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Population fluctuation of soil microarthropods in different parts of newly emerged virgin deltaic Island, West Bengal, India.

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Abstracts:

Soil microarthropods have important role in maintaining soil fertility. The major contribution of arthropods to soil is through decomposition and humification of all organic matter. Soil inhabiting microarthropods were divided into different functional groups. Present study is based on seasonal diversity, habitat quality and species specific differences of micro arthropods abundance in different selected parts of Nayachar Island, Purba Medinipur, West Bengal, India. A total of 44 species of microarthropods were identified. Soil sample have been collected seasonally (Pre monsoon, monsoon, post monsoon) from each selected sites over 30 months. The soil physico-chemical parameters were study in laboratory standard method.

Key words: Soil microarthropods, Population, Diversity, Fertility.

Introduction:

The living organisms in soil range from microorganisms, small and large invertebrates to small mammals. Arthropods represent as much as 85% of the soil fauna in species richness. They comprise a large proportion of the meso and macrofauna of the soil. Macrofauna contribute to improve soil structure, aeration and water infiltration. They predate on soil organisms and help to maintain biological equilibrium in soil. Mesofauna are important plant pathogens. Microfauna are important predators of bacteria and algae, thus regulating their population in soil (D.J.Bagyarj *et al* 2016). Soil fauna such as microarthropods enhance ecosystem services by accelerating key determinants of an ecosystem for primary productivity including decomposition of organic matter, soil minaralization , energy flow , nutrient cycling and maintaining of soil physical structure (Yang and Chen 2009). Little information is available on diversity and community structure of soil microarthropods from Indian coastal regional soil. No substantial study has been done on soil microarthropods subjected to seasonal diversity, population dynamics and impact of soil fertility of newly emerged virgin deltaic Island (Nayachar) , West Bengal , India. In the present study, we investigate, seasonal diversity, habitat quality and species specific difference of micro arthropods abundance in different parts of the Nayachar Island.

Material & Methods:

Soil samples were collected with the help stainless steel corer (Inner –cross sectional diameter is 8.5sq/cm) from a depth of 5cm per plot at monthly interval (Curry 1971) during July 2003- to December 2005. The Samples were collected from three sub-sampling sites of each study sites (Latitude 21°58′33″N and longitude 88°04′54″E). Therefore, nine-corer samples were collected from each study site. In this study, to extract the soil fauna, the apparatus used was slightly modified as that of Macfadyen (1955). The study carried out in the coastal environment of West Bengal experienced three distinct seasons mainly determined by two major meteorological parameters (temperature and rainfall) each with four months duration *viz*. Premonsoon (March-June), Monsoon (July-October), Postmonsoon (November-February). (Chaudhuri and Choudhury 1994). (Nayachar Island Map ,source Researchgate.net)

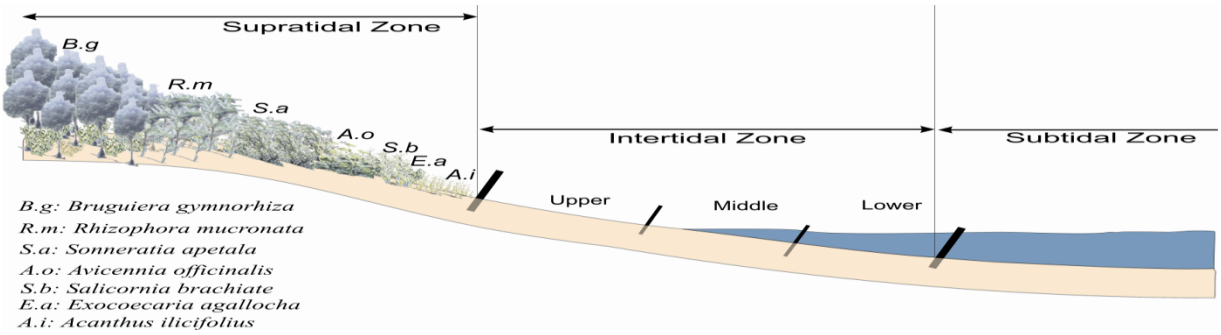

Fig 1- Zonation of Study sites

Results & Discussion:

The Nayachar Island representing the study site, is encircled on all of its sides by the Hooghly estuary along with its tributaries and enjoys a position just opposite to the port of Haldia in West Bengal. The island is spindle shaped having a total area of about 29.38 sq km. It is silt deposited island and is flat with an average height of 3′ to 5′ from riverbed. The formation of the island was the outcome of the interactions and deposition of sediments of

high tide and low tide processes of the estuarine water since 1988. It bifurcated the Hooghly estuary into Haldia and Rangafalla channels. This island has been formed because of sediment deposition during the past several decades and started accreting from 1945. Between 1967 and 1997, the island progressively enlarged in its area (Dey *et al* 2008). The Calcutta port trust started re-vegetating this erosion prone island with mangroves in collaboration with Zoological Survey of India at its Northeastern region covering an area of about 4 sq km during 1991.

