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Diversity of soil inhabiting oribatida (Acari) under cultivated and uncultivated land types from Punjab, Pakistan

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Suborder Oribatida is land-dwelling group of mites distributed across different geographic regions of the world. This study shows the assessment of diversity, richness, evenness, and abundance of families of Oribatid from uncultivated and cultivated soils collected from ten different localities of Punjab, Pakistan. Overall, 9 families of Oribatida were observed in both soil types having Oribatellidae, Oppiidae, and Scheloribatidae as dominating families. Uncultivated soil had more richness (S=07), abundance (46.01 ± 2.61) and Shannon diversity index (H'=1.77 ± 0.03) compared to cultivated soil with richness (S=5), abundance (25.35 ± 1.14) and Shannon index (H'= 1.47 ± 0.03). Maximum abundance value of oribatid mites (62 ± 11.87) was recorded from Murree for uncultivated soil while in case of cultivated soil, it was recorded from Faisalabad (29.83 ± 7.28). The maximum family richness of Oribatid mites was observed in Faisalabad and Chakwal (S=07) while minimum family richness (S=05) was observed from T.T. Singh.
Keywords: Oribatida, oribatillidae, cunaxidae, Scheloribatidae, Pakistan.

INTRODUCTION

Oribatid mites are considered as a dominant group of soil microarthropod prevailing in wide range of habitats (Gergocs and Hufnagel, 2009; Singh and Ray, 2015). Oribatid mites have significant role in enhancing soil fertility by decomposition of organic matter and many other biological processes occurring in soil (Rahgozar *et al.*, 2019). They are known to feed on living and dead plant parts, fungi and interact with their environment for different biological processes such as accumulation of heavy metals, Ca-storage, decomposition process and soil structure formation. Hence, they can be used as indicator of changes in soil parameters (Behan-Pelletier, 1999; Maraun and Scheu, 2000).

The population density of oribatid mites in soils with agricultural use can reach up to several hundred thousand individuals/ m^2 (Norton, 1990), but the use of modern agriculture implements like tillage application, chemicals insecticides and fertilizer have affected the biodiversity and species richness of the mites (Singh and Ray, 2015). Many studies have shown the decrease in the density as well as diversity of oribatid mite species from the uncultivated to cultivated ecosystem (Arroyo *et al.*, 2005; Loranger-Merciris *et al.,* 2007; Minor and Cianciolo, 2007). Culik *et al.* (2002) observed lower population of soil micro arthropods in cultivated soil (agriculture soil) than the uncultivated (non-agriculture) due to the soil tillage. The alteration of land for agriculture production increase danger and extinction of soil arthropods (Decaens *et al.*, 2006). Increased use of agriculture machinery and inputs deteriorates the chemical processes resulting the negative impact on land, purification, and reprocessing of natural material (Rana *et al.*, 2010). Higher amount of soil moisture in another factor in increase diversity of population of oribatida (Mirzaei-Pashami *et al*., 2020). Humidity of microhabitats is an important factor that effects on the abundance, distribution and diversity of oribatid mites (Seyd and Seaward, 1984; Siepel, 1996; Maturna, 2000; Rahgozar *et al*., 2019).

Study on the soil dwelling Oribatid has not been performed before in Pakistan. This work was carried out with the objective to estimate the diversity, richness, evenness and abundance of families of Oribatida from different areas of Punjab and study the impact of farming practices on oribatid mite communities.

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MATERIALS AND METHODS

The samplings were performed in ten different areas (Faisalabad, Toba Tek Singh, D.G. Khan, Lodhran, Gujranwala, Murree, Chakwal, Layyah, Bhakkar and Bahawalpur) belonging to four agroecological zones (Irrigated plain, Barani, Thal and Cholistan) of Punjab, Pakistan (PARC, 1997). The soil samples were collected from the cultivated fields and their adjoining uncultivated areas. A sampling core of 1000 cm^3 (h= 12.73 cm, diameter= 11.29 cm) were used to collect the samples at the distance of 10 feet. Then these samples were brought to Acarology Research Laboratory, University of Agriculture, Faisalabad. Berlese's funnel was used for the extraction of mites from soil samples. The samples were collected at bimonthly interval from the same locality for one year. A total of 360 samples were collected during the study. Ethanol (70%) was used for the storage of extracted soil mites. Oribatid mites were sorted under a light stereoscope and stored in Ethanol separately. These specimens were perpetually mounted on the microscopic slides by using Hoyer's medium. The mounted specimens were examined under phase contrast microscope (Meji Japan: MT4210H) and identified up to family level with the help of taxonomic keys of Krantz and Walter, 2009; Evans and Till, 1979. The biodiversity counts were done by using Shannon diversity index (Shannon, 1948) to estimate the richness, abundance, evenness and diversity of oribatid mites (Kikkawa, 1996) by using Shannon-Wiener diversity index for soil type I and II. The formula is as follow.

$$H' = \sum (Pi - ln(pi))$$

H' is diversity, p^i is the proportion of ith group.

