Persian J. Acarol., 2019, Vol. 8, No. 2, pp. 147–159.
http://dx.doi.org/10.22073/pja.v8i2.43052
Journal homepage: http://www.biotaxa.org/pja

Article

Biodiversity and species richness of oribatid mites (Acari: Oribatida) in orchards of East Azerbaijan province, Iran

Maryam Rahgozar[1*], Karim Haddad Irani-Nejad[1], Mohammad-Reza Zargaran[2] and Alireza Saboori[3]

1. *Department of Plant Protection, Faculty of Agriculture, University of Tabriz, Tabriz, Iran; E-mails: rahgozar@tabrizu.ac.ir, khaddad@tabrizu.ac.ir*
2. *Department of Forestry, Faculty of Natural Resources, Urmia University, Urmia, Iran; E-mail: M.Zargaran@urmia.ac.ir*
3. *Department of Plant Protection, Faculty of Agriculture, University of Tehran, Karaj, Iran; E-mail: saboori@ut.ac.ir*

[*] Corresponding author

ABSTRACT
Oribatid mites are one of the dominant soil microarthropods. These mites have an important role in increasing soil fertility through organic materials decomposition. Oribatid mite communities (Acari: Oribatida) were investigated in orchards of five regions (Ahar, Kaleibar, Varzaghan, Heris and Horand) in East Azerbaijan province, Iran. The oribatid mites were studied in each orchard (apple orchards with size of approximately 0.4 ha were selected) by collecting 12 samples taken from a maximum depth of 20 cm. Sampling was performed for six months in 2015. The oribatid species diversity (Shannon-Wiener index), Species richness (Rarefaction and Jackknife methods), Evenness by Shannon's index and similarity (Sorensen index) were calculated with Ecological Methodology 6.0 software for all the regions. A total of 75 species belonging to 57 genera and 38 families of oribatid mites were collected and identified. The highest number of species (54 spp.) was found in the orchards of Kaleibar, while the studied orchards of Varzaghan had the lowest number of species (21 spp.). One–way ANOVA analysis showed that the Shannon–Wiener species diversity was highest in Kaleibar (H = 3.409) and Ahar (H = 3.419). Also, Kaleibar and Ahar had the highest species richness (Kaleibar: 79.8 species, Ahar: 70.7 species). Among studied regions, Kaleibar and Ahar had the highest species richness and species diversity but Varzaghan showed the lowest values, apparently because of geographical and climate differences between these regions.

KEY WORDS: Acariformes; climate; diversity; rarefaction; Sarcoptiformes; similarity; species richness.

PAPER INFO.: Received: 30 January 2019, Accepted: 19 February 2019, Published: 15 April 2019

INTRODUCTION

Oribatid mites are one of the dominant soil microarthropod groups (Singh and Ray 2015) with limited dispersal abilities (Starý and Block 1998). Their densities can reach several hundred thousand individuals per square meter (Norton 1990). These mites have an important role in increasing soil fertility through organic materials decomposition (Singh and Ray 2015), but in agricultural fields, their natural population and biology are affected by different factors such as fertilizers, crop rotation, cultivation, irrigation, etc. (Singh and Ray 2015). Oribatid mites act as decomposers of organic materials, contribute in nutrient cycling and soil formation (Acharya and Basu 2014; Iranpoor and Akrami 2016; N'dri *et al*. 2017). Their active instars feed on a wide variety of material including living and dead plants as well as fungi, moss, lichens and carrion residues. Some of them are intermediate hosts of tapeworms and some species are predaceous (Behan-Pelletier 1999). Oribatid mites are present almost anywhere, many are arboreal, a few are aquatic and some species are adapted to all niches (Norton and Behan-Pelletier 2009). The composition of mite communities in soil reflects the rating of stress in the soil ecosystem and may represent the condition of soil functioning (Gulvik 2007). Diversity and species richness are among the direct properties of community structure that can be used to acquire information about environmental quality (Van Straalen 2005). Generally, three levels of diversity can be distinguished: Alpha, Beta and Gamma diversity. Alpha diversity is used to calculate diversity within a specific region or ecosystem, and identified by the number of species; Beta diversity includes changes of diversity among ecosystems, and Gamma diversity is a measure of the whole diversity inside a large region (Whittaker 1972). Alpha diversity consists of the species richness and evenness of a given area (Whittaker 1972). Beta diversity can be calculated by means of similarity coefficients such as Simpson and Jaccard Similarity indices (Zargaran *et al*. 2011). One of the important reasons of biodiversity decline in agro-ecosystems is agricultural processes, which change the native vegetation communities to monocultures (Lascaleia *et al*. 2018). By evaluating biodiversity, an ecosystem health can be determined. Biodiversity evaluation can be used as an effective tool for systematic use of living organisms for evaluating the quality of the environment and the ecosystem health. Another advantage of studying biodiversity is identification of weaknesses in the ecosystem caused by contamination or habitat destruction (Heidari *et al*. 2012).

There are few studies concerning the biodiversity of mites in Iran e.g. biodiversity of Mesostigmata (Ostovan and Farzane 2004, Arjmandi Nejad *et al*. 2006, Bahrami *et al*. 2011, Amani *et al*. 2015) and Oribatida (Hashemi-Khabir *et al*. 2014, 2015; Ramezani and Mossadegh 2014; Keshavarz-Jamshidian *et al*. 2015). However, , there is no study on oribatid mites in agro-ecosystems in Iran or East Azerbaijan province, so far. Also, there is no report on diversity and richness of the mites in East Azerbaijan province. Therefore, in this study, we investigated Alpha and Beta diversity of oribatid mites in the soil of orchards in five regions (Ahar, Kaleibar, Varzaghan, Heris and Horand) in East Azerbaijan province, Iran.

