

## Article

### **Species richness of oribatid mites (Acari: Oribatida) in rangelands of West Azerbaijan Province, Iran**

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#### **Abstract**

In order to study the species richness of oribatid mites in rangelands of West Azerbaijan Province (Northwestern Iran), soil samples were taken in eight different sites of rangelands including Ghooshchi (1600–1750 and 1750–2000 m a.s.l), Ghasemloo (1300–1450, 1450–1600 and 1600–1750 m a.s.l) Roze-Chai (1450–1600 m a.s.l), Marmisho (1750–2000 m a.s.l) and Ordooshahi (1300–1450 m a.s.l) areas at three different times (mid-May, mid-August and mid-October) of the year 2012. In total, 71 species belonging to 49 genera, 32 families and 20 superfamilies were collected and identified. The oribatid species richness was calculated for all the samples with the Ecological Methodology 6.0 software. One-way ANOVA revealed significant differences ( $P < 0.01$ ) in oribatid species richness among sites ( $P < 0.01$ ). Ghasemloo 2 (44 species) had the highest species and Ordooshahi (14 species), Ghooshchi 1 (19 species) and Roze-Chai (24 species) had the lowest species richness, respectively. Also, there were significant differences ( $P < 0.01$ ) in species richness at different altitudes. In this regard, Ghooshchi 2 and Marmisho (1750–2000 m a.s.l) had the highest species richness among the studied areas.

**Keywords:** Altitude, rarefaction, richness, soil mites, diversity.

#### **Introduction**

Biodiversity is the variety and variability of all the living beings within communities, ecological complexes and their functions (Sandlund *et al.* 1992; Ashouri & Kheradpir 2009). Whittaker (1972) introduced three levels of diversity including alpha, beta and gamma: alpha diversity refers to the diversity within a particular area or ecosystem, and is usually expressed by the number of species; beta diversity is a change (or turnover) of diversity between ecosystems, whereas gamma diversity is a measure of the overall diversity within a large region.

Alpha diversity includes species richness and evenness. McIntosh (1967) was the first to coin the term species richness, but the concept itself is the oldest and most fundamental concept of biological diversity (Peet 1974). It is related to the number of species present in a community or in a specified unit. The true species richness is difficult and frequently impossible to record. However, based on species occurrence and abundance data, it is possible to extrapolate or compare the richness of areas using rarefaction method (Magurran 1996).

Oribatid mites (Acari, Oribatida) that are minute and mainly soil dwelling arthropods, can be found in almost every kind of soil habitats as well as some non-soil microhabitats (e.g. lichen, moss, tree bark, etc.). Apart from the diversity of habitats, their excessive adaptation ability is also shown by density and species richness. In most habitats, they constitute the largest proportion of microarthropods. Oribatid mites mainly consume living or dead parts of plants or fungi, whereas there are also some predators and scavengers (Behan-Pelletier 1999). As a consequence, they consume various kinds of food, and as such, they participate in numerous ways in the structure of the food web (Lebrun & van Straalen 1995).

However, there is a little information concerning the ecology of oribatid mites in Iran. Accordingly, the aim of this study is to make an inventory of oribatid mite species richness and factors influencing the mite richness in rangelands of West Azerbaijan Province.

## Materials & methods

The current investigation was carried out in eight different regions including: Ghooshchi 1, Ghooshchi 2, Ghasemloo 1, Ghasemloo 2, Ghasemloo 3, Roze-Chai, Marmishoo and Ordooshahi in the rangelands of West Azerbaijan Province in northwestern Iran. Table 1 shows the characteristics of each region.

The oribatid mites were studied in each rangelands by collecting 20 samples containing 2–4 trowels of soil taken from a maximum depth of 20 cm at three different times (mid-May, mid-August and mid-October) of the year 2012. Soil samples were transferred to the Acarological Laboratory, Department of Plant Protection, Faculty of Agriculture, University of Tabriz. Mites were extracted using a Berlese funnel and stored in Oudemans's solution, cleared in Nesbitt's fluid and mounted on microscopic slides using Hoyer's medium (Krantz 1978). The slides were kept in an oven at 45–50 °C for 2–3 weeks.

Specimens were identified using valid keys (Balogh 1972; Balogh & Balogh 1988, 1990, 1992a, b; Murvanidze 2008; Akrami & Saboori 2012) and if it was needed, sent to an expert for confirmation. In a few cases, identification of species was not yet possible, in which cases the genus name is used followed by "sp.". Number of species and abundance of each species per sampling unit was used to estimate species richness.

The oribatid species richness (individual based rarefaction) was calculated for all the samples with the Ecological Methodology 6.0 software.

