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Biodiversity and Ecology of Soil Oribatid Mites (Acari: Oribatida) in the Grassland Habitats of Eastern Mongolia

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Abstract

Composition, abundance, distribution, and diversity of oribatid mite communities were investigated at five study areas in Eastern Mongolia. A total of 88 species of oribatid mites were recorded from the studied areas. The largest number of species (51 spp.) was found in the habitats of river valleys, while the plain steppe which covers the largest area contained the lowest species richness (24 spp.). Three other sub-regions with similar landscape types show approximately the same species richness (39 to 45 spp.), although they are located relatively far from each other. The oribatid mite faunas of all sub-regions were essentially similar to each other.

The abundances of oribatid mites were higher in mountain-steppes (5240 to 9800 ind./ m^2), and lower in the plain steppe and river basins (3520 to 3535 ind./ m^2). Oribatid mite communities were characterized by species with relatively similar abundances. The results of species diversity and evenness indices indicate species-rich assemblages with low dominance.

Keywords Biodiversity, species richness, oribatid mites, grassland, Eastern Mongolia.

Introduction

The Eastern Mongolia ecosystem encompasses the forest–steppe landscape situated at the south-eastern end of the Siberian taiga forest, plus the tall and short grass steppe of the south-western part of the Manchurian steppe, and the small mountains and hills which are situated in the western edge of the Great Hinggan Mountains. The region includes various habitats such as wetlands along the basin of rivers and lakes, bogs, moors, hummocks and hills etc. in addition to the large area of grassland (Obruchev, 1947; Dashnyam, 1974).

Although types of ecosystems similar to the Eastern Mongolian steppe can be found in Eastern Europe, North America, Northern Africa, Middle Asia and Australia, these are greatly affected by human activities and have mostly changed their ecological conditions. Eastern Mongolia is largely covered by extended steppe landscapes with short and tall grasses. Several protected areas such as 'Khalkh Numrug', 'Mongol Daguur' and 'Eastern Mongolia' national parks, 'Ugtam', or 'Lkhachinvandad', 'Yakhi Nuur' and 'Ganga Nuur' nature reserves have been established in this landscape covering about 1,340,943 hectare in order to protect the characteristic wildlife and landscape features of the region (Enebish & Myagmarsuren, 2000).

Many endangered or rare animal species registered in the International Red Data Book or in the Mongolian Red Data Book such as elk, otter, black-tailed gazelle, sea-gull etc. inhabit the Eastern Mongolian steppe. Moreover, the Eastern Mongolian steppe is one of the main habitats for various species of birds and mammals included in the CITES and Ramsar conventions. However, during the last decades human influence has increased in this region due to active development of agriculture and industry (Batjargal et al., 2001).

Up to date, there is no thorough research on biodiversity and ecology of the soil dwelling organisms in the Eastern Mongolian steppe, especially the soil arthropods. Most of the previous research works on insects and other arthropods was conducted mainly in the central, northern and western regions of the country, but the eastern part of the country remained poorly studied, probably due to its remote location and difficult accessibility.