RESULTS

A total of 9 families (viz. Oribatellidae, Oppiidae, Scheloribatidae, Haplozetidae, Nothridae, Tectocepheidae, Galumnidae, Lohmanniidae and Phthiracaridae) of Oribatida were reported from the ten localities of Punjab, Pakistan. Variation was reported in abundance, diversity, richness and evenness in diverse localities and in cultivated and uncultivated soil types. The uncultivated soil was more diverse in term of all parameters of diversity as compared to the cultivated soil.

Abundance of Oribatida varied significantly between uncultivated and cultivated soils (F=38.27, P=0.000). The interaction response between the localities and soil types was non-significant. Maximum value of abundance was recorded in Barani region (53.50±6.57), followed by Irrigated plain (48.77±3.96), Thal (42.25±4.34) and Cholistan (39.5±4.77) in uncultivated soils, while in case of cultivated soils, maximum value of abundance was recorded from Irrigated plain having a mean value of 28.17±1.96 (Table 1).

Abundance of Oribatida in different localities showed significant difference in different soil types (F=53.05, P=0.000). The maximum mean value of abundance in uncultivated soil was recorded from Murree (62.00±11.87), followed by Faisalabad (57.50±7.26), T.T.Singh (54.00±7.15) while the mean abundance of Oribatida in other localities were statistically at par with each other. Similarly, in cultivated soil, the maximum mean abundance was recorded from Faisalabad (29.83±7.28) and D.G. Khan (29.5±3.55) while the mean abundance between the other localities was statistically similar to each other (Fig. 1).

Table 1. Abundance of Oribatida (individuals per sample) in different zones and soil types in Punjab.

Zones	Soil types		Mean±S.E
	Uncultivated	Cultivated	
Irrigated plain	48.77±3.96	28.17±1.96	38.47±2.57
Thal	42.25±4.34	24.75±1.78	33.50±2.93
Barani	53.50±6.57	25.33±1.67	39.42±4.43
Cholistan	39.50±4.77	23.17±2.91	31.33±3.94
Mean±S.E	46.01±2.61A	25.35±1.14B	

Means sharing different letters are significantly different from each other.

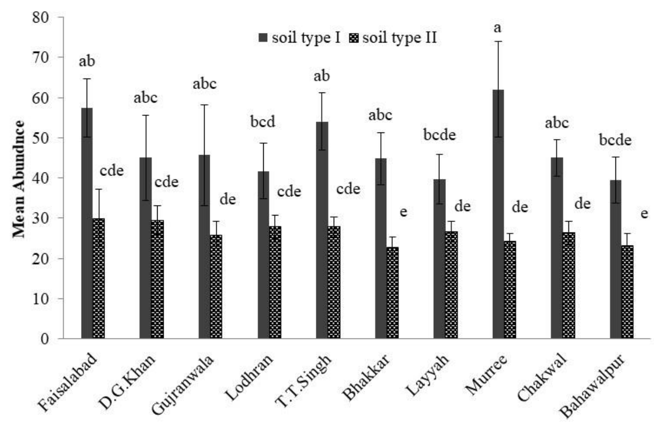

Figure 1. Abundance of Oribatida in different localities of Punjab. Soil type I – uncultivated, Soil type II – cultivated. Means sharing the same letter are not significantly different at P ≤ 0.05.

The richness of Oribatida in different zones was significantly different among different soil types (F= 44.5, P=0.000) and non-significant among different zones and interaction factor between soil type and locality. Uncultivated soil had higher richness with value of 6.68±6.92 as compared to cultivated soil (5.10±5.31). In case of uncultivated soil, maximum richness was found in Barani zone (7.25±0.22), while the richness of other zones remained at par with one another. Similarly, for cultivated soil, maximum richness was found in Barani zone (5.33±0.26) followed by Thal (5.25±0.39) Cholistan (5.00±0.52) and Irrigated plain (4.83±0.17) (Table 2).

Table 2. Family richness of Oribatida (families per sample) in different zones and soil types in Punjab.

Zones	Soil types		Mean±S.E
	Uncultivated	Cultivated	
Irrigated plain	6.40±0.23	4.83±0.17	5.62±0.18B
Thal	6.58±0.29	5.25±0.39	5.92±0.28AB
Barani	7.25±0.22	5.33±0.26	6.30±0.26A
Cholistan	6.50±0.56	5.00±0.52	5.75±0.43AB
Mean±S.E	6.68±6.92A	5.10±5.31B	

Means sharing different letters are significantly different from each other.