The soil of this study site was covered with grasses and sedges *like Cynodon dactylon, Digitaria sp, Echinochloa sp* and the vegetation of the supratidal zone was composed of a good number of mangrove plants like *Sonneratia apetala*(Buch-Hum) which was first planted during a afforestation program of Haldia Port Trust in the year 1991 subsequently, several mangrove plants appeared in this zone and experienced luxuriant growth which were represented mainly by *Avicennia marina(L), A officinalis (L), Heritiera fomes (L), Bruguiera gymnorhiza (L) Rhizophora mucronata (L), Exocoecaria agallocha (L), Xyllocarps mekongensis* Koening and *X granatum.* Other halophytic vegetations like *Salicornia brachiate* Roxb, *Acanthus ilicifolius* (L) and *Ipomoea bilobata (L)* have been grown up in different parts of this island with the *passage* of time.

Physicochemical parameters: Soil in this study site was found to be alluvial in nature, brown in colour and clay loam in texture. Air temperature recorded minimum 22^{o}C in January, February (2004) and maximum 40^{o}C in May (2004,2005) in this study site . Soil temperature was minimum in January (14^{o}C) and maximum in April (31 ^{o} C). Maximum rainfall was recorded as 10cm (July, August 2003,2004). The surface soil relative humidity variation was minimum in February (68%) and maximum in July (98%) in the year 2003. The hydrogen ion concentration (p H) of soil was minimum in October 2004(6.6) and reached to a maximum of 7.5 in August (2005). The total amount of organic carbon (%) experienced a wide range of variation with a minimum value of 3% in July 2003 and maximum value of 6.7% in November 2004. A minimum value of 0.2ppt in December 2003 and maximum value of 2.1ppt in July 2004 in respect to salinity were registered in this study site. A minimum value of 3200ppm in February 2005 and maximum value of 4847ppm in November 2005 in respect to total nitrogen were registered .A minimum value of 220ppm in July 2003 and maximum value of 360ppm in September 2004 in respect to total phosphate phosphorus were estimated. A minimum value of 140ppm in December 2004 and maximum value of 280 ppm in October 2005 in respect to available potassium were registered in this study site .

Faunal Diversity: Different groups of soil microarthropods *viz.* Acarina , Collembola, Coleoptera, Diptera, Isopoda, Hymenoptera, Arachnid, Centiped and Milliped have been recorded from the study site (Nayachar Island). The order Acarina included 9 families *viz.* Oribatulidae, Haplozetidae, Galumnidae, Oppiidae, Tectocepheidae, Trhypochthoniidae, Nanhermanniidae, Belbidae and Ceratozetidae among which maximum number of species belonged to family Oribatulidae (3 species) followed by Oppiidae (2 species) , Tectocepheidae (2 species) , Haplozetidae (1species), Galumnidae (1species), Trhypochthoniidae (1 species), Nanhermanniidae (1species), Belbidae (1species) and Ceratozetidae (1species). The order Collembola at the same study site was represented by 4 families. Maximum number of species (6 species) were found to belong under the family Entomobryidae followed by Isotomidae (5 species), Smithuridae (3 species) and Onychiuridae (1 species). The order Coleoptera at the same study site was composed of 3 families *viz*. Carabidae, Staphylinidae and Dytiscidae. The order Diptera was represented by two families namely Mycetophilidae and Tipulidae. Both the orders Isopoda and Hymenoptera were represented by 1 family *viz.* Oniscoidae (2 species) and Formicidae (4 species) respectively. The order Hymenoptera of this study site was represented by 1 family *viz*.. Other soil arthropods were Araneae, Chilopoda(Centiped) and Diplopoda (Milliped) .The order Araneae was represented by 3 families *viz.* Salticidae, Pholcidae and Urocteidae . Therefore, In this study site(Nayachar Island) was found to harbour 13 species of Acarina , 15 species of Collemola , 3 families of Coleoptera, 2 families of Diptera, 2 species of Isopoda, 4 species of Hymenoptera , 3 species of Araneae and 1 unidentified species each under Centiped and Milliped and thereby supported the lives of 44 microarthropod species belonging to 29 genera and 24 families including 5 families under Coleoptera and Diptera, the genera and species under those 5 families could not be identified. Besides, 2 unidentified species under Centiped and Milliped were also recorded.

