Entomological Communications, 4, 2022: ec04015
doi: 10.37486/2675-1305.ec04015
e-ISSN: 2675-1305
Open Access Full Text Article

Scientific Note

Oribatid mites in agricultural and natural soils: a case study of vertical distribution

Harol Revelo-Tobar[1,2], Edith G. Estrada-Venegas[1,2], Armando Equihua-Martínez[1,2], Jorge Valdez-Carrasco[2]

[1]*Colegio de Postgraduados, Campus Montecillo, Montecillo, Mexico State, Mexico.* [2]*Private Laboratory of Entomology and Acarology (ENTOMOACARI), Emilio Carranza, La Trinidad, Texcoco, Mexico.*
Corresponding author: edith_ev@yahoo.com.mx

Edited by: Gilberto J. de Moraes (Guest Editor)

Received: March 28, 2022. Accepted: May 02, 2022. Published: May 31, 2022.

Abstract. The vertical distribution of oribatid mites was evaluated in a natural soil (pine-oak forest) in the municipality of San Juan Nuevo and an agricultural soil (avocado crop) in the municipality of Uruapan in Michoacán, Mexico. Samples were taken in seven layers distributed in a 100 cm deep trench. A total of 466 oribatid mites/cm^3, representing 37 species of 29 genera were identified. In both sites, the highest abundance and biodiversity were found in the top 5 cm layer. *Nothrus anauniensis* Canestrini & Fanzago, 1877 (Nothridae), *Ramusella* (*Insculptoppia*) *merimna* Balogh & Mahunka, 1977 (Oppiidae), *Allogalumna* (*Acrogalumna*) sp. 1 (Galumnidae) and *Scheloribates* sp. 2 (Scheloribatidae) were found at the greatest depths (10-25 cm in natural soil and 25-50 cm in agricultural soil).

Keywords: Avocado, biodiversity, ecology, Oribatida.

The state of Michoacán has a vast and varied agricultural production, and avocado is the most economically important crop. The state has undergone an accelerated change in land use, mainly in areas of natural pine and oak forests, as the edaphoclimatic conditions in those areas favor avocado cultivation (Vidales 2009). Human impact on the ecosystem affects the edaphic biota, which is constituted in large part by mites of the suborder Oribatida (Estrada-Venegas 2012). These are abundant in natural soils, mainly in organic and alluvial strata (Norton & Behan-Pelletier 2009). In this environment, they fulfill important functions, participating in the decomposition of organic matter and nutrient recycling, allowing a whole food web of microscopic decomposers to function in equilibrium (Ghilarov 1963).

The vertical distribution of oribatids is affected in response to soil characteristics, as moisture content, presence of roots, dead organic matter and degree of disturbance at different depths (Leetham & Milchunas 1985; Urhan et al. 2008). Several small oribatid species, such as those of the family Oppiidae, can move vertically in the soil through macro and micro pores (Evans et al. 1961; Holt 1981). Previous reports have indicated their patterns of vertical distribution in soils of different countries (Leetham & Milchunas 1985; Mitchell 1978; Perdue & Crossley Jr. 1990), but not in Mexico.

Knowledge about the edaphic microarthropods in Michoacán is limited (Palacios-Vargas & Iglesias 2004). The present study was conducted in a forest area of pine (*Pinus michoacana* Martínez., Pinaceae) and oak (*Quercus rugosa* Nee, Fagaceae) in Nuevo San Juan Parangaricutiro (19°23'27.8''N; 102°10'30.8''W), at 2160 m altitude, and in a conventional avocado (*Persea americana* Mill. var. Hass, Lauraceae) cultivation (AC) in Uruapan (19°23'47.2'N; 102°05'58.1''W), at 1,725 m altitude. Both municipalities are located in Michoacán. The soil of both sites is classified as Andosol (FAO 2009), with the following characteristics: forest with sandy texture in the first 10 cm and loam in the deeper strata, with granular structure, abundant roots up to 50 cm, dense forest cover of pine and oak, shrubs and some small grasses, dense layer of leaf litter; avocado cultivation with loamy texture in all strata, more clayey at greater depths, little presence of roots, dense weed cover, sparse leaf litter at advanced stage of decomposition when the experiment was conducted.

