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Oribatid faunal abundance: An indicator for evaluation of environmental harshness in agro-ecosystem

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Abstract
Present study is an ecological interpretation between three contrasting agro-ecosystem, first one is a waste land (WL), without agricultural practice, second one is a fodder field (FF) and third one is a sugarcane field (SF). Last two systems are differently treated by chemical manure and insecticides. Therefore, the microclimate of three systems is different in their soil ecological parameters. Species composition of soil Oribatid fauna in the three sites are quite different. The study reveals that WL represents 24 species, FF represents 20 species and SF represents 16 species of Oribatid mite. Sorenson Quotient of similarity shows that the similarity between WL-FF &WL-SF is slightly similar but between FF-SF shows moderately dissimilar. Present result signifies that the environmental manipulation due to agriculture practice is the cause of variation in faunal composition and variation in similarity index of Oribatid mite between three agro-ecosystems. In turn it may be concluded that Oribatid faunal abundance is the indicator of environmental harshness that can be arranged in SF< FF< WL.

Keywords: Oribatida, mites, agro-ecosystem, environmental harshness

1. Introduction
Oribatid mites, commonly called "moss" mites or "beetle" mites, are microarthropods (body size of 100 to 1000 μm) which live in almost all possible habitats including soil, litter, compost heaps, lichens, mosses, leaves, bark of trees, bird nest, house dust and various other places. These mites constitute the main part of soil microarthropods in terms of number of individuals and number of species. Over 9,000 oribatid species under 1,204 genera belonging to 169 families have so far been recorded in the world [1].
Soil inhabiting Oribatida are of immense importance due to their direct and indirect effect on man, animal and environment. These mites feed on a wide variety of material including living and dead plants, fungal hyphae and spores, lichens and carrion. Some are predaceous, but none is parasitic.
These mites play a vital role to promote soil fertility through degradation of organic matter [2]. Many oribatid species sequester calcium and other minerals in their thickened cuticle. Thus, their bodies may form important 'sinks" for nutrients, especially in nutrient-limited environments such as peatlands [3, 4].
Oribatid mite community composition would show a strong response to change in habitat and land-use type [5, 6]. Soil oribatids have tremendous potentiality as bioindicator of the quality of soil and of anthropogenic interferences such as agricultural manipulations [7-11], industrial pollution [12-15], radioactive pollution [16], reclamation of land [17] etc.
However, no in depth study has so far been done on the effect of agricultural practices on the soil inhabiting oribatida in India. Fin agro-environment.

2. Materials and Methods
2.1 Description of study sites
The present study was conducted in three study sites situated in Midnapore Subdivision of Paschim Medinipur district in West Bengal, India. Two agricultural fields *viz.*, a fodder field and a sugarcane field and a wasteland were selected for the purpose. No agricultural or other human interference was in force in wasteland. The sites were located within a radius of 5 km. aerial distance. A detailed description of the sites alongwith agricultural manipulations is given below.

2.2 Wasteland (WL)

This site (22°25′ 24.1′′ N, 87°17′ 33.5′′E) was located within the boundary of Raja N. L. Khan Women's College, Midnapore. This was a plot which was not being used for any purpose, agriculture or otherwise. There was no grazing or no human activity. It was almost free from any disturbance. There was no industry in the vicinity. An open area of 5 meter5 meter was selected for the purpose of sampling. The most dominant floral component was *Evolvulus nummularius*. Other important plant species, mostly weeds and grass, were *Eleusine indica*, *Kyllinga monocephala*, *Ruellia tuberosa*, *Phyllanthus fraternus* etc. (Table – 2).

2.3 Fodder field (FF)

An area of 5 × 5 meter in a fodder field of Midnapore town (22°25′ 44.5′′ N, 87°18′ 50′′E) was selected for sampling. This was a demonstration plot maintained by the office of the Deputy Director of Animal resource Development, Government of West Bengal where *Avena fatua* and *Zea mays* were cultivated alternately as fodder. Avena was sown between 15 November to 8 December and harvested in between January and February. This field was kept fallow till May. Maize was sown in June and harvested in August. A brief account of the agricultural manipulations undertaken is stated below.

