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Biodiversity of Soil Inhabiting Prostigmata (Arachnida: Acari) from Different Agro-Ecological Zones of Punjab, Pakistan

Ahmad Kamran Khan[1], Muhammad Hamid Bashir[2]*, Shanza Ahmed[3], Muhammad Amjad Bashir[1], Shahbaz Ali[1], Syeda Amber Hameed[4], Munaza Batool[5], Irfan Ahmed[6] and Muhammad Naeem Khan[7]

[1]*Department of Plant Protection, Ghazi University, Dera Ghazi Khan*
[2]*Department of Entomology, University of Agriculture, Faisalabad*
[3]*Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad*
[4]*Department of Zoology, Ghazi University, Dera Ghazi Khan*
[5]*Department of Soil and Environmental Sciences, Ghazi University, Dera Ghazi Khan*
[6]*Yunnan Provincial Key Laboratory of Animal Nutrition and Feed, Yunnan Agricultural University, Kunming 650201, Yunnan, PR China.*
[7]*Government College of Science, Wahdat Road, Lahore.*

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AKK designed and study, performed experimental work and wrote the article. MHB analyzed the data and supervised the work. SA and IA helped in experiment. MAB, SA, SAH, MB and MNK reviewed the article.

Key words
Cheylatidae, Cunaxidae, Prostigmata, Punjab, Pakistan

ABSTRACT

Suborder Prostigmata is extensively distributed geographically and present in all the terrestrial ecosystem. Family richness, diversity, abundance and evenness of soil inhabiting Prostigmata mites population in disturbed and undisturbed soil were estimated from five different localities of Punjab, Pakistan. Soil sampling was done after two months interval for a year 2014. Family richness, abundance and Shannon diversity indexes were higher in undisturbed soil as compared to the disturbed one in all the localities, while low variability with respect to evenness had been found in two different types of soil. The highest diversity of soil inhabiting Prostigmata were recorded in undisturbed type of soil in the month of June at Faisalabad locality (H'=1.33) and lowest (H=0.00) in disturbed soils in October, December at Gujranwala and Chakwal. The highest values of family richness (S=04) was reported in undisturbed soil at Faisalabad, D.G. Khan and Chakwal and the lowest (S=0) was found from Gujranwala, and Chakwal disturbed soil.

INTRODUCTION

Suborder Prostigmata is one of the important suborder of mites having 1100 genera and more than 14 000 species worldwide having broad geographic distribution and diversity of eating habits in all terrestrial ecosystems (Kethley, 1990). Most of these mites are small, free-living predators, parasites, fungal feeders in the soil; however, some species are plant feeders. Even though, the specific role of prostigmata in soil ecosystem is very limited, but they may play an important role in maintenance of the physico-chemical and biological properties in soil where they are dominant (Kethley, 1990).

Many soil-dwelling Prostigmata species are predacious in nature, some are fungivorous and these species may become abundant in decomposing organic matter (Heyer, 2009). Some families of Prostigmata are well known inhibiters of disturbed soil (Lagerlof and Andren, 1988; Crossley *et al*., 1992; Tian *et al*., 1997), and respond rapidly to disturbance such as ploughing and cultivation (Behan-Pelletier, 1999). Soil arthropods respond very quickly to the changes in their living environment. Information obtained from soil arthropods can be used to describe every aspect of the ecosystem (Kremen *et al*., 1993).

Modern agricultural tools used in different agricultural practices, such as, use of tillage machinery, chemical fertilizers, pesticides have severe impacts on the soil biodiversity and soil ecosystem. Soil microarthropods was low in agriculture soil having conventional tillage practices as compared to the non-agricultural environment with no tillage practices (Culik *et al*., 2002).

Among these serious effects, the debasement of soil quality and negative effect on soil biodiversity are again and again considered as key dangers for the future (Solbrig, 1991). Modification of common greenery into agro biological systems and farming increase have significant effect on soil groups since they include changes inside the essential determinants of soil biodiversity, e.g., vegetation and microclimate (Decaens and Jimenez, 2002; Wall *et al*., 2001). Land utilize change and agrarian increase

* Corresponding author: hamid_uaf@yahoo.com
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produce extreme natural surroundings debasement or annihilation for soil biota (Decaens *et al*., 2006). Increased agri-cultivating weakens the soil key processes and coming about negative effect on soil, hydrological forms, detoxification, structure and reusing of natural matter (Rana *et al*., 2010).

