Pakistan J. Zool., vol. 49(2), pp 677-683, 2017. **DOI**: http://dx.doi.org/10.17582/journal.pjz/2017.49.2.677.683

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

Ahmad Kamran Khan[1], Muhammad Hamid Bashir[1,*], Bilal Saeed Khan[1] and Nazir Javed[2]

[1]*Department of Entomology, University of Agriculture, Faisalabad, Pakistan*
[2]*Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan*

Article Information
Received 03 March 2016
Revised 20 June 2016
Accepted 29 August 2016
Available online 02 April 2017

Authors' Contributions
AKK designed the study, performed experimental work and wrote the article. BSK and NJ helped in planning of experiment. MHB analyzed the data and supervised the work.

Key words
Ascidae, Ameroseiidae, Macrochelidae, Pachylaelapidae, Laelapidae.

ABSTRACT

Mesostigmata are known to be the most diverse group of predatory mites within soil ecosystems, involved in maintaining the soil health. Biodiversity of Mesostigmata can be used to access the soil health within a geographical region. Family richness, diversity, abundance and evenness of soil inhabiting Mesostigmata mites in cultivated and undisturbed soil were estimated from five different localities of Punjab, Pakistan in 2014. Family richness, abundance and Shannon diversity indexes were higher in undisturbed soil as compared to the cultivated soil in all the localities, while low variability in evenness had been found. The highest diversity of soil inhabiting Mesostigmata (H'=1.93) was recorded in undisturbed soil in April at Dera Ghazi Khan locality and lowest diversity (H'=0.50) in cultivated soils in August at Gujranwala. The highest family richness (S=10) was reported in undisturbed soil at D.G.Khan and the lowest (S=3) was found in cultivated soils in Gujranwala, Chakwal and Bhakkar.

INTRODUCTION

Mesostigmata is one of the largest groups of free living mites among the soil dwelling arthropods in soil ecosystem (Kordeshami *et al*., 2015). They have successfully adapted to a wide range of habitats. Many of them are adapted for life as parasites of vertebrates and invertebrates (Koehler, 1999; Salmane, 2000; Beaulieu and Weeks, 2007). The majority of Mesostigmata are free-living as predators associated with soil and decaying matter (Skorupski *et al*., 2009). They are associated with the small insects, nematodes and microorganisms such as fungi and bacteria within soil ecosystem (Koehler 1999; Schneider *et al*., 2012; Manu *et al*., 2013; Nazari and Hajizadeh, 2013). They are involved in regulating densities of different soil invertebrates through their feeding and can alter different biochemical processes, which ultimately have influence on soil fertility (Badejo and Ola-Adams, 2000). They are sensitive to soil disturbance (Beaulieu and Weeks, 2007), which is why they are widely used as bioindicators of changes in soil conditions and ecosystems (Karg and Freier, 1995; Koehler, 1999; Mineiro *et al*., 2009).

Previous studies revealed the close association of soil arthropods, including mites diversity, with agricultural practices and different inputs used for growing crops (Gulvik, 2007). Diversity and abundance of soil mite's fauna have been affected by cultivation practices and other factors (Seastedt, 1984). Different agricultural practices such as tillage and the use of pesticides and fertilizers are the main cause of change of soil properties, which can have adverse effect on biodiversity of soil inhabiting mites (Gergocs and Hufnagel, 2009; Begum *et al*., 2014). For example, tillage practices immediately reduced 50% of soil mite population (Hulsmann and Wolters, 1998). The use of different agrochemicals such as fertilizers and pesticides has also results in the reduction in soil mites populations (Arroyo and Iturrondobeitia, 2006) and soil microbial activity (Yousaf *et al*., 2013).

The order Mesostigmata, which contains more than 12,000 known species, is the largest and highly diverse group among Acari (Walter and Proctor, 1999; Krantz and Walter, 2009). This group is cosmopolitan in distribution (Evans and Till, 1979). More than 100 families of Mesostigmata have been reported worldwide as being associated with the soil (Koehler, 1997, 1999; Gulvik, 2007; Salmane and Brumelis, 2008).

