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A STUDY ON SOIL INVERTEBRATES IN DIFFERENT TERRESTRIAL ECOSYSTEMS OF SIMILIPAL BIOSPHERE RESERVE, MAYURBHANJ, ORISSA

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ABSTRACT

Density and biomass of certain soil invertebrates were studied in different ecosystems of Similipal Biosphere Reserve. The density of soil invertebrates like ants, termites, arachnida, myriapoda, nematodes, earthworms and larvae was significantly different (ANOVA) among cropland, fallowland and forest ecosystems. Although the biomass of all these invertebrates was higher in forest ecosystem, it was not statistically significant among these three types of systems. Ant, termite and myriapoda were absent in cropland whereas arachnida and myriapoda were absent in fallowland.

INTRODUCTION

Soil is one of the most important ecological factors which support all types of life form directly or indirectly. It is a treasure house of variety of invertebrates and to lesser extent vertebrates. Soil formation is a natural process and takes a thousand of years to form a small layer of soil (Dash, 2005).

The interaction of various factors influencing the process of soil formation culminates into a variety of soil types, which depends upon the parent matter and other factors, *e.g.* climatic, topographic and biological etc. to ensure which types of the soil will develop in an area (Sharma, 2005). Different types of soil may be defined by the nature of the mineral matrix, the vertical distribution of organic matter and the movement of redeposition of various inorganic components. The profiles of the different types of soil differ markedly in respect to their physio-chemical and biological properties (Sharma, 2005). The uppermost horizon consists of freshly fallen or partially decomposed organic matter. This horizon is well developed in forest and may be completely absent in fallowlands and croplands (Sharma, 2005). On the reverse, the difference, *i.e.*, existing between horizons of croplands and forests is further increasing due to excessive use of fertilizer and pesticides in the crop fields.

Soil invertebrate fauna (surface dwellers) from Similipal Biosphere Reserve (SBR) has been reported earlier (Ramakrishna *et al*., 2006). But no literature is available on the soil invertebrates of SBR that has different forest types at various altitudes having varied habitats. Therefore, the present study was undertaken to verify the biological variations amongst three different terrestrial ecosystems in SBR. Density and biomass of invertebrates are also compared between the three systems to know suitable habitat of a species.

MATERIALS AND METHODS

Study area

The study area is at the south-east side (Latitude 21°35' N and Longitude 86°22' E; Dey *et al*., 2010) gets more precipitation (*i.e.* about 1,846 mm rainfall during monsoon; Dey *et al*., 2010) of SBR *i.e.* in and around Katuria, Sanadei and Labanyadeipur villages of Kaptipada block in the district of Mayurbhanj, Orissa, India. Soil samples for cropland and fallowland ecosystems were taken from peripheral zone and for forest ecosystem soil was taken from buffer zone (part of Katuria) of SBR. The forest of study area is drying deciduous and soil is red loamy (Dey *et al*., 2010). The undulating valley forest of this region is mostly covered by the plant species of Sal, Piasal, Arjun, Asan, Jamun, Tendu and Kusum. As the soil has poor moisture retention capacity, the xerophytic species are also found in this region. This undulating valley forest are interlaced with a number of streams those are not perennial in nature, but their water flow accumulate the decomposed biomass for better habitat of the soil invertebrates (Dey *et al.*, 2010).

Collection of samples

The red loamy soil of study site is usually dry and hard to excavate during other periods of the year except post-monsoon period which is easy for excavation. Therefore, the samples were collected during the months of September-November (post-monsoon period) for consecutive 3 years from 2007-2009 from the study area. For collection of samples, soil block of 25 × 25 × 30 cm were dug up by crowbar and five replica were made for each type of ecosystem (cropland, fallowland and forest; Anderson and Ingram, 1992).The soil monolith was divided into 3 tiers (*i.e.,* 0-10 cm, 11-20 cm and 21-30 cm), *i.e.,* from each sample three sub-samples were collected. The soils masses were taken out and from that soil invertebrates observed visually were collected out by hand picked method (Dash and Patra, 1977; Senapati and Dash, 1981) and were kept in small plastic jars which contain 5% formalin for preservation. Then these jars containing samples were taken into laboratory and soil invertebrates of different species were sorted into major invertebrate groups (ant, termite, arachnida, myriapoda, nematode, earthworm and larva).They were weighed after soaking in a blotting paper for biomass study by monopan balance (Roy Electronics, Varanasi) and counted by hand for density study of each type and expressed as no/m^2. Further, as the weight was taken from formalin fixed samples, it is slightly less than the freshly weighed animals. Therefore, a correction factor of 6.39 was multiplied in case biomass study as per Senapati and Dash (1980). It was then expressed as gram fresh weight. As there is no significant difference of data between years, the data of three years were pooled together and expressed as mean ± s.d. of 15 replicates.

