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Impact of Edaphic Factors on Soil Microarthropods at an Agricultural Land of Alluvial Plains in North Dinajpur, West Bengal, India

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Abstract Sampling was conducted at an agricultural land located in the alluvial plains of Northern Bengal. Total abundance of microarthropods tended to increase during the post-monsoon season while a decline was observed in the summer. Not all the groups however followed the same pattern of fluctuation. Oribatid mites were marginally higher in abundance than mesostigmatids and appeared to be the most numerically dominant group. Negative correlation coefficients with the abundance were obtained for soil temperature, moisture and pH while the coefficient was positive for organic carbon. Only soil temperature however, was significantly correlated with the abundance ($p < 0.05$).

Keywords Agricultural land, Soil microarthropods, Edaphic factors.

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Introduction

Soil microarthropods constitute a significant share of soil mesofauna and take up an important role in mobilizing the soil nutrients in the edaphic ecosystem. Diversified natures of works have been attempted around the globe on several aspects related to the abundance, diversity, ecological role, utility of soil microarthropods. Their indicator value have been investigated and highlighted by a number of workers (Bhattacharya and Bhattacharya 1981, Moitra et al. 2013, Lakshmi and Joseph 2016, Calugar and Ivan 2016, Rieff et al. 2016). Impact of several factors like fire, composition of mosses and shrubs, earthworm movements on the population of microarthropods have been taken up by the workers like Cameron et al. (2013), Rutigliano et al. (2013), Bokhorst et al. (2014). Impact of heavy metals and other pollutants on soil microarthropods have also been addressed by a few workers (Bhattacharya and Bhattacharya 1985, Manu et al. 2017, Moitra 2017).

Present work was taken up to address the dearth of data in the agricultural lands of alluvial plains in the North Bengal region. A few studies on ecology of soil microarthropods in the agriculture fields were attempted in the southern part of Bengal but, very little information is available in the region covered in the current work.

Materials and Methods

Five subplots were selected with 1 m^2 area at and

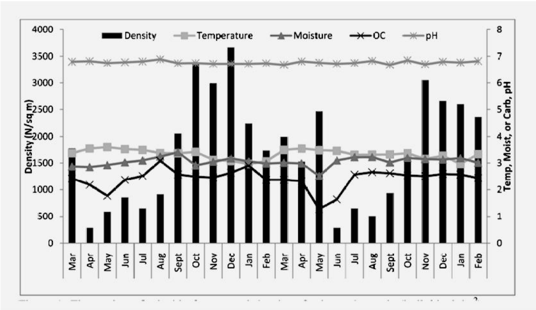

Fig. 1. Fluctuation of edaphic factors and dencity of microarthropods (individuals / m^2) at the sampling site. (Temperature recorded in '°C'; moisture measured in '%'; organic carbon in (%) ; temperature and moisture in logarithmic values).

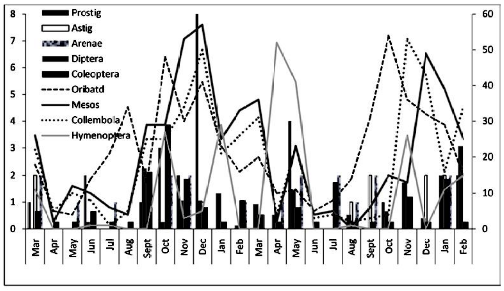

Fig. 2. Monthly fluctuation of abundance of microarthropods (total individuals in 25 cores per month; Prostigmata, Astig = Astigmata, Mesos = Mesostigmata ; Prostigmata, Astigmata, Arenae, Diptera and Coleoptera in primary axis, rests in secondary axis).

around a cultivation land. Five cores (5 cm depth, 5 cm diameter) of soil samples were collected from each of the plot in a collection effort, Sampling was conducted for a period of two years (March 2015 to February 2017) with monthly intervals. Microarthropod extraction was done with Tullgrenfunnel apparatus (Macfadyen 1953). Sorting was done with needles and fine camel hair brush ; 80% alcohol was used for long term preservation of the specimens. Logarithmic transformations of data were made according to the applicability in parametric statistics.

Collection site

The agriculture land sampled (25°38′07′′ N, 88°22′10′′ E) was located near the Dalimgaon railway station under the Kalyagunj block in the district of Uttar Dinajpur, West Bengal. Jute was the major cultivation product of the land hat occupied the site tentatively during the months from March to August, while during September to November, paddy was sown and harvested. Sub plots were selected at the corners along a straight line, adjacent to the narrow earthen way between the cultivation lands. Each of the subplots was located around 30 m away from its previous plot. Location was so selected that the direct anthropogenic interferences and sowing of the crops remain at minimum. Some herbs, shrubs and grasses grew occasionally in and around the plots that included *Lantana camara* (Verbenaceae), *Clerodendrum infortunatum* (Lamiaceae), *Leucas aspera* (Lamiaceae), *Athyriumfilix-femina* (Athyriaceae), *Paspalum conjugatum* (Poaceae), *Pancicum repens* (Poaceae). The area is under the sub-tropical humid climatic zone.