Monthly and seasonal population fluctuation of different microarthropods

Acarina extracted from this study site belonged to 9 species such as *Scheloribates thermophilus, Scheloribates parvus, Scheloribates praeincisus, Xylobates seminudus, Galumna flabellifera, Oppia sp, Multioppia* and *Tectocepheus velatus* . The peak population density of Acarina fauna was found in the month of September in 2003 and that of minimum was recorded in the month of August 2003. In 2004, maximum total population was recorded in the month of October, which was thought to be due to extended monsoon upto October. In 2005 peak population was also observed in September when organic carbon and available

potassium were maximum. Analysis of species wise population density revealed peak in October (2004) of a most dominant species *Scheloribates thermophilus* (6.91%) which displayed moderate peak in the month of September (2003) and that of minimum was found in the month of March, April (2004). The average population density of this species was 0.64±0.07 . The species, *Scheloribates parvus* was considered as second dominant species as revealed by its relative abundance (5.43%) average population density was 0.51±1.This species showed its highest peak in October (2003) followed by a moderate peak in the month of September (2004). The third dominant species *Scheloribates praeincisus (4.23%)*showed its peak in November (2004) and exhibited a moderate peak in the month of September (2005). This species showed average population density of 0.39±0.04 . Similar trend of population fluctuation was observed for other five species *viz. Xylobates seminudus, Galumna flabellifera, Oppia sp, Multioppia sp* and *Tectocepheus velatus* .

The order Collembola was represented by 6 dominant species as revealed for relative abundance such as *Isotomurus balteatus, Isotomiella minor, Sminthurides appendiculatus, Entombrya sp, Sinella sp* and *Lepidocyrtus sp* . The peak population density of total Collembola was recorded in the month of October (2003) and that of minimum was observed in the month of August (2003). In 2004, maximum total population was in the month of October and this might be due to extended monsoon upto October. In 2005, peak population was also observed in November . Analysis of species wise population density revealed peak in October (2004) of a dominant species *Isotomurus balteatus (4.51%)* which displayed a moderate peak in the month of September (2003) and that of minimum was found in the month of March (2004). The average population density of this species was 0.42±0.57. The species *Isotomiella minor* was considered as second dominant species as revealed by its relative abundance (3.43%) and the average population density of this species was 0.32±0.04. This species showed its highest peak in October (2004) followed by a moderate peak in the month of September (2005). The third dominant species *Sminthurides appendiculatus* (3.39%) showed its peak in September (2005) and exhibited a moderate peak in the month of October (2004). The average population density of this species was 0.31±0.3. Similar trend of population fluctuation was observed for other 3 species *viz. Entomobry sp, Sinella sp and Lepidocyrtus sp*.

Coleoptera was represented by 2 major families such as Carabidae and Staphylinidae . The families Carabidae and Staphylinidae recorded from this study site. The species belonged to these families could not be identified, as because all collected materials were immature

hindering their identification upto species level identification was not possible. These family has been treated as taxon like the identified other arthropods. The peak population density of Coleoptera fauna was found in the month of November (2003) and that of minimum was recorded in the September (2003). In 2004, maximum total population was recorded in the month of October, which was thought to be due to extended monsoon upto October. In 2005, peak population was also observed in the month of October . Analysis of species wise population density revealed peak in October (2004) of a dominant family Carabidae (4.51%) which displayed moderate peak in the month of September (2003) and that of minimum was found in the month of April (2004). The average population density of this family was 0.418±0.04. Another dominant family was Staphilinidae showed its peak in October (2005), which displayed moderate peak in the month of December (2003) and that of minimum was found in the month of April (2004). The average population density of this family was 0.496±0.05.

Diptera extracted from this study site belonged to single family such as Mycetophilidae . The species belonging to this family could not be identified, as because all collected materials were immature hindering their identified upto species level identification was not possible. This family has been treated as taxon like the identified other arthropods. The peak population density of Diptera fauna was found in the month of October (2003) and that of minimum was recorded in the month of August (2003). In 2004, maximum total population was recorded in the month of November. In 2005, peak population was also observed in the month of October. Analysis of species wise population density revealed peak in November(2005) of a dominant family Mycetophilidae (4.47%) which displayed moderate peak in the month of November (2004) and that of minimum was found in the month of April (2005). The average population density of this family was 0.414±0.05.

