUL	-	-	-				-	-	-	60.0	40.0	-	-	-	-
AUG	-	-	-	27.3	-	-	-	45.5	-	27.3	-	-	-	-	-
SEP	16.7	20.8	12.5	12.5	8.3	-	-	16.7	-	4.2	8.3	-	-	-	-
OCT	18.8	12.5	12.5	18.8	-	-	-	-	-	-	12.5	-	-	25.0	-
NOV	16.1	12.9	6.5	-	-	12.9	9.7	-	16.1	-	6.5	-	6.5	6.5	6.5
DEC	6.9	10.3	3.4	3.4	13.8	13.8	10.3	-	3.4	-	6.9	10.3	10.3	3.4	3.4

In addition to the general seasonal trend for either the soil fungi or those available in the gut of the species of collembola undertaken, the Ivlev-index (1961) was worked out to bring a true picture of whether there was any particular period of the season of selectivity and also whether species were selective feeders. In Seira indica it was seen that the maximum coefficient occurred for Trichoderma viride, Aspergillus niger, Penicillium chrysogenum, Mucor recemosus, Alternaria alternata in the month of October for the first three and August for the last two respectively. Species like Penicillium nigricans and Absidia sp. occurred in maximum in the month of March and February respectively, while in Fusarium sp. and Pythium sp. it occurred in May and April respectively as maximum. Finally Absidia spinosa, Mucor circinelloides, Doratomyces sp., Mycogone sp. and Cephalosporium sp. occurred maximum for the first three in the month of December and the last two in the month of January. Hence very clearly the maximum peaks occurred either in autumn, early spring or winter for different fungal species (Fig. 27).

For Seira lateralis more or less, a similar trend was followed except that the fungal species differed in the seasonal maximal coefficients. In this case Trichoderma viride and Mycogone sp. occurred maximum in October, while Penicillium nigricans and Mucor recemosus in August, while Aspergillus niger and Penicillium chrysogenum in November. The one group which occurred maximum in summer was Alternaria alternata, Absidia sp. and Cladosporium sp. occurred maximum in the month of February and March respectively. Absidia spinosa, Mucor circinelloides and Absidia sp. occurred in the month of December as maximum, and for Absidia sp. this was the second peak. Lastly, Fusarium sp., Cephalosporium sp. and Doratomyces sp. occurred maximum in the month of January (Fig. 28).

Fig. 27 : Showing the index of electivity and its seasonal fluctuation in the Collembola species- *Seira indica*.