Results and Discussion

The observation is based on the sampling conducted

Table 1. Descriptive statistics for edaphic factors recorded at the site. (StDev = Standard deviation, SE = Standard error of mean).

Temperature, Moisture, Organic carbon and pH						
Variable	Mean	Median	StDev	SE	Minimum	Maximum
Temperature (°C)	28.196	28.750	4.884	0.997	19.400	36.200
Moisture (%)	21.437	21.090	3.484	0.711	12.410	29.910
OC (%)	2.4117	2.5000	0.3817	0.0779	1.2800	3.0800
pH	6.7671	6.7550	0.0546	0.0111	6.6800	6.8900

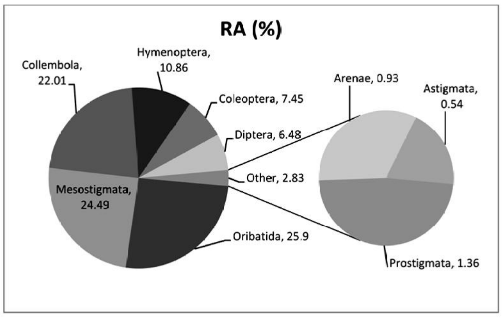

Fig. 3. Relative abundance (%) of soil microarthropod groups at the sampling site.

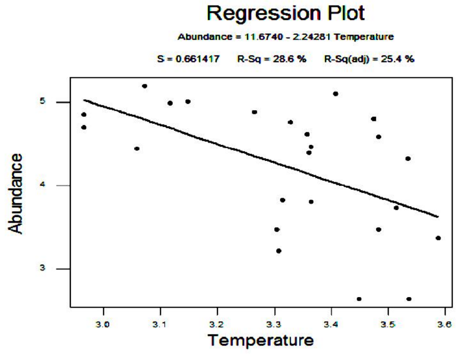

Fig. 4. Regression line taking abundance as the dependent variable and the soil temperature as the predictor. (S= Standard distance of data values from regression line ; R-Sq = Coefficient of determination ; R=Sq (adj) = Coefficient of determination adjusted for the degree of freedom).

during March, 2015 to February, 2017. The soil temperature recorded at the site ranged during the period from 19.4°C to 36.2°C with a mean of 28°C. Soil moisture varied from 12.41% to 29.91% having a mean of 21.43%. Organic carbon content and pH in the soil exhibited a range from 1.28% to 3.08% and 6.68 to 6.89 respectively (Fig. 1). Other statistical details are given in Table 1.

Estimated density of microarthropods in soil varied within a range from 285 / m^2 to 3665 / m^2 with a mean of 1743 / m^2 during the study period. Greater abundance for most of the groups was recorded during the post monsoon and winter while the minima were recorded during the summer (Table 2, Figs. 1, 2).

Relative abundance of soil oribatids mites (25.9%) was highest among the microarthropod groups followed by mesostigmata (24.49%). Other two groups of soil mites Prostigmata and Astigmata exhibited low abundance (1.36% and 0.54% respectively). Collembolans, which are generally observed to be abundant in soil, had a marginally lower relative abundance (22.01%) than that of mesostigmatid mites (Fig. 3). Greater abundance of oribatids, mesostigmatids and collembolans in soil is a common observation the soil of West Bengal (Ghosh and Roy 2004, Joy 2006, Moitra et al. 2013, Moitra 2017).

The organic carbon content of the soil exhibited significant positive and negative correlations with the soil moisture and the temperature respectively. Correlation coefficients were negative between the abundance of soil microarthropods and the soil temperature, moisture and pH, of which only impact of

Table 2. Descriptive statistics for edaphic factors recorded at the site. (StDev = Standard deviation, SE = Standard error of mean, Ql = First quartile, Q2 = Third quartile).

Abundance (per month, 25 cores) and Density (individuals / m^2)								
Variable	Mean	Median	StDev	SE	Minimum	Maximum	Q1	Q3
Abundance	85.6	86.0	50.3	10.3	14.0	180.0	34.5	126.3
Density	1743	1751	1025	209	285	3665	703	2571

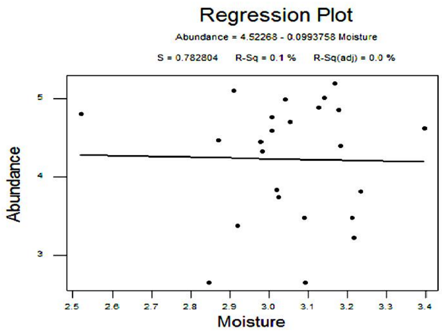

Fig. 5. Regression line taking abundance as the dependent variable and the soil moisture as the predictor.