Biodiversity of soil inhabiting Mesostigmata has been studied in different parts of the world (Skorupski *et al*., 2008; Kamczyc and Gwiazdowicz, 2009; Maribie *et al*., 2011; Manu and Onete, 2014), but very few refer

* Corresponding author: hamid_uaf@yahoo.com
0030-9923/2017/0002-0677 $ 9.00/0

to Indo-Pakistan region. In Uttar Dinajpur, west Bengal India, mesostigmatid mite group exhibited highest relative abundance during the post monsoon ranged from 9.17% to 38.5% (Sarkar *et al*., 2015).

No work on biodiversity of soil-inhabiting Mesostigmata has been carried out in any region of Pakistan. The present study was done with the objectives to study the biodiversity of different families of Mesostigmata in different ecological regions of Punjab Pakistan and to estimate the impact of agricultural practices on populations of these mites.

MATERIALS AND METHODS

The sampling of soil was done from five localities: Faisalabad (31.3543° N, 72.8833° E), D.G. Khan (29.8166667° N, 70.6027778° E), Gujranwala (32.1500° N, 74.1833° E), Chakwal (32.9303° N, 72.8556° E) and Bhakkar (31.6333° N, 71.0667° E), selected from each agro-ecological regions of Punjab, Pakistan (PARC, 1996). One site from each locality was selected for soil sampling from cultivated field and uncultivated adjoining area. Cultivated soils were considered as disturbed whereas uncultivated were considered as undisturbed. Three samples were collected randomly at the distance of 10 feet with the help of a steel core of 1000 cm^3 volume (h= 12.73 cm, diameter = 11.29 cm) from both cultivated and uncultivated areas. The soil samples were transported immediately to Acarology Research Laboratory, University of Agriculture, Faisalabad. Soil mites were extracted by using the Berlese funnel. The sampling from the same localities was repeated at two months intervals till the 12th month. The extracted soil mites were stored in 70% ethanol and were sorted out from the rest of the soil organism under dissecting microscope. The sorted Mesostigmata 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 the family level. Biodiversity parameters were calculated by using the Shannon diversity index (Shannon, 1948).

RESULTS AND DISCUSSION

A total of 10 families of suborder Mesostigmata were recorded from the soils of various agro-ecological zones of Punjab, Pakistan. Differences in diversity, abundance and richness were found among the different localities and two different types of soils. The soils under cropping system had lower diversity, abundance and richness of mites, compared to the undisturbed soil. The diversity index (H') varied in different months as well as in different locations of Punjab. Maximum diversity was reported in D.G. Khan (H'=1.93) in April, whereas the minimum diversity was 0.50 in Gujranwala in August in the cultivated soil (Fig. 1). There was comparatively higher diversity of Mesostigmata in undisturbed soils comparing with cultivated soils of the same locality throughout the reporting period. The graph represents that the variation in H value is more prominent in cultivated land as fluctuation are more intense in cultivated lands as compared to uncultivated soils.