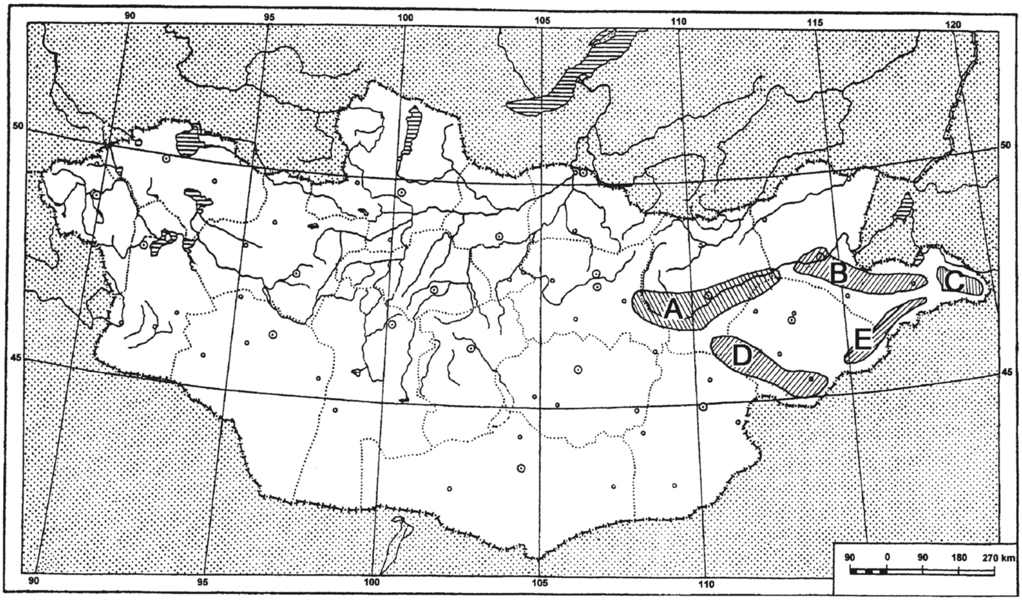

Figure 1: Study areas in Eastern Mongolia. A: Yazaar area in District Bayanmunkh, Province Khentiy, B. Menengiin Tal area in District Matad, Province Dornod, C: Numrug and Degee Gol area in District Khalkh Gol, Province Dornod, D: Shiliin Bogd area in District Dariganga, Province Sukhbaatar, E: Lkhachinvandad area in District Erdenetsagaan, Province Sukhbaatar.

However, for a better understanding of the ecological processes occurring within the protected areas of Eastern Mongolia it is important to examine the biodiversity and ecology of the various soil organisms living there.

The study of oribatid mite biodiversity in grassland habitats of Eastern Mongolia is part of ongoing research on biodiversity assessments in various habitats in this region. The present paper deals with data on composition, diversity, and distribution patterns of oribatid mite communities in the different sub-regions of Eastern Mongolia.

Study area

The study areas were selected according to two main criteria: geographical location and vegetation characteristics, thus representing the principal habitat types in the research region. Sample sites were grouped into five sub-regions according to the geographical location and the habitat types, and are identified by the short location names such as 'Numrug', 'Lkhachinvandad', 'Menengiin Tal', etc.

The region named 'Numrug' covers the wetland habitats along the basin of rivers Numrug and Degee, and small mountains and hills along the river basins; 'Lkachinvandad' includes the areas of mountain-steppe around Mt. Lkhachinvandad; 'Menegiin Tal' represents the large area of plain grassland habitats in Eastern Mongolia; 'Shiliin Bogd' includes the short-grass steppe habitats with small hills around this mountain, and 'Yazaar' covers mountain-steppe habitats with sparse broadleaved stands in the region around this mountain (figure 1). Each sub-region includes typical associations of habitats, which are similar to one another not only with respect to the geographical location, but also with regard to the habitat types (figure 2).

Figure 2: Different landscapes of study areas. A: Grassland habitat in Menengiin Tal area, B: Mountain steppe in Yazaar area, C and D: Dry mountain steppes in Lkhachinvandad and Shiliin Bogd areas, E: River valley in Numrug area.

Methods

A total of 114 soil samples were collected from 68 locations covering all the main habitats in this area. Soil cores were taken using a cubic sampler of $100\,\mathrm{cm}^2$ in surface area and 10 cm in depth.

Sampling was performed in May and June of 2003. Soil samples were brought to the laboratory for extraction of animals using Tulgren funnels, and extracted more than 12,000 specimens of soil microarthropods.

The following indices were used for data analysis as applied and summarized by Magurran (1988), Krebs (1989), and Southwood (1996).

In each sub-region, the species richness (S) of oribatid mites was assessed by counting the number of species present. Also, the total theoretical oribatid species richness for each sub-region was calculated using the jacknife estimator (S). The jacknife uses the number of species actually observed plus the number of species unique to any sample, weighted by the number of samples to estimate a overall species richness:

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

where s is the observed total number of species present in n quadrants, n – total number of quadrants sampled, k – number of unique species.