MATERIALS AND METHODS

This study was conducted in orchards of five regions of East Azerbaijan province, northwest of Iran including Ahar, Kaleibar, Varzaghan, Heris, and Horand. Table 1 shows the characteristics of each region.

Table 1. Characteristics of studied sites.

County	Latitude (N)	Longitude (E)	Climatic conditions†
Ahar	38° 24'–38° 31'	47° 01'– 47° 56'	Semi-humid, cold
Kaleibar	38° 39'–38° 56'	47° 02'–47° 10'	Semi-humid, cold
Varzaghan	38° 25'–38° 33'	46° 36'–47° 41'	Semi-arid, cold
Heris	38° 11'–38° 25'	46° 36'–46° 41'	Semi-arid, cold
Horand	38° 38'–38° 47'	47° 15'–47° 17'	Semi-arid, very cold

† Office of Natural Resources in East Azerbaijan province, Iran (received 10.9.2018).

Field sampling and mite extraction

The oribatid mites were studied in each orchard (apple orchards with size of approximately 0.4 ha were selected) by collecting of 12 samples in each orchard taken from a maximum depth of 20 cm. Sampling was performed for six months in 2015 (May, June, July, August, September, and October). Soil samples were collected from soil under the tree and transferred to the acarological laboratory. Mites were extracted using a Berlese funnel (depending on the amount of soil moisture, 24–48 hours) and kept in 75% ethanol, cleared in Nesbitt's fluid and mounted on microscope slides using Hoyer's medium (Krantz 1978). The slides were kept in an oven at 45–50 °C for 3–4 weeks.

Specimens were identified using several keys (e.g. Balogh 1972; Gilyarov 1975; Balogh and Balogh 1988, 1990, 1992a, b; Akrami and Saboori 2012) ; also some species were confirmed by experts.

Data analyses

The number and abundance of each species per sample was used to estimate the species richness. The oribatid species richness (rarefaction and Jackknife), evenness (Shannon's index), biodiversity (Shannon-Wiener index), faunal similarity between studied regions (Sorensen's similarity index) were calculated for all samples using the Ecological Methodology 6.0 software. Differences among the sites were evaluated using one-way analysis of variance (ANOVA), and means differences of diversity and evenness were tested with Tukey's test (at 95% confidence level).

1– Species richness

Species richness of oribatid communities was expressed by Rarefaction and Jackknife method. The community structure of oribatid mites was analyzed using abundances of adult oribatids.

1–1– Rarefaction method

Rarefaction statistical method was used to estimate the number of species expected in a random sample of individuals taken from a collected samples using following formula (Schowalter 1996; Magurran 2004):

$$E\left(\hat{S}_n\right) = \sum_{i=1}^{s}\left[1 - \frac{\binom{N-N_i}{n}}{\binom{N}{n}}\right]$$

where *E* $(\hat{S}_n)$ is the expected number of species in a random sample of *n* individuals; *S* – Total number of species in entire collection; *Ni* – number of individuals in species *i*; *N* – total number of individuals in collection; *n* – value of sample size (number of individuals) chosen, for standardization ($n \leq N$).

1–2–Jackknife method

Jackknife method was used to calculate of whole species richness by using the number of species really observed plus the number of unique species to any sample, weighted by the number of samples.

$$\mathbf{S} = \boldsymbol{s} + \left(\frac{\boldsymbol{n}-\mathbf{1}}{\boldsymbol{n}}\right)\boldsymbol{k}$$

where *s* is the observed total number of species present in *n* quadrants; *n* – total number of quadrants sampled; *k* – number of unique species (Schowalter 1996; Magurran 2004).

2– Evenness

Evenness of oribatid communities was expressed by Shannon's index.

SEI= Hs/Hmax

where *SEI* is the Shannon's measure of evenness; *Hs*– Shannon's index; *Hmax*– maximum rate of Shannon's index (Schowalter 1996; Magurran 2004).

3– Biodiversity

Biodiversity of oribatid communities was expressed by Shannon-Wiener index.

$$H = -\sum_{i=1}^{N_o} [p_i * \log p_i]$$

where *H* is the Shannon–Wiener index; p_i– proportion of total sample represented by species *i* ($P_i = n_i/N$); *N* – number of species (Schowalter 1996; Magurran 2004).

4– Similarity

Amount of similarity between oribatid mite communities in the studied regions expressed by Soerensen's index.

$$\mathbf{Ss = 2a / (2a + b + c)}$$

where *a* is the number of species shared between 2 regions (A and B), *b* – number of species in (B) is not in A, *c* – number of species in (A) is not in (B) (Magurran 2004).

RESULTS AND DISCUSSION

In this study, 75 species belonging to 57 genera and 38 families were collected from orchards of the studied regions (Table 2). Some taxa could be only identified at genus level. In each region, a different species composition and richness was found. For example, Kaleibar showed the highest species richness (59 spp.) and Varzaghan had the lowest species richness (21 spp.). 54, 41, and 31 species were recorded from other three regions (Ahar, Horand, and Heris) respectively.

Table 2. Species composition (Nomenclature according to Subías 2004) and occurrence of oribatid mites in orchards of studied regions in East Azerbaijan province, Iran. A = Ahar, K = Kaleibar, V= Varzaghan, He= Heris and Ho = Horand.