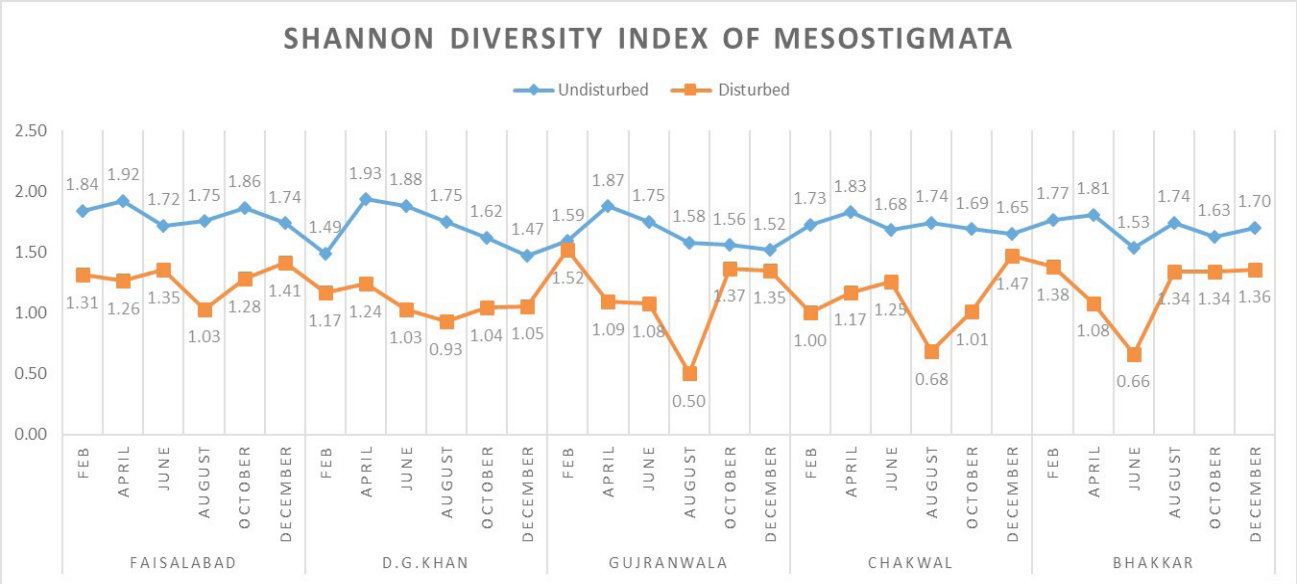

Fig. 1. Shannon diversity index of mesostigmata of undisturbed and disturbed type of soil of different localities of Punjab.

Maximum number of families were reported from D.G. Khan region (S=10), followed by Faisalabad and Chakwal (S=9) and Gujranwala and Bhakkar (S=8). Family richness showed minor variability in different localities, but differed significantly between the cultivated and undisturbed soil types (Fig. 2). Families Ameroseiidae, Ascidae, Parasitidae, Laelapidae, Pachylaelapidae were recorded throughout the reporting period in all the localities, while Uropodidae, Phytoseiidae, Sejidae, Rhodacaridae were less abundant. Differences in evenness were observed in different localities. In general, evenness of Mesostigmata families was lower in cultivated soils, as compared to undisturbed soils (Table I).

Ascidae were the most abundant family, with 136 individuals in Faisalabad, followed by 133, 98, 73, and 70 in D.G.Khan, Gujranwala, Chakwal and Bhakkar. The families Sejidae, Rhodacaridae were not reported from cultivated soils in Faisalabad; Phytoseiidae and Rhodacaridae were absent in D.G. Khan; Sejidae, Uropodidae and Rhodacaridae were not found in Gujranwala; Phytoseiidae, Sejidae and Rhodacaridae were absent from Chakwal; Phytoseiidae and Rhodacaridae were not reported in cultivated soil from Bhakkar (Table II).

Table I.- Evenness of suborder Mesostigmata of undisturbed and disturbed type of soils from different localities of Punjab, Pakistan.

Localities	February		April		June		August		October		December	
	Undis-turbed	Dis-turbed	Undis-turbed	Dis-turbed	Undis-turbed	Dis-turbed	Undis-turbed	Dis-turbed	Undis-turbed	Dis-turbed	Undis-turbed	Dis-turbed
Faisalabad	0.95	0.82	0.92	0.78	0.96	0.97	0.90	0.94	0.96	0.80	0.97	0.88
D.G. Khan	0.93	0.73	0.88	0.77	0.97	0.74	0.90	0.66	0.83	0.75	0.82	0.76
Gujranwala	0.99	0.85	0.96	0.79	0.98	0.78	0.98	0.66	0.97	0.99	0.94	0.97
Chakwal	0.96	0.72	0.94	0.73	0.86	0.78	0.97	0.62	0.81	0.73	0.96	0.91
Bhakkar	0.99	0.82	0.93	0.94	0.86	0.78	0.97	0.60	0.91	0.82	0.95	0.97