A 0.50 m wide x 1 m long x 1 m deep trench was excavated in each ecosystem. The trench walls were then sectioned in seven layers, according to depth (0-2, 3-5, 6-10, 11-25, 26-50, 51 - 75 and 76 - 100 cm). One soil sample (15 cm^3) was collected from each layer of each trench to extract the oribatid mites in Berlese-Tullgren funnels, for two weeks. The mites were separated into morphospecies with the aid of a stereoscopic microscope, quantified and a representative sample of adults was separated (10 specimens were extracted from the most abundant groups and all specimens were studied from the least abundant groups) and macerated in lactic acid for subsequent identification. Permanent preparations were done using Hoyer's liquid as mounting medium, dried at 45°C. Species were identified with group-specific keys (Balogh & Balogh 1988; 1990; Subias & Balogh 1989; Ermilov et al. 2014). In addition, one soil sample was collected from each layer of each ecosystem for the determination of pH, electrical conductivity (EC), organic carbon, nitrogen, true density and soil texture. The determination of the diversity and abundance of oribatid mites along the soil layers was carried out, describing the characteristics of each environment.

A total of 466 oribatids/cm^3 were collected. Of these, 447 and 19 ind./cm^3 were found in the natural forest (95.9% of the total abundance) and the avocado cultivation (4.1%), respectively. In total, 37 species belonging to 29 genera of 17 families were identified. *Belbodamaeus* (*Epidamaeus*) *palaciosi* Iglesias & Guzmán, 2012, *Ramusella* (*Insculptoppia*) *merimna* Balogh & Mahunka, 1977, *Allogalumna* (*Acrogalumna*) sp. 1 and *Galumna* sp. 1 were found in both ecosystems (Tab. 1). Five species were found only in the avocado cultivation, whereas 28 species were found only in the natural forest.

In the natural forest, the highest abundance and number of species were found in the top 5 cm soil layer. From the top 2 cm layer, 236 oribatids/cm^3 were collected, representing 19 species, while in the 3-5 cm layer, 207 oribatids/cm^3 were collected, representing 23 species. In the avocado cultivation, the highest density (9 mites/cm^3, representing five species) was found in the top 2 cm layer; in this ecosystem, in the 3-5 cm layer 2 mites/cm^3, representing two species. The maximum

Table 1. Abundance (n°., ind./cm³) of oribatid mites found in the soil profile of the forested area (FA) and avocado plantation (AC).