Species diversity was calculated using the Shannon-Wiener index (H').

$$H' = \sum_{n=1}^{i} \frac{N_i}{N} \cdot \log_2 \left(\frac{N_i}{N}\right) \tag{2}$$

where N_i is the number of individuals belonging to the ith species, N – total number of individuals, S – number of species.

Evenness of oribatid communities was expressed by Pielou's index (J'):

$$J' = \frac{H'}{H'_{max}} = \frac{H'}{\log_2 S} \tag{3}$$

The Soerensen's index of similarity (Ss) was used to compare oribatid mite communities between studied sub-regions:

$$S_S = \frac{2a}{2a+b+c} \tag{4}$$

where a is the number of species shared among compared sub-regions, b – number of species in the first sub-region, c – number of species in the second sub-region.

Figures of oribatid density refer to the mean number of individuals per square meter of soils. The community structure of oribatid mites was analyzed using abundances of adult oribatids.

Results & Discussion

A total of 88 species of oribatid mites representing 56 genera and 33 families were recorded from the studied sub-regions of Eastern Mongolia (table 1). Several taxa were identified down to genus level, and some species from the study region have been described as new to science (Bayartogtokh, 2004a, b). It is obvious that each sub-region has a different species composition and richness. For instance, the basins of Rivers Numrug and Degee show a higher species richness (51 spp.) than all other sub-regions. On the other hand, Menengiin Tal steppe contained the lowest species richness (24 spp.), although it is the largest among the areas studied. The three other sub-regions, i.e. Mts. Lkhachinvandad, Shiliin Bogd and Yazaar have approximately the same number of species, although they are located relatively far from one another (45, 39, and 39 species, respectively).

The total theoretical richness of the studied sub-regions was estimated at 64.9 species for the basins of Numrug and Degee rivers, 51.2 species for Lkhachinvandad, 44.0 species for the Shiliin Bogd, 44.3 species for Yazaar, and 25.7 species for the Menengiin Tal steppe area (figure 3).

The number of species shared among two sites ranges from a maximum of 26 species (Lkhachinvandad and Shiliin Bogd), to a minimum of 14 species (Numrug and Menengiin Tal). Only the following eight species, namely: *Tectocepheus velatus, Hypovertex laticuspis, Peloribates angulatus, Zygoribatula frisiae, Scheloribates latipes, Ceratozetes heterocuspis, Eupelops acromios* and *Eupelops mongolicus* were found in all study sites. Another nine species inhabited four out of five sub-regions, while 33 species were confined to a single region only.

Table 1: Species composition and occurrence of oribatid mites in various sub-regions of Eastern Mongolia. Sub-regions: N = Numrug, MT = Menengiin Tal, L = Lkhachinvandad, SB = Shiliin Bogd, Y = Yazaar.