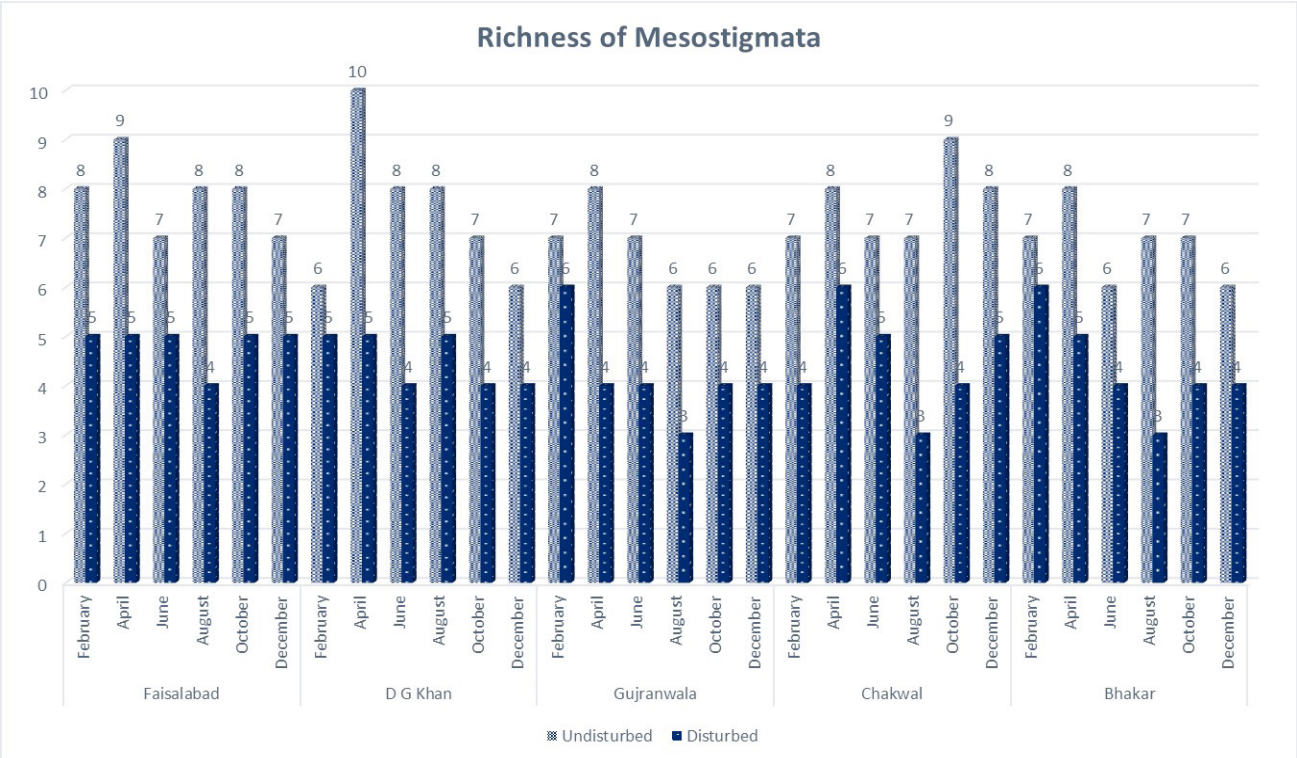

Fig. 2. Family richness of suborder Mesostigmata of undisturbed and disturbed type of soils from different localities of Punjab, Pakistan.

Table II.- Relative abundance of different families of Mesostigmata from undisturbed and disturbed type of soils.