In order to measure soil moisture content the soil samples were weighed and then were dried in an oven at 105 °C for about 24 hours until all the moisture was driven off. After removing from oven, they were cooled slowly at room temperature and weighed again. The moisture content in the soil was calculated using the following formula:

$$\text{Moisture content} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times 100$$

**Table 1.** Characteristics of studied sites.

Sampled sites	Altitude (m a.s.l)	Latitude (N)	Longitude (E)	Climate*	Annual mean precipitation (mm)	mean temperature (°C)
Ordooshahi	1300–1450	37° 27'	45°15'	Semi-arid cold	< 300	10–12.5
Ghasemloo 1	1300–1450	37° 17'	45° 08'	Mediterranean very cold	300–400	< 7.5
Ghasemloo 2	1450–1600	37° 14'	45° 08'	Mediterranean very cold	300–400	< 7.5
Ghasemloo 3	1600–1750	37° 11'	45° 08'	Semi-arid cold	400–500	7.5–10
RozeChai	1450–1600	37° 37'	45° 55'	Semi-arid cold	400–500	7.5–10
Marmisho	1750–2000	37° 32'	45° 45'	Humid very cold	500–600	< 7.5
Ghooshchi 1	1600–1750	37° 59'	45° 56'	Semi-humid very cold	300–400	5–7.5
Ghooshchi 2	1750–2000	37° 01'	45° 56'	Humid very cold	300– 400	5–7.5

\*Based on Emberger climate classification method.

The soil texture was measured using the hydrometer method. This method quantitatively determines the physical proportions of three sizes of primary soil particles as determined by their settling rates in an aqueous solution using a hydrometer. Proportions are represented by stated class sizes: sand ranging from 2000–50 µm; silt ranging from 50–2.0 µm and clay < 2.0 µm. Soil pH of sites were measured by pH meter (Metrohm, Model 691). SPSS 19 (Bayazidi *et al.* 2012) were used for correlation analyses and for calculating differences between regional species richness (one-way ANOVA).

## Results

In total, 71 species belonging to 49 genera, 32 families and 20 superfamilies were found at different sites in the studied areas. The distribution and abundance of oribatid species is provided in Table 2.

The one-way ANOVA revealed significant differences in oribatid species richness among sites ( $F_{7,311} = 19.95$ ,  $P < 0.01$ ). Ghasemloo 2 (44 species) had the highest and Ordooshahi (14 species), Ghooshchi1 (19 species) and Roze-Chai (24 species) had the lowest species richness, respectively (Table 3).

The results of analysis (ANOVA) revealed that species richness was significantly different ( $F_{1,311} = 17.41$ ,  $P < 0.01$ ) at different sampling times. In all sites, the oribatid species richness was high at the first sampling time (mid-May) and the lowest richness was observed at the second sampling time (mid-August). Results revealed that Ghooshchi 2 and Ordooshahi had the maximum and minimum species richness in mid-May, respectively. Ghasemloo1 and Ordooshahi had the maximum and minimum species richness in mid-August, respectively and Ghasemloo 2 and Ordooshahi had the maximum and minimum species richness in mid-October, respectively (Table 3).

\* There were very few of oribatid mites in mid-August, so this time was not considered in statistic analysis.