No work on biodiversity of soil inhabiting Prostigmata has been carried out in any region of Pakistan. Being very important microfauna of soil, the present study was done with the objectives to study the biodiversity of different families of Prostigmata from different ecological regions of Punjab Pakistan and to estimate the impact of agricultural practices on the population of these mites.

MATERIALS AND METHODS

The sampling of soil was done from ten localities viz. Faisalabad, Toba Tek Singh, D.G. Khan, Lodhran, Gujranwala, Murree, Chakwal, Layyah, Bhakkar and Bahawalpur from four agroecological zones (Irrigated plain, Barani, Thal and Cholistan) of Punjab, Pakistan (PARC, 1980). The samples were collected from the cultivated (disturbed) fields as well as the adjoining uncultivated (undisturbed) areas. The samples were collected randomly at the distance of 10 feet with the help of a steel core of volume 1000 cm^3 (h= 12.73 cm, diameter= 11.29 cm). The soil samples were transported immediately to Acarology Research Laboratory, University of Agriculture, Faisalabad for soil mites' extraction by using the Berlese funnel.

The sampling was repeated after two months' interval from the same locality till the 12^{th} month. The extracted soil mites were stored in 70% ethanol and were sorted out from the rest of the soil organism under microscope. The sorted soil mite's specimens were permanently mounted on the microscopic slides using the Hoyer's medium. The permanent mounted specimen were studied under the phase contrast microscope and identified up to family level. The Shannon diversity index (Shannon, 1948) was used to estimate the richness, abundance, evenness and diversity of soil mites.

RESULTS AND DISCUSSION

A total of 5 families of suborder prostigmata were recorded from the soils of various agro ecological zones and ten localities of Punjab, Pakistan. The results showed the difference in the diversity, abundance, richness and evenness between different localities and two different types of soils. The undisturbed type of soil showed more diverse in term of diversity, abundance, richness and evenness as compared to the disturbed type of soil, which is under cropping system.

Table I. Zones×Soil types interaction for abundance, family richness, diversity and evenness of Prostigmata in different zones of Punjab (Mean±S.E).

Zones	Soil type I	Soil type II	Mean±S.E
Abundance			
Irrigated plain	8.10±0.61	4.93±0.50	6.52±0.44A
Thal	5.75±0.39	4.75±0.72	5.25±0.41AB
Barani	5.83±1.54	2.50±0.57	4.17±0.87B
Cholistan	8.00±1.91	6.00±0.68	7.00±1.02A
Mean±S.E	6.92±0.49A	4.55±0.34B	
Family richness			
Irrigated plain	3..03±0.10a	2.1±0.14c	2.57±0.10A
Thal	2.75±0.13ab	2.33±0.19bc	2.54±0.12A
Barani	2.42±0.38bc	1.33±0.28d	1.88±0.26B
Cholistan	2.83±0.31ab	2.17±0.17bc	2.50±0.19A
Mean±S.E	2.76±3.04A	1.98±2.21B	
Diversity			
Irriagated plain	1.00±0.04b	0.62±0.05e	0.81±0.04B
Thal	0.94±0.05bc	0.73±0.05de	0.38±0.004B
Barani	0.73±0.12de	0.39±0.09a	0.56±0.08A
Cholistan	0.91±1.09bcd	0.70±0.07cde	0.81±0.07B
Mean±S.E	0.93±0.03A	0.60±0.4B	
Evenness			
Irrigated plain	0.93±0.01	0.85±0.04	0.89±0.02A
Thal	0.95±0.01	0.92±0.02	0.93±0.01A
Barani	0.76±0.11	062±0.13	0.69±0.08B
Cholistan	0.91±0.02	0.92±0.03	0.91±0.02A
Mean±S.E	0.90±0.02	0.83±0.04	

Means sharing similar letter are not significantly different.

Abundance of Prostigmata significant varied among different zones (F=4.02, P=0.009) and soil types (F=12.44, P=0.000) of Punjab, Pakistan, but interaction between the zones and soil types was non-significant (Table III). Prostigmata was more abundant in Cholistan zone (7.00±1.02), followed by irrigated plain (6.52±0.44), Thal (5.25±0.41) and Barani zone (4.17±0.87). Maximum mean abundance of Prostigmata was recorded in soil type I (6.92±0.49) while it was (4.55±0.34) in soil type II (Table I).