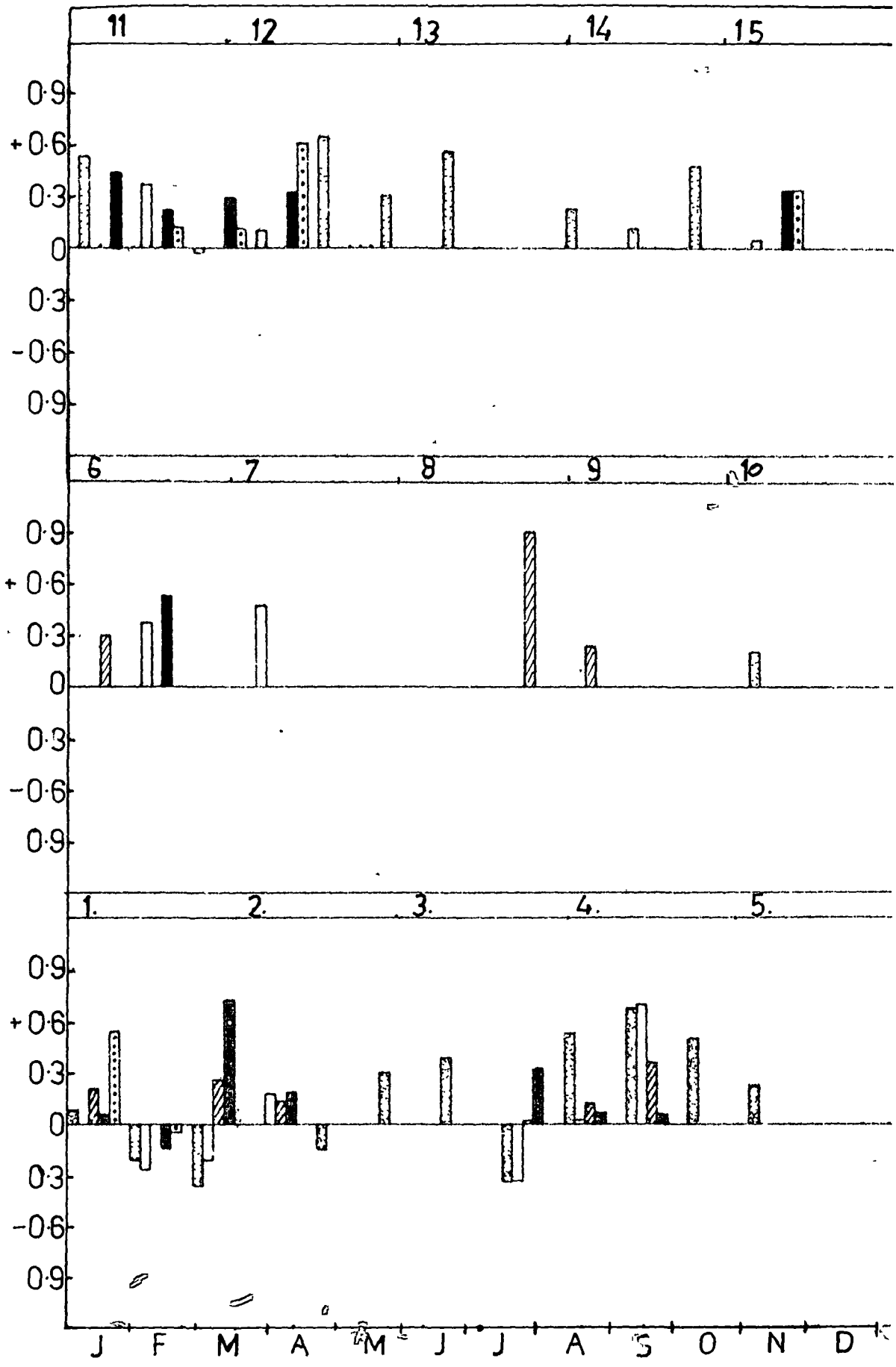
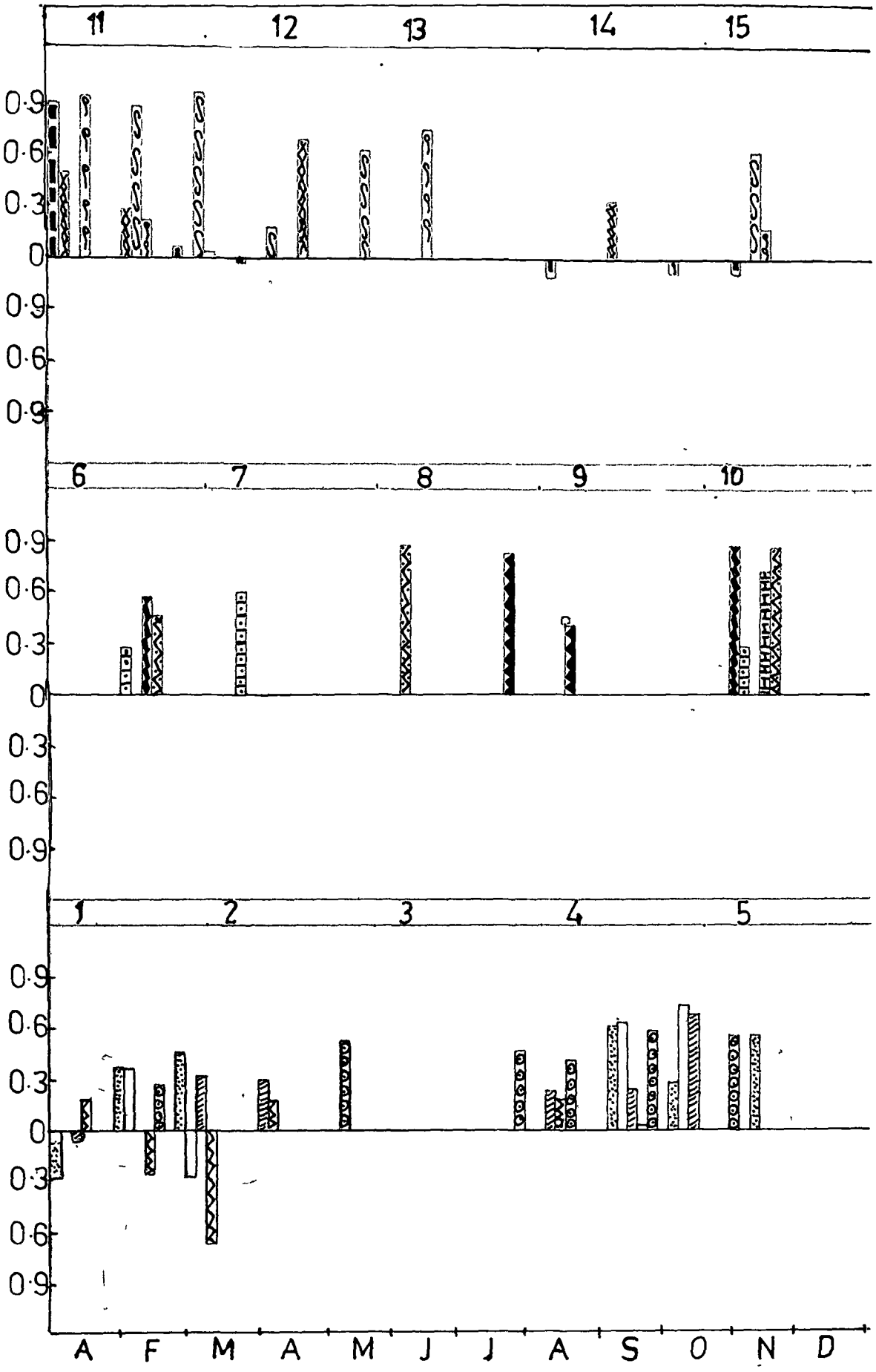

11
12
13
14
15
0·9
+0·6
0·3
0
0·3
-0·6
0·9
6
7
8
9
10
0·9
+0·6
0·3
0
0·3
-0·6
0·9
1.
2.
3.
4.
5.
0·9
+0·6
0·3
0
0·3
-0·6
0·9
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 28 : Showing the index of electivity and its seasonal fluctuation in the Collembola species- Seira lateralis.