Species name	**Regions**				
	A	**K**	**V**	**H**	**H**
Aphelacarus acarinus acarinus (Berlese, 1910)	*			*	
Gilarovella demetrii Lange, 1974	*	*		*	
Hypochthonius luteus Oudemans, 1917		*			
Sphaerochthonius splendidus (Berlese, 1904)	*	*		*	*
Cosmochthonius reticulatus Grandjean, 1947	*	*			*
Cosmochthonius sp.	*				
Phyllozetes emmae (Berlese, 1910)	*			*	*
Haplochthonius (*H.*) *simplex* (Willmann, 1930)				*	
Haplochthonius (*H.*) *sanctaeluciae* Bernini, 1973				*	
Brachychthonius hauserorum (Mahunka, 1979)	*		*	*	
Poecilochthonius italicus (Berlese, 1910)	*	*			
Sellnickochthonius gracilis (Chinone, 1974)	*	*	*		
Parhypochthonius aphidinus Berlese, 1904	*		*		
Acrotritia ardua (C. L. Koch, 1841)	*	*	*	*	*
Papillacarus aciculatus (Berlese, 1905)	*	*		*	*
Epilohmannia cylindrica cylindrica (Berlese, 1904)	*	*	*	*	*
Epilohmannia gigantea Berlese, 1916		*			
Nothrus anauniensis Canestrini & Fanzago, 1877	*	*		*	*
Malaconothrus sp.	*	*			
Hermanniella septentrionalis Berlese, 1910	*				

Table 2. Continued.

Species name	Regions				
	A	**K**	**V**	**H**	**H**
Jacotella frondeus (Kulijev, 1979)	*	*		*	*
Licnodamaeus fissuratus (Balogh & Mahunka, 1965)	*				
Licnodamaeus pulcherrimus (Paoli, 1908)	*	*			
Belba (*Belba*) *daghestanica* Bulanova–Zachvatkina, 1962	*	*			
Metabelbella zachvatkini Bulanova–Zachvatkina, 1967		*			*
Damaeolus ornatissimus Csiszar, 1962		*			
Fosseremus laciniatus (Berlese, 1905)	*	*		*	*
Ceratoppia quadridentata (Haller, 1882)		*			
Austrocarabodes (*Austrocarabodes*) *foliaceisetus* Krivolutsky, 1971	*	*	*	*	*
Tectocepheus minor Berlese, 1903	*	*			*
Tectocepheus velatus (Michael, 1880)	*	*	*	*	*
Striatoppia sp.	*	*			*
Multioppia (*Hammeroppia*) *wilsoni laniseta* Moritz, 1966					*
Anomaloppia ozkani Ayyildiz, 1989		*		*	*
Ramusella (*Ramusella*) *sengbuschi* Hammer, 1968		*			*
Ramusella (*Ramusella*) *puertomonttensis* Hammer, 1962		*	*	*	*
Ramusella (*Rectoppia*) *damavandica* Akrami & Subías, 2008		*		*	*
Discoppia (*Cylindroppia*) *cylindrica* (Perez–Inigo, 1965)	*	*			
Microppia minus minus (Paoli, 1908)	*		*	*	
Rhinoppia (*Rhinoppia*) *subpectinata* (Oudemans, 1900)	*	*			*
Graptoppia (*Graptoppia*) *sundensis acuta* Ayyildiz, 1989	*	*	*	*	
Oppiella (*Oppiella*) *nova nova* (Oudemans, 1902)	*	*		*	*
Lasiobelba (*Lasiobelba*) *decui* (Vasiliu & Ivan, 1995)	*				*
Suctobelbella (*Suctobelbella*) *italica* (Mahunka, 1966)	*				
Suctobelbella (*Suctobelbella*) *acutidens* (Forsslund, 1941)		*			
Berlesezetes aegypticus (Bayoumi, 1977)	*	*		*	*
Scutovertex minutus (C. L. Koch, 1836)	*				
Passalozetes (*Passalozetes*) *africanus* Grandjean, 1932	*	*	*	*	*
Oribatula (*Zygoribatula*) *connexa connexa* Berlese, 1904	*	*	*	*	*
Oribatula (*Zygoribatula*) *connexa ucrainica* (Iordansky, 1990)	*	*	*	*	
Oribatula (*Zygoribatula*) *frisiae* (Oudemans, 1900)	*	*	*	*	*
Oribatula (*Zygoribatula*) *exarata* Berlese, 1916			*		
Oribatula (*Zygoribatula*) *undulata* Berlese, 1916	*	*			
Oribatula (*Oribatula*) *tibialis tibialis* (Nicolet, 1855)	*	*	*		*
Oribatula (*Oribatula*) *tibialis allifera* Subías, 2000	*	*	*		*
Liebstadia similis (Michael, 1888)	*	*			*
Scheloribates (*Scheloribates*) *laevigatus* (C. L. Koch, 1835)	*	*	*	*	*
Scheloribates (*Scheloribates*) *labyrinthicus* Jeleva, 1962	*	*	*	*	*
Indoribates (*Haplozetes*) *iranicus* Mortazavi, Akrami & Hajizadeh, 2011	*	*			
Peloribates sp.		*			*
Protoribates (*Protoribates*) cf. *kargilensis* (Kardar & Mattu, 1999)		*			
Protoribates (*Protoribates*) *paracapucinus* (Mahunka, 1988)	*	*	*	*	*
Ceratozetes conjunctus Mihelčič, 1956	*	*		*	*
Trichoribates (*Trichoribates*) *berlesei* (Jacot, 1929)	*				*
Punctoribates (*Punctoribates*) *angulatus* Bayartogtokh, Grobler & Cobanoglu, 2000	*	*			*
Peloptulus (*Peloptulus*) *denticuspidatus* Bayartogtokh & Aoki, 1999	*	*		*	*

Table 2. Continued.