Families	Faisalabad		DG Khan		Gujranwala		Chakwal		Bhakkar	
	Undis-turbed	Dis-turbed	Undis-turbed	Dis-turbed	Undis-turbed	Dis-turbed	Undis-turbed	Dis-turbed	Undis-turbe	Dis-turbed
Ameroseiidae	82	29	99	32	61	12	36	17	39	15
Parasitidae	27	23	23	29	19	21	20	5	22	22
Macrochelidae	31	6	32	8	40	17	24	1	18	11
Laelapidae	57	12	54	11	22	12	37	18	30	13
Pachylaelapidae	66	15	46	15	45	20	34	19	33	13
Ascidae	103	33	92	41	78	20	48	25	49	21
Uropodidae	11	4	14	2	8	0	5	2	0	0
Sejidae	28	0	13	1	9	0	3	0	0	0
Rhodacaridae	8	0	2	0	3	0	8	0	7	0
Phytoseiidae	0	0	13	0	0	0	4	0	8	0

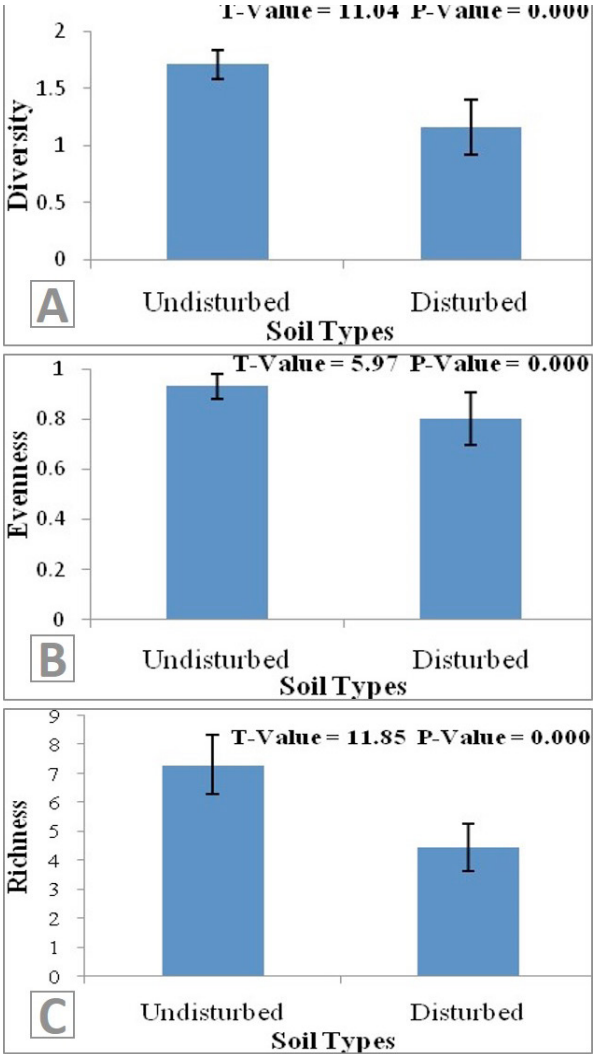

Fig. 3. Comparison of means of Shannon diversity index, evenness and richness of disturbed and undisturbed soils.

Highly significant variation was observed in Shannon diversity index of cultivated and undisturbed soils (T-Value = 11.04, P-Value = 0.000). The average diversity index of undisturbed soils (1.71± 0.13) was reported to remain higher than cultivated soils (1.15± 0.24). Evenness and richness were also reported to differ significantly (T-Value = 5.97, P-Value = 0.000: T-Value = 11.85, P-Value = 0.000, respectively). Values of evenness and richness were higher in undisturbed soils (0.93± 0.05; 7.3± 1.02 respectively) as compared to cultivated soils (0.80± 0.11; 4.47± 0.82) (Fig. 3).

Previous studied revealed that diversity and abundance of soil mites varied between the undisturbed and disturbed types of soil (Badejo and Tian, 1999; Badejo and Ola-Adams, 2000; Noti *et al*., 2003; Cianciolo and Norton, 2006; Minor and Cianciolo, 2007). Diversity, richness, evenness and relative abundance of soil mites were reported to be higher in undisturbed soils as compared to the disturbed ones. Current results are also in an agreement with Hulsmann and Wolters (1998) who reported that the tillage practices reduced soil mites population by 50%, and with Arroyo and Iturrondobeitia (2006) who concluded that the use of fertilizers, inorganic wastes, burning of crop residual material, and pesticide application decrease the biodiversity of soil organisms.