11
12
13
14
15
0·9
0·6
0·3
0
0·3
0·6
0·9
6
7
8
9
10
0·9
0·6
0·3
0
0·3
0·6
0·9
1
2
3
4
5
0·9
0·6
0·3
0
0·3
0·6
0·9
A
F
M
A
M
J
J
A
S
O
N
D

In the Salina yosii, maximum were recorded during winter months like, Aspergillus niger, Absidia spinosa, Mycogone sp., Cephalosporium sp. and Cladosporium sp. all in the month of December. In January, Penicillium chrysogenum, Penicillium nigricans and Pythium sp. recorded maximum. Coefficients in Absidia sp. and Doratomyces sp. was recorded maximum in February and Mucor circinelloides sp. in the month of November. The remaining species like Alternaria alternata and Fusarium sp. occurred in July while Mucor racemosus occurred in August and Trichoderma viride in September as maximum coefficients (Fig. 29).

In the last species Entomobrya kali a more or less similar phenomena was seen except that in April, Pythium sp. recorded maximum and Alternaria alternata and Fusarium sp. in July, August recorded maximum for Mucor racemosus, while Trichoderma viride and Aspergillus niger in September. In October, November maximum records were those of Doratomyces sp. and Mucor circinelloides sp. respectively. All the remaining recorded during the winter months of either December or January, the former having fungal species like Absidia sp., Mycogone sp., Cephalosporium sp. and Cladosporium sp. while the latter both the Penicillium species were recorded (Fig. 30).

Fig. 29 : Showing the index of electivity and its seasonal fluctuation in the Collembola species-*Salina yosii*.

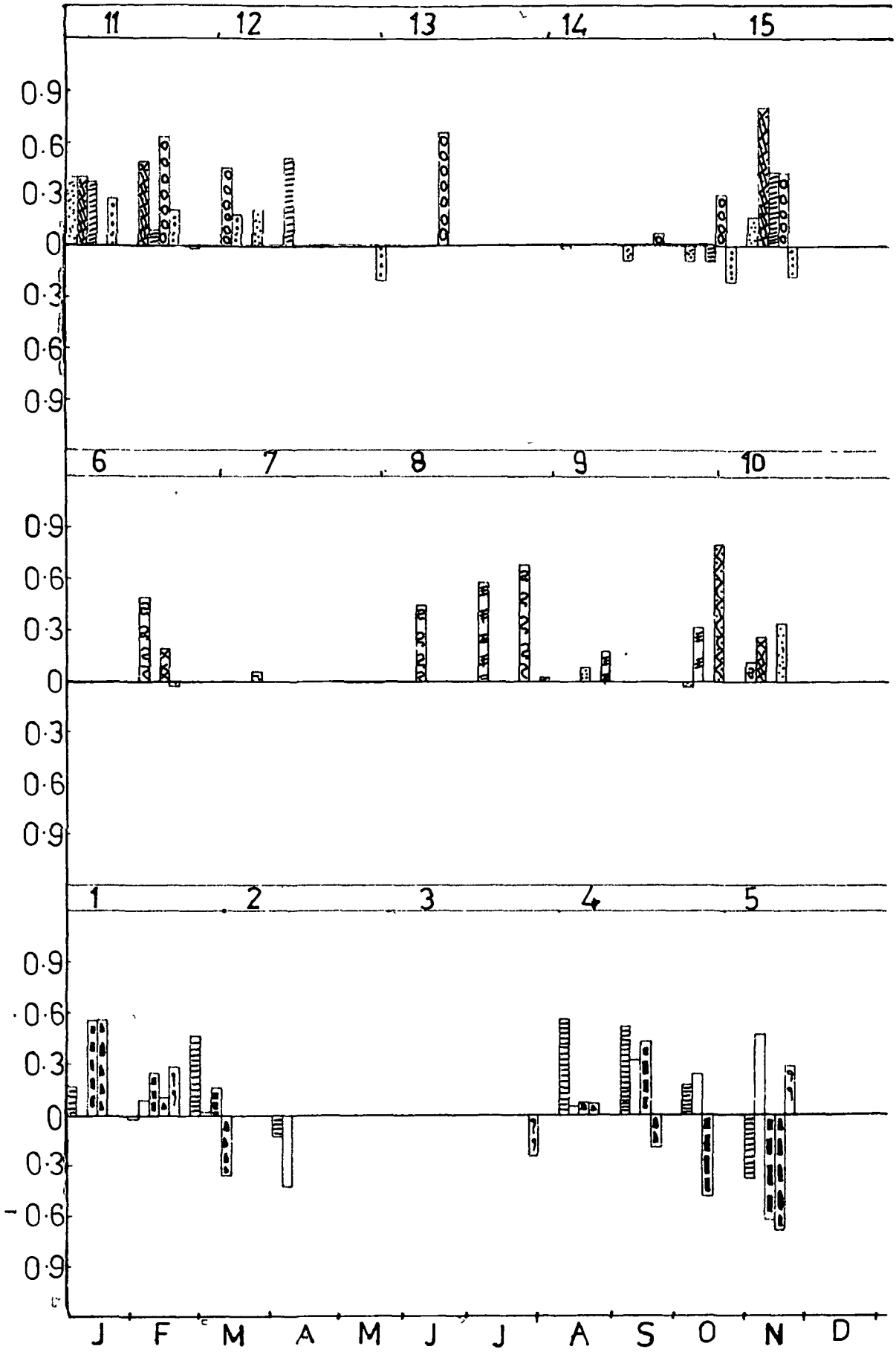
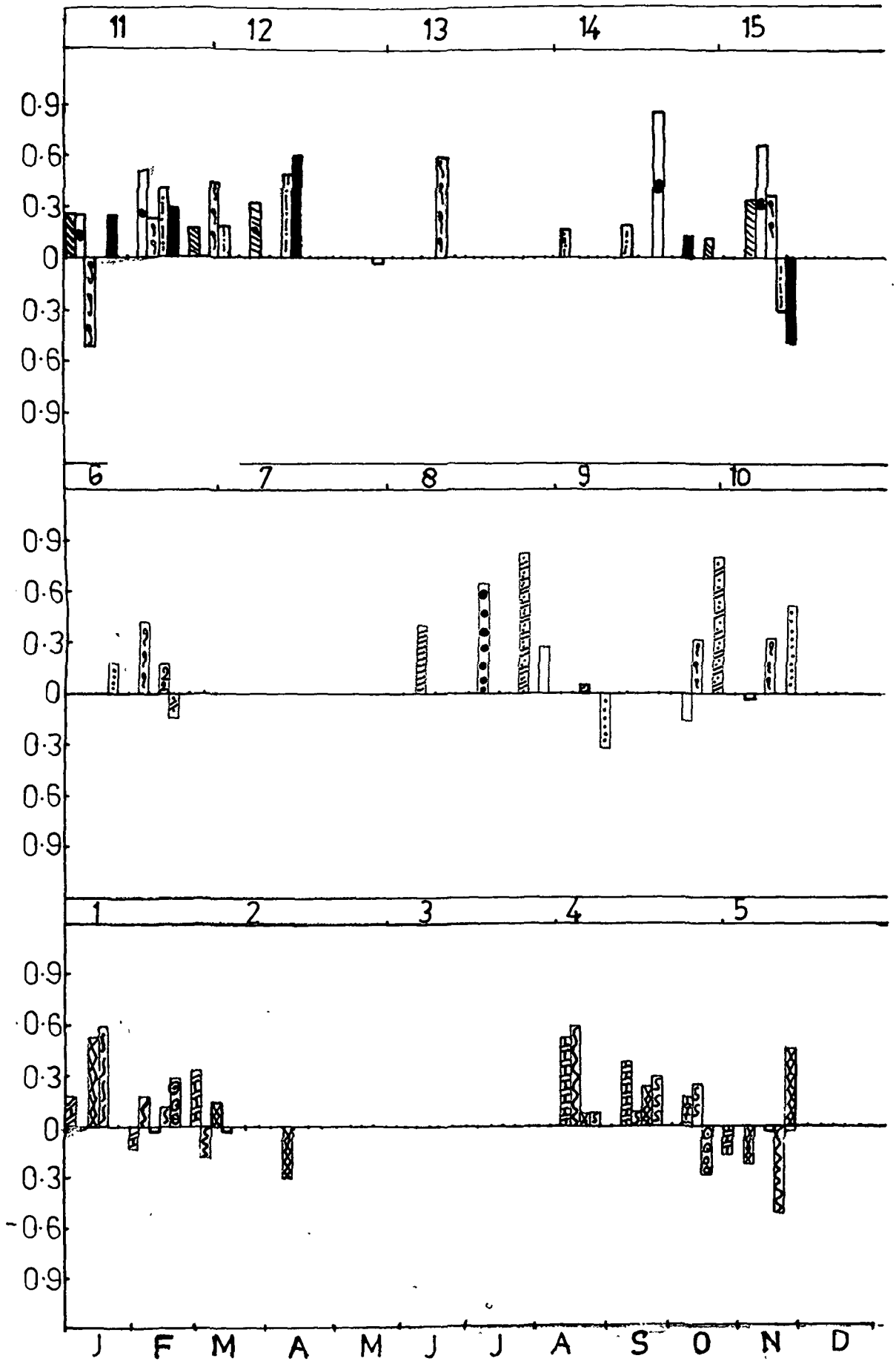