**Table 2.** Distribution and abundance of oribatid species in the sites.

Family/Species	Marmisho			Roze-Chai			Ghooshchi 1			Ghooshchi 2		
	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.
<b>Sphaerochthoniidae</b>												
<i>Sphaerochthonius splendidus</i>	5	1	0	0	0	0	3	0	0	4	0	0
<b>Cosmochthoniidae</b>												
<i>Cosmochthonius lanatus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Euphthiracaridae</b>												
<i>Rhysotritia ardua</i>	0	0	0	0	0	0	0	0	0	2	0	0
<b>Steganacaridae</b>												
<i>Steganacarus (Tropacarus) carinatus</i>	0	0	0	0	0	2	0	0	0	0	0	0
<i>Atropacarus (A.) striculus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Phthiracidae</b>												
<i>Phthiracarus lentulus</i>	0	0	0	0	0	4	0	0	0	0	0	0
<b>Lohmanniidae</b>												
<i>Papillacarus pseudoaciculatus</i>	8	0	0	0	0	0	0	0	0	0	0	0
<b>Nothridae</b>												
<i>Nothrus borussicus</i>	0	0	0	0	0	0	1	0	0	1	0	0
<i>N. anauniensis</i>	0	0	0	0	0	0	0	0	5	0	0	5
<b>Hermanniellidae</b>												
<i>Hermanniella septentrionalis</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Neoliodidae</b>												
<i>Neoliodes ionicus</i>	0	0	0	0	0	0	0	0	0	1	0	0
<b>Gymnodamaeidae</b>												
<i>Plesiodamaeus ornatus</i>	12	0	4	10	1	0	0	0	0	1	0	19
<b>Aleurodamaeidae</b>												
<i>Aleurodamaeus setosus</i>	16	0	0	1	0	0	0	0	0	0	0	0
<b>Licnodamaeidae</b>												
<i>Licnodamaeus fissuratus</i>	0	0	0	0	0	0	0	0	0	1	0	0
<i>L. pulcherrimus</i>	23	2	5	0	0	0	0	0	0	0	0	0
<b>Damaeidae</b>												
<i>Metabelbella</i> sp.	28	0	11	0	0	0	0	0	0	0	0	0
<i>Belba daghestanica</i>	0	0	0	0	0	0	0	0	2	4	0	7
<b>Compactozetidae</b>												
<i>Eupterotegaeus ornatissimus</i>	0	0	2	0	0	0	0	0	0	0	0	0
<b>Damaeolidae</b>												
<i>Damaeolus ornatissimus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Fosseremus quadripertitus</i>	0	0	0	0	0	0	0	0	0	1	0	7
<b>Eremaeidae</b>												
<i>Eremaeus cordiformis</i>	0	0	4	0	0	0	0	0	0	0	0	0
<b>Liacaridae</b>												
<i>Adoristes (A.) ovatus</i>	0	0	0	0	0	0	1	0	0	0	0	6

**Table 2.** Continued.

Family/Species	Marmisho			Roze-Chai			Ghooshchi 1			Ghooshchi 2		
	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.
<b>Xenillidae</b>												
<i>Xenillus (X.) setosus</i>	0	0	2	0	0	0	0	0	0	0	0	1
<i>X. singularis</i>	0	0	0	0	0	0	0	0	0	1	0	0
<b>Carabodidae</b>												
<i>Carabodes willmanni</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>C. paraspinosus</i>	0	0	0	0	0	1	0	0	0	0	0	0
<i>Austrocarabodes (A.) foliaceisetus georgiensis</i>	20	0	10	0	0	0	2	0	0	1	0	0
<b>Tectocephidae</b>												
<i>Tectocephus velatus</i>	32	0	8	10	1	7	0	0	0	2	2	58
<i>T. minor</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ramusella (Insculptoppia) insculpta</i>	1	0	0	2	0	0	0	0	0	0	0	0
<i>R. (Ramusella) sengbuschi s. str</i>	7	0	12	5	2	0	10	2	18	16	4	0
<i>R. (R.) tokyoensis</i>	2	0	15	0	0	0	0	0	0	4	2	0
<i>Graptoppia (G.) sundensis acuta</i>	0	0	0	0	0	0	0	0	0	5	1	0
<i>Dissorhina ornata</i>	2	0	0	0	0	0	0	0	0	0	0	0
<i>Neoppia sp</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Microzetidae</b>												
<i>Microzetes (M.) baloghi</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Berlesezetes aegypticus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Scutoverticidae</b>												
<i>Scutovertex minutus</i>	0	0	0	0	0	0	0	0	0	2	0	0
<b>Passalozetidae</b>												
<i>Passalozetes africanus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bipassalozetes striatus</i>	0	0	0	0	0	0	0	0	0	1	0	0
<i>B. sabulosus</i>	0	0	0	0	0	0	0	0	0	0	0	1
<b>Oribatulidae</b>												
<i>Oribatula (Zygoribatula) undulata</i>	0	0	0	0	0	0	1	0	0	0	0	0
<i>O. (Z.) debilitranslamellata</i>	1	0	0	0	0	0	0	0	0	0	0	0
<i>O. (Z.) skrjabini</i>	0	0	0	3	0	0	7	0	0	0	0	0
<i>O. (Z.) connexa connexa</i>	21	0	0	0	5	0	20	0	12	18	2	0
<i>O. (Z.) connexa ucrainica</i>	20	0	13	0	0	0	2	0	0	49	5	0
<i>Oribatula (O.) pallida</i>	6	0	0	3	0	0	0	0	0	0	0	0
<i>Oribatula (Z.) exarata</i>	8	0	0	2	1	9	0	0	0	21	0	0
<i>Oribatula (O.) tibialis allifera</i>	14	0	10	0	0	0	1	0	7	2	0	0

