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A STUDY ON EARTHWORM POPULATION AND DIVERSITY WITH SPECIAL REFERENCE TO PHYSICOCHEMICAL PARAMETERS IN DIFFERENT HABITATS OF SOUTH 24 PARGANAS DISTRICT IN WEST BENGAL

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INTRODUCTION

The silent role of earthworms in improving soil properties especially role of earthworms in promoting soil fertility, has been known since ancient times. Darwin (1881) was the first to observe and offer a scientific explanation of their true role in the ecosystem and his conclusions led to an upsurge of interest in earthworms from the late nineteenth century onwards (Vejdovsky 1884; Beddard 1895, 1912; Michaelsen 1900; Stephenson 1923, 1930; and Bahl 1950).

Earthworms are widely distributed throughout the world particularly in the temperate and tropical regions and their population contributes about 80% of the total biomass of the soil (Kale 1997; Nainawat and Nagendra 2001). Researchers have identified and named more than 4400 distinct species of earthworms worldwide (Sinha 2009), each with unique physical, biological and behavioural characteristics that distinguish each one of them from the other and Julka *et al*. (2009) reported 590 species of earthworms from India. Earthworms are perhaps the most important soil organisms in terms of their influence on organic matter breakdown, soil structural development and nutrient cycling, especially in productive ecosystems (Kooch *et al*., 2007). The earthworm cast increases organic compound, *cytokinin* and *auxin* concentration in the soil (Krishnamoorthy and Vajranabhaiah 1986) which is considered positive on ecosystems.

Distribution of earthworms is usually irregular (Guild 1952; Satchell 1955; Svendsen 1957) and the numbers vary in relation to the type of soil (Evans and Guild 1947; Curry 1998) and ecological factors especially edaphic factors (moisture and temperature) (Murchie 1958; Kaleemurrahman and lsmail 1981).

The present study was carried out in different habitats in the South 24 Parganas district in West Bengal which include both natural and human managed ecosystems where earthworms are mostly distributed in patches. Regular field estimates of seasonal variation in earthworm populations were made for two consecutive years in different fields of South 24 Parganas. The fields represent different ecological niches. This study was done with the objective to know distribution of earthworms in relation to some soil physico-chemical parameters across different sampling sites.

MATERIALS AND METHODS

Study Area: South 24 Parganas district of the State of West Bengal, India, falls within the great active delta of the river Ganga. The soils are alluvial and contains 15% sand, 69% silt and 18% clay. The direct deposits of the Ganga alluvium are salt free and rich in nutrients (Raychaudhuri *et al.,* 1963).

The present study was conducted at seven different habitats within three locations namely, 1. Budge budge, 2. Pujali and 3. Bamanghata in South 24 Parganas. Climate of the area is tropical and characterised by mean annual maximum and minimum temperatures 36.3^{0}C and 13.3^{0}C respectively, mean annual rainfall 1760 mm and relative humidity which varied between 71% to 85%. Three distinct seasons generally predominate in this region during the year: Summer (March to May) Monsoon (June to October) and Winter (November to February). Maximum precipitation occurred between July and September.

Study sites: For the survey of population dynamics of earthworms, seven sites each characterized by different habitat were chosen in South 24 Parganas. Three habitats at Budge Budge area, two habitats at Pujali and two habitats at Bamanghata area. The sites were selected from different plots with varied habitat properties, *viz.* a. cultivated paddy Field, b. ornamental garden (Rose garden), c. side of a clear Ganga water canal; d. settled fly ash land; e. a grassland at the centre of village hut with grazing cows and goats; f. bank of Hooghly river; g. bank of sewage canal.

Earthworm Sampling: Earthworms and soil samples were collected 3 times in a year, *i.e.* pre-monsoon (summer), monsoon (rainy season) and post monsoon (winter) period for a period of two years during 2011 to 2013. A sampling grid (20 m × 20 m) was marked at each site, containing 16 units of 5 m × 5 m, which were further divided into subunits of 1 m^2. These 1 m^2 subunits were selected randomly and no subunit was sampled twice. During each sampling month, for each study site three widely separated subunits were randomly selected for sampling. Earthworms were collected by conventional digging (25 cm x 25 cm x 30 cm) and hand sorting method (Anderson and Ingram1993) from each quadrat. Earthworms were counted and narcotised by dropping them in 70% ethyl alcohol. They were removed from alcohol after their movement stopped. Then worms were transferred to 5% formalin for fixation and identification.