11
12
13
14
15
0·9
0·6
0·3
0
0·3
0·6
0·9
6
7
8
9
10
0·9
0·6
0·3
0
0·3
0·6
0·9
1
2
3
4
5
0·9
0·6
0·3
0
0·3
0·6
0·9
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 30 : Showing the index of electivity and its seasonal fluctuation in the Collembola species Entomobrya kali.


11
12
13
14
15
0·9
0·6
0·3
0
0·3
0·6
0·9
6
7
8
9
10
0·9
0·6
0·3
0
0·3
0·6
0·9
1
2
3
4
5
0·9
0·6
0·3
0
0·3
-0·6
0·9
J
F
M
A
M
J
J
A
S
O
N
D

DISCUSSION

While observing the gut contents of the four species of Collembola and correlating it with those in the soil from where these species were extracted, it seemed, that, generally there is no regular pattern between the soil fungal flora over the season nor of the fungal flora in the gut. Among the dominant species of fungi from site A, which was the youngest abandoned fallow and site D the oldest abandoned fallow there was significant differences over the seasonal abundance of the various fungal species.

When the gut contents of Seira indica and Seira lateralis collembola species from the same site, was compared with the soil, it was seen that among the dominant fungal species, like Trichoderma viride, Penicillium chrysogenum, Aspergillus niger and Fusarium sp. recorded peaks of abundance in the soil, in the guts of Seira indica and Seira lateralis around the same month except for the last which in Seira lateralis showed a contrasting increase when actually in the soil this was declining. One dominant species in the soil was Penicillium nigricans, which was not recorded in the gut of either of these two collembola species. However, fungal species like Alternaria alternata, Absidia spinosa, Mucor recemosus which were least recorded in the soil was found to be atleast 20% or more in the guts of both species and had a similar peak of abundance. In addition to this Mucor circinelloides recorded in Seira indica was replaced by Mycogone sp. in Seira lateralis.