Family	Species	Soil depth (cm)											
		0-2		3-5		6-10		11-25		26-50		Total	
		FA	AC	FA	AC	FA	AC	FA	AC	FA	AC	FA	AC
Euphthiracaridae	*Euphthiracarus* sp. 1	0	0	1	0	0	0	0	0	0	0	1	0
Phthiracaridae	*Hoplophorella* sp. 1	0	0	1	0	0	0	0	0	0	0	1	0
Nothridae	*Nothrus anauniensis*	0	0	1	0	0	0	1	0	0	0	2	0
Plasmobatidae	*Solenozetes* sp. 1	6	0	0	0	0	0	0	0	0	0	6	0
Aleurodamaeidae	*Aleurodamaeus* sp. 1	0	0	3	0	0	0	0	0	0	0	3	0
Damaeidae	*Belbodamaeus* (*Epidamaeus*) *palaciosi*	6	0	4	1	0	0	0	0	0	0	10	1
Cepheusidae	*Reticulocepheus* sp. 1	1	0	0	0	0	0	0	0	0	0	1	0
Gustavidae	*Gustavia* sp. 1	2	0	0	0	0	0	0	0	0	0	2	0
Eremobelbidae	*Eremobelba* sp. 1	1	0	35	0	0	0	0	0	0	0	36	0
	Eremobelba piffli	1	0	13	0	0	0	0	0	0	0	14	0
Oppiidae	*Wallworkoppia cervifer*	18	0	63	0	0	0	0	0	0	0	81	0
	Ramusella (Insculptoppia) merimna	0	0	1	0	0	0	1	1	0	1	2	2
	Pseudoamerioppia barrancensis	0	0	3	0	0	0	0	0	0	0	3	0
	Oxyoppia (Oxyoppiella) sp. 1	0	0	3	0	0	0	0	0	0	0	3	0
	Ramusella (Ramusella) sp. 1	0	2	0	0	0	0	0	0	0	0	0	2
	Cheloppia sp. 1	0	0	2	0	0	0	0	0	0	0	2	0
	Oppiella nova	0	1	0	0	0	0	0	0	0	0	0	1
	Arcoppia sp. 1	0	1	0	0	0	0	0	0	0	0	0	1
Suctobelbidae	*Suctobelbella* (*Flagrosuctobelba*) sp. 1	0	0	5	0	1	0	0	0	0	0	6	0
	Suctobelbidae Gen 1, sp. 1	0	0	1	0	0	0	0	0	0	0	1	0
	Allosuctobelba sp. 1	0	0	1	0	0	0	0	0	0	0	1	0
	Suctobelbella (*Suctobelbella*) sp. 2	1	0	0	0	0	0	0	0	0	0	1	0
Microzetidae	*Schalleria* sp. 1	1	0	6	0	0	0	0	0	0	0	7	0
	Acaroceras similis	0	0	3	0	0	0	0	0	0	0	3	0
Achipteriidae	*Anachipteria* sp. 1	10	0	0	0	0	0	0	0	0	0	10	0
Ceratozetidae	*Adoribatella* sp. 1	11	0	0	0	0	0	0	0	0	0	11	0
	Ceratozetes sp. 1	0	0	1	0	0	0	0	0	0	0	1	0
Scheloribatidae	*Scheloribates* (*Scheloribates*) sp. 2	0	4	0	1	0	0	0	0	0	0	0	5
	Scheloribates (*Scheloribates*) *elegans*	0	0	0	0	0	0	0	2	0	3	0	5
	Scheloribates (*Scheloribates*) sp. 1	2	0	2	0	0	0	0	0	0	0	4	0
	Lauritzenia sp. 1	1	0	0	0	0	0	0	0	0	0	1	0
Galumnidae	*Allogalumna* (*Acrogalumna*) sp.1	82	0	38	0	0	0	1	0	0	1	121	1
	Pergalumna sp. 3	41	0	0	0	0	0	0	0	0	0	41	0
	Pergalumna sp. 1	14	0	16	0	0	0	0	0	0	0	30	0
	Galumna sp. 1	21	0	2	0	0	0	0	0	0	0	23	0
	Pergalumna sp. 2	14	0	0	0	0	0	0	0	0	0	14	0
	Galumna sp. 2	3	1	2	0	0	0	0	0	0	0	5	1
Total		236	9	207	2	1	0	3	3	0	5	**447**	**19**

depths at which oribatid mites were found were 11-25 cm in the natural forest and 26-50 cm in the avocado cultivation; in the first, 3 oribatids/cm³ belonging to three species were found between 11-25 cm, whereas in the second, 5 oribatids/cm³ belonging to three species were found between 26-50 cm.

The most abundant species, mainly in the surface strata were: *Eremobelba* sp. 1 (Eremobelbidae) 36 ind./cm ³, *Pergalumna* sp. 3 (Galumnidae) 41 ind./cm ³, *Wallworkoppia cervifer* (Mahunka, 1983) (Oppiidae) 81 ind./cm³ and *Allogalumna* (*Acrogalumna*) sp.1 (Galumnidae) 121 ind./cm³. Also, *Nothrus anauniensis* Canestrini & Fanzago, 1877 (Nothridae), *Ramusella* (*Insculptoppia*) *merimna* Balogh & Mahunka, 1977 (Oppiidae), *Allogalumna* (*Acrogalumna*) sp. 1 and *Scheloribates* (*S.*) *elegans* (Scheloribatidae) were the species found at the greatest depth (10 to 25 cm in natural soil and 25 to 50 cm in agricultural soil). They were also found in the superficial layers (0 to 5 cm).