**Table 2.** Continued.

Family/Species	Marmisho			Roze-Chai			Ghooshchi 1			Ghooshchi 2		
	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.
<b>Liebstadiidae</b>												
<i>Liebstadia (L.) similis</i>	0	0	3	0	0	3	2	0	5	0	0	0
<b>Protoribatidae</b>												
<i>Protoribates (P.) paracapucinus</i>	12	0	1	2	0	0	11	0	4	0	0	0
<b>Scheloribatidae</b>												
<i>Scheloribates fimbriatus</i>	0	0	0	0	0	0	0	0	0	2	0	0
<i>Grandjeanobates</i> sp.	0	0	0	0	0	0	0	0	0	1	0	0
<b>Phenopelopidae</b>												
<i>Eupelops acromios</i>	0	0	7	0	0	0	0	0	0	0	0	0
<b>Hemileiidae</b>												
<i>Hemileius (Simkinia) ovalis</i>	0	0	0	0	0	0	4	0	0	0	0	0
<i>Hemileius (H.) robustus</i>	0	0	0	0	0	0	0	0	0	3	0	0
<b>Punctoribatidae</b>												
<i>Punctoribates (P.) angulatus</i>	100	1	13	19	0	42	6	0	0	40	0	0
<i>Punctoribates (P.) punctum</i>	10	0	14	12	0	26	9	1	14	2	0	0
<b>Haplozetidae</b>												
<i>Lauritzenia fusifer</i>	16	0	45	4	0	0	0	1	5	81	3	32
<b>Galumnidae</b>												
<i>Galumna iranensis</i>	32	4	9	8	0	4	0	0	0	42	0	0
<i>Galumna karajica</i>	15	3	4	2	0	0	1	0	0	0	0	0
<i>Pergalumna</i> sp.	5	0	2	0	0	0	0	0	0	0	0	0
<b>Oribatellidae</b>												
<i>Tectoribates</i> sp.	1	0	0	0	0	0	0	0	0	0	0	0

**Table 2.** Continued.

Family/Species	Ghasemloo 1			Ghasemloo 2			Ghasemloo 3			Ordooshahi		
	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.
<b>Sphaerochthoniidae</b>												
<i>Sphaerochthonius splendidus</i>	4	0	0	12	0	0	2	0	0	0	0	0
<b>Cosmochthoniidae</b>												
<i>Cosmochthonius lanatus</i>	0	0	0	1	0	0	0	0	0	0	0	0
<b>Euphthiracaridae</b>												
<i>Rhysotritia ardua</i>	3	0	0	0	0	0	0	0	0	0	0	0
<b>Steganacaridae</b>												
<i>Steganacarus (T.) carinatus</i>	0	0	4	0	0	4	0	0	3	0	0	0
<i>Atropacarus (A.) striculus</i>	0	0	0	0	0	3	0	0	0	0	0	0
<b>Phthiracidae</b>												
<i>Phthiracarus lentulus</i>	0	0	0	0	0	2	0	0	4	0	0	0
<b>Lohmanniidae</b>												
<i>Papillacarus pseudoaciculatus</i>	0	0	0	2	0	0	0	0	0	0	0	0