The low diversity and abundance of soil inhabiting mites may be due to different agricultural practices such as tillage, pesticides and fertilizers used for cultivation of crops. These practices are the main cause of alteration of microclimate, soil properties and characteristics which ultimately have adverse impact on diversity of soil microarthropods (Badejo and Lasebikan, 1988; Badejo, 1990; Badejo and Akinyemiju, 1993; Moore, 1994; Gergocs and Hufnagel, 2009). Due to cultivation, soil carbon is lost (about 50–75%) through the breakdown of soil aggregates, exposing once-protected organic matter

to degradation, erosion by wind and runoff, and leaching of dissolved organic carbon (Lal, 2002). Application of herbicides and the use of inorganic fertilizers and pesticides also have harmful effect on soil biota (Maribie *et al*., 2011). On the other hand, the uncultivated soils have more plant residue, which provides available food resource for the microarthropods and tones down extreme temperatures, which ultimately reduces the rate of moisture loss from the soil surface (Coleman *et al*., 2002; Bedano *et al*., 2006). Based on the results of present study, it can be concluded that the diversity, richness and abundance of soil inhabiting Mesostigmata mites is negatively affected by the intensive cultivation practices.

CONCLUSIONS

The soils with extensive agricultural practices were found to have low diversity of Mesostigmata of soil. This may be concluded that the disturbance of the soils may reduce the biodiversity of soil inhabiting microorganisms.

ACKNOWLEDGMENTS

The authors acknowledge Higher Education Commission (HEC) of Pakistan for financial support under Indigenous 5000-Ph.D Fellowship Program for completion of this research work.

Statement of conflict of interest

Authors have declared no conflict of interest.

REFERENCES

Arroyo, J. and Iturrondobeitia, J.C., 2006. Differences in the diversity of oribatid mite communities in forest and agro systems lands. *Eur. J. Soil Biol.*, **42**: 259-269. https://doi.org/10.1016/j.ejsobi.2006.01.002

Badejo, M.A., 1990. Seasonal abundance of soil mites (Acarina) in two contrasting environments. *Biotropica*, **22**: 382-390. https://doi.org/10.2307/2388555

Badejo, M.A. and Akinyemiju, O.A., 1993. Response of soil mites to hexazinone application in Nigeria. *Sci. Total Environ.*, **2**: 1156-1159.

Badejo, M.A. and Akinwole, P.O., 2006. Microenviromental preferences of oribatid mite species on the floor of a tropical rain forest. *Exp. appl. Acarol*., **40**: 145-156. https://doi.org/10.1007/s10493-006-9029-y

Badejo, M.A. and Ola-Adams, B.A., 2000. Abundance and diversity of soil mites of fragmented habitats in a biosphere reserve in southern Nigeria. *Pesq. Agrapec. Brasil.*, **35**: 2121-2128. https://doi.org/10.1590/S0100-204X2000001100001

Badejo, M.A. and Lasebikan, B.A., 1988. Comparative studies on the acarine populations of a secondary regrowth forest and a cassava plantation in Ile-Ife, Nigeria. *Pedobiologia,* 32: 111-116.

Badejo, M.A. and Tian, G., 1999. Abundance of soil mites under four agroforestry tree species with contracting litter quality. *Biol. Fert. Soils*, **30**: 107-112. https://doi.org/10.1007/s003740050595

Beaulieu, F. and Weeks, A.R., 2007. Free-living Mesostigmata mites in Australia: their roles in biological control and bioindication. *Aust. J. exp. Agric*., **47**: 460-478. https://doi.org/10.1071/EA05341

Bedano, J.C., Cantu. M.P. and Doucet, M.E., 2006. Influence of three different land management practices on soil mite (Arachnida: Acari) densities in relation to a natural soil. *Appl. S. Ecol*., **32**: 293-304. https://doi.org/10.1016/j.apsoil.2005.07.009

Begum, F., Bajracharya, R.M., Sitaula, B.K., Sharma, S., Ali, S. and Ali, H., 2014. Seasonal dynamics and land use effect on soil microarthropods communities in the Mid-hills of Nepal. *Int. J. Agron. agric. Res.*, **5**: 114-123.