A similar analysis in the oldest abandoned fallow (Site D) and the collembola species associated, revealed that only Alternaria alternata and Fusarium sp. when forming a peak in the soil was also a peak in the guts of both the species, while Penicillium nigricans and Absidia sp. had similar peaks both in soil and in

the gut of E. kali. They showed a different pattern in S. yosii and in fact the former fungal sp. always recorded below 20%, though revealed a peak similar to soil recording only 16%. Doratomyces sp. showed similar peak of abundance between soil and Salina yosii gut contents but totally different for Entomobrya kali gut contents. Aspergillus niger recorded maximum in mid-monsoon, showed peaks of abundance in the guts of Salina yosii and Entomobrya kali, only in the autumn months. Acremonium sp. which did show more than 10% in the soil was totally absent in the guts of both the species. In addition to these, fungal species like Trichoderma viride, Penicillium chrysogenum, Mucor racemosus and Pythium sp., which occurred well below 10% in the soil but was present as peaks of 20% or more in the gut of S. yosii. Of these, the last two species were also present in the gut of Entomobrya kali while the former two were absent. Mycogone sp. similarly occurred in the gut of E. kali and not in the gut of S. yosii.

As a general occurrence of various fungal species of the gut of the collembola irrespective of area from where they were collected, it was seen that Aspergillus niger, Fusarium sp.; Absidia spinosa, Alternaria alternata and Mucor racemosus occurred in the guts of all the four species of Collembola irrespective for whether these formed 10% or more in the soil from different sites. Trichoderma viride and Penicillium chrysogenum were seen to occur only in S. indica, S. lateralis and Salina yosii guts, while Penicillium nigricans in the gut of Entomobrya kali only. Species like Doratomyces sp. and Pythium sp. seemed to show a relation to the collembola from different sites in that they failed to occur in the guts of S. indica and S. lateralis while present in Salina yosii and E. kali. Interestingly, enough, Mycogone sp. was found only in S. lateralis and E. kali, the

former from the youngest abandoned fallow and the latter from the oldest abandoned fallow. Mucor circinelloides was a species which occurred only in the gut of S. indica and nowhere else.

Ivlev, 1961 index of electivity when applied to show whether there was any selectiveness phenomenon, was seen that no true conclusions can be obtained, even though the values ranged from (-) to + values of 1. Certain species of fungi, which showed a seasonal peak of abundance for these balues, showed that it never coincided with either the percentage peaks in the soil or gut. This proves beyond doubt that the 4 species of collembola undertaken were non-specialized and the feeding was random with effect of intensity only during the autumn months immediately after rains.

From all the above, it was seen that the four species of collembola were more or less non-specialized feeders (Petersen, 1971; McMillan, 1975). This low degrees of specialization was probably attributed to the food available to these decomposers always in excess (Healey, 1972). In the present study, it was seen when even particular fungal species becomes rare, yet there does not seem to be a distinct selective advantage in contrast to Emlen (1973). In all the four species of collembola undertaken there was no incidence at all of empty guts. This was probably because of the region under consideration which always had high humidity and rainfall above average in comparison to rest of India. However, it has been seen that there was high feeding activities immediately after the onset of monsoon (Joose, 1976). It is seen that there is a great synchronisation of total collembola population to the feeding behaviour as seen here; where the amplitude of population fluctuations increase in autumn (Smith, 1972; Joose and Testerink, 1977). This, therefore primarily attributed to soil moisture condition thananything else

(Verhoef, 1977). Out of the nearly 10 or 11 species of fungi it was seen that more than 50% are common the gut and also similarity in the gut contents between the two species from the same habitat. This is in concordance with the several studies, that the gut contents of collembolan species living under similar conditions, show similarity (Poole, 1959; Gilmore and Raffensperger, 1970; Bodvarsson, 1970; McMillan and Healey, 1971). But this ability of such extensive numbers of detritus species not only co-existing in habit but also utilising identical food resources, conflicts general theory of ecological concepts, as the latter is well established, than related species sharing same habitats evolve food differentiation and hence the concept of ecological niche (De-Bach 1966; Slobodkin et.al. 1967; Reynoldson and Davies, 1970).

From the present study it revealed that for most fungal species there was no direct relationship in the gut of these collembola species. This may be attributed to undetected differences in their soil fungal utilisation. Further, species of collembola are known to vary in their ability to digest particular components and also vary in the activity range of their own enzyme component (Von Torne, 1967a; 1967b). In addition it is understood that in the present study, the microhabitat differences between species have been left undetected because of the complexity of the work. We will agree that the low degree of food specificity in these species was due to an interaction, reducing competition pressure between the species which superficially utilise the rather uniform resources under moist soil conditions (Anderson and Healey, 1972).

Despite this fact, fungi among microflora are the most efficient penetrators of plant remains and within a limited period, nutrients get incorporated in microbial tissues, which

represents not only production of equal or similar food resources but also a high quality of nutrition. From the present study, it was further seen that the index after Ivlev (1961) also proves non-selectivity of food irrespective of the age of the fallow and the differences of the species undertaken.

REFERENCES

Agrell, I. 1941 Zur okologie der collembolen untersuchungen im Schwedischen Lappland opuscula. Entomol. Suppl. III : 1-236.