**Table 2.** Continued.

Family/Species	Ghasemloo 1			Ghasemloo 2			Ghasemloo 3			Ordooshahi		
	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.
<b>Nothridae</b>												
<i>Nothrus borussicus</i>	0	0	0	1	0	2	0	0	5	0	0	0
<i>Nothrus anauniensis</i>	1	0	0	0	0	6	0	0	2	0	0	0
<b>Hermanniellidae</b>												
<i>Hermanniella septentrionalis</i>	0	0	0	0	0	1	0	0	1	0	0	0
<b>Neoliodes</b>												
<i>Neoliodes ionicus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Gymnodamaeidae</b>												
<i>Plesiodamaeus ornatus</i>	85	0	19	26	0	0	10	1	4	0	0	0
<b>Aleurodamaeidae</b>												
<i>Aleurodamaeus setosus</i>	0	0	0	14	0	0	5	0	0	0	0	0
<b>Licnodamaeidae</b>												
<i>Licnodamaeus fissuratus</i>	24	0	0	29	0	0	11	0	0	0	0	0
<i>Licnodamaeus pulcherrimus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Damaeidae</b>												
<i>Metabelbella</i> sp.	4	0	9	0	0	20	1	0	6	0	0	0
<i>Belba daghestanica</i>	2	0	0	3	0	0	0	0	3	0	0	0
<b>Compactozetidae</b>												
<i>Eupterotegaeus ornatissimus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Damaeolidae</b>												
<i>Damaeolus ornatissimus</i>	0	0	0	0	0	5	0	0	0	0	0	0
<i>Fosseremus quadripertitus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Eremaeidae</b>												
<i>Eremaeus cordiformis</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Liacaridae</b>												
<i>Adoristes (A.) ovatus</i>	0	0	0	0	0	0	0	0	6	0	0	0
<b>Xenillidae</b>												
<i>Xenillus (X.) setosus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Xenillus singularis</i>	0	0	1	0	0	0	0	0	0	0	0	0
<b>Carabodidae</b>												
<i>Carabodes willmanni</i>	0	0	0	0	0	3	0	0	15	0	0	0
<i>Carabodes paraspinosus</i>	0	0	0	0	0	0	0	0	2	0	0	0
<i>Austrocarabodes (A.) foliaceisetus georgiensis</i>	0	1	0	62	3	0	0	0	0	0	0	0
<b>Tectocephidae</b>												
<i>Tectocephus velatus</i>	0	1	7	5	0	16	5	0	5	15	1	0
<i>T. minor</i>	0	0	0	2	0	0	0	0	0	0	0	0
<b>Oppiidae</b>												
<i>Ramusella (R.) puertomonttensis</i>	0	0	4	1	0	0	1	0	0	0	0	0
<i>Anomaloppia iranica</i>	0	0	0	0	0	0	5	0	0	0	0	0
<i>Rhinoppia subpectinata</i>	0	0	13	0	0	38	0	0	54	0	0	0
<i>R. obsoleta</i>	4	0	0	0	0	51	0	0	25	0	0	0

**Table 2.** Continued.

Family/Species	Ghasemloo 1			Ghasemloo 2			Ghasemloo 3			Ordooshahi		
	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.
<b>Oppiidae</b>												
<i>R. bipectinata</i>	0	0	0	0	0	1	0	0	0	0	0	0
<i>Discoppia</i> ( <i>Cylindroppia</i> ) <i>cylindrica</i>	0	0	0	5	0	0	0	0	0	0	0	0
<i>Microppia minus</i>	3	0	0	7	0	0	0	0	1	0	0	0
<i>Oppiella (O.) nova</i> <i>nova</i>	0	0	2	0	0	7	0	0	14	1	0	3
<i>Ramusella</i> ( <i>Insculptoppia</i> ) <i>insculpta</i>	1	0	0	0	0	0	0	0	0	0	0	0
<i>R. (R.) sengbuschi s.</i> <i>str.</i>	65	1	17	237	0	15	12	0	0	0	0	0
<i>Ramusella (R.)</i> <i>tokyoensis</i>	126	0	10	121	1	17	7	0	19	15	0	0
<i>Graptoppia (G.)</i> <i>sundensis acuta</i>	12	0	0	1	0	0	10	0	0	0	0	0
<i>Dissorhina ornata</i>	0	0	0	3	0	0	0	0	0	0	0	0
<i>Neoppia sp.</i>	1	0	0	0	0	0	0	0	0	0	0	0
<b>Microzetidae</b>												
<i>Microzetes (M.)</i> <i>baloghi</i>	0	0	0	0	0	4	0	0	0	0	0	0
<i>Berlesezetes</i> <i>aegypticus</i>	0	0	0	2	0	0	1	0	0	0	0	0
<b>Scutoverticidae</b>												
<i>Scutovertex minutus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Passalozetidae</b>												
<i>Passalozetes africanus</i>	0	0	0	0	0	0	0	0	0	30	0	0
<i>Bipassalozetes</i> <i>striatus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>B. sabulosus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Oribatulidae</b>												
<i>Oribatula</i> ( <i>Zygoribatula</i> ) <i>undulata</i>	0	0	0	0	0	0	3	0	0	9	0	0
<i>O. (Z.)</i> <i>debilitranslamellata</i>	7	0	3	0	0	0	16	0	0	0	0	0
<i>O. (Z.) skrjabini</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>O. (Z.) connexa</i> <i>connexa</i>	18	7	0	0	1	0	17	2	0	14	2	0
<i>O. (Z.) connexa</i> <i>ucrainica</i>	18	7	0	0	0	0	30	2	3	21	0	0
<i>Oribatula (O.) pallida</i>	3	0	0	0	0	0	3	0	0	0	0	0
<i>Oribatula (Z.) exarata</i>	22	0	0	0	1	6	1	0	0	0	0	6
<i>Oribatula (O.) tibialis</i> <i>allifera</i>	0	0	0	0	0	10	5	0	5	2	0	0
<b>Liebstaadiidae</b>												
<i>Liebstadia (L.) similis</i>	0	0	0	0	0	4	2	2	0	0	0	0
<b>Protoribatidae</b>												
<i>Protoribates (P.)</i> <i>paracapucinus</i>	0	0	8	4	0	0	0	0	0	1	0	0