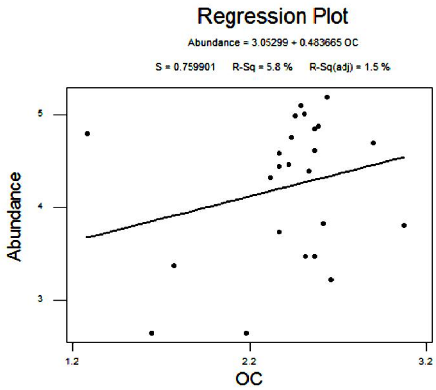

Fig. 6. Regression line taking abundance as the dependent variable and the organic carbon content of the soil as the predictor. (OC = organic carbon).

temperature appeared statistically significant ($p<0.05$). Only positive correlation was noticed between the organic carbon and the abundance but it was not significant (Table 3). Negative correlation between the temperature and the abundance of soil microarthropods was earlier reported by Tripathi et al. (2007) and Moitra (2017) at different parts in West Bengal while, positive impact of organic carbon on numerical abundance was observed by Chitrapati and Singh (2006), Tripathi et al. (2007), Moitra et al. (2012). Regression equation was constructed taking abundance of soil microarthropods as the response and the edaphic factors as the predictors. The multiple regression analysis corroborated the observation of the significant role of temperature compared to other three selected factors as the t test indicated greater weightage of the coefficient of it. Selected edaphic factors collectively could explain 24.1% of abundance data variation as the coefficient of determination (R^2) adjusted for the degree of freedom indicated (Table 4). Simple regression equations and the regression lines worked out using each of the edaphic factors as a separate predictor and the abundance as the response also substantiated the significant impact of soil temperature on the abundance. Coefficient of determination was highest for temperature followed by soil pH (Figs. 4–7).

Table 3. Result of correlation analysis between the abundance of microarthropods and edaphic factors.

	Abundance	Temperat	Moisture	OC
Temperat	−0.535			
	0.007			
Moisture	−0.022	−0.347		
	0.917	0.097		
OC	0.241	−0.490	0.680	
	0.256	0.015	0.000	
pH	−0.257	0.287	0.081	0.199
	0.225	0.173	0.705	0.351

Cell contents : Pearson correlation
p–value

Table 4. Result of multiple regression analysis. (Abundance as dependent variable ; temperature, soil moisture, organic carbon and pH as predictors ; Coef = Coefficient, SE Coef = Standard error of coefficient ; S = Standard distance of data values from regression line ; R–Sq = Coefficient of determination ; R-Sq (adj) = Coefficient of determination adjusted for the degree of freedom ; T = t-statistics for testing null hypothesis coefficients equal to 0 ; P = p values of the tests).

The regression equation is
Abundance = 28.4 – 2.02 Temperature–1.66 Moisture+0.577 OC – 2.04 pH

Predictor	Coef	SE Coef	T	P
Constant	28.42	18.57	1.53	0.142
Temperat	−2.0186	0.9785	−2.06	0.053
Moisture	−1.657	1.103	−1.50	0.149
OC	0.5775	0.5753	1.00	0.328
pH	−2.043	2.922	−0.70	0.493

S = 0.6672 R–Sq = 37.3% R–Sq (adj) = 24.1%

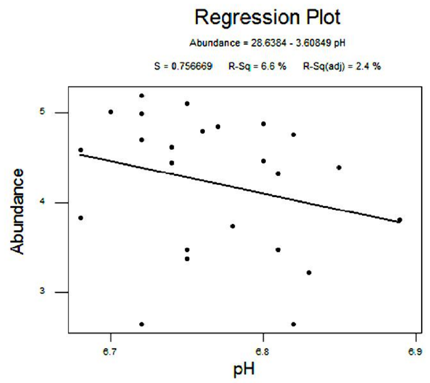

Fig. 7. Regression line taking abundance as the dependent variable and the soil pH as the predictor.

Abundance of soil microarthropods is largely influenced by the edaphic and climatic conditions other than their own biological and physiological factors and their interactions. The effect is the outcome of a complex interaction within and between the edaphic factors. The significant negative effect of soil temperature appeared to be due to the warm climatic condition of the region. Soil moisture is often found to be significantly correlated with the abundance and the effect is generally positive. In the current study, the apparently rare observation of negative impact (though not significant) might be due to the availability of plenty of water as which is the primary requirement of agriculture of jute and paddy. pH and organic carbon flactuated within a narrow range and remained within a favorable limit that is why the correlation for these factors remained statistically not significant.

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