Isopoda extracted from this study site belonged to 1 major species such as *Philoscin sp* . The peak population density of Isopoda fauna was found in the month of November (2003) and that of minimum was recorded in the month of August (2003). In 2004, maximum total population was recorded in the month of October, which was thought to be due to extended monsoon upto October. In 2005, peak population was also observed in September when soil factors like organic carbon and total nitrogen content were maximum . Analysis of species wise population density revealed peak in October (2005) of a dominant species *Philoscin sp* (4.23%), which displayed moderate peak in the month of November (2004). The average population density of this species was 0.39±0.56 (Fig-2)

The order Hymenoptera was represented by 2 major species such as *Monomorium destructor* and *Monomorium floricola* . The peak population density of Hymenoptera fauna was recorded in the month of November in 2003 and that of minimum was recorded in the month of August 2003 when total nitrogen and moisture content were minimum. In 2004, maximum total population was recorded in the month of November when soil factor like organic carbon available potassium content were maximum. In 2005, peak population was also observed in November . Analysis of species wise population density revealed peak in November (2003) of a dominant species *Monomorium floricola* (2.27%), which displayed moderate peak in the month of December (2004) and that of minimum was found in the month of March, April (2004). The average population density of this species was 0.21±0.05. The species *Monomorium destructor* was considered as second dominant species as revealed by its relative abundance (1.91%) and the average population density of this species was 0.18±0.03. This species showed its highest peak in October (2003) followed by a moderate peak in the month of November (2004) and that of minimum was recorded in the month of March (Fig-2)

Arthropods extracted from this study site belonged to Araneae, the population density of different major species under the order Araneae showed highest peak in the month of October (2003) and that of minimum was recorded in the month of March 2004. Araneae extracted from this site belonged to one major species such as *Marpissa sp*. The species *Marpissa sp* showed its highest peak in October (2003) and that of minimum was recorded in the month of (March 2004 - July 2004)

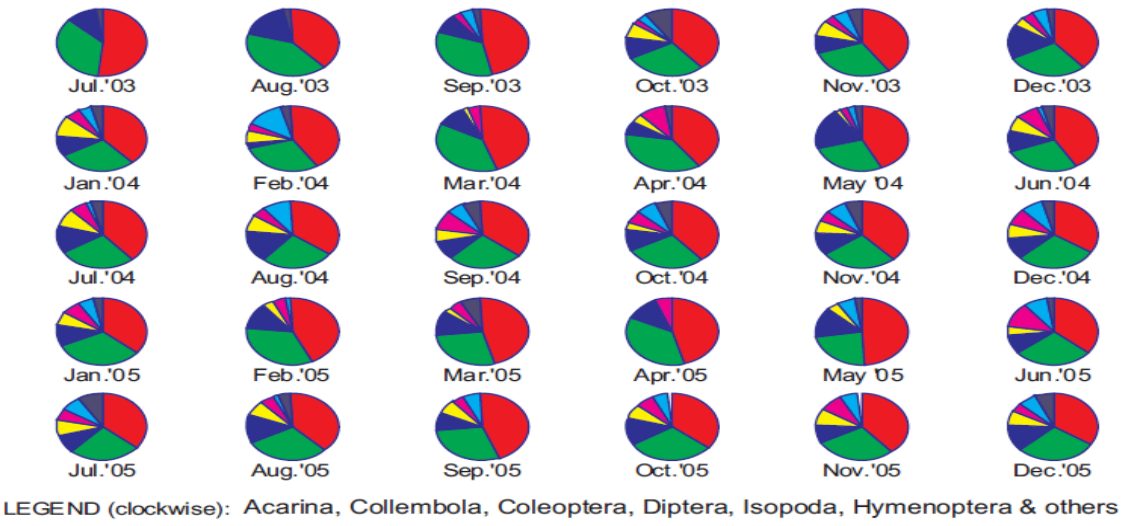

Fig-2

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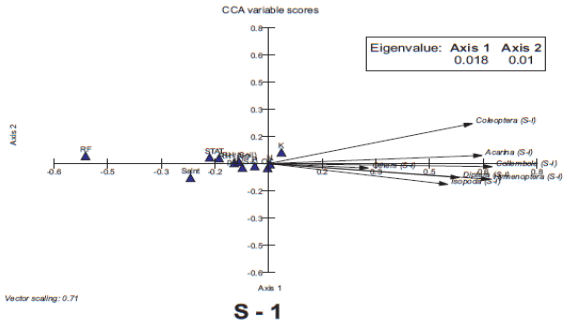