Species name	Regions				
	A	**K**	**V**	**H**	**H**
Eupelops torulosus (C. L. Koch, 1839)		*			
Eupelops somalicus (Berlese, 1916)		*			*
Oribatella (*Oribatella*) *neonominata* Subías, 2004		*			
Achipteria (*Achipteria*) *coleoptrata* (Linnaeus, 1758)		*			
Achipteria (*Achipteria*) *nitens* (Nicolet, 1855)	*	*			
Parachipteria punctata (Nicolet, 1855)		*			
Tectoribates campestris Behan–Pelletier & Walter, 2013	*				*
Pergalumna (*Pergalumna*) *microtuberculata* Bayartogtokh & Akrami, 2014	*		*		*
Galumna karajica Mahunka & Akrami, 2001	*	*			
Galumna iranensis Mahunka & Akrami, 2001		*			*
Total number of species in each region	**54**	**59**	**21**	**31**	**41**

The number of expected species in 100 (number of) individuals of the studied regions was estimated (with Rarefaction method). Namely: 23.24 species for Ahar, 26.39 species for Kaleibar, 21.03 species for Horand, 19.22 species for Heris and 11.34 species for Varzaghan (Fig. 1).

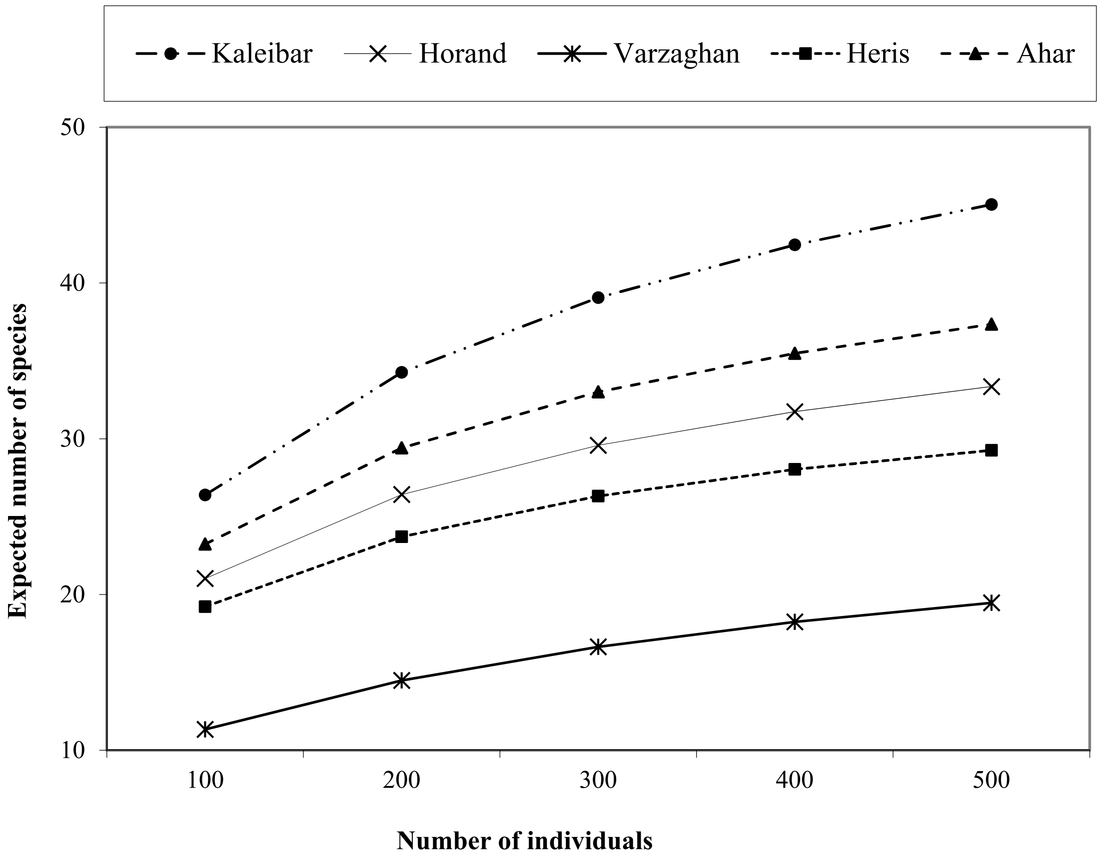

Figure 1. Theoretical species richness diagram of oribatid mites obtained by the rarefaction method (95% confidence levels) in orchards of studied regions in East Azerbaijan province, Iran.

The number of shared species between two regions ranged from a maximum of 41 species (Ahar and Kaleibar) to a minimum of 14 species (Varzaghan and Horand). Only eight species including *Acrotritia ardua* (C.L. Koch, 1841), *Epilohmannia cylindrica cylindrica* (Berlese, 1904), *Austrocarabodes* (*A.*) *foliaceisetus* Krivolutsky, 1971, *Tectocepheus velatus* (Michael, 1880), *Passalozetes* (*Passalozetes*) *africanus* Grandjean, 1932, *Oribatula* (*Zygoribatula*) *connexa connexa* Berlese, 1904, *Oribatula* (*Zygoribatula*) *frisiae* (Oudemans, 1900), *Scheloribates* (*Scheloribates*) *laevigatus* (C. L. Koch, 1835), *Scheloribates* (*Scheloribates*) *labyrinthicus* Jeleva, 1962, and *Protoribates* (*Protoribates*) *paracapucinus* (Mahunka, 1988) were found in all studied regions. Anderson (1977) suggested that abundant species may have high adaptations due to using broad groups of resources.