Anderson, J.M. & I.N. Healey. 1972 Seasonal and interspecific variation in major components of the gut contents of some woodland Collembola. J. Anim. Ecol. 41 : 359-368.

Bellinger, P.F. 1954 Studies of the soil fauna with special reference to the Collembola. Connecticut Agric. Exper. Sta. Bull. No. 583, 67 p.

Bodvarsson, H. 1970 Alimentary studies on seven common soil, inhabiting Collembola of Southern Swsden. Entomol. Scand. 1 : 74-80.

Christiansen, K. 1964 Bionomics of Collembola. A Rev. Ent. 9 : 147-178.

Day, G.M. 1950 Influence of earthworms on soil microorganisms. Soil Sci. 69 : 175-184.

DeBach, P. 1966 The competitive displacement and co-existence principles. A Rev. Ent. 11 : 183-212.

de with, N.D. & E.N.G. Joosse. 1971 The ecological effects of molting in Collembola. Rev. Ecol. Sol. 8 : 111-117.

Dowding, P. 1976 Allocation of resources, nutrient uptake and release by decomposer organisms. In: The role of terrestrial and aquatic organisms in decomposition processes (J.M. Anderson, A. Macfadyen eds.). Oxford, Blackwell. 169-183 p.

Dunger, W. 1962 Methoden zur vergleichenden Auswertung von Futterungsversuchen in der Bodenbiologie. Abhandl. Ber. Naturkundemuseums. 37 : 143-162.

Emlen, J.M. 1973 Ecology : an evolutionary approach. Addison-Wesley. Reading. Mass.

Ernsting, G. 1977 Predation and co-existence of collembolan prey species. In: Soil organisms as components of ecosystems (U. Lohm & T.Persson eds). Proc. VI. Int. Soil Zoology Coll. Ecol. Bull. 25 p.

Gilmore, S.K. & E.M. Raffensperger. 1970 Foods ingested by Tomocerus spp. (Collembola : Entomobryidae) in relation to habitat. Pedobiologia. 10 : 135-140.

Healey, I.N. 1965 Studies on the production biology of soil Collembola with special reference to a species of Onychiurus. Thesis, University of Wales.

_____ 1971 Apterygotes, Pauropods and Symphylans. In: J. Phillipson (ed.). "Methods of study in quantitative soil ecology". Blackwell, Oxford. 209-232 p.

Hutchinson, G.E. 1951 Copepodology for the ornithologist (Review). Ecology. 32 : 571-577.

Ivlev, V.S. 1961 Method otsenki obespechehhosti ryb pishchei (A Method of determining the food requirements of fish). Trudy Soveshch Ikhtiol kom. 13 : 330-336.

Jones, D.A. 1972 Cyanogenic glycosides and their function. In phyto-chemical ecology, ed. J. Harborne, Academic Press, London. 103-104 p.

Joosse, E.N.G. 1976 Littoral apterygotes (Collembola and Thysanura). In marine insects. (L. Cheng,ed). Amsterdam, North Holland, 36 p.

_____ & G.J. Testerink. 1977 Control of number in Collembola. In soil organisms as components of ecosystems. (U. Lohm, T. Persson, eds.). Proc. VI. Int. Soil Zoology. Coll. Ecol. Bull. 25 p.

Kines, K.A. & R.N. Sinha. 1973 A laboratory study of fauna and flora in an agricultural soil in Manitoba. The Manitoba Entomologist. 7 : 59-66.

Knight, C. 1961 The Tomocerinae in old field stands of North Carolina. Ecology. 42 : 140-149.

Knight, C.B. & R.A. Angel. 1967 A preliminary study of the dietary requirements of Tomocerus (Collembola). Am. Midl. Nat. 77 : 510-517.

Kollmansperger, F. 1956 Lumbticiden in humiden und ariden Gebieten und ihre Bedeutung fur die Fruchtbarkeit des Bodens. Rapp. VI. Congr. Intern. Sci. Sol. Paris. C : 293-297.

Levi, M.P. & E.B. Cowling. 1969 Role of nitrogen in wood deterioration. VII Physiological adaptation of wood destroying and other fungi to substrates deficient in nitrogen. Phytopathology. 59 : 460-468.

Luxton, M. 1972 Studies on the oribatid mites of a Danish beech wood soil. I Nutritional biology. Pedobiologia. 12 : 434-463.

Macfadyen, A. 1957 "Animal Ecology". Pitman Publ. 264 p.

Macfadyen, A. 1963 The contribution of the microfauna to total soil metabolism in Doeksen, J. and Drift, J. Van der, eds., Soil organisms. 3-17 p.

Martin, J.P. 1950 Use of acid, rose bengal and streptomycin in the plate method for estimating soil fungi. Soil. Sci. 69 : 215-232.

Massoud, Z. 1971 Un element caracteristique de la pedofaune les collemboles. In La vie dans les sols ed. P. Pesson, Gauthier-Villars, Paris. 335-388 p.

McMillan, J.H. 1975 Interspecific and seasonal analysis of the gut contents of three collembola (Family : Onychiuridae). Rev. Ecol. Biol. Sol. 12 : 449-457.

_____ & I.N. Healey. 1971 A quantitative technique for the analysis of gut contents of Collembola. Rev. Ecol. Biol. Sol. 8 : 295-300.

Mills, J.T. & R.N. Sinha. 1971 Interactions between the spring tail, Hypogastrura tullbergi and soil borne fungi. J. Econ. Ent. 64 : 398-401.