**Table 2.** Continued.

Family/Species	Ghasemloo1			Ghasemloo 2			Ghasemloo 3			Ordooshahi		
	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.	May	Aug.	Oct.
<b>Scheloriobatidae</b>												
<i>Scheloriobates fimbriatus</i>	1	0	0	0	0	0	0	0	0	0	0	0
<i>Grandjeanobates</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0
<b>Phenopelopidae</b>												
<i>Eupelops acromios</i>	0	0	0	0	0	7	0	0	6	0	0	0
<b>Hemileiidae</b>												
<i>Hemileius (Simkinia) ovalis</i>	0	0	0	7	0	0	18	0	0	0	0	0
<i>H. (H.) robustus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<b>Punctoribatidae</b>												
<i>Punctoribatates (P.) angulatus</i>	185	4	32	423	6	35	118	4	27	1	2	0
<i>P. (P.) punctum</i>	203	0	10	89	0	19	50	0	20	0	0	0
<b>Haplozetidae</b>												
<i>Lauritzenia fusifer</i>	33	2	0	120	0	22	0	0	12	3	0	5
<b>Galumnidae</b>												
<i>Galumna iranensis</i>	2	3	5	3	0	0	26	0	0	7	0	0
<i>G. karajica</i>	0	0	0	3	0	8	2	0	0	2	0	0
<i>Pergalumna</i> sp.	0	0	0	0	0	0	2	0	0	0	0	0
<b>Oribatellidae</b>												
<i>Tectoribatates</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0

Data analysis showed that there were significant differences ( $F_{3,316} = 7.108$ ,  $P < 0.01$ ) of species richness in different altitudes (1300–1450 m a.s.l, 1450–1600 m a.s.l, 1600–1750 m a.s.l and 1750–2000 m a.s.l). Marmisho and Ghooshchi 2 (1750–2000 m a.s.l) had the highest and Ghasemloo1 and Ordooshahi (1300–1450 m a.s.l) had the lowest species richness, respectively.

**Table 3.** Expected and actual species richness of oribatid mites in sampled sites.

Studied sites	Species richness					
	Sampling time					
	Mid-May		Mid-August		Mid-October	
	expected	actual	expected	actual	expected	actual
Ordooshahi	12.46	13	1.8	3	2.98	3
Ghasemloo 1	23.60	24	7.25	8	14.58	15
Ghasemloo2	26.28	26	5.33	5	24.95	25
Ghasemloo3	25.17	26	4.56	5	22.58	23
Roze-Chai	16.49	17	5.26	6	11.66	13
Marmisho	26.12	27	4.40	5	23.97	24
Ghooshchi1	14.8	16	2	3	8.97	9
Ghooshchi 2	29.35	30	6.68	7	12.69	13

Correlation analysis showed a positive relationship ( $r = 0.499$ ,  $P < 0.05$ ) between soil moisture and species richness and a strong negative relationship ( $r = -0.71$ ,  $P < 0.01$ ) between soil pH and species richness of oribatid mites.

**Table 4.** Characteristics of sampled soils.

Studied sites	Soil moisture %			Soil texture			Soil pH
	Sampling time			Si.C (Silty-Clay)			
	mid-May	Mid-August	Mid-October	Clay	Silt	Sand	
Ordooshahi	10.70	3.55	10.04	47	48	5	8.08
Ghasemloo 1				C.L (Clay-Loam)			7.51
	9.39	1.90	7.2	34	37	29	
Ghasemloo2				Si.C (Silty-Clay)			7.62
	17.47	6.14	4.77	15	42	13	
Ghasemloo3				Si.C (Silty-Clay)			7.62
	16.68	2.27	7.2	46	47	3	
Roze-Chai				S.L (Silty-Loam)			7.68
	4.02	0.88	5.66	17	23	60	
Marmisho				C (Clay)			7.50
	17.10	4.14	17.4	44	25	31	
Ghooshchi1				L (Loam)			7.59
	8.40	0.78	4.82	20	29	51	
Ghooshchi 2				Si.C (Silty-Clay)			7.50
	21.01	1.69	9.14	41	46	13	

## Discussion

Our results indicated that there were a significant differences among studied sites. Ghasemloo 2 (44 species) had the highest and Ordooshahi (14 species), Roze-Chai (24 species) and Ghooshchi 1 had the lowest species richness in comparison with other sites. The influence of abiotic site factors such as soil texture, pH, moisture content and climate on soil organisms and their activity has been widely studied. Soil moisture in some ecosystems can be a stronger determinant of microarthropod community composition than either vegetation or soil properties (Nielsen *et al.* 2010).