A total of 11 species were found in only one orchard among the studied regions. These species are *Cosmochthonius* sp., *Haplochthonius simplex* (Willmann, 1930), *Haplochthonius sanctaeluciae* Bernini, 1973, *Epilohmannia gigantean* Berlese, 1916, *Licnodamaeus fissuratus* (Balogh & Mahunka, 1965), *Ceratoppia quadridentata* (Haller, 1882), *Scutovertex minutes* (C. L. Koch, 1836), *Protoribates* (*Protoribates*) cf. *kargilensis* (Kardar & Mattu, 1999), *Eupelops torulosus* (C. L. Koch, 1839), *Achipteria* (*Achipteria*) *coleoptrata* (Linnaeus, 1758), and *Parachipteria punctata* (Nicolet, 1855). These rare species could have specific requirements to the habitats, or their low numbers could be associated with sampling errors. This error might have been caused due to the closeness of some orchards to forests in the area. Anderson (1977) suggested that rare species can be excluded because of competition with abundant generic species, or species may be rare because they engross a rare habitat or they have high special feeding habits. Oribatid mites have limited dispersal abilities (Starý and Block 1998) and existence of rare species in any microhabitat can be a random process (i.e. temporary movement of species between microhabitats) (Murvanidze and Mumladze 2014).

Structure of oribatid mite communities was compared using several parameters (Table 3). Theoretical and real species richness in Kaleibar (S = 79.8, s = 59 spp.) and Ahar (S = 70.7, s = 54 spp.) were significantly higher than other regions. The mean comparison (Tukey's test, 95% confidence levels) showed that Shannon-Wiener species diversity index was significantly higher in Ahar and Kaleibar (Table 3). Varzaghan showed the lowest value for species richness (S = 30.2, s = 21) and species diversity ($1 - \hat{D} = 0.703$, H = 2.154). Diversity in Varzaghan, Heris, and Horand placed in one group. Simpson evenness in Varzaghan was significantly higher (E = 0.568) than other regions. Ahar and Kaleibar showed the lowest values. Shannon evenness index had no significant difference between studied regions.

Table 3. Community structure parameters of oribatid mites during the year 2015 in the orchards of studied regions (95% confidence levels).

Parameter	Ahar	Kaleibar	Varzaghan	Heris	Horand	Significant
Shannon–Wiener diversity index (H)	3.419 [a]	3.409 [a]	2.154 [b]	2.463 [b]	2.622 [b]	*
Shannon evenness index (SEI)	0.707	0.766	0.784	0.640	0.627	n.s.
Theoretical species richness (S)	70.7	79.8	30.2	41.8	57.7	–
Species richness (s)	54	59	21	31	41	–
Expected number of species (in 100 individuals)	23.24	26.39	11.34	19.22	21.03	–

Different letters in each column indicate significantly different values at $p \geq 0.05$.
* Significant at $p < 0.05$, n.s.: Non significant, –: Not calculated.

The changes in species diversity among studied regions (β–diversity), calculated by Soerensen's similarity indexes (Table 4), showed highest similarity between Kaleibar–Ahar, and Kaleibar–Horand orchards. This may be explained by the similar geographical conditions among these regions. The lowest similarity, observed between Kaleibar and Varzaghan, is probably because of different geographical and climatic conditions in two regions. In addition, sampling places in Kaleibar, Horand, and Ahar generally, were very close to forests, but there was no forest in Varzaghan. Ecological, biological and geographical parameters can affect species diversity directly as well as indirectly by changing soil parameters. In addition, climate changes could potentially increase habitat complexities (Maraun and Scheu 2000).

Table 4. Similarity of oribatid mite fauna in the studied regions (Sorensen's index). A= Ahar, K= Kaleibar, V= Varzaghan, He = Heris, and Ho= Horand.

	Sorensen's similarity index				
	A	**K**	**V**	**He**	**Ho**
Ahar	-	0.73	0.51	0.59	0.67
Kaleibar		-	0.40	0.56	0.72
Varzaghan				0.58	0.45
Heris				-	0.64
Horand					-

Shannon-Wiener diversity index ranges from 0 to 5 where zero indicates that the environment is under severe stress and 5 represents a healthy environment. Among studied regions, Shannon-Wiener in Ahar and Kaleibar was higher and Varzaghan showed the lowest value (Table 3). This may be due to the lowest average temperature throughout the sampling year in Varzaghan (Meteorological Organization of East Azerbaijan province, 2018). The correlation between average annual temperature and species richness in the studied regions was highly significant ($R^2 = 0.9935$, $p = 0.0033$). Also, climatic data (Office of Natural Resources in East Azerbaijan province, Iran; received 10.9.2018) indicated that Varzaghan had the lowest temperature among studied regions. Although we did not measure the temperature of soil in the studied regions, soil temperature and microhabitat could be affected by the air temperature. Species richness in Ahar and Kaleibar is higher than other studied regions. This finding can be due to different climatic conditions in studied regions. According to Office of Natural Resources in East Azerbaijan province, Ahar and Kaleibar are Semi-humid and cold; Varzaghan and Heris are Semi-arid and cold, and Horand is Semi-arid and very cold. The mean annual humidity in Varzaghan is lower than Kaleibar. Uvarov (2003) has reported that temperature is an important environmental factor that effects soil biota activity. Temperature has considerable effects on respiration, trophic activity, reproduction and development of soil invertebrates, especially microarthropods (Van Straalen 1994). Climate changes have direct impact on soil microarthropod community abundance and their composition via changing soil microclimate and have indirect effects through changing resource availability and the composition of the soil food web (Kardol *et al*. 2011). Gan (2013) studies showed that temperature contributed significantly to the variation in species composition. High temperature favorably affects respiration, trophic activity, reproduction and development of oribatid mites (Ermilov and Lochynska 2008). Kaleibar and Ahar showed the higher species richness and diversity. The high species richness and Shannon diversity index in a region show its stability (Zargaran *et al*. 2011) and richness is an important factor affecting the Shannon-Wiener index (Mahmoudi 2007). In an ecosystem, diversity and stability should be complementary to each other (Zargaran *et al*. 2011).