Mitchell, M.J. & D. Parkinson. 1976 Fungal feeding of oribatid mites (Acari : Cryptostigmata) in an aspen woodland soil ecology. 57 : 302-312.

Parks, D. 1976 Nitrogen level and cellulose decomposition by fungi. Int. Biodetn. Bull. 12 : 95-99.

Petersen, H. 1971 Collembolernes ernaeringsbiologie og dennes Okologiske betydning. Ent. Ent. Meded. 39 : 97-118.

Poole, T.B. 1959 Studies on food of Collembola in a Douglas fir plantation. Proc. Zool. Soc. London. 132 : 71-82.

_____ 1961 An ecological study of the Collembola in a coniferous forest soil. Pedobiologia. 1 : 113-137.

Reynoldson, T.B. & R.W. Davies. 1970 Food niche and co-existence in lake dwelling triclads. Animal populations in relation to their food resources (Ed. by A. Watson). Blackwell Scientific Publications, Oxford. Symp. 10 : 125-128 p.

Sharma, G.D. & Kevan, D.K. McE. 1963b Observations on Folsomia similis (Collembola-Isotomidae) in Eastern Canada. 'Pedobiologia'. 3 : 48-61.

_____ 1963c Observations on Pseudosinella petterseni and Pseudosinella alba (Collembola : Entomobryidae) in Eastern Canada. Pedobiologia. 3 : 62-74.

Singh, S.B. 1969 Studies on the gut contents of a suctorial Collembolan Friesea mirabilis (Tullberg.) (Insecta). Entomologist. 102 : 180-184.

Slobodkin, L.B., F.E. Smith & N.C. Hairston. 1967 Regulation in terrestrial ecosystems and the implied balance of nature. Am. Nat. 101 : 109-124.

Smith, F.E. 1972 Spatial heterogeneity, stability and diversity in ecosystems. Trans. Conn. Acad. Arts. Sci. 44 : 309-335.

Stebaeva, S.K. 1967 Pedobiologische Experimente mit ausgetauschen Bodenblocken im Sudostlichen Altai-Gebirgeund der Severna ja Baraba. Pedobiologia. 7 : 172-191.

Tikhomirov, B.A. 1969 Specific features of the Zoocomponent of tundra biocoenoses. Trans. Moscow Naturalists Soc. 38 : 172-183 (In Russian with English Summary).

Torne, E. Von. 1961 Beispiele fur mikrobiogene Einflusse auf den Massenwechsel Von Bodentieren Pedobiologia. 1 : 146-149.

——————— 1976a Beispiele fur indirekte Einflusse Von Bodentieren af die Rotte von Zellulose, Pedobiologia. 7 : 220-227.

——————— 1976b Beispiele fur mikrobiologene Einflusse auf den Massenwechsel Von Bodentieren, Pedobiologia. 7 : 296-305.

Verhoef, H.A. 1977 Soil moisture and the population dynamics of co-existing Collembola. In: Soil organisms as components of ecosystems. (U. Lohm, T. Persson, eds.). Ecol. Bull. (Stockholm), 25 p.

Watson, A. 1970 Animal populations in relation to their food resources. Oxford - Blackwell.

Zinkler, 1969 Vergleichande untersuchungen Zum Wirkungsspektrum der Carbonhydrasen Von Collembolen (Apterygota). Verh. Deutsch. Zool. Ges. 640-644 p.

GENERAL DISCUSSION AND CONCLUSION

GENERAL DISCUSSION AND CONCLUSION

It is known that a wide range of habitats occurring as a mosaic differing in soil and litter type and also vegetation cover has been very well worked out in temperate climates. This is still to be seen from a comparative base in tropical situation as there have not been a total ecological study of soil fauna. This is more so in the Indian situation and the region under consideration, North-Eastern India, where there are hardly very few reports. It was therefore felt how ecological segregation could be achieved by environmental factors and biotic factors besides the contrast in life forms of these areas.

It is established that soil fauna of agronomic system is notoriously impoverished in comparison to uncultivated forest or grassland ecosystems. Tillage practices disrupt to an appreciable extent both the structure of the soil and the biotic community (Allison, 1973). Hence, it is all the more because for high degrees of depletion of soil fauna in cultivated lands brought into agriculture from natural forest and without the input of fertilizers when left fallow. Therefore the response of soil fauna to such disturbances, determine which species and the mode of location in addition to the ability to survive the disturbance of the inbuilt quality of recolonization by migration. The recovery of disturbed fauna will always be slow and a causative factor as resistance would be the limited rate of recolonization as seen from the present investigation that though there is an immediate migration to areas on discontinuity of the tillage practices, a real stabilization takes many years (Greenslade and Greenslade, 1977), where in the present study it was seen to be 20 years. This proves that there is an action of some factors determining the suitability

of habitat for soil fauna like the climatic structure, food supply and underlying predation pressure. In this process of succession and recolonization, competitive interaction could be expected to play a major role in population processes and dynamics. This is all the more true in humid tropics where the climate is usually favourable (Bullock, 1967) and competition to be diffuse (Terborgh, 1971; MacArthur, 1972). For any one species liable to interact with a mosaic of others at differing densities and in a number of permutations and combinations, Anderson and Healey (1972) was of the opinion that fugitive species could co-exist with superior competitors by migrating to temporarily unexploited patches in the habitat. But both opportunatist and fugitive species are r-strategists, (MacArthur and Wilson, 1967); r-K spectrum (Southwood,1977). These therefore, have the potential to buffer the temporal change and its effects in the supply of resources caused by variation in weather or density of key species within normal variation ranges. Du Plessis (1978) has strongly contended that it is the sensibility of the endemic fauna for habitat changes and the human land use practices responsible for the destruction of natural populations which are established and thereby creating avenues for the spurt of undesirable elements. While these are mainly based on the present climate and the recent manipulations and impacts by land, the closest affinities among the soil faunal communities could always be related to a consequence of factors in the geological substratum and to characteristics that the "natural ecosystems" would have possessed, if left undisturbed. In other words the response of any soil faunal system or sub-system to the present ecological conditions precedes that of the soil system or sub-system, the composition and structure mainly determined by historical events.