	Sub-regions				
Name of species	**N**	**MT**	**L**	**SB**	**Y**
Hypochthonius rufulus (C. L. Koch, 1836)	+		+		
Brachychthonius sp.			+	+	
Eniochthonius minutissimus (Berlese, 1904)		+	+		
Phthiracarus sp.	+				
Rhysotritia cf. *ardua* (C. L. Koch, 1841)			+	+	
Epilohmannia cylindrical (Berlese, 1904)	+				
Nothrus borussicus (Sellnick, 1929)	+				
Camisia biverrucata (C. L. Koch, 1839)				+	
C. horrida (Hermann, 1804)		+	+	+	+
C. segnis (Hermann, 1804)		+			
Heminothrus targioni (Berlese, 1855)	+				
Trhypochthonius tectorum (Berlese, 1896)			+	+	
Trimalaconothrus glaber (Michael, 1888)	+				
Arthrodamaeus sp.	+		+		
Nortonella mongolica (Bayartogtokh & Aoki, 1997)				+	
Pedrocortesella inaequalis (Balogh & Mahunka, 1965)	+			+	+
Belba heterosetosa (Bayartogtokh, 2004)			+	+	
B. mongolica (Bayartogtokh, 2000)	+				
B. crassisetosa (Bayartogtokh, 2000)	+				
Belbodamaeus rarituberculatus (Bayartogtokh, 2004)	+		+		+
Epidamaeus angustirostratus (Bayartogtokh, 2001)	+		+	+	+
E. aokii (Bayartogtokh, 2001)				+	
E. granulatus (Bayartogtokh, 2000)		+	+		+
E. mongolicus (Bayartogtokh, 2000)	+				
E. nortoni (Bayartogtokh, 2004)				+	+
E. microtuberculatus (Bayartogtokh, 2004)			+		
E. weigmanni (Bayartogtokh, 2004)	+				
Eueremaeus crassisetosus (Bayartogtokh, 2003)			+		
E. granulatus (Mihelcic, 1955)					+
Proteremaeus punctulatus (Bayartogtokh, 2000)	+		+	+	+
Birsteinius mongolicus (Mahunka, 1964)				+	
Procorynetes tsendsureni (Bayartogtokh, 1998)				+	
Astegistes pilosus (C. L. Koch, 1840)	+				
Cultroribula dentata (Willmann, 1950)					+
Tectocepheus alatus (Berlese, 1913)	+				
T. velatus (Michael, 1880)	+	+	+	+	+
Oppiella nova (Oudemans, 1902)	+		+	+	

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Table 1 continued ...	**Sub-regions**				
Name of species	**N**	**MT**	**L**	**SB**	**Y**
Oppiella sp.	+		+	+	+
Suctobelba sp.1			+	+	
Suctobelba sp.2			+		
Banksinoma sp.		+			
Bipassalozetes gobiensis (Mahunka, 1964)	+		+		+
B. mahunkai (Bayartogtokh & Aoki, 1997)		+	+		
B. mongolicus (Bayartogtokh & Aoki, 1997)		+		+	+
Hypovertex laticuspis (Balogh & Mahunka, 1965)	+	+	+	+	+
H. stenolamellatus (Golosova, 1984)			+		
Scutovertex grandulosus (Balogh & Mahunka, 1965)	+	+	+		
Hapolzetes ulykpani (Bayartogtokh & Aoki, 1998)		+	+	+	+
H. vindobonensis (Willmann, 1935)	+	+			+
Peloribates angulatus (Bayartogtokh, 2000)	+	+	+	+	+
Peloribates sp.				+	
Eporibatula prominens (Bayartogtokh & Aoki, 1998)	+		+	+	+
Oribatula elegantissima (Balogh & Mahunka, 1965)	+				
Oribatula sp.					+
Zygoribatula bulanovae (Kulijev, 1961)	+	+	+	+	
Z. frisiae (Oudemans, 1900)	+	+	+	+	+
Zygoribatula sp.			+		
Liebstadia similis (Michael, 1888)	+		+	+	+
Scheloribates corpusculum (Bayartogtokh, 2000)					+
S. laevigatus (C. L. Koch, 1836)	+				+
S. latipes (C. L. Koch, 1844)	+	+	+	+	+
S. pallidulus (C. L. Koch, 1840)	+		+		
Ghilarovus sp.	+		+	+	
Ceratozetoides aokii (Bayartogtokh, 1999)	+				
C. heterocuspis (Balogh & Mahunka, 1965)	+	+	+	+	+
Diapterobates oblongus (C. L. Koch, 1879)					+
Fuscozetes tatricus (Seniczak, 1993)	+				
Trichoribates punctatus (Shaldybina, 1971)	+		+	+	
T. trimaculatus (C. L. Koch, 1836)		+	+	+	+
Minguezetes hexagonus (Berlese, 1908)	+				+
Punctoribates brevicuspidatus (Bayar. & Aoki, 1998)	+		+		
P. punctum (C. L. Koch, 1839)	+	+		+	+
Zachvatkinibates latilamellatus (Bayar. & Aoki, 1998)			+	+	+
Oribatella shaldybinae (Rjabinin, 1974)	+				+
Oribatella sp.	+		+		
Eupelops acromios (Hermann, 1804)	+	+	+	+	+
E. mongolicus (Bayartogtokh, 2000)	+	+	+	+	+
Eupelops torulosus (C. L. Koch, 1836)			+		
Peloptulus latilamellatus (Bayartogtokh & Aoki, 1997			+		+
Propelops canadensis (Hammer, 1952)		+			+
Anachipteria deficiens (Grandjean, 1932	+			+	
Tectoribates deserticola (Balogh & Mahunka, 1965)			+		
T. mongolicus (Bayartogtokh, 1997)	+	+			+