Statistically significant linear correlations ($p < 0.10$, $p < 0.05$) were found respectively between pH (negative) and EC (positive) with the number of individuals of *B.* (*L.*) *palaciosi* ($r = -0.84$, $r = 0.92$), *Galumna* sp. 2 ($r = -0.84$, $r = 0.92$), *Scheloribates* (*S.*) sp. 1 ($r = -0.87$, $r = 0.95$) and *Pergalumna* sp. 1 ($r = -0.87$, $r = 0.95$). In the avocado cultivation, a statistically significant and positive linear correlation was detected with the percentage of soil silt content; thus, the greater the depth, the higher the percentage of silt content ($r = 0,89$, $p < 0.05$). The negative relationship between pH and the abundance of oribatid mites could be due to the high percentage of organic matter and humidity recorded in the forest area, which benefits the mites and also favors the decomposition processes, producing humic acids that acidify the soil (Alamilla-Pastrana et al. 2014; Erdmann et al. 2012). The remaining variables (organic carbon, nitrogen, relative density and soil aggregates) showed no significant correlations with depth.

In the two ecosystems, the highest abundance was observed in the top 2 cm layer. However, the greatest diversity of species was found in the 3-5 cm layer in the natural forest and in the top 2 cm layer in the avocado cultivation. The first two layers of the natural forest (0-2 and 3-5 cm) are characterized by having organic material (O_{i-a}) in different levels of decomposition, constituted by more than 40% of visible leaves (O_i) and material in advanced decomposition process (O_e). In the avocado cultivation, most of the organic material was constituted by material already decomposed and in the humification process (O_a). These results are similar to those of several authors (Mitchell 1978; Hansen & Coleman 1998; Fredes et al. 2009; Lehmitz et al. 2012), who reported high abundance and diversity of oribatid mites species in the soil surface. This pattern is compatible with the putative role of oribatid mites as decomposers of organic matter (Murphy 1955).

Our results showed a contrasting difference between the ecosystems in terms of oribatid abundance and diversity, reinforcing the importance of preserving soil coverage to maintain the natural quality of the ecosystems.

Acknowledgments

To Consejo Nacional de Ciencia y Tecnología (CONACyT) and ENTOMOACARI laboratory for the financial support for master´s studies of the first author. To the reviewers for their valuable recommendations for improving the manuscript.

Authors' Contributions

H.R.T., E.G.E.V. and A.E.M. collected and processed the samples. H.R.T. and E.G.E.V. identified the specimens, and H.R.T wrote the manuscript. E.G.E.V., A.E.M. and J.V.C. revised, corrected, and translated the manuscript.

Conflict of interest Statement

The authors declare no potential conflict of interest.

References

Alamilla-Pastrana, E.; May-Uicab, D.; Vázquez, M. (2014) Relación entre el contenido de materia orgánica y la riqueza y abundancia de los ácaros óribátidos en suelos de Cozumel, Quintana Roo, México. *Entomología Mexicana*, 1: 84-89.

Balogh, J.; Balogh, P. (1988) *The soil mites of the world. Oribatid mites on Neotropical Region I*. Hungary, Bunapest: Akadémiai Kiado.

Balogh, J.; Balogh, P. (1990) *The soil mites of the world. Oribatid mites on Neotropical Region II*. Hungary, Bunapest: Akadémiai Kiado.

Erdmann, G.; Scheu, S.; Maraun, M. (2012) Regional factors rather than forest type drive the community structure of soil living oribatid mites (Acari, Oribatida). *Experimental and Applied Acarology*, 57(2): 157-169. doi: 10.1007/s10493-012-9546-9

Ermilov, S.; Alvarado-Rodríguez, O.; Retana-Salazar, A. (2014) Two new species of Pergalumna (Acari, Oribatida, Galumnidae) from Costa Rica, including a key to all species of the genus from the Neotropical region. ZooKeys, 23(435): 7-23. doi: 10.3897/zookeys.435.8213

Estrada-Venegas, E. G. (2012) Ácaros en suelos cultivados. In: Estrada-Venegas, E. G.; Chaires-Grijalva, M. P.; Acuña-Soto, J. A.; Equihua-Martínez, A. (Eds.), *Ácaros de importancia en el suelo*, pp. 195-203. Texcoco: Colegio de Postgraduados.