Further, it is noted that though soil fauna might vary little in the efficiency, they utilized their resources, the carrying capacity of the environment would depend on the niche breadth or the number of resources within the environment that each specialization have evolved a mechaism for exploitation. Corollary will be, when there are many species of one group or community in a given habitat the evolutionary strategies for these groups would be to diversify the food resources utilized as much as possible so that a reduction of competition to a low level is achieved (Blackith, 1974). In addition to all these ecological factors in the formation of soil it is certain groups of soil invertebrates like micro- meso- and macrofauna which are responsible by way of their metabolic activities for accumulation of organic matter in and on the soil. Therefore, several dominant species capable of reproducing and surviving for long periods at below qptimum levels of environmental factors like pH, salinity and temperature would likely be encountered in the early stages of soil formation, represented either by large presence of micro, meso or macrofauna. Stabilization effect would truely be indicative of the presence and abundance of macrofauna in contrast to the other two groups. This fact was seen very clearly from the present study. However though some soil fauna are capable of living under extreme conditions, there is a threshold level beyond the damage of the soil could show population dynamics irreversible. It is for this reason though quantitative variation at species level is ideal yet it does not allow to draw definitive conclusions for such studies in disturbed ecosystems. It is therefore the whole community which is a good ecological indicator of the impact of jhumming and the outcome of colonization after such a process in lands which lieg fallow.

CONCLUDING REMARKS

With the fore-going discussion, it is seen that the present investigation incorporated in the first chapter on the total population dynamics of groups and community of soil fauna, their interactions with physical-chemical factors of the environments and soil and the identification of succession and recolonization in disturbed ecosystems and landscapes left abandoned or fallow for considerable lengths of time.

It is seen that the immediate abandonment of land after tillage shows a total increase only in mesofauna and to some extent to microfauna. A definite successional pattern was seen in the colonization of macrofauna which steadily increased from the youngest abandoned fallow to the oldost abandoned fallow proportionately. This therefore could be the deciding factor for a relation to soil fertility and recovery of land in such disturbed areas. The present study further revealed that it was the moisture gradient highly responsible to vertical migration in the soil faunal lands and temperature was only secondary. In tropics, such disturbed ecosystems create harsh environments with extremes of temperature, moisture in the tropics, therefore a direct impact of heavy rains creates a positive response.

The second chapter incorporated the life history strategies of our dominant species of Collembola, the group which did play a significant role in the abundance of total soil fauna. Here again it was seen in two species each from the youngest and the oldest abandoned fallow. Further, the life histories were worked out under a combination of various environmental factors like pH,

temperature and salinity. However, though one factor like temperature either by itself or coupled with salinity did show marked effects on the life histories of these species yet in general there was hardly any difference in the species undertaken.

The third and last chapter was done by utilizing the same four dominant species of Collembola in relation to their feeding behaviour in the field. The study revealed that this species undertaken were non-selective and non-specialized in their feeding. In certain aspects it revealed dominance of those in the soil to be proportionally dominant in the gut of the species. The index of selectivity proves that they were definitely non-elective in their approach of feeding. The increase of environmental stability is usually considered as the governing factor for the differences found between communities attached to either different horizons of the soil or different soil types is a significant factor. This further affects the mode of reproduction and type of development in the light of environmental properties in relation to the utility of food resources for the dynamic aspects of an ecosystem.

REFERENCES

Allison, F.E. 1973 Soil organic matter and its role in crop production. Elsevier, New York, 637 p.

Anderson, J.M. & I.N. Healey 1972 Seasonal and inter-specific variations in major components of the gut contents of some woodland Collembola. J. anim. Ecol. 41, 359-368.

Blackith, R.E. 1974 The ecology of Collembola in Irish blanket Bogs. Proc. Royal Irish. Acad., 74 B (16). 202-226.

Bullock, J.A. 1967 The arthropods of some tropical soils and leaft litter. Tropical ecology. 8: 74-87.

Du Plessis, S.F. 1978 In ondersoek na die verspreiding en taksonomic van die Microchaetinae (Oligochaeta) in Suid Afrika. Unpublished thesis. Potchefstroom University for C.H.E., South Africa.

Greenslade, P.J.M. & P. Greenslade. 1977 Some effects of vegetation cover and disturbance on a tropical ant. fauna. Insectes Sociaux. 24: 163-182.

MacArthur, R.H. 1972 Geographical ecology patterns in the distribution of species, Harper and Row, New York.

_____ & E.O. Wilson 1967 The theory of island biogeography. Princeton Univ. Press Princeton, New Jersey.

Southwood, T.R.E. 1977 Habitat, the templet for ecological strategies. J. Anim. Ecol. 46 : 337-365.

Terborgh, J. 1971 Distribution on environmental gradients: theory and a preliminary interpretation of distributional patterns in the avifauna of the Cordillera Vilcababa, Peru. Ecology 52 : 23-40.