Diversity and species richness were high in Kaleibar and Ahar (Table 3), moisture content in these regions (according to climatic data) is higher than other regions. Therefore, it seems that diversity and species richness can be affected by climate. Gan (2013) observed that climatic factors explained considerable amount of variation in the species composition of soil oribatid communities and there is a positive association between oribatid mite community and climatic features. Responses of soil animals depend on microclimatic and climatic conditions. Cool and wet conditions enhance both biomass and diversity of soil mesofauna, while warmer and drier conditions have negative effects on them (Haimi *et al*. 2005). Kardol *et al*. (2011) study showed that microarthropod communities are affected by soil moisture content (precipitation as direct effect and weather warming as indirect effect). Moisture–induced changes soil microarthropod abundance and combination of their community may affect ecosystem decomposers functions. Hutson and Veitch (1983) observed that mean annual population densities of oribatid mites were high in wet regions, and their overall proportion increased from dry to wet regions because the amount of soil organic matter increases in less arid regions. Previous researches show that humidity of microhabitats is an important factor that influences the abundance, distribution, and diversity of oribatid mites (Seyd & Seaward 1984; Siepel 1996; Smrž & Kocourková 1999; Maturna 2000). Moisture changes may have indirect effects on fungivorous fauna and oviposition of oribatid mites with affecting the fungal community (Hågvar 1998).

Generally, many factors have impact on soil microarthropods. For example, pH and altitude (Hashemi-Khabir *et al*. 2014), soil moisture content (Siepel 1996; Hess 2008; Gergócs and Hufnagel 2009; Klimek and Rolbiecki 2009; Hashemi-Khabir *et al*. 2014), elevated CO_2 (Haimi *et al*. 2005; Kardol *et al*. 2011), heavy metal pollution (Gergócs and Hufnagel 2009; Keshavarz-Jamshidian *et al*. 2015), soil organic carbon (Hutson and Veitch 1983) and other factors can change the abundance or composition of the oribatid communities.

ACKNOWLEDGEMENTS

We gratefully thank to Dr. Seyed Yahya Salehi–Lisar (Department of Plant Sciences, University of Tabriz, Iran) for help with sampling, Dr. Tobias Pfingstl (Institute of Zoology, Karl–Franzens–Universitate Graz, Austria) for confirmation of species, and Prof. Roy A. Norton (College of Environmental Science and Forestry, State University of New York, Syracuse, USA) for registering the senior author in his library for access to literature necessary for providing the manuscript. We are grateful to an anonymous reviewer for his/her useful comments which improved the quality of the paper.

REFERENCES

Acharya, S. & Basu, P. (2014) Diversity and richness of soil oribatid mites (Arthropoda, Arachnida, Acarina) in grape orchads, Nashik, Maharashtra. *International Journal of Research Studies in Biosciences*, 2(7): 23–27.

Akrami, M.A. & Saboori, A. (2012) *Acari of Iran, Vol. 2: Oribatid mites*. University of Tehran Press, 281 pp. (In Persian).

Amani, M., Khajeali, J., Noorbakhsh, F., Joharchi, O. & Sabzalian, M.R. (2015) Species diversity of laelapid soil mites (Acari: Laelapidae) under different land use types in Saman and Shahrekord. *Iranian Journal of Applied Ecology*, 4(13): 89–98 (In Persian with English abstract).

Anderson, J.M. (1977) The organization of soil animal communities. *Ecological Bulletin*, 25: 15–23.

Arjmandi Nejad, A.R., Ostovan, H., Ramroodi, S. & Naroui, M.R. (2006) Biodiversity of edaphic mites in Sistan region, Iran. *In*: Bruin, J. (Ed.), *Abstract book of 12th International Congress of Acarology, Amsterdam, The Netherlands*, p. 15.

Bahrami, F., Arbabi, M., Vafaei Shoushtari, R. & Kazemi, Sh. (2011) Mesostigmatic mites associated with Coleoptera and biodiversity calculation of these mites phoretic on Dung beetles in Golestan Province (North of Iran). *Middle-East Journal of Scientific Research*, 9(3): 345–366.

Balogh, J. (1972) *The oribatid genera of the world*. Akadémiai Kiado, Budapest, 188 pp.

Balogh, J. & Balogh, P. (1988) *Oribatid mites of the Neotropical region I*. Akadémiai Kiado, Budapest, 335 pp.

Balogh, J. & Balogh, P. (1990) *Oribatid mites of the Neotropical region II*. Akadémiai Kiadó, Budapest, 333 pp.

Balogh, J. & Balogh, P. (1992a) *The oribatid mites genera of the world*, *Vol. 1*. Hungarian Natural History Museum, Budapest, 263 pp.

Balogh, J. & Balogh, P. (1992b) *The oribatid mites genera of the world*, *Vol. 2*. Hungarian Natural History Museum, Budapest, 375 pp.

Behan–Pelletier, V. M. (1999) Oribatid mite biodiversity in agro-ecosystems: role for bioindication. *Agriculture, Ecosystems & Environment*, 74: 411–423.

Ermilov, S. & Lochynska, M. (2008) The influence of temperature on the development time of three oribatid mite species (Acari, Oribatida). *North-Western Journal of Zoology*, 4(3): 247–281.

Gan, H. (2013) *Oribatid mite communities in soil: structure, function and response to global environmental change*. Ph. D. thesis, University of Michigan, 164 pp.

Gergócs, V. & Hufnagel, L. (2009) Application of oribatid mites as indicators. *Applied Ecology and Environmental Research*, 7(1): 79–98.

Gilyarov, M.S. (1975) *A key to the soil-inhabiting mites. Sarcoptiformes*. Nauka. Moscow, USSR. 740 pp.

Gulvik, M.E. (2007) Mites (Acari) as indicators of soil biodiversity and land use monitoring: a review. *Polish Journal of Ecology*, 55(3): 415–440.