Statistical analysis

Student's t-test was used to find out the level of significance between two sets of data (Croxton *et al.*, 1982). Differences among mean density and biomass in relation to ecosystems were determined by one-way analysis of variance (ANOVA) (Croxton *et al.*, 1982). A difference was considered to be statistically significant if $p < 0.05$.

RESULTS

The biological characteristics (density and biomass) of some soil invertebrates such as ant, termite, arachnida, myriapoda, nematode, earthworm and larva were studied as these are visible in three different soil ecosystems (cropland, fallowland and forest ecosystems) in the month of September-November for 3 years (2007-2009).The findings were presented in Table 1.

It was found that ants were absent in the samples collected from the cropland whereas their mean number (density) was 28.80 and 51.20 in fallowland and forest ecosystems, respectively. Termites were also absent in cropland. There mean number was 73.63 in fallowland and 192.00 in forest ecosystem. Arachnids were absent in fallowland, but their mean number was 6.40 and 28.80 in cropland and forest ecosystems, respectively. Myriapods were absents in both cropland and fallowland whereas their mean number was 19.20 in forest ecosystem. Mean number of nematodes was 3.20, 57.60 and 67.20 in cropland, fallowland and forest ecosystems, respectively. Mean number of larvae was 6.40 in cropland, 32.00 in fallowland and 60.80 in forest ecosystem. It was found that earthworm were present in all type of soil ecosystems (cropland, fallowland and forest ecosystem). Their mean number was 64.00, 19.20 and 86.40 in cropland, fallowland and forest ecosystems, respectively (Table 1).

Mean weight (biomass) of ants was 0.85g and 3.16g in fallowland and forest ecosystems, respectively. It was observed that mean weight of termites was 3.6 7g in fallowland and 11.59g in forest ecosystem. Mean weight of arachnids was 3.55g and 9.18g in cropland and forest ecosystems, respectively. Myriapods were only present in forest ecosystem and its mean weight was 6.33g. It was found that mean weight of nematodes was 0.20g, 2.23g and 3.36g in cropland, fallowland and forest ecosystems, respectively. Mean weight of larvae was 0.04g in cropland, 4.59g in fallowland and 19.27g in forest ecosystem. The biomass of 29.54g, 6.12g and 25.54g were the mean weight of earthworm in cropland, fallowland and forest ecosystems, respectively (Table 1).

It was observed that there was no significant difference between density of ants in fallowland and forest ecosystem and in between biomass of ants in fallowland and forest ecosystem. There was no significant difference in both density and biomass of termites between fallowland and forest ecosystem. It was shown that density and biomass of arachnids in between cropland and forest ecosystem were significantly different ($p < 0.05$) from each other. It was observed that density and biomass of nematodes in between cropland and fallowland were significantly different ($p < 0.05$) from each other. Density of nematodes in between cropland and forest ecosystem and

Table 1: Biological characteristics (density and biomass) of different soil invertebrates in cropland, fallowland and forest ecosystems of SBR

Name of the group	Parameter	Soil types Cropland	Fallowland	Forest
Ant	No.	-	28.80 ± 28.62	51.20 ± 47.19
	g fresh wt.	-	0.85 ± 1.52	3.16 ± 2.96
Termite	No.	-	73.60 ± 121.64	192.00 ± 112.56
	g fresh wt.	-	3.67 ± 6.82	11.59 ± 6.52
Arachnida	No.	6.40 ± 8.76	-	28.80* ± 13.38
	g fresh wt.	3.55 ± 3.32	-	9.18* ± 4.24
Myriapoda	No.	-	-	19.20 ± 28.62
	g fresh wt.	-	-	6.33 ± 9.26
Nematode	No.	3.20 ± 7.15	57.60** ± 24.26	67.20* ± 62.37
	g fresh wt.	0.20 ± 0.45	2.23** ± 0.91	3.36 ± 3.72
Earthworm	No.	64.00 ± 29.93	19.20** ± 13.38	86.40*** ± 54.96
	g fresh wt.	29.54 ± 12.59	6.12 ± 4.91	25.54 ± 25.64
Larvae	No.	6.40 ± 14.31	32.00** ± 19.59	60.80* ± 20.86
	g fresh wt.	0.40 ± 0.90	4.59** ± 3.41	19.27*,*** ± 8.86

Data were mean ± S.D. of 15 replicates of each ecosystem. *$p < 0.05$ in comparison to cropland, **$p < 0.05$ in comparison to cropland and ***$p < 0.05$ in comparison to fallowland respectively between different ecosystems of the same group

Table 2: Summary of computations for one-way analysis of variance (f-test) of data of density of different soil invertebrates in cropland, fallowland and forest ecosystems of SBR

Source of variation	Sum of square(SOS)	Degrees of freedom (d.f.)	Mean Squares(MS)
Between treatment	B-D = 16942.81	u-1 = 3-1 = 2(n_1)	B-D/(u-1) = 8471.40
Residual	A-D = 24488.22	U(v-1) = 3(7-1) = 18(n_2)	(A-B)/{u(v-1)} = 1360.45
Total	A-D = 41431.04	(u × v)-1 = (7 × 3)-1 = 20	