Soil Sampling and Analysis: Composite soil samples were collected from each site under study and standard methods were followed for analysis. Soil temperature recorded at 0-10 cm. depth using soil thermometer. Moisture content of fresh soil was determined by oven drying the matter at 105^{0}C for 8 hours (Baurman and Velthorst 1996) and expressed as a percentage of weight of the soil samples. Soil pH was measured by digital pH meter. Organic nitrogen was determined by micro Kjeldahl method (Jackson 1962) and organic carbon by wet digestion method (Walkley and Black 1934).

RESULTS AND DISCUSSION

A total of six species of six genera under two families (Megascolecidae, Octochaetidae) found from 505 examples of earthworms collected from South 24 parganas of West Bengal are presented in Table 1. Only two species, *viz.*, *Lampito mauritii* and *Metaphire posthuma* occur in abundance in most of the areas. *E orienta* is also found in six habitats, *i.e.* except one habitat it occurs in most of the areas. In contrast, two species of earthworms are very site specific such as *Amynthas* diffringens *i*n the bank of river Hooghly and *Dichogaster bolaui* in rose garden.

Table 1. Systematic position of earthworm species present in South 24 parganas

Order	Family	Genera	Species
Haplotaxidae	Megascolecidae	*Metaphire*	*M. posthuma* (Vaillant)
		Perionyx	*P. excavatus* Perrier
		Amynthas	*A. diffringens* (Baird)
		Lampito	*L. mauritii* Kinberg
	Octochaetidae	*Dichogaster*	*D. bolaui* (Michaelsen)
		Eutyphoeus	*E. orientalis* (Beddard)

Table 2. Earthworm Population in different habitats

Species Name	***Metaphire posthuma***	***Perionyx excavatus***	***Amynthas diffringens***	***Lampito mauritii***	***Dichogaster bolaui***	***Eutyphoeus orientalis***	**Total**
Habitat							
Paddy field	16	5	-	21	-	2	44
Rose Garden	5	2	-	15	8	3	33
Chorial Canal side	7	3	-	42	-	4	56
Settled Ash field	6	-	-	27	-	-	33
Bank of river Hooghly	9	-	6	21	-	2	38
Grazed Grassland within village	19	-	-	102	-	4	125
Sewage canal side	34	4	-	131	-	7	176
No. of Examples	96	14	6	359	8	22	505

Habitat wise distribution of different species of earthworms in South 24 Pgs. region is presented in Table-2. Among the species the anecic *Lampito mauritii* is the only species common across all the habitats. Out of these six species *Lampito mauritii* is the dominant (n=359), second ranking is *Metaphire posthuma (n*=96*),* and third and fourth in the rank respectively are *Eutyphoeus orientalis* (n=22), *Perionyx excavatus* (n=14), *Amynthus diffringens* (n=6) and *Dichogaster bolaui* (n=8) are the rare ones (Table 2). *L. mauritii* and *M. posthuma* are the common inhabitants of all the seven habitats. *A. diffringens* and *D. bolaui* showed exclusive inhabitation in the bank of Hooghly river and rose garden respectively, while *E. orientalis* is most common species in all the habitats except settled ash field. *P. excavatus* restricted to the habitats (paddy field, rose garden, Chorial canal side) of Budge Budge area only.

The population density of earthworm species based on their distribution in different habitats showed in fig. 1. The high population density of earthworm species is found in Sewage canal side, due to high nitrogen (6.10 gm/kg) and high organic carbon (51.71 gm/kg). Steady moisture range (16.5% -24.7%) all over the year with pH range 6.71-7.31 (almost neutral). The high earthworm density (population and distribution) is associated with high C/N ratio reported by Lee (1985). According to Shakir and Dindal (1997), population density of earthworms is positively correlated with pH and negatively correlated with species diversity. The density of earthworms is dependent on carbon and nitrogen content (Kale and Krisnamoorthy, 1978). Low density are found in rose garden and settled ash field indicative of human interference.