Mechanical ploughing was done in the second week of November. The field was ploughed thrice at an interval of 5 days. Farmyard manure was added to the soil at the rate of 2500 Kg/Acre the day before the 3rd ploughing (1Acre = 0.4047 hectare). One day after third ploughing seeds of Avena were broadcasted in the field. This is followed by irrigation which was repeated at an interval of 15 days till harvesting was done.

After germination of seeds urea was applied at the rate of 30-35 Kg/Acre twice at an interval of 25 days. This was the only chemical fertilizer which was being used. 25 day after broadcasting the crop is pruned to maintain the crop height at 3 inch (7.5 cm.). The crop is allowed to grow till it attained a eight of about 11/2 ft. (45 cm.). First harvesting was done by leaving 3 inches (7.5 cm.) stubble from the soil surface. Such harvesting was done for two more times. No insecticide and pesticide was used in this field.

For maize cultivation, the field was prepared in the same way except that the ploughing was done in the month of June and crop was harvested after 50-60 days after sowing. Other agricultural manipulations were same as in case of Avena but no irrigation was needed since the crop was rain-fed.

2.4 Sugarcane field (SF)

A six month old perennial sugarcane field at Kamarmuri village (23°29′35.6′′N, 87°41′42.7′′E) of Salbony block was selected for the purpose of investigation. A brief account of agricultural manipulations in the field is given below.

Before raising the crop, the field was ploughed in the month of September. After ploughing, Aldrin @ 9 Kg/Acre, Diamonium phosphate @ 90 Kg/Acre, potash @ 50 Kg/Acre, urea @ 30 Kg/Acre and cowdung manure @ 1500 Kg/Acre, were applied to soil and the field was ploughed again. The crop was planted in row at a gap of 1ft. (30 cm.) between the row. 25 days after plantation, urea was spread in the soil at a rate of 300 kg/Acre. During the entire cropping period, urea was applied at the rate of 30 Kg/Acre once in a month. Two insecticides namely Cypermethrin 10% EC and Parathion 50% EC were also sprayed at monthly interval. Irrigation of the field was done once in a week. The harvesting was done once in April and again in November. Such sugarcane field was maintained for 3 years.

SF was subjected to more agricultural manipulation because of application of inorganic fertilizers and insecticides application which were lacking in FF.

2.5 Soil Sampling

Soil samples were collected at monthly interval on the 7th day of each month between 8.00 hrs to 9.00 hrs. From 3 sampling sites between February 2002 to January 2004. During each sampling occasion 5 soil samples of 5 cm x 5 cm size up to the depth of 10 cm were collected with the help of a hand spade from each site for extraction of microarthropods.

Soil microarthropod fauna along with oribatid mites were extracted with a modified Tullgren extractor, the procedure lasting for 24 hours.

Generic identification was based on Balogh and Balogh [18] and for classification and species nomenclature Subias [1] was followed.

To measure the similarity between two community samples, coefficient of Sorensen [19] was used as the following equation.

$$QS = \frac{2c}{a+b}$$

Where,

QS = Sorensen similarity coefficient

a = No. of species in sample A

b = No. of species in sample B

c = No. of species common in sample A and sample B

Degree of similarity of otherwise was judged following under mentioned scale:

>.71	strongly similar.
.61 – 70	moderately similar.
.51 - .61	slightly similar.
.41 – 50	moderately dissimilar.
<.40	strongly dissimilar.

2.6 Dominance index (DI)

Dominance index (McNaughton and Wolf [20] was estimated according to the following formula:

$$DI = \frac{100\,(Y1 + Y2)}{Y}$$

Where,

DI = Dominance index.