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Table 1 continued ...	**Sub-regions**				
Name of species	**N**	**MT**	**L**	**SB**	**Y**
Lepidozetes conjunctus (Schweizer, 1922)	+			+	+
L. dashidorzsi (Balogh & Mahunka, 1965)					+
Acrogalumna sp.	+				
Angulagolumna asiatica (Grishina, 1981)	+				
Galumna rossica (Sellnick, 1926)	+	+		+	+
Total number of species in each sub-region	51	24	45	39	39

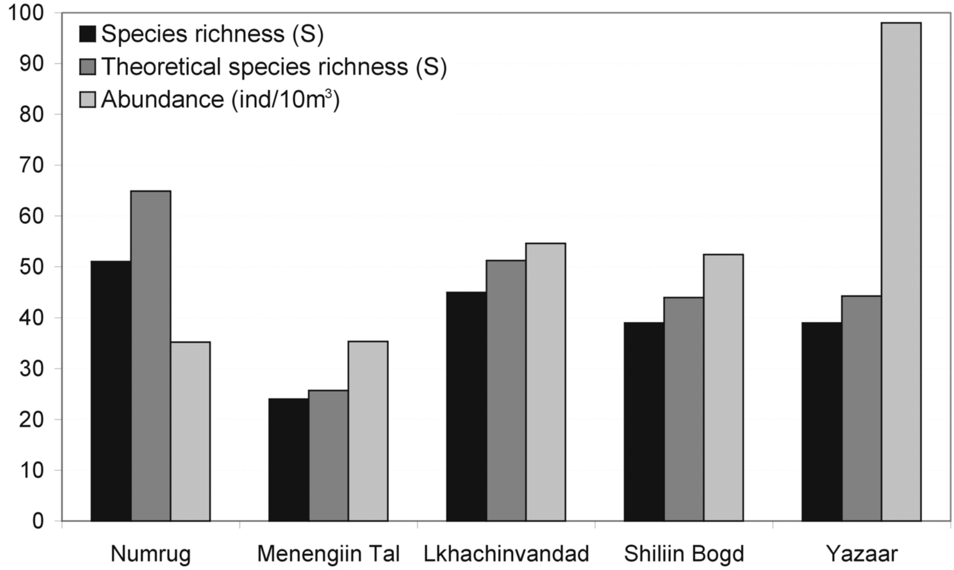

Figure 3: Actual and theoretical species richness and population density of oribatid mites in Eastern Mongolia.

14 species are rather rare or restricted to one habitat within this geographical region; these are: *Phthiracarus* sp., *Epilohmannia cylindrica, Heminothrus targioni, Trimalaconothrus glaber, Belba mongolica, Belba crassisetosa, Epidamaeus mongolicus, Eueremaeus crassisetosus, Procorynetes tsendsureni, Cultroribula dentata, Tectocepheus alatus, Hypovertex stennolamellatus, Peloribates* sp., and *Angulogalumna asiatica.* Most of these are found in only one or two habitat types.