Source of variation	Degrees of freedom	F(calculated)	F(tabulated),At $p < 0.05$
Between treatment	$n_1 = 2$	6.22	3.60
Residual	$n_2 = 18$		

[$A = \sum x^2$, $B = \sum x^2/n$, $D = (\sum x^2)/N$]

Table 3: Summary of computations for one-way analysis of variance (f-test) of data of biomass of different soil invertebrates in cropland, fallowland and forest ecosystems of SBR

Source of variation	Sum of square(SOS)	Degrees of freedom (d.f.)	Mean Squares(MS)
Between treatment	B-D = 328.87	u-1 = 3-1 = 2(n_1)	B-D/(u-1) = 164.43
Residual	A-D = 1180.48	U(v-1) = 3(7-1) = 18(n_2)	(A-B)/{u(v-1)} = 65.58
Total	A-D = 1509.00	(u × v)-1 = (7 × 3)-1 = 20	

Source of variation	Degrees of freedom	F(calculated)	F(tabulated),At $p < 0.05$
Between treatment	$n_1 = 2$	2.51	3.60
Residual	$n_2 = 18$		

[$A = \sum x^2$, $B = \sum x^2/n$, $D = (\sum x^2)/N$]

in between fallowland and forest ecosystem were significantly different ($p < 0.05$). Rests did not show significant difference between them. Densities of larvae in between fallowland and forest ecosystem were not significantly different, but all the rest were significantly different ($p < 0.05$). Density of earthworms in between cropland and fallowland and in between fallowland and forest ecosystem were significantly different ($p < 0.05$), whereas rests were not.

One-way analysis of variance (ANOVA) of density (Table 2) of soil invertebrates (ants, termites, arachnida, myriapoda, nematodes, earthworms and larvae) among cropland, fallowland and forest ecosystem was significantly different ($p < 0.05$) whereas biomass (Table 3) of soil invertebrates among cropland, fallowland and forest ecosystem was not significantly different.

DISCUSSION

The surface vegetation and chemical parameters of soil are influenced due to application of high dose of inorganic fertilizers, herbicides and pesticides in case of fallowland and cropland for agricultural purposes. Loss of surface litter or organic matter from the surface of forest soil is due to burning and physical removal of litter for fuel purpose. These factors strongly influence the faunal communities characterized by high species diversity and biomass but when the forest system is modified into agricultural purpose there is decrease in species diversity as well as biomass of soil invertebrates (Srivastava and Singh, 1989). A decrease in population density and biomass of ant, arachnida, myriapoda and termite was observed in the present study on cropland and forest ecosystems of SBR. This may be due to the use of herbicides and pesticides in croplands and removal of surface litters in forests as reported by Srivastava and Singh, 1989 in their study in similar conditions. Ao (1987) also found the diversity of soil surface as well as that of decomposer arthropods was greater in undisturbed tropical woodland than in the adjacent slash- and burn-cultivated area due to change in land use pattern.

The earthworm population in cropland is less than that of forest ecosystem of SBR (Table 1). Decrease in population density in cropland over reserve forest of SBR can be correlated to low organic matter content in soil and the use of pesticides. Copper based pesticides are a major concern to earthworm population which has been worked out by many scientists (Malecki *et al*., 1982; Bengtsson *et al*., 1983; Curry, 1986). More number of earthworm species belonging to all ecological types (anecic, epianecic, endogeic and epigeic) are found in reserve forest while only few types are found in fallowland and again less are found in cropland ecosystems in SBR. Shakir and Dindal (1997) have observed a similar pattern of distribution. They found earthworm population and biomass of 111.5 no. m^{-2} and 15.5 g m^{-2} in Hardwood forest and 85.9 no. m^{-2} and 10.1 g m^{-2} in Norway spruce plantation, respectively with 6 and 5 numbers of species in forest and spruce plantation, respectively. The difference between the earthworm populations at different sites is due to the availability of quality and quantity of food which depends on the litter composition. In the forest ecosystem the dominant litters is a mixture of leaves of various trees which is a good source of food for earthworm, thereby in the present study a variety of species of earthworm were found in forest than cropland or fallowland ecosystems of SBR. Reduction in number of earthworm species with respect to land use pattern has been studied by many workers (Daugbjerg *et al*., 1988; Krivolutzkii and Pokarzhevskii, 1991; Dennis *et al*., 1994; Fragoso and Rojas, 1994; Behera *et al*., 1999; Mele and Carter, 1999; Lawrence and Bowers, 2002; Wahlen and Costa, 2003; Wahlen, 2004).

The factors which are responsible for different distribution (density) of earthworms in the present three ecosystems may be responsible for differential distribution of larvae and nematodes in these ecosystems.

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