Cianciolo, J.M. and Norton, R.A., 2006. The ecological distribution of reproductive mode in oribatid mites, as related to biological complexity. *Exp. appl. Acarol.*, **40**: 1-25. https://doi.org/10.1007/s10493-006-9016-3

Coleman, D., Fu, S., Hendrix, P. and Crossely, Jr, D., 2002. Soil foodwebs in agroecosystem: Impacts of herbivory and tillage management. *Eur. J. Soil Biol.*, **38**: 21-28. https://doi.org/10.1016/S1164-5563(01)01118-9

Evans, G.O. and Till, W.M., 1979. Mesostigmata mites of Britiain and Ireland (Chelicerate: Acari-Parasitiformes). An introduction of their external morphology and classification. *Trans. zool. Soc. Lond.,* **35**: 139-262. https://doi.org/10.1111/j.1096-3642.1979.tb00059.x

Gergocs, V. and Hufnagel, L., 2009. Application of oribatid mites as indicators (Review). *Appl. Ecol. environ. Res.,* **7**: 79-98. https://doi.org/10.15666/aeer/0701_079098

Gulvik, M.E., 2007. Mites (Acari) as indicators of soil biodiversity and land use monitoring: A review. *Pol. J. Ecol.*, **55**: 415-440.

Hulsmann, A. and Wolter, V., 1998. The effect of different tillage practices on soil mites, with particular references to Oribatida. *Appl. Soil Ecol*., **9**: 327-332. https://doi.org/10.1016/S0929-

1393(98)00084-5

Kamczyc, J. and Gwiazdowicz, D., 2009. Soil mites (Acari, Mesostigmata) from Szczeliniec Wielki in the Stolowe Mountains National park (SW Poland). *Biol. Lett.,* **46**: 21-27. https://doi.org/10.2478/v10120-009-0010-4

Karg, W. and Freier, B., 1995. Parasitiforme Raubmilben als Indikatoren für den Okologischen Zustand von Ökosystemen. *Mitteil. Biol. Bundesan. Land Forstwirtsch*. Berlin-Dahlem, **308**: 1-96.

Koehler, H.H., 1997. Mesostigmata (Gamasina, Uropodina), efficient predators in agroecosystems. *Agric. Ecosyst. Environ*., **62**: 105-117. https://doi.org/10.1016/S0167-8809(96)01141-3

Koehler, H.H., 1999. Predatory mites (Gamasina, Mesostigmata). *Agric. Ecosyst. Environ.*, **74**: 395-410. https://doi.org/10.1016/S0167-8809(99)00045-6

Kordeshami, A.B., Khajehali, J. and Nemati, A., 2015. Some edaphic Mesostigmata mites from Lordegan, Chaharmahal Bakhtiari province with their world distribution. *J. Crop Prot.*, **4**: 589-604.

Krantz, G.W. and Walter, D.E., 2009. *A manual of acarology*. Third edition. Texas Tech University Press; Lubbock, Texas, pp. 807.

Lal, R., 2002. Soil carbon dynamics in cropland and rangeland. *Environ. Pollut.*, **116**: 353-362. https://doi.org/10.1016/S0269-7491(01)00211-1

Manu, M., Bancila, R.I. and Onete, M., 2013. Soil mite communities (Acari: Gamasina) from different ecosystem types from Romania. *Belg. J. Zool.*, **143**: 30-41.

Manu, M. and Onete, M., 2014. Taxonomical structure of the soil mite's fauna from a cliff ecosystem and its adjacent area (Doftana valley, Romania). *Rom. J. Biol. Zool.*, **59**: 113-121.

Maribie, C.W., Nyamasyo, G.H.N., Ndegwa, P.N., Mungatu, J.K., Lagerlof, J. and Gikungu, M., 2011. Abundance and diversity of soil mites (Acari) along a gradient of land use types in Taita Taveta, Kenya. *Trop. Subtrop. Agroecosyst.,* **13**: 11-26.