Some oribatid species are characteristic for the wetlands and bogs along the basin of rivers, and have not been found elsewhere, namely: *Nothrus borussicus, Heminothrus targioni, Epilohmannia cylindrica, Trimalaconothrus glaber, Belba mongolica, B. crassisetosa, Epidamaeus mongolicus, Phthiracatus* sp., *Fuscozetes novus, Acrogalumna* sp., and *Angulogalumna asiatica.*

Only two species of oribatids were found exclusively in the plain grassland habitats: *Camisia segnis* and *Banksinoma* sp., although it is known that the first species is also found in the forested habitats of Central Mongolia. The following species *Trhypochthonius tectorum, Brachychthonius* sp., *Camisia biverrucata, Rhysotritia ardua, Belba heterosetosa, Epidamaeus aokii, E. microtuberculatus, E. nortoni, Eueremaeus crassisetosus, Birsteinius mongolicus, Procorynetes tsendsureni, Suctobelba* sp.1, *Suctobelba* sp.2, *Hypovertex stenolamellatus, Peloribates* sp., *Zy-*

Table 2: Community structure parameters of oribatid mites in the studied sub-regions. Sub-regions. N = Numrug, MT = Menengiin Tal, L = Lkhachinvandad, SB = Shiliin Bogd, Y = Yazaar.

Parameter	**N**	**MT**	**L**	**SB**	**Y**
Species richness (S)	51	24	45	39	39
Theoretical species richness (S)	64.9	25.7	51.2	44.0	44.3
Species diversity (H')	4.42	3.32	2.92	3.85	3.89
Evenness (J')	0.83	0.72	0.57	0.76	0.75
Abundance (ind./m2)	3520	3535	5460	5240	9800

goribatula sp., *Eupelops torulosus* and *Tectoribates deserticola* are characteristic of the habitats of short grass mountain-steppe, although some of these have been previously recorded in more humid habitats of Mongolia and other areas of the Palaearctic region (Balogh & Mahunka, 1965; Seyd et al., 1996; Bayartogtokh, 1998, 2001).

In the present study the oribatid species *Eueremaeus granulatus, Cultroribula dentata, Oribatula* sp., *Scheloribates corpusculum, Diapterobates oblongus* and *Lepidozetes dashidorzsi* are found exclusively in the litter and soil of broad-leaved stands composed by birch trees.

Structure of oribatid mite communities was compared using five different parameters (table 2). The species richness in the Numrug (51 spp.) and Lkhachinvandad (45 spp.) areas is significantly higher than in the other areas. In contrast, species diversity is the lowest of all studied sub-regions ($H' = 2.92$) in Lkhachinvandad, while Numrug shows the highest value for species diversity ($H' = 4.42$). The two mountain steppe areas (Shiliin Bogd and Yazaar) have nearly the same diversity of oribatid mites, while the grassland habitats of Menengiin Tal area show a relatively low species diversity. The highest diversity value of H' in the Numrug sub-region is a consequence of the overall low dominance of species as well as of the greater evenness in the distribution of species' abundances ($J' = 0.83$). Three other sub-regions, Shiliin Bogd, Yazaar, and Menengiin Tal show also relatively high values of evenness, ranging between 0.72 and 0.76.

The combination of species diversity and evenness indices suggest species-rich assemblages low in dominance, with the exception of the Lkhachinvandad area. The low species diversity and evenness in the latter area might reflect the extremely high dominance of only a few species such as *Scheloribates latipes* and *Tectocepheus velatus*, which accounted for the majority (more than 67 % of total individuals) of oribatids in the community. Generally, the number of individuals and their dominance fluctuates considerably until a stable community has developed (Webb, 1994).

The changes in species diversity between the studied sub-regions (β-diversity) were calculated by means of Soerensen's similarity index (table 3). This comparison of the oribatid mite fauna of the different landscape types suggests that the species composition of oribatids at all sub-regions is essentially similar. The highest similarity is observed between the areas of Lkhachinvandad and Shiliin Bogd. This indicates that the oribatid mite faunas of those regions share the highest number of common species. This may be explained by the close distance between those sub-regions or by the relatively similar (mountainous) landscape types, vegetation cover, and soil types. The lowest similarity is observed between the sub-regions Numrug and Menengiin Tal (SS = 0.27). This result is self-explanatory, as the two areas feature very different landscapes, vegetation, and soil types.