Abundance of Prostigmata in different localities of Punjab, Pakistan shown in Table II revealed that highly significant difference of mean abundance of Prostigmata was recorded in soil types (F=23.04, P=0.000) while no difference of means with respect to localities and interaction L×S. Maximum mean value was recorded in T.T. Singh (10.50±1.23) in soil type I, followed by Faisalabad

(10.00±1.51) and Bahawalpur (8.00±1.91) while the mean abundance of Prostigmata in other localities were at par. Similarly, in soil type II, maximum mean abundance was recorded in Lodhran (7.33±1.71) and Bahawalpur (6.00±0.68) while the mean abundance between the other locality remained at par in soil type II (Fig. 1A).

Table II. ANOVA of Prostigmata abundance, richness, diversity and evenness in different localities of Punjab.

SOV	DF	SS	MS	F	P
Abundance					
Localities (L)	9	200.91	22.32	2.44	0.015
Soil types (S)	1	210.68	210.68	23.04**	0.000
Localities×Soil types	9	135.91	15.10	1.65^{NS}	0.111
Error	100	914.50	9.15		
Total	119	1461.99			
Family richness					
Localities (L)	9	12.500	1.389	3.63**	0.0006
Soil type (S)	1	20.833	20.833	54.52**	0.000
Localities×Soil types	9	2.167	0.241	0.63^{NS}	0.498
Error	100	36.300	0.382		
Total	119	97.167			
Diversity					
Localities (L)	9	1.792	0.199	3.089**	0.002
Soil type (S)	1	3.120	3.120	48.408**	0.000
Localities×Soil types	9	0.299	0.033	0.517	0.859
Error	100	6.446	0.064		
Total	119	11.658			
Evenness					
Localities (L)	9	0.964	0.1071	1.98**	0.0494
Soil type (S)	1	0.1491	0.1491	2.76^{NS}	0.1001
Localities×Soil types	9	0.1832	0.0204	0.38^{NS}	0.9441
Error	100	5.412	0.0541		
Total	119	6.7083			

NS, Non-significant (P>0.05); ** highly significant, (P<0.01).

The statistical results of family richness of Prostigmata in different zones given in Table III showed that highly significant difference of family richness of Prostigmata was found in different zones (F=5.02, P=0.003) and soil types (F=22.29, P=0.000). The interaction value between soil and the sampling sites were also found non-significant (Table III). Maximum richness of family of Prostigmata (2.76±3.04) was found in soil type I as compared to soil type II (1.98±2.21). Among various zones, maximum richness was observed in Irrigated plain (2.57±0.10), followed