Hågvar, S. (1998) Mites (Acari) developing inside decomposing spruce needles: biology and effect on decomposition rate. *Pedobiologia*, 42: 358–377.

Haimi, J., Laamanen, J., Penttinen, R., Raty, M., Koponen, S., Kellomaki, S. & Niemela, P. (2005) Impacts of elevated CO2 and temperature on the soil fauna of boreal forests. *Applied Soil Ecology*, 30: 104–112.

Hashemi-Khabir, Z., Haddad Irani-Nejad, K., Moghaddam, M. & Khanjani, M. (2015) Community structure of oribatid mites (Acari: Oribatida) in rangelands of West Azerbaijan Province, Iran. *International Journal of Acarology*, 41(4): 344–355.

Hashemi-Khabir, Z., Haddad Irani-Nejad, K., Moghaddam, M., Khanjani, M. & Zargaran, M.R. (2014) Species richness of oribatid mites (Acari: Oribatida) in rangelands of West Azerbaijan Province, Iran. *Persian Journal of Acarology*, 3(4): 293–309.

Heidari, N., Yazdian, H., Zahraii, B. & Jafarzade Haghighi-Fard, N.A. (2012) Biological evaluation of Kashkanrood river based on diversity and population structure of macrobenthos. *First National Conference on Environmental Protection and Planning, Hamedan, Iran*, pp. 1–12 (In Persian).

Hess, C. (2008) *The relationship of oribatid soil mite abundance to abiotic and biotic factors*. M. Sc. thesis, University of Texas at Arlington, USA, 59 pp.

Hutson, B.R. & Veitch, L.G. (1983) Mean annual population density of Collembola and Acari in the
soil and litter of three indigenous South Australian forests. *Australian Journal of Ecology*, 8: 113–126.

Iranpoor, A. & Akrami, M.A. (2016) Oribatid mites (Acari: Oribatida) from the biosphere reserve Dasht-e Arjan and Parishan, and Chehel Cheshmeh region (Fars Province), Iran. *Persian Journal of Acarology*, 5(3): 189–205.

Kardol, P., Reynoldsa, W.N., Norbyb, R.J. & Classena, A.T. (2011) Climate change effects on soil microarthropod abundance and community structure. *Applied Soil Ecology*, 47: 37–44.

Keshavarz-Jamshidian, M., Saboori, A., Akrami, M.A. & van Straalen, N.M. (2015) Oribatid mite communities in contaminated soils nearby a lead and zinc smelting plant in Zanjan, Iran. *Systematic and Applied Acarology*, 20(3): 251–262.

Klimek, A. & Rolbiecki, S. (2009) Oribatid mites (Acari: Oribatida) on plantations of chokeberry and blackcurrant under microirrigation. *Biological Letters*, 46(2): 89–96.

Krantz, G.W. (1978) *A manual of Acarology*. 2nd edition. Oregon State University Book Store, Corvallis, Oregon, 509 pp.

Lascaleia, M.C., Reynolds, C., Magagula, C.N., Roets, F. & Mccleery, R.A. (2018) Dung beetle richness decreases with increasing landscape structural heterogeneity in an African savanna–agricultural mosaic. *Insect Conservation and Diversity*, 11(4): 396–406.

Maturna, J. (2000) Oribatid communities (Acari: Oribatida) inhabiting saxicolous mosses and lichens in the Krkonose Mts. (Czech Republic). *Pedobiologia*, 44: 40– 62.

Magurran, A.E. (2004) *Measuring Biological Diversity*. Blackwell Publishing. Oxford, UK, 256 pp.

Mahmoudi, J. (2007) The study of species diversity in plant ecological groups in Kelarabad protected forest. *Iranian Journal of Biology*, 20(4): 353–362 (In Persian with English abstract).

Maraun, M. & Scheu, S. (2000) The structure of oribatid mite communities (Acari, Oribatida): patterns, mechanisms and implications for future research. *Ecography*, 23(3): 374–383.

Meteorological organization of East Azerbaijan province (2018). Available from: http://eamo.ir/ (accessed on 8.8.2018).

Murvanidze, M. & Mumladze, L. (2014) Oribatid mite (Acari: Oribatida) diversity in different forest stands of Borjom–Kharagauli National Park (Georgia). *Persian Journal of Acarology*, 3(4): 257–276.

N'dri, J. K., Zon, S.D., Tondoh, J. E. & Lagerlöf, J. (2017) Changes in mite richness and diversity along a gradient of land-use intensity from mid-west Ivory Coast. *Tropical Ecology*, 58(3): 497–506.

Norton, R.A. (1990) Acarina: Oribatida. *In*: Dindal, D.L. (Ed.), *Soil Biology Guide*. Wiley, New York, pp. 779–803.

Norton, R.A. & Behan-Pelletier, V.M. (2009) Suborder Oribatida. *In*: Krantz, G.W. & Walter, D.E. (Eds.), *A manual of Acarology*. 3rd edition. Texas Tech University Press, pp. 430–564.

Ostovan, H. & Farzane, D. (2004) Biodiversity of macrochelid mites (Acari: Mesostigmata) in Tehran region. *Abstract book of the 16th Iranian Plant Protection Congress, Tabriz, Iran*, p. 280.

Ramezani, L. & Mossadegh, M. (2014) Biodiversity of oribatid mites in two different microhabitats of Khuzestan province (Southwestern Iran). *Journal of Crop Protection*, 3(4): 443–448.

Schowalter, T. (1996) *Insect ecology*. Oregon University Press, 479 pp.

Seyd, E.L. & Seaward, M.R.D. (1984) The association of oribatid mites with lichens. *Zoological Journal of the Linnaean Society*, 80: 369–420.

Siepel, H. (1996) The importance of unpredictable and short term environmental extremes for biodiversity in oribatid mites. *Biodiversity Letters*, 3(1): 26–34.