Fg-3 Biplot of CCA showing environmental vs different gouprs of soil microarthropods

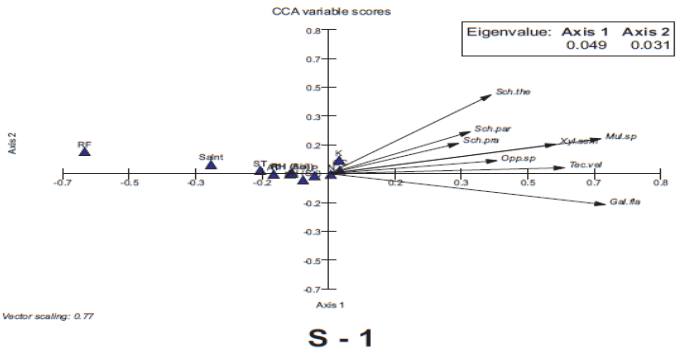
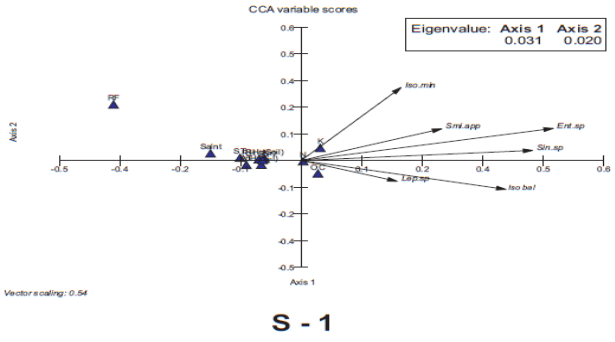
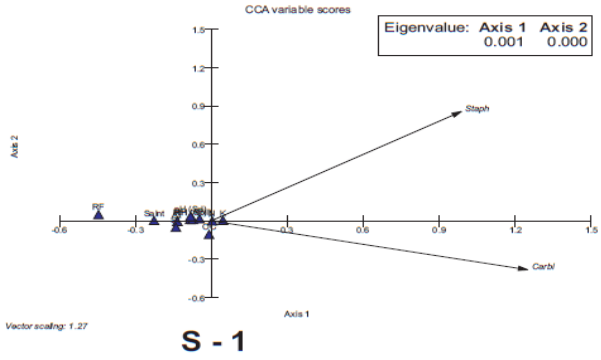


Fig-4 Biplot of CCA showing environmental



Figg-5 Biplot of CCA showing environmental vs different species of Collembola



vs different species of Acarina

Fig-6 Biplot of CCA showing environmental vs different species of Coleoptera

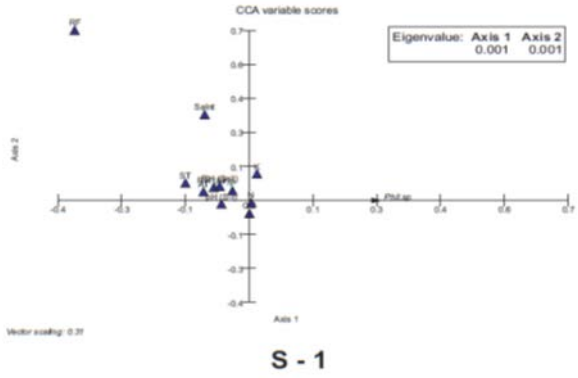


Fig 7: Biplot of CCA showing environmental vs different species of Diptera

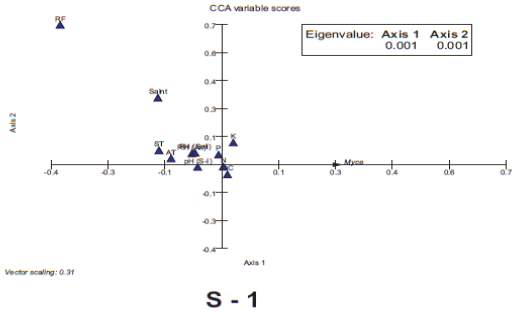


Fig-8.Biplot of CCA showing environmental vs different species of Isopoda

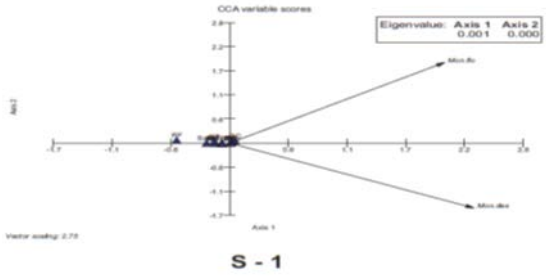


Fig-9 Biplot of CCA Showing environmental Vs different different species of other Species of Hymenoptera