The richness of Oribatida in different localities of Punjab revealed statistically significant differences (F=66.18, P=0.000) between the soil types while no differences were detected for species richness among different localities. The maximum richness of Oribatida was observed from Faisalabad and Chakwal having mean values of 7.33±0.33 and 7.33±0.21, respectively. The richness of Oribatida in other localities remained at par with one another. Similarly in cultivated soils, maximum species richness was detected from Faisalabad and Chakwal with men values 5.17±0.48 and 5.17±0.31, respectively. The richness of Oribatida remained at par in other localities (Fig. 2).

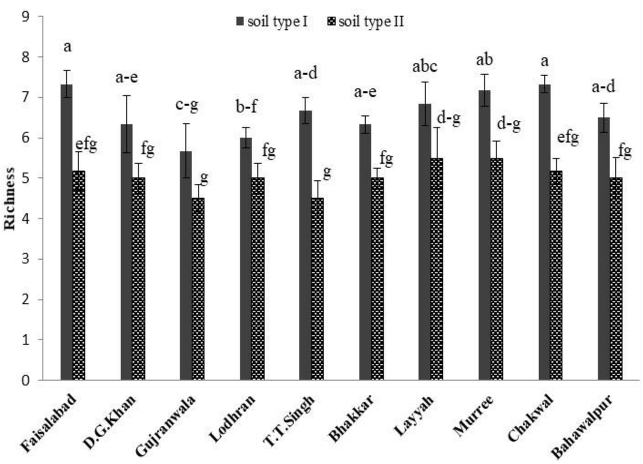

Figure 2. Family richness of Oribatida (families per sample) in different localities and soil types of Punjab. Soil type I – uncultivated, Soil type II – cultivated

The diversity of soil mites varied significantly with respect to soil types (F=39.87, P= 0.000), while different zones showed no significant differences in diversity of mites. Maximum mite diversity (1.77±0.03) was reported from uncultivated soil compared to cultivated soil. Barani zone had highest mean diversity (1.87±0.04) followed by Thal (1.77±0.04), irrigated plain (1.74±0.04) and Cholistan (1.74±0.09) for uncultivated soils, while in case of uncultivated soil, Barani and Thal regions had highest mite diversity (1.53±0.06) followed by Cholistan (1.46±0.14) and irrigated plain (1.42±0.05) (Table 3).

The diversity of soil mites varied significant (F=58.18, P=0.000) in different soil types but not for different localities. Uncultivated was more diverse (1.77±0.03) as compared to cultivated (1.47±0.03) (Fig. 3).

Table 3. Shannon diversity for families of Oribatida in different zones and soil types in Punjab.

Zones	Soil types		Mean±S.E
	Uncultivated	Cultivated	
Irrigated plain	1.74±0.04	1.42±0.05	1.58±0.04
Thal	1.77±0.04	1.53±0.06	1.65±0.04
Barani	1.87±0.04	1.53±0.06	1.70±0.05
Cholistan	1.74±0.09	1.46±0.14	1.60±0.09
Mean±S.E	1.77±0.03A	1.47±0.03B	

Means sharing different letters are significantly different from each other.

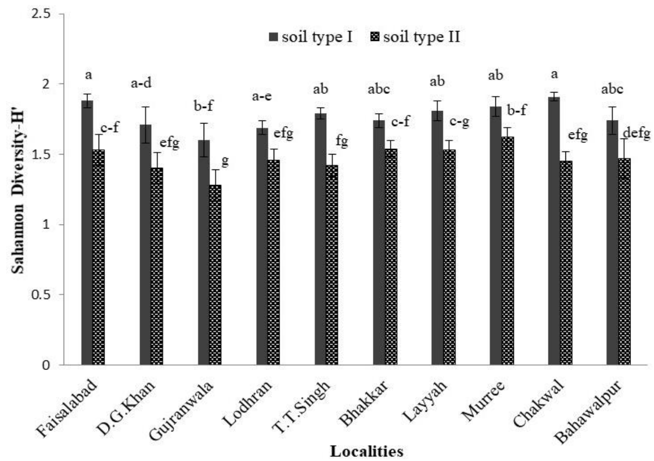

Figure 3. Shannon diversity (families) of Oribatida in different localities and soil types of Punjab. Soil type I – uncultivated, Soil type II – cultivated**.**

The evenness of Oribatida varied significantly between different soil types (F=5.39, P=0.02), while no significant differences were observed among different ecological zones. The uncultivated soil had higher evenness value (0.94±0.09) compared to cultivated soil with mean value of 0.91±0.01 (Table 4). Significant differences for evenness of Oribatida in different soil types (F=6.08, P=0.016), were reported while no significant difference was found between the different localities and no interaction between soil types and different localities. For uncultivated soils, the maximum evenness was reported from T.T. Singh (0.95±0.03), followed by Murree and D.G. Khan (0.94±0.02), Bahawalpur and Gujranwala (0.94±0.02) while in uncultivated soils, T.T. Singh had maximum evenness of Oribatid mites (0.93±0.0), followed by Chakwal and Gujranwala (0.092±0.01) (Fig. 4).