*Y*1 & *Y*2 = abundance of two most common species

Y = total abundance of all species

3. Result and Discussion

Findings relating physicochemical properties of soil are shown in table-3. Colour of the soil was light yellowish brown in all the three sites. However, mean value of physicochemical properties of soil were significantly different in the three sites. The three sites can be arranged on the basis of various physicochemical parameters in the descending order as follows:-

Moisture Content	: SF > FF > WL
Water *holding* Capacity	: SF > WL > FF
pH	: FF > WL > SF
Ec	: FF > WL > SF
Available nitrogen	: FF > SF > WL
Available Phosphate	: FF > SF > WL

Available Potassium : FF > SF > WL
Organic Carbon : FF > WL > SF

Density and diversity of soil biota is largely dependent upon physicochemical properties of soil which vary even within a span of few meters. Though edaphic factors are mostly dependent upon the microclimatic variations, anthropogenic interferences like cultivation also play very important role in altering the nature of soil which ultimately influences the faunal composition.

The soil of the three study sites was slightly acidic in nature. Physicochemical properties of the soil varied significantly between the three study sites. Dunn's multiple comparison test revealed that water holding capacity and pH significantly differed between WL & SF and between WL & FF. While electrical conductivity, available nitrogen and organic carbon significantly differed between WL & FF and between FF & SF, moisture content and available potassium differed significantly between WL & SF only and available phosphate differed significantly between FF & SF.

Thus the findings clearly revealed that the three sites were distinct in their edaphic nature. The type of cultivation profoundly altered the physicochemical nature of the soil. Use of farmyard manure in the FF might have increased the amount of most of the edaphic factors under study. Pandit & Bhattacharya [21] have also reported that agricultural practice altered the edaphic properties of soil.

Present study reveals that WL represents 24 species, FF represents 20 species and SF represents 16 species of Oribatid mite (table-1). Sorenson Quotient of similarity (Table-2 & Fig. 1) shows that the similarity between WL-FF &WL-SF is slightly similar but between FF-SF shows moderately dissimilar. Present result signifies that the environmental manipulation due to agriculture practice is the cause of variation in faunal composition and similarity index of Oribatid mite.

Dominance index generally increased with the increase in environmental harshness, stress and perturbation [22, 23]. Findings of the present investigation also confirmed this (Table-4). SF, which was subjected to more agricultural manipulation was under more stress as compared to WL or FF, had high dominance index. This was further confirmed by the findings of the Dominance-Diversity curve (Fig. 2). Skubala & Ciosk [24] and Pandit & Bhattacharya [7] have also made similar observations.

In conclusion it may be opined that the oribatid mites of soil act as good indicator of the environmental stress and perturbation due to human interference in the form of agricultural manipulation.