According to Table 4, it is clear that the humidity of soil in Ghasemloo 2 is different compared with Ordooshahi, Roze-Chai and Ghooshchi 1. It is most likely that the soil moisture content plays an important role in this regard. In the present study, correlation analysis indicated that species richness was significantly correlated with soil moisture.

Previous results indicated that soil moisture had the highest direct effect on the life of oribatid communities; most of the species prefer high soil moisture (Klimek & Rolbiecki 2009). All of the studies support the theory, that oribatid mites generally like habitats with high humidity (Hess 2008; Gergócs & Hufnagel 2009; Skubala & Marzec 2013) and they are susceptible to drought (Gergócs & Hufnagel 2009). Humidity of microhabitats is fundamental factor influencing the diversity, abundance and distribution of oribatid mites (Seyd & Seaward 1984; Siepel 1996; Smrž & Kocourková 1999; Matorna 2000) whereas the drought limits their distribution (Siepel 1996). Moisture changes may also affect the fungal community and thereby, have indirect effects on the fungivorous fauna and the oviposition of oribatid mites (Hågvar 1998).

It's noticeable that despite of the relatively high humidity in Marmisho and Ghooshchi 2 (Table 4), high richness was observed in Gasemloo 2 with almost similar

humidity. The difference of plant species density has presumably caused this. The cover vegetation in Marmisho and Ghooshchi 2 was sparser. Puskás *et al.* (2008) found that sparse vegetation cover provides unfavorable conditions for oribatid mites.

The soil texture in Roze-Chai and Ghooshchi1 may be responsible of low moisture content in the soil and so the low species richness of oribatid mites. The soil texture in these two sites is sandy-loam and loamy, respectively. Sandy loam and loamy are types of soils that are dominated by sand particles (Table 4). Sand particles are often larger and more solid than other types of particles found in soil, and for this reason, there is normally more space for water to move freely through it. This kind of soils have little capacity for retaining water that is why they are usually drier than clayey soils.

According to the results, there was strong negative relationship between species richness and soil pH. Soil pH is generally regarded as one of the major important environmental factors for soil fauna. There is information about the pH preferences of some soil mites species in the laboratory (Van Straalen & Verhoef 1997; Liiri *et al.* 2002), but it has been suggested that the response of a species to soil pH can be varied with changing environmental factors (Liiri *et al.* 2002). Many species are intolerant to acidic environments but oribatids reach the highest densities in raw humus soils with low pH (Hågvar & Abrahamsen 1980; Koskenniemi & Huhta 1986; Didden 1993).

The soil acidity in Ordooshahi had tendency toward high pH which is not favorable for mites. Therefore, it can be one of the important factors that lead to lowest richness there.

According to rarefaction curves in all sites, it is clear that the oribatid species richness was high at the first sampling time (mid-May) and the lowest richness was observed in the second sampling time (mid-August). In mid-August, because of the high temperature, the richness of oribatid mites was low and it seems that the high temperature had a negative effect on the oribatid community. Like moisture, temperature is a factor responsible for decreasing richness. Warming and changes in precipitation amounts, for example, can directly alter soil temperature and moisture, factors that strongly influence the microarthropod reproduction and development rates (e.g. Van Straalen 1994; Uvarov 2003). In fact, soil microarthropods are extremely responsive to changes in soil moisture, a pattern seen in numerous studies across diverse ecosystems (e.g. Frampton *et al.* 2000; Pflug & Wolters 2001; Lindberg *et al.* 2002; Tsiafouli *et al.* 2005; Moron-Rios *et al.* 2010). Unlike soil moisture, warming impacts on microarthropods have been context dependent and abundance responses varied across experiments (e.g. Coulson *et al.* 1996; Huhta & Hänninen 2001; Hågvar & Klanderud 2009). Sjørusen *et al.* (2005) suggested that warming may indirectly alter soil microarthropod communities by causing a shift in the abundance and composition of soil organisms upon which they prey. Hodkinson *et al.* (1996) showed the extent of tolerance depends on the moisture of the soil, while it was found that warming had no strong deteriorating effect on oribatids. If fluctuations in the temperature cause significant changes in oribatid communities, it must be suspected that this change had not been caused directly by temperature, but indirectly, via another factor (e.g. plant physiology (Kardol *et al.* 2011), the quantity of food, moisture, predators or a competitor group) which, in turn, had been affected by temperature (Gergócs & Hufnagel 2009).