Evans, G. O.; Sheals, J. G.; Macfarlane, D. (1961) *The terrestrial Acari of the British Isles*. London: British Museum (Natural History).

FAO (2009) *Guía para la descripción de suelos*. Roma: FAO.

Fredes, N.; Martínez, P.; Laborde, V.; Osterrieth, M. (2009) Microartrópodos como indicadores de disturbio antrópico en entisoles del área recreativa de Miramar, Argentina. *Ciencia Del Suelo*, 27(1): 89-101.

Ghilarov, M. (1963) On the interrelations between soil dwelling invertebrates and soil microorganisms. In: Doeksen, I.; Van Der Drift, J. (Eds.), *Soil Organisms*, pp. 255-259. Amsterdam: North-Holland Publishing Co.

Hansen, R. A.; Coleman, D. C. (1998) Litter complexity and composition are determinants of the diversity and species composition of oribatid mites (Acari: Oribatida) in litterbags. *Applied Soil Ecology*, 9(1-3): 17-23. doi: 10.1016/S0929-1393(98)00048-1

Holt, J. (1981) The vertical distribution of cryptostigmatic mites, soil organic matter and macroporosity in three North Queensland rainforest soils. *Pedobiologia*, 22: 202-209.

Leetham, J.; Milchunas, D. (1985) The composition and distribution of soil microarthropods in the shortgrass steppe in relation to soil water, root biomass, and grazing by cattle. *Pedobiologia*, 28(5): 311-325.

Lehmitz, R.; Russell, D.; Hohberg, K.; Christian, A.; Xylander, W. E. R. (2012) Active dispersal of oribatid mites into young soils. *Applied Soil Ecology*, 55: 10-19. doi: 10.1016/j.apsoil.2011.12.003

Mitchell, M. (1978) Vertical and horizontal distributions of oribatid mites (Acari: Cryptostigmata) in an Aspen woodland soil. *Ecology*, 59(3): 516-525.

Murphy, P. (1955) Ecology of the fauna of forest soils. In: McE. Kevan, D. K. (Ed.), *Soil Zoology*, pp. 99-124. London.

Norton, R. A.; Behan-Pelletier, V. (2009) Suborder Oribatida. In: Krantz, G. W.; Walter, D. E. (Eds.), *A manual of acarology*, pp. 430-564. Texas: Texas Tech University Press.

Palacios-Vargas, J. G.; Iglesias, R. (2004) Oribatei (Acari). In: Llorente Bousquets, J.; Morrone Juan, J.; Yáñez Ordóñez, O.; Vargas Fernández, I. (Eds.), *Biodiversidad, taxonomía y biogeografía de artrópodos: hacia una síntesis de su conocimiento*, pp. 431-468. Ciudad de México: CONABIO.

Perdue, J.; Crossley Jr, D. (1990) Vertical distribution of soil mites (Acari) in conventional and no-tillage agricultural systems. *Biology and Fertility of Soils*, 9: 135-138.

Subias, L.; Balogh, P. (1989) Identification keys to the genera of Oppiidae Grandjean, 1951 (Acari: Oribatei). *Acta Zoologica Hungarica*, 35(3): 355-412.

Urhan, R.; Katılmış, Y.; Kahveci, Ö. (2008) Vertical distribution of soil mites (Acari) in Dalaman (Muğla prov.- Turkey). *Munis Entomology & Zoology*, 3(1): 333-341.

Vidales, F. (2009) Contaminación por agroquímicos. In: Chávez-León, G; Tapia Vargas, L. M; Bravo Espinoza, M.; Záenz Reyes, T.; Muñoz Flores, H. J.; Vidales Fernández, I.; Larios Guzmán, A.; Rentería Ánima, J. B.; Villaseñor Ramírez, F. J. Sánchez Pérez, J., et al. (Eds.), *Impactos ambientales y socioeconómicos del cambio de uso del suelo forestal a huertos de aguacate en Michoacán*, pp. 45-46. Uruapan: INIFAP, CIRPAC.