Table 1: Oribatid species of the study sites

Sl. No.	Name of Species	Abbreviation of Species	WL	FF	SF
I. Family : Haplochthoniidae Hammer, 1959					
1.	*Haplochthonius (H.) simplex* (Willmann, 1930)	HAS	+	–	+
II. Family : Epilohmanniidae Oudemans, 1923					
2.	*Epilohmannia pallida indica* Bhattacharya & Banerjee, 1979	EPPI	+	+	–
III. Family : Lohmanniidae Berlese, 1916					
3.	*Javacarus javacarus kuehnelti* Balogh, 1961	JAJK	+	–	+
4.	*Meristacarus degradatus* Haq & Jaikumar, 1993	MED	+	–	–
IV. Family : Euphthiracaroidae Jacot, 1930					
5.	*Acrotritia otaheitensis* (Hammer, 1972)	ACO	+	+	–
V. Family : Trhypochthoniidae Willmann, 1931					
6.	*Allonothrus (A.) russeolus reticulatus* Hammer, 1972	ALRR	+	–	–
7.	*Allonothrus (A.) indicus* Bhaduri & Raychaudhuri, 1968	ALI	–	+	–
8.	*Archegozetes longisetosus* Aoki, 1965	ARL	+	+	+
9.	*Archegozetes magnus medosetosus* Mahunka, 1978	ARMM	–	–	+
VI. Family : Nanhermanniidae Sellnick, 1928					
10.	*Cyrthermannia vicinicornuta* Aoki, 1965	CYV	–	+	–
VII. Family : Eremobelbidae Balogh, 1961					
11.	*Eremobelba capitata* Berlese, 1913	ERC	–	+	–
VIII. Family : Oppiidae Sellnick, 1937					
12.	*Brachioppiella sp.*	BR	–	+	–
13.	*Multioppia (M.) simplitricha* Sanyal & Bhaduri, 1989	MUS	+	+	+
14.	*Ramusella (R.) sengbuschi* Hammer, 1968	RAS	+	+	+
15.	*Ramusella (Insculptoppia) ananthakrishni* (Sanyal & Bhaduri, 1989)	RAA	+	+	–
IX. Family : Tectocepheidae Grandjean, 1954					
16.	*Tectocepheus velatus sarekensis* Tragardh, 1910	TEVS	+	+	–
17.	*Tectocepheus sp.*	TE	+	–	–
X. Family : Austrachipteriidae Luxton, 1985					
18.	*Lamellobates (L.) molecula molecula* (Berlese, 1916)	LAMM	+	+	+
19.	*Lamellobates (Paralamellobates) misella* (Berlese, 1910)	LAM	+	+	+
XI. Family : Oribatulidae Thor, 1929					
20.	*Oribatula sp.*	OR	–	–	+
XII. Family : Caloppidae Balogh, 1960					
21.	*Chaunoproctus abalai* Bhaduri, Bhattacharya & Chakraborti, 1975	CHA	+	–	+
22.	*Chaunoproctus minor* (Belogh, 1958)	CHM	+	–	–

XIII. Family : Scheloribatidae Jacot, 1935					
23.	*Scheloribates (S.) fimbriatoides* Hammer, 1977	SCF	+	–	–
24.	*Scheloribates (S.) fimbriatus fimbriatus* Thor, 1930	SCFF	+	+	+
25.	*Scheloribates (S.) praeincisus interruptus* (Berlese, 1916)	SCPI	+	+	+
XIV. Family : Protoribatidae J. & P. Balogh, 1984					
26.	*Protoribates (P.) dentatus* (Berlese, 1883)	PRD	+	–	–
27.	*Protoribates sp.*	PR	+	–	+
XV. Family : Haplozetidae Grandjean, 1936					
28.	*Lauritzenia (Incabates) nuda* (Hammer, 1961)	LAN	–	+	–
29.	*Lauritzenia (Incabates) tenuifusus* (Berlese, 1916)	LAT	–	–	+
XVI. Family : Galumnidae Jacot, 1925					
30.	*Cryptogalumna grandjeani* Balakrishna & Haq, 1985	CRG	+	–	–
31.	*Galumna (G.) crenata* Deb & Raychandhuri, 1975	GAC	+	+	+
32.	*Galumna (G.) parascaber* Deb & Raychaudhuri, 1975	GAP	+	+	–
33.	*Galumna sp.*	GA	–	+	–
Unidentified species					
34.	Unidentified – 1	UN-1	–	+	–
35.	Unidentified – 2	UN-2	–	–	+
TOTAL			24	20	16

WL = Wasteland, FF = Fodder field, SF = Sugarcane field, + = Present, – = Absent

Table 2: Sorensen's Quotient of Similarity

Similarity Index between WL and FF	0.59	Slightly similar
Similarity Index between WL and SF	0.60	Slightly similar
Similarity Index between FF and SF	0.44	Moderately dissimilar