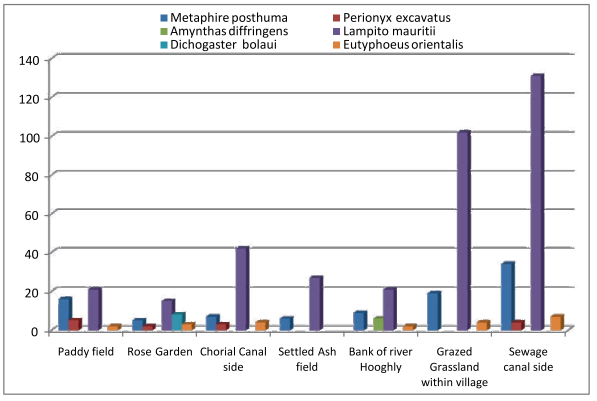

Fig 1. No. of species in different study fields

Abundance being an expression of the species richness these measures are appropriate in assessing the domination of a species in a set of species (Table 2). The study revealed that *Lampito mauritii* showed higher abundance and less in *Amynthus diffringens*. *L. mauritii* representing 71% density of total earthworm species population, followed by *M. posthuma* (19%), *E. orientalis* (4%), *P. excavates* (3%), *D. bolaui* (2%) and the lowest is *A. diffringens* (1%). *L. mauritii* showed wide range of tolerance to edaphic factors, where as *A. diffringens* has low ranges of ecological tolerance.

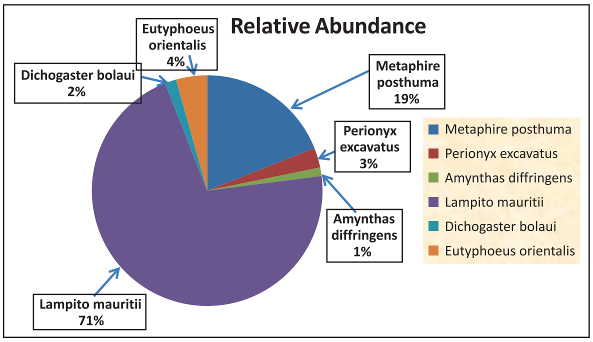

Fig. 2. Abundance of different species indicating diversity

The distribution of earthworms was mainly dependent on the physicochemical characteristics of the soil. Edwards and Lofty (1972) have reported that earthworm activity is influenced of soil parameters besides feed. Influence of soil conditions on earthworm population is also reported by Chaudhuri and Mitra (1983). Each habitat of South 24 Parganas mainly comprise of alluvial soil. Soil moisture, organic carbon and nitrogen is found to be significantly correlated with the distribution of the earthworms (Ismaiel and Murthy 1985; Ganihar1996). Soil pH in this region varied from neutral to slightly acidic. Edwards and Lofty (1977) suggested that earthworm species generally have narrow range of pH to live. Most of them prefer neutral soils, but some can tolerate acidic or alkaline soils to some extent. The pH values recorded in the present study are within the range for the distribution of earthworms.

The seasonal dynamics over an annual cycle showed that the earthworm population are high in the wet period and low in summer and winter. The

Table 3. Inhabitance of earthworm species of South 24 Parganas in relation to physicochemical characteristics of soils from different habitats

Habitat	GPS reading	Species	Moisture of soil (%)	Temperature of soil (°C)	pH	Organic Carbon (gm/kg) Average	Nitrogen (kjeldahl) (gm/kg) Average	C/N ratio
Paddy field	N22^{0}27.443´ E088^{0}09.986´	*M. posthuma* *P. excavatus* *L. mauritii* *E. orientalis*	5.52-18.8	15.3-30.1	7.33-7.4	20.50	1.90	10.78
Rose Garden	N22^{0}27.446´ E088^{0}09.883´	*M. posthuma* *L. mauritii* *D. bolaui* *E. orientalis*	8.9-18.7	15.6-32.3	6-5.-6.8	14.0	1.70	8.23
Chorial Canal side	N22^{0}27.452´ E088°09.836´	*M. posthuma* *L. mauritii* *E. orientalis*	12.2-19.9	15.4-29.8	7.40-7.49	13.61	1.65	8.24
Settled Ash field	N22^{0}28.203´ E088°09.114´	*M. posthuma* *L. mauritii*	4.08-14.4	15.2-31.0	7.20-7.29	6.73	1.45	4.64
Bank of River Hooghly	N22^{0}28.429´ E088^{0}09.169´	*M. posthuma* *A. diffringens* *L. mauritii* *E. orientalis*	8.3-13.7	15.0-30.9	6.29-7.3	8.72	1.06	8.2
Grazed Grassland within village	N22°31.187´ E088°28.211´	*M. posthuma* *L. mauritii* *E. orientalis*	8.02-18.3	16.2-31.0	7.11-7.35	9.56	5.79	1.65
Sewage canal side	N22°31.171´ E088°28.247´	*M. posthuma* *P. excavatus* *L. mauritii* *E. orientalis*	16.5-24.7	15.7-31.1	6.71-7.31	51.71	6.10	8.47