Table 4. Evenness of Oribatida in different zones and soil types in Punjab.

Zones	Soil types		Mean±S.E
	Uncultivated	Cultivated	
Irrigated plain	0.94±0.01	0.91±0.01	0.92±0.01
Thal	0.94±0.01	0.91±0.01	0.92±0.01
Barani	0.93±0.01	0.91±0.02	0.92±0.01
Cholistan	0.94±0.01	0.91±0.04	0.92±0.02
Mean±S.E	0.94±0.09A	0.91±0.01B	

Means sharing different letters are significantly different from each other.

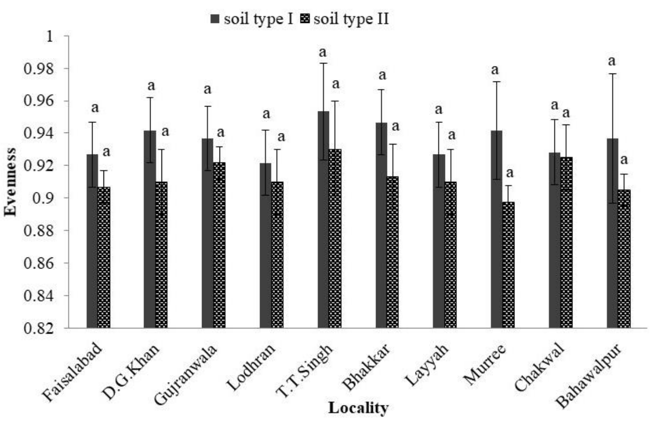

Figure 4. Evenness of Oribatida in different localities and **soil types of Punjab.** Soil type I – uncultivated, Soil type II – cultivated.

DISCUSSION

Many studies revealed the variation in the diversity, richness, abundance and evenness of soil mite among the uncultivated and cultivated soil types (Badejo and Tian, 1999; Badejo and Ola-Adams, 2000; Noti *et al*., 2003; Cianciolo and Norton, 2006; Minor and Cianciolo, 2007). The higher diversity, richness, evenness and relative abundance of Oribatida were found in uncultivated soil types due to the disturbance in the soil by use of different agricultural practices. Hulsmann and Wolters (1998) found that the 50% of soil mites' population was affected due to use of tillage. The current results are also in agreement with the Arroyo and Iturrondobeitia (2006) who concluded that the use of chemical insecticides, fertilizers, and pesticide application can decrease the soil biodiversity.

The main factors of soil biodiversity loss are identified as the use of different agricultural practices (Mclaughlin and Mineau, 1995). These agricultural practices are not only the main factors responsible for changing the microclimate of soil, soil properties and features but also have adverse impact on diversity of soil microarthropods (Badejo and Lasebikan, 1988; Badejo, 1990; Badejo and Akinyemiju, 1993; Badejo and Straalen, 1993; Moore, 1994; Badejo *et al.,* 1997; Gergocs and Hufnagel, 2009).

Crop residues on the soil surface may increase the amount of organic matter and moisture contents in the soil which effects the diversity of soil mite (Bedano *et al.,* 2005). This may be attributed to higher organic matter, higher water capacity, an increase in water penetration speed, higher ventilation and lower compression in the no-tillage system.

Breakdown of soil particles occur due to agricultural practices, which results in soil carbon losses, degradation of organic matter and leaching of soil organic carbon (Lal, 2002). The use of different agro chemicals including pesticides, weedicides and synthetic fertilizers also have deleterious impact on soil creatures (Maribie *et al.,* 2011). The organic matter from plant residue in the uncultivated soil act as a food source for the soil microarthopods and also play affective role in maintaining the soil moisture, ultimately provide a proper environment for population growth of micro-arthropods (Coleman *et al.,* 2002; Bedano *et al.,* 2006). On the basis of the results, the present study concluded that diversity of the soil inhabiting Oribatida is severely affected by the use of agrochemicals and other agricultural practices.

Authors Contributions statement: Ahmad Kamran Khan designed the study, collected the specimens, mounted and identified the specimens, analyzed the data and wrote article. Muhammad Hamid Bashir supervised the work, identified the specimens, helped in write up of this paper. Shanza Ahmed, Irfan Ahmed and Muhammad Ahsan Khan helped in the collection and analysis of data.

Conflict of interest: The authors declare no conflicts of interest.

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