Table 3: Physicochemical properties of the soil of study sites

Edaphic Parameters	**WL**	**FF**	**SF**
Colour	Light yellowish brown 10YR6/4	Light yellowish brown 10YR 6/4	Light yellowish brown 10YR 6/4
	x ± SE (Min-Max)	x ± SE (Min-Max)	x ± SE (Min-Max)
Moisture content (%)	8.30 ± 0.97 (3.37 – 19.27)	9.87 ± 0.94 (3.62 – 17.17)	11.87 ± 0.88 (5.07 – 19.03)
Water holding capacity (%)	51.45 ± 0.72 (47.07 – 59.91)	51.23 ± 0.83 (44.53 – 60.23)	44.92 ± 0.77 (36.50 – 49.60)
pH	6.41 ± 0.06 (6.03 – 7.00)	6.43 ± 0.05 (5.93 – 6.97)	6.08 ± 0.08 (5.43 – 6.90)
Electrical conductivity (mmhos/cm)	0.17 ± 0.03 (0.05 – 0.66)	0.20 ± 0.02 (0.11 – 0.41)	0.13 ± 0.01 (0.03 – 0.25)
Available Nitrogen (ppm)	146.21 ± 6.50 (111.67 – 222.33)	172.92 ± 5.00 (134.33 – 223.67)	139.13 ± 6.17 (93.00 – 213.33)
Available Phosphate (ppm)	23.40 ± 0.77 (18.00 – 30.60)	29.62 ± 1.88 (17.40 – 46.80)	26.91 ± 1.29 (18.00 – 42.30)
Available Potassium (ppm)	89.50 ± 5.64 (63.00 – 160.00)	117.29 ± 11.67 (44.00 – 300.00)	105.33 ± 3.45 (66.00 – 143.00
Organic carbon (%)	0.63 ± 0.07 (0.24 – 1.30)	0.73 ± 0.03 (0.49 – 0.95)	0.44 ± 0.03 (0.22 – 0.72)

WL=Wasteland, FF=Fodder field, SF=Sugarcane field

Table 4: Dominance Index of oribatid species

	WL	**FF**	**SF**
Dominance index of McNaughton & Wolf	59.28	60.74	78.53

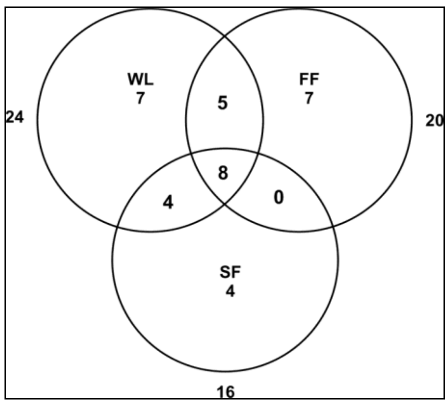

Fig 1: Number of Oribatid species in Wasteland (WL), Fodder field (FF), Sugarcane field (SF)

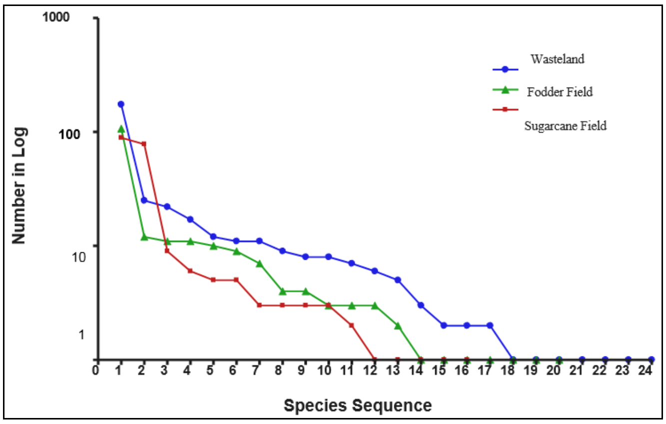

Fig 2: Dominance-Diversity curve of oribatid community

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