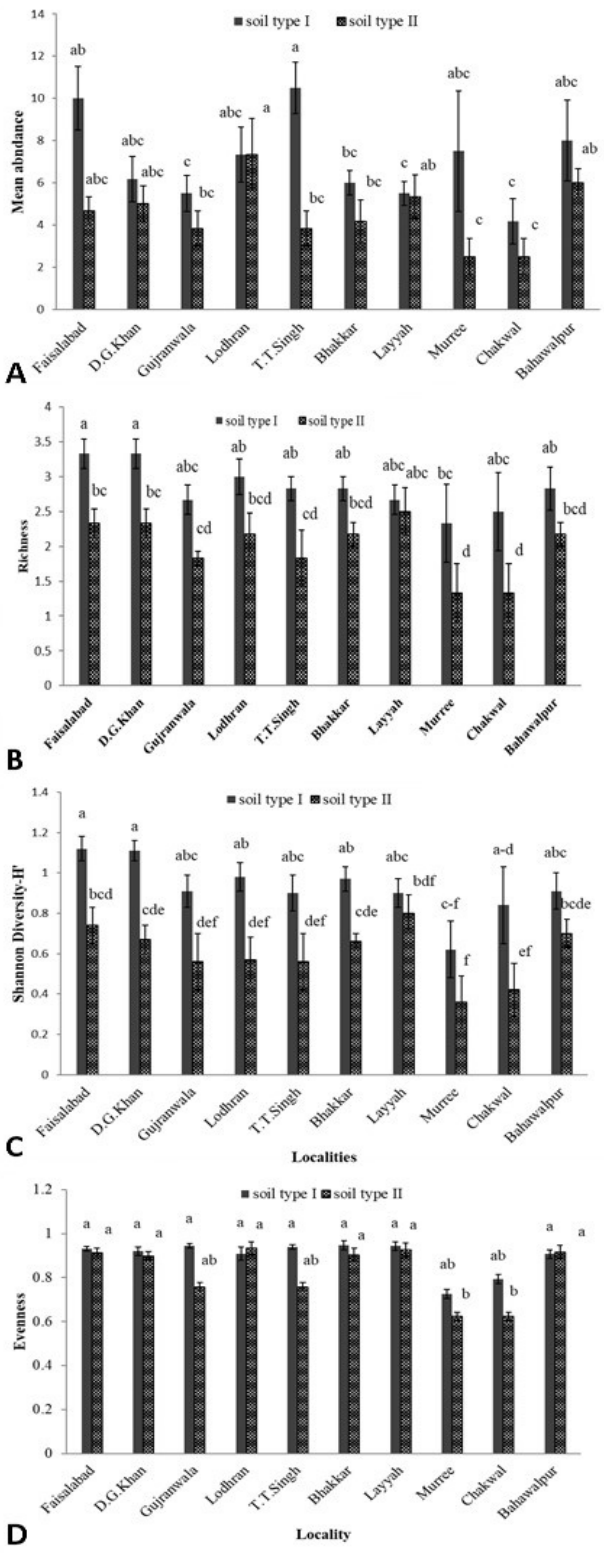

Fig. 1. Abundance (A), richness (B), diversity (C) and evenness (D) of Prostigmata in different localities of Punjab.

by Thal (2.54±0.12), Cholistan (2.50±0.19) and Barani (1.88±0.26). In soil type I, maximum richness was found in Irrigated plain zone (3.03±0.10), while the richness of Prostigmata remained at par with one another in remaining zones. Similarly, in soil type II, maximum family richness of Prostigmata was found in Thal (2.33±0.19), while the richness remained at par with one another in remaining zones (Table I).

Table III. ANOVA of abundance, family richness, diversity, and evenness of Prostigmata in different zone of Punjab.

SOV	DF	SS	MS	F	P
Abundance					
Zone (Z)	3	119.17	39.73	.02**	0.009
Soil types (S)	1	123.07	123.07	12.44**	0.000
Zones×Soil types		24.41	8.14	0.82^{NS}	0.484
Error	112	1107.73	9.89		
Total	119				
Family richness					
Zone (Z)	3	8.850	2.950	5.02**	0.003
Soil type (S)	1	13.104	13.104	22.29**	0.000
Zones×Soil types	3	1.650	0.550	0.94^{NS}	0.426
Error	112	65.833	0.588		
Total	119				
Diversity					
Zone (Z)	3	1.269	0.423		
Soil type (S)	1	1.787	1.787		
Zones×Soil types	3	0.169	0.056		
Error	112	7.099	0.063	6.6712**	0.000
Total	119			28.1874**	0.000
Evenness					
Zone (Z)	3	0.879	0.293	0.898^{NS}	0.118
Soil type (S)	1	0.07312	0.07312		
Zones×Soil types	3	0.05588	0.01863	5.820**	0.000986
Error	112	5.63932		1.452^{NS}	0.230704
Total	119	6.72137		0.370^{NS}	0.774856

NS, non-significant (P>0.05); ** highly significant, (P<0.01).

The statistical analysis of richness of Prostigmata in different localities shown in Table II revealed highly significant difference of richness among the localities (F= 3.63, P=0.000) and soil types (F=54.52, P=0.000). The interaction value between the sampling sites and soil types were non-significant. Maximum richness of Prostigmata was found in Faisalabad and D.G. Khan localities in soil type I with 3.33±0.21 and 3.33±0.22 values, respectively, while the richness in other localities remained at par. Similarly, in soil type II, maximum richness was found in the similar localities with value of 2.33±0.20 and 3.33±0.22 respectively (Fig. 1B).

The Shannon diversity of Prostigmata varied highly significantly in different zones (F=6.67, P=0.000) in different soil types (F=28.19, P= 0.000) while no significant difference was found in interaction between the soil types in different zones (Table III). Soil type I was found more diverse (0.93±0.03) as compared to soil type II (0.60±0.04). By comparing the diversity in different zones, the results revealed that Thal zone was more diverse (0.83±0.04) followed by Irrigated plain (0.81±0.04) and Cholistan zone (0.81±0.07) and Barani (0.56±0.08) respectively. By comparing the mean diversity of zones in different soil types, maximum mean diversity was found in Irrigated plain (1.00±0.04) in soil type I followed by Thal (0.94±0.05), Cholistan (0.91±0.09) and Barani (0.73±0.12). Similarly, in soil type II, maximum diversity was reported in Thal (0.73±0.05), followed by Cholistan (0.70±0.07), Irrigated plain (0.62±0.05) and Barani (0.39±0.09) (Table I).