Mineiro, J.L. De. C., Lindquist, E.E. and de Moraes, G.J., 2009. Edaphic ascid mites (Acari: Mesostigmata: Ascidae) from the state of Sao Paulo, Brazil, with description of five new species. *Zootaxa,* **2024**: 1-32.

Minor, M.A. and Cianciolo, J.M., 2007. Diversity of soil mites (Acari Oribatida, Mesostigmata) along a gradient of LUTs in New York. *Appl. Soil Ecol.*, **35**: 140-153. https://doi.org/10.1016/j.apsoil.2006.05.004

Moore, J.C., 1994. Impact of agricultural practices on soil food web structure: Theory and application. *Agric. Ecosyst. Environ.,* **51**: 239-247. https://doi.org/10.1016/0167-8809(94)90047-7

Nazari. M. and Hajizadeh, J., 2013. A checklist to the Parasitid mites (Mesostigmata, Parasitidae) of Iran with nine new records and a key for Guilan Province Parasitidae species. *Entomofauna,* **34**: 397-408.

Noti, M., Andre, H.M., Ducarne, X. and Lebrum, P., 2003. Diversity of soil oribatid mites (Acari: oribatida) from high Katanga (Democratic republic of Congo): a multiscale and multifactor approach. *Biodivers. Conserv.,* **12**: 767-785. https://doi.org/10.1023/A:1022474510390

Pakistan Agricultural Research Council, 1996. *National Agricultural Research plan*. Agro-Ecological zones of Punjab, pp 159. [online]. Available at http://old.parc.gov.pk/Maps/AgroEcoPunjab.html.

Salmane, I., 2000. Fauna of soil-dwelling predatory gamasina mites (Acari: Mesostigmata) in seashore habitats of the kurzeme coast, Latvia. *Ekologia*, **19**: 87-96.

Salmane, I. and Brumelis, G., 2008. The importance of the moss layer in sustaining biological diversity of Gamasina mites in coniferous forest soil. *Pedobiologia*, **52**: 68-76. https://doi.org/10.1016/j.pedobi.2008.03.002

Sarkar, S.K., Chakrobarty, K. and Moitra, M.N., 2015. A study on variation of relative abundances and group diversities of major soil microarthropods taxa at four different sites in Uttar Dinajpur, west Bengal, India. *W.J. Environ. Biosci.,* **4**: 7-15.

Schneider, F.D., Scheu, S. and Brose, U., 2012. Body mass constraints on feeding rates determine the consequences of predator loss. *Ecol. Lett.*, **15**: 436-443. https://doi.org/10.1111/j.1461-0248.2012.01750.x

Seastedt, T.R., 1984. The role of micro-arthropods in decomposition and mineralization processes. *Anu. Rev. Ent.*, **29**: 25-46. https://doi.org/10.1146/annurev.ento.29.1.25

Shannon, C.E., 1948. A mathematical theory of communication. *Bell Syst. Tech. J.*, **27**: 379-423. https://doi.org/10.1002/j.1538-7305.1948.tb00917.x

Skorupski, M., Belter, W., Kamczyc, J. and Wierzbicka, A., 2008. Soil mites (Acari, Mesostigmata) of the "Torfowiska Doliny Izery' reserve in the sudety mountains. *Soil Organis.*, **80**: 261-270.

Skorupski, M., Belter, W., Kamczyc, J. and Wierzbicka, A., 2009. The first reaction of soil mite fauna (Acari, Mesostigmata) caused by conversion of

Norway spruce stand in the Szklarska Poręba Forest District. *J. For. Sci*., **55**: 234-243.

Walter, D.E. and Proctor, H.C., 1999. *Mites: Ecology, evolution and behaviour*. University of NSW Press, Sydney and CABBI Wallingford, pp. 322.

Yousaf, S., Khan, S. and Aslam, M.T., 2013. Effect of pesticides on the soil microbial activity. *Pakistan J. Zool.,* **45**: 1063-1067.