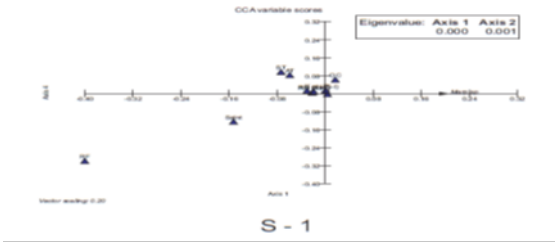


Fig-10. Biplot of CCA Showing environmental VS microarthropod

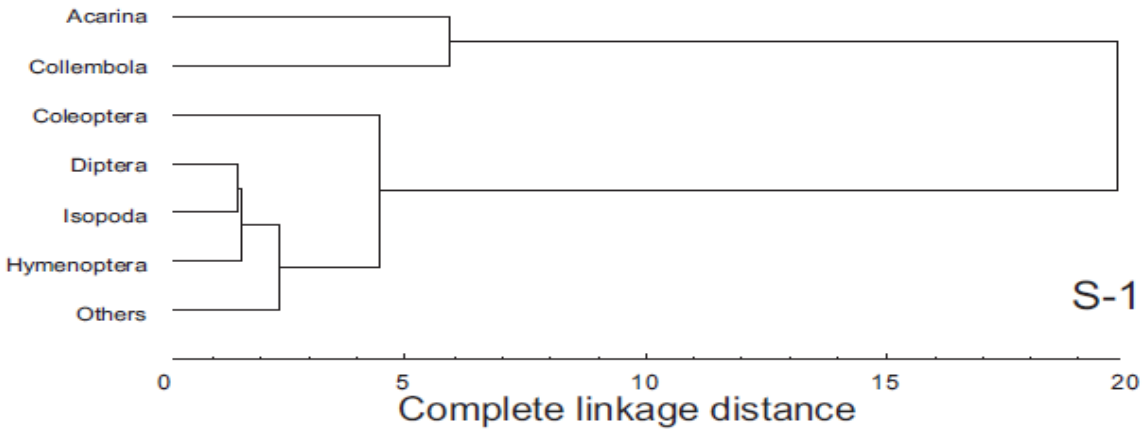


Fig-11.Cluster analysis based on population density of different groups of soil microarthropods showing their nature of association

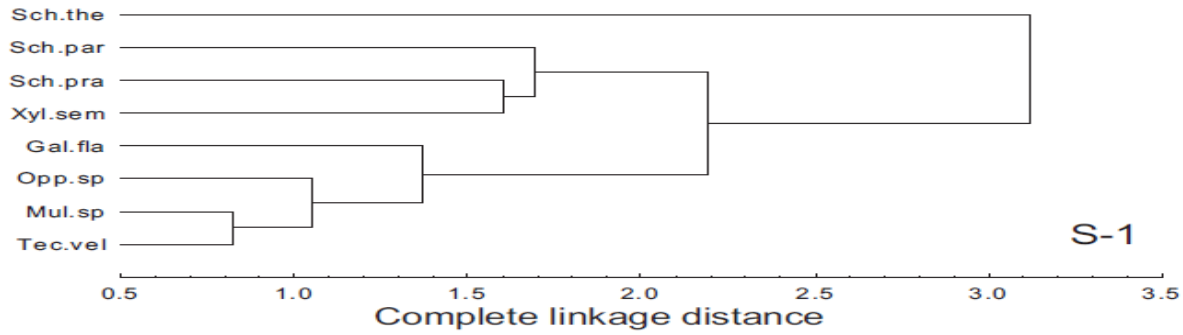


Fig-12.Cluster analysis based on population density of different species of Acarina showing their nature of association .