Singh, L.A. & Ray, D.C. (2015) Effect of no-tillage and tillage on the ecology of mite, (Acarina, Oribatida) in two different farming systems of paddy field in Cachar district of Assam. *Journal of Environmental Biology*, 36(1): 319–333.

Smrž, S. & Kocourková, J. (1999) Mite communities of two epiphytic lichen species (*Hypogymnia physodes* and *Parmelia sulcata*) in the Czech Republic. *Pedobiologia*, 43: 385–390.

Starý, J. & Block, W. (1998) Distribution and biogeography of oribatid mites (Acari: Oribatida) in Antarctica, the sub-Antarctic islands and nearby land regions. *Journal of Natural History*, 32(6): 861–894.

Subías, L.S. (2004) Listado sistemático, sinonímico y biogeográfico de losácaros oribátidos (Acariformes: Oribatida) del mundo (except fósiles). *Graellsia*, 60 (número extraordinario): 3–305. Online version accessed in February 2016, 593 pp. Available from: http://escalera.bio.ucm.es/usuarios/bba/cont/docs/RO_1.pdf

Uvarov, A.V. (2003) Effects of diurnal temperature fluctuations on population responses of forest floor mites. *Pedobiology*, 47: 331–339.

Van Straalen, N.M. (1994) Adaptive significance of temperature responses in Collembola. *Acta Zoologica Fennica*, 12: 135–142.

Van Straalen, N.M. (2005) The use of invertebrates in ecological surveys of contaminated soils. *In*: Doelman, P. & Eijackers, J.P. (Eds.), *Vital soil: Function, value and properties*. Elsevier, Amsterdam, The Netherlands, pp. 159–130.

Whittaker, R.H. (1972) Evolution and measurement of species diversity. *Taxon*, 21(2/3): 213–251.

Zargaran, M.R., Safaralizadeh, M.H. & Pourmirza, A.A. (2011) A study on the abundance and species diversity of cynipid wasps (Hym.: Cynipidae) in West Azerbaijan province, Iran. *Journal of Entomological Society of Iran*, 31(2): 63–77 (In Persian with English abstract).

تنوع و غنای گونه‌ای کنه‌های اریباتید (Acari: Oribatida) باغ‌های استان آذربایجان شرقی، ایران

مریم رهگذر[۱*]، کریم حداد ایرانی نژاد[۱]، محمدرضا زرگران[۲] و علیرضا صبوری[۳]

۱- گروه گیاه‌پزشکی، دانشکده کشاورزی، دانشگاه تبریز، تبریز، ایران؛ رایانامه‌ها: rahgozar@tabrizu.ac.ir و khaddad@tabrizu.ac.ir
۲- گروه جنگلداری، دانشکده منابع طبیعی، دانشگاه ارومیه، ارومیه، ایران؛ رایانامه: M.Zargaran@urmia.ac.ir
۳- گروه گیاه‌پزشکی، پردیس کشاورزی و منابع طبیعی دانشگاه تهران، کرج؛ ، ایران؛ رایانامه: saboori@ut.ac.ir

* نویسنده مسئول

چکیده

کنه‌های اریباتید یکی از بندپایان غالب خاک‌اند و با تجزیه مواد آلی خاک نقش مهمی در افزایش حاصل‌خیزی خاک دارند. در این پژوهش، جمعیت‌های کنه‌های اریباتید (Acari: Oribatida) در باغ‌های پنج شهرستان (اهر، کلیبر، ورزقان، هریس و هوراند) در استان آذربایجان شرقی بررسی شد. نمونه‌برداری در سال ۱۳۹٤ در طی شش ماه انجام شد و در هر باغ (باغ‌های سیب با اندازهٔ تقریبی ۰/٤ هکتار) ۱۲ نمونه خاک از عمق حداکثر ۲۰ سانتی‌متری جمع‌آوری شد. تنوع کنه‌های اریباتید (شاخص شانون–واینر)، غنای گونه‌ای (روش ریرفکشن و جک نایف)، یکنواختی (شاخص شانون) و شباهت (شاخص سورنسن) با استفاده از نرم افزار Ecological Methodology 6.0 در همهٔ مناطق محاسبه شد. در مجموع ۷۵ گونه، ۵۷ جنس متعلق به ۳۸ خانواده از کنه‌های اریباتید جمع‌آوری و شناسایی شدند. بیشترین تعداد گونه‌ی یافت شده (٥٤ گونه) متعلق به باغ‌های کلیبر بود، در حالی‌که ورزقان کمترین تعداد گونه (۲۱ گونه) را به خود اختصاص داد. آنالیز واریانس یک طرفه نتایج نشان داد که بیشترین تنوع زیستی مربوط به کلیبر (H = ۳/٤۰۹) و اهر (H = ۳/٤۱۹) بود. همچنین کلیبر و اهر به ترتیب با ۷۹/۸ و ۷۰/۷ گونه، بیشترین غنای گونه‌ای را به خود اختصاص دادند. در میان مناطق مورد مطالعه، کلیبر و اهر بیشترین تنوع و غنای گونه‌ای را داشتند، اما ورزقان کمترین میزان را به خود اختصاص داد که می‌تواند به دلیل تفاوت اقلیمی و جغرافیایی بین این مناطق باشد.

واژگان کلیدی: Acariformes؛ اقلیم؛ تنوع؛ ریرفکشن؛ Sarcoptiformes؛ شباهت؛ غنای گونه‌ای.

اطلاعات مقاله: تاریخ دریافت: ۱۳۹۷/۱۱/۱۰، تاریخ پذیرش: ۱۳۹۷/۱۱/۳۰، تاریخ چاپ: ۱۳۹۸/۱/۲٦