According to the Table II, the results revealed that there was significance difference of mean diversity of Prostigmata in sampling sites (F=3.09, P= 0.003) and highly significant difference of mean in different soil types (F=48.41, P=0.000) while non-significant results were found in their interactions (F=0.517, P=0.8596). Soil type I found more diverse soil (0.93±0.03) as compared to soil type II (0.60±0.04). Faisalabad was found the most diverse in this group with (1.12±0.06), followed by D.G. Khan (1.11±0.05), Lodhran (0.98±0.07), Bhakkar (0.97±0.06), Gujranwala and Bahawalpur (0.91±0.08), (0.91±0.09) while minimum was found at Murree (0.62±0.14). Similarly, in soil type II, Layyah was the most diverse (0.80±0.09), followed by Faisalabad (0.74±0.09) and Bahawalpur (0.70±0.07) while minimum diversity was found in Murree (0.36±0.13) (Fig. 1C).

The statistical results regarding the evenness of Prostigmata in different zones and soil types shown in Table III revealed that different zones have significant difference of evenness of Prostigmata (F=5.820, P=0.0001) while no significant difference of evenness of Prostigmata in different soil types and interaction was found. Maximum mean evenness was reported in Thal zone (0.93±0.01), Cholistan (0.91±0.02), Irrigated plain (0.89±0.02) and Barani (0.69±0.08) (Table I).

The Evenness of Prostigmata in different localities of Punjab, Pakistan shown in Table II. The results revealed that evenness of Prostigmata soil mites varied significant in different localities but no significant difference was found between different soil types and interaction among localities and soil type.

Mean comparison tested through LSD test showed that mite evenness was maximum in Bhakkar and Layyah (0.94±0.02), followed by Gujranwala, Layyah and Faisalabad (0.93±0.01) while in soil type II, maximum evenness was found in Lodhran and Layyah (0.93±0.03), followed by Bahawalpur (0.92±0.03) and Faisalabad (0.91±0.02) (Fig. 1D).

Previous studies reported the variation of soil mite diversity, abundance, richness and evenness among the undisturbed and disturbed type of soils (Badejo and Tian, 1999; Badejo and Ola-Adams, 2000; Cianciolo and Norton, 2006; Minor and Cianciolo, 2007). Diversity, richness, evenness and relative abundance of soil mites were reported to be higher in undisturbed type of soils as compared to the disturbed type. Hulsmann and Wolters (1998) reported that the tillage practices reduced 50% of soil mites' population by which the current results are also in an agreement these results and with the Arroyo and Iturrondobeitia (2006) who concluded that the use of fertilizers, inorganic wastes, burning of crop residual material and pesticide application decreased the biodiversity of soil organisms.

Different agricultural practices has been recognized as one of the best benefactors to the loss of soil biodiversity because of the substantial measure of land assigned to this practice (McLaughlin and Mineau, 1995). Different agricultural practices such as tillage, drainage, crop rotation, grazing, and the intensive use of pesticides and fertilizers not only is the main cause of alteration of soil microclimate, soil properties and characteristics but also which ultimately have adverse impact on diversity of soil microarthropods (Badejo and Lasebikan, 1988; Badejo, 1990; Badejo and Akinyemiju, 1993; Badejo and Straalen, 1993; Badejo *et al*., 1997; Gergocs and Hufnagel, 2009).

Due to agricultural practices, breakdown of soil aggregates occurs resulted the losses of soil carbon, degradation of organic matter, and leaching down the soil dissolved organic carbon (Lal, 2002). Different use of pesticides, weedicides and use of other inorganic fertilizers for soil fertility also have harmful effect on soil creatures (Maribie *et al*., 2011). The plant residue on the undisturbed soil act as an available food source for the microarthopods and also affective in reduction of the moisture losses from the surface of the soil provide a suitable environment for microarthopods to increase their population and become more diverse (Coleman *et al*., 2002; Bedano *et al*., 2006). Based on the results of present study, it can be concluded that the soil inhabiting Prostigmata diversity, richness and abundance is severely affected by the exhaustive agricultural practices.

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Conflict of interest

The authors have declared no conflict of interest.

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