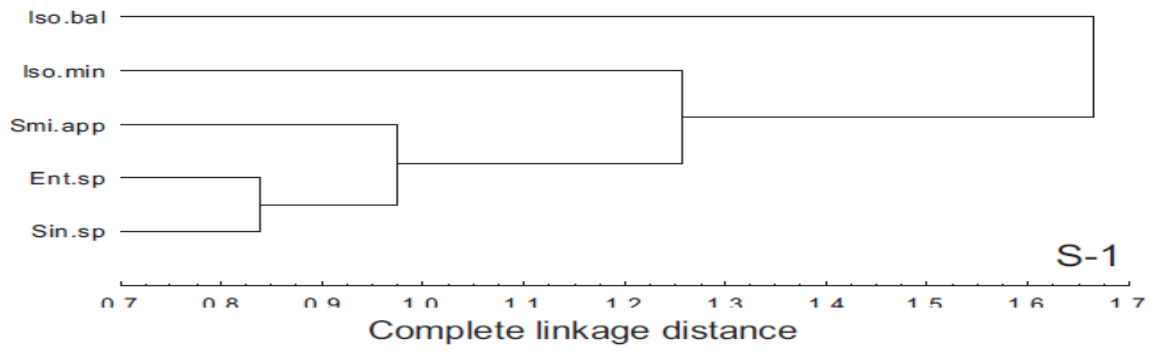


Fig-13.Cluster analysis based on population density of different species of Collembola showing their nature of association

Discussion:

The present study was based on the sampling of microarthropods of four selected eco-zones of Midnapur (East) coast of West-Bengal, India, over a period of 30 months (July 2003-December 2005). In this study site (Nayachar Island) was with good mangrove coverage. The supratidal part of the present study sites were covered with different types of vegetations and earlier observations by Hazra & Choudhuri (1990) , Dey *et al* (2010)showed that surface soil vegetations exert an indirect influence on the soil micro arthropods population through its effect on the porosity of soil, humus formation and soil moisture. The nature of vegetation in diffrent sampling sites differed from each other . In a study on soil microathropods especially on collembola in various forest types of Poland including both deciduous and coniferous trees, Szeptucki (1967) noticed similar faunal composition of both of these sites, although they differed in terms of soil, sloping, exposition, microclimate etc. The results of this study revealed that main factor regulating the collembolan fauna in those forests was the presence of coniferous trees, which provided litter and their decomposition products with special chemical features.

According to Edwards and Lofty (1969), Dey *et al(2005)* the soil microarthropods fauna of a certain locality was determined by a complex of factors, both ecological and historical. Therefore, in their views, the degree of similarities in species composition, between two different study sites could be used as an index of an overall ecological similarity and the influence of vegetation types although was indirect, exerted, perhaps, through its effect on soil type, microfloral composition, or soil moisture. Hagvar (1960) found that, in coniferous forest floor, the number of species of collembola increased with increasing soil fertility but the diversity of species was maximum having moderate nutrient contents of soil. Mattson and

Addy 1975 found that the insect population after being appeared in certain sites capable of regulating nutrient cycling through their influence on vegetation and soil litter complex, but as yet, the magnitude of such effects of arthropods on ecosystem nutrient cycling has not been investigated. Hazra and Sanyal (1996), Dey *and* Hazra (2020) found that, in mangrove forest of an island of river Hooghly, in West Bengal , the diversity of collembolan species was increased in the site where mangrove was raised artificially and also noticed that the density of microarthropods fauna increased alongwith the increased concentration of moisture and nitrate (Fig-3-11)

The soil fauna as recorded in the present study belonged to seven groups like Acarina, Collembola, Coleptera, Diptera, Isopoda, Hymenoptera, and miscellaneous soil microarthropods. The population density of each showed different seasonal fluctuation trend in respect to other such groups. Moreover, the number of species belonging to different microarthropodal groups and also in different sampling sites also differed considerably. In the present study 13 species of Acarina under 9 families and 10 genera were recorded at study site(Nayachar Island) *viz. Scheloribates thermophilus , Scheloribaties parvus , Scheloribates praeincisus, Oppia sp, Multioppia sp, Tectocepheus velatus, Tectocephous sp. Xylobates seminudus, Galumna flabellifera, Allonothrus sp, Masthermannia sp, Metabelba obtusus* and *Hypozetes sp*;

In the present study, 15 species of collembola under 4 families and 10 genera were recorded at study site(Nayachar Island) *viz , Isotomurus balteatus , Isotomiella minor, Sminthurieds appendiculatus, Entomobrya sp, Sinella sp, Lepidocyrtus sp, Proisotoma sp , Cyphoderus sp, Smintharides aauaticus, Cryptophygus sp* and *Isotoma sp;*