Seasonal temperature variations commonly induce vertical movements of soil animals in the soil profile (Luxton 1981; Didden 1993). The developmental rate of

collembolans, mesostigmatic and oribatid mites are often temperature-dependent (Bhattacharya *et al.* 1978; Hopkin 1997; Walter & Proctor 1999).

According to the results of Stamou & Sgardelis (1989), it can be concluded that the community of oribatid mites is largely influenced by temperature, although several later studies showed that temperature does not influence on community composition (Haimi *et al.* 2005). Ermilov & Lochynska (2008) believe that high temperature favorably affects respiration, trophic activity, reproduction and development of oribatid mites.

Results indicated that there were significant differences ( $P < 0.01$ ) in species richness at different altitudes. In this regard, Ghooshchi 2 and Marmisho (1750–2000 m a.s.l) had the highest species richness among the studied areas. It may be because of the high soil moisture in Ghooshchi 2 and Marmisho (1750–2000 m a.s.l) compared with other areas. Altitude is one of the main factors affecting (indirectly) the abundance and community structure of animals and plants (Körner 2007). Altitude gradients affect animal communities in various ways, species richness often increases up to certain elevation and decrease at higher altitudes (e.g. Rahbek 1995; Colwell & Lees 2000; Lomolino 2001). Comparison of elevations above sea level attracted great attention and primarily the abundance and species richness of oribatids have been studied in zones of different altitudes. However, obtained data are not concordant, since according to Migliorini & Bernini (1999) and Fagan *et al.* (2006), the abundance of oribatids decreased with altitude, but Jing *et al.* (2005) and Reynolds *et al.* (2003) observed an opposing tendency. Fagan *et al.* (2006) pointed out a decrease in species richness while Migliorini & Bernini (1999) observed a growth in diversity as a function of increasing altitude. Changing species composition along an altitudinal gradient reflects changing abiotic environmental conditions, such as air pressure, temperature, moisture (Körner 2007) and also biotic factors, like predation as well as resources supply. A combination of increasing biotic harshness with decreasing availability of food resources as the driving factors for changing species composition along gradients (Fischer *et al.* 2014).

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## غنای گونه‌های کنه‌های اربیاتید (*Acari: Oribatida*) در مراتع استان آذربایجان غربی، ایران

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### چکیده

به منظور بررسی غنای گونه‌های کنه‌های اربیاتید در مراتع استان آذربایجان غربی نمونه‌برداری از ۸ منطقه شامل قاسملو (ارتفاع ۱۴۵۰-۱۳۰۰، ۱۶۰۰-۱۴۵۰ و ۱۷۵۰-۱۶۰۰ متر از سطح دریا)، قوشچی (ارتفاع ۱۷۵۰-۱۶۰۰ و ۲۰۰۰-۱۷۵۰ متر از سطح دریا)، روضه‌چای (ارتفاع ۱۶۰۰-۱۴۵۰ متر از سطح دریا)، مارمیشو (ارتفاع ۲۰۰۰-۱۷۵۰ متر از سطح دریا) و اردوشاهی (ارتفاع ۱۴۵۰-۱۳۰۰ متر از سطح دریا) در سه نوبت (اواخر اردیبهشت، اواخر تیر و اواخر شهریور) در سال ۱۳۹۱ انجام شد. در مجموع، ۷۱ گونه از ۴۹ جنس متعلق به ۳۲ خانواده و ۲۰ بالاخانواده جمع‌آوری و شناسایی شدند. غنای گونه‌های کنه‌های اربیاتید با استفاده از نرم‌افزار Ecological Methodology محاسبه شد. نتایج تجزیه آماری یک‌طرفه نشان داد که تفاوت معنی‌داری ( $P < 0.01$ ) بین غنای گونه‌های مناطق مختلف وجود دارد. قاسملو ۲ (۴۴ گونه) بیشترین و اردوشاهی (۱۹ گونه)، قوشچی ۱ (۱۹ گونه) و روضه‌چای (۲۴ گونه) کمترین غنای گونه‌ای را در بین مناطق داشتند. همچنین غنای گونه‌های تفاوت معنی‌داری ( $P < 0.01$ ) در ارتفاعات مختلف داشت. مناطق قوشچی ۲ و مارمیشو (ارتفاع ۲۰۰۰-۱۷۵۰ متر از سطح دریا) بیشترین غنای گونه‌ای را در بین مناطق نشان دادند.

واژگان کلیدی: ارتفاع، ریرفکشن، غنا، کنه‌های خاکزی، تنوع.

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