Table 4. Simpson Diversity indices of earthworm species in seven different habitats
Simpson Diversity index, $D = \sum n(n-1)/N(N-1)$ (Simpson, 1949)

Habitat	No. of species	D-values
Paddy field	4	0.36
Rose garden	4	0.27
Chorial Canal side	3	0.57
Settled ash field	2	0.69
Bank of river Hooghly	4	0.37
Grazed grassland within village	3	0.68
Sewage canal side	4	0.59

present study showed a preference of earthworms to Sewage canal side, may be related to higher moisture in the soil. A significant decline in abundance of earthworms in summer can be attributed to changes in soil temperature and moisture (Whalen *et al*., 1998). The temperature and moisture affect on the diversity of earthworms (Edwards, 1996; Blakemore, 2006).

The results obtained show that the density of earthworms is dependant on Carbon and Nitrogen content of soils. The nature of the organic matter affects the abundance and species diversity of earthworms. When nitrogen content is high, C/N ratio reduces and earthworm density falls. It is the relative values carbon and nitrogen that affect the earthworm population. The higher nitrogen content, high organic carbon and corresponding high C/N ratio is found at sewage canal side. The lower nitrogen content and low organic carbon is found at settled ash field, where the minimum occurrence of species found. The occurrence of most of the species in sewage soil shows that earthworms prefer to live in soil rich in organic carbon and nitrogen.The present observations are more or less in agreement to the findings of other workers (Lavelle 1974; Edwards and Lofty 1977; Appelhof 1981; Lee 1985).

To quantify the biodiversity of a habitat, the formula of Simpson Diversity index is used. Here D (Simpson Diversity index) = $\sum n(n-1)/N(N-1)$, where n denotes the total number of organisms of a particular species and N denotes the total number of organisms of all species. Table 4 is calculated from Table 2. The value of D varies between 0 and1.With this index 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity.

Simpson index of diversity varies in between land use types (rose garden : 0.27 and settled ash field: 0.69) in spite of the large no. of samples. This difference is due to habitats containing many different species but with most individuals belonging to few common species. Table 4 shows the lower value in rose garden (0.27) which means the highest diversity. In rose garden moisture holding capacity ranges from 8.9% to 18.7% with pH of 6to 6.8, with organic carbon 14.0 gm/kg and total nitrogen is 1.70 gm/kg, appear to be favourable for higher earthworm diversity. Study shows the highest value in settled ash field (0.69) which gives the lowest diversity. This locality attributed to the dry soil with low moisture holding capacity (4.08%-14.4%) in addition to the low availability of carbon (6.73 gm/kg) and nitrogen (1.45 gm/kg). Kale (1998) reported that abundance and diversity of earthworm species affected by carbon and nitrogen content of the soil, and that is why settled ash field gives the lowest diversity. The next higher diversity is paddy field (0.36), whose C/N ratio is 10.78 with moisture content ranges from 5.52% to 18.8 %. Then comes bank of river Hooghly (0.37). The C/N ratio is here 8.2 with moisture content 8.3% to 13.7% .The low C/N ratio of Chorial canal side (0.57) is 8.24 with a high moisture range of 12.2% to 19.9% have low diversity than earlier habitat, The sewage canal side (0.59) has high moisture range of

16.5 %to 24.7% with C/N ratio of 8.47, Grazed Grassland within village (0.68) have moisture range of 16.2 to 31.0 with lower C/N ratio of 1.65. The high availability of feed and moisture content maintained in the man made environment (Rose garden) appear to be the positive factors. Fragoso *et al.* (1999) reported that the structural composition in earthworm communities varied depending on the type of agro-ecosystem. Similar observations are evident from the data of the present study. Difference between the earthworm communities at different localities indicates that environmental heterogeneity is important in promoting earthworm diversity (beta diversity), as it has been shown by (Fragoso and Lavelle, 1987) in the forests of Mexico.

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