In the present study, 3 families of Coleoptera were recorded at study site , *viz* Carabidae, Staphylinidae, and Dyticidae; Two families were recorded under the order Diptera at study site ; *viz* Mycetophilidae and Tipulidae . Isopoda included two species from study site *viz. Philoscin sp, Procellionides sp.*

In the present study 4 species of Hymenoptera under 1 family and 2 genus were recorded at study site-1,*viz. Monomorium destructor, Monomorium floricola, Monomorium lationde* and *Pheidola roberti*

In the present study, 3 species and two other groups were recorded and were considered as miscellaneous group of soil microarthropods at study site*viz. Marpissa sp, Artema sp, Uroctea sp,* Centiped and Milliped;

Analysis of relative abundance of 44 species belonging to 29 genera and 24 families of revealed that of which 21 species could be included in the categories of Eudominant

(RA>10%), dominant (RA=5.1-10%) , subdominant (RA=2.1-5.0%) and recedent (RA=1.1-2%) (Skubala 1999). These 21 species were regard as major species and subjected to further analysis (Fig-11-13)

Thus, most of the predominant soil microarthropods forms encountered here found to exhibit a single peak in a year. According to Straalen (1997), Dey *et al* (2012) within soil arthropods community some species have sharp peak in respective to months where others tend to fluctuate gradually throughout the year .The pattern of seasonal variation appeared to be different in different forms, which perhaps indicated the existence of different breeding periods. Existence of single peak suggested the probability of single generation per year. Bellinger , 1954 opined that the species, which showed two annual peaks , had two generations in a year. In the same study, the occurrence of peak population in various soil arthropods was related to their life cycles and peak populations of different species were caused by the prevalence of a large number of Juveniles in the samples. The population peaks on the other hand could be correlated with the period of egg- lying in the field in species where data on times of egg-laying were available.

The population fluctuation of same species registered sharp differences in from one site to another site which might be the effect of soil type, microbial population, environmental and edaphic parameters of a particular site. In the year 1954, Bellinger suggested that the habitat preference of soil animals be determined by soil microflora with many edaphic factors. According to Torne (1961) certain microflora present as gut symbionts in Collembola might have an important role in the digestion of plant materials consumed by the host.

Canonical correspondence analysis (CCA) a multivariate analysis has been used for the analysis of species assemblage structure (Ysebaert and Herman 2002). CCA of the present investigation revealed that different ecological parameters of both soil and metrological parameters had different intensity of impact on soil microarthropodal faunal distribution and abundance. The results also highlighted order and species assemblage structure at different study sites area (Fig-3-11).

A population is defined as any group of organism of the same species occupying a particular space and functioning as a part or a biotic community, which in turn is defined as an assemblage of population that function as an interactive unit through coevolved metabolic transformations in a prescribed area of physical habitat.

Interaction at these levels between genetic system and physical systems affects the course of natural section and, thereby, determines not only the survivility of individual organisms but

also how ecosystem as a whole change over evolutionary time (Odum and Barrett, 2005), Dey and Hazra(2020).

Icon plot, In this type of Icon plot data value for each case are plotted as a pie chart for 30 individual months during the study periods; cases was arranged clock wise (Starting at 12 '0'clock) relative values of selected variables was represented by the size of the pie slices. In the present study relative variation of Acarina, Collembola, Coleoptera were found quite consistence while other all micoarthropods are extremely vary from month to month (Fig-3)

The term cluster analysis has been carried out for grouping objects of similar kind into respective categories. In other words cluster analysis is an exploratory data analysis tool which aims at sorting different objects into groups in a way that the degree of association between two objects is maximal if they belong to the same group and minimal otherwise. In case of complete linkage method, the distances between clusters are determined by the greatest distance between any two objects in the different clusters (that is by the "furthest neighbors"). This method usually performs quiet well in case when the objects actually form naturally distinct "clumps". In present study, the dendogram showed two basic major groups. Acarina and Collembola concentrated in one group while rest in another groups. Similar observation found by Torne (1961)(Fig-11-13).

Most of the predominant soil microarthropodal forms encountered here found to exhibit a single peak in a year. The pattern of seasonal variation appeared to be different in different forms, which perhaps indicated the existence of different breading periods. On the other hand, population fluctuation of some species have shown difference in abundance or peak population one site to other sites which was supposed to be due to the effect of soil type, environmental and edaphic parameters of a particular site. As mentioned in the previous sections that soil microarthropods help ecosystem functioning by way of imparting important role in food-chain-food web system vis-à-vis in trophic relationship and also help nutrient cycling as decomposer.

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