As to the population density of oribatid mites, the mean abundance in the Lkhachinvandad area shows much higher values (9800 ind./ m^2) than in all other sub-regions. Two other areas, Shiliin Bogd and Yazaar show similar consistently low population densities of oribatids with 5240 and 5460 ind./ m^2, respectively. Mean oribatid densities were significantly lower in Numrug and

Table 3: Similarities of oribatid mite fauna in the studied sub-regions (Sorensen index). Sub-regions: N = Numrug, MT = Menengiin Tal, L = Lkhachinvandad, SB = Shiliin Bogd, Y = Yazaar.

	N	MT	L	SB	Y
Numrug	1.0	0.27	0.33	0.33	0.34
Menengiin Tal		1.0	0.32	0.32	0.36
Lkhachinvandad			1.0	0.38	0.33
Shiliin Bogd				1.0	0.37
Yazaar					1.0

Menengiin Tal areas (3520 and 3535 ind./ m^2, respectively) than in the previously mentioned areas. The causes of these differences might be the different contents of moisture, organic matter, soil structure, and vegetation composition in each studied area. Comparative data on actual and theoretical species richness, and mean abundances of oribatid mites in the five sub-regions are shown in figure 3.

Oribatid mite assemblages vary between the five sub-regions. The number of dominant species, defined as species which exceed 5 % of the total population density in at least one site, was 17 throughout all the sub-regions (table 4). However, there is no species dominant in all the sub-regions. Three ubiquitous species, *Tectocepheus velatus, Scheloribates latipes*, and *Peloribates angulatus* dominate the oribatid assemblages at two to four different sub-regions with 5.0 % to 60.8 % dominance.

Additionally another ubiquitous species, *Hypovertex laticuspis* together with *Proteremaeus punctulatus, Eporibatula prominens, Liebstadia similis, Eupelops mongolicus* and *Lepidozetes conjunctus* dominate the oribatid assemblages at the mountain steppe areas with 6.0 % to 16.4 % dominance. Restricted to the river valleys, *Bipassalozetes gobiensis, Zygoribatula frisiae, Ceratozetoides aokii, Punctoribates punctum*, and *Astegistes pilosus* show 5.3 % to 7.4 % dominance, while *Galumna rossica* reaches 7.9 % dominance. In the plain grassland area, only two species reach a proportion of more than 5 % here but not elsewhere: *Tectoribates mongolicus* and *Banksinoma* sp. with 13.3 % and 26.5 %, respectively.

Bohsack (1971) described temperate zone oribatid communities as consisting of a few relatively abundant species and a large number of comparatively rare species. Also in all our study areas, a few abundant species account for the majority of the oribatid population, whereas most species occur in small numbers.

For instance, only two dominant species out of 45 species in the mountain steppe area Lkhachinvandad account for 67.1 % the total number of oribatid individuals. Three other sub-regions, Menengiin Tal, Shiliin Bogd and Yazaar, are dominated by four species, which together comprise 51.0 % to 72.5 % of the oribatid numbers. Only the river valley habitats of Numrug show a relatively large number of dominant species with respect to the total species (8 out of 24 species), but the relative dominance of certain species is rather low (5–12.9 %).

Some of the rarer species from the different habitats, in particular *Eniochthonius minutissimus, Epilohmannia cylindrica, Heminothrus targioni, Belba mongolica, B. crassisetosa, Eueremaeus crassisetosus, Procorynetes tsendsureni, Tectocepheus alatus, Hypovertex stenolamellatus, Lepidozetes dashidorzsi* and *Angulogalumna asiatica* are represented by only single or a few specimens. These species may be naturally rare due to specific requirements of food or habitat, or perhaps the particular optimal habitat has not been sampled. However, most of these species are also rare in various habitats of the other regions of Mongolia. Hagvar (1994) suggested that rarer species may represent transitory populations in the process of either immigrating or emigrating, and/or may be replacing common species during times of habitat disturbance and stress. However, many species are rare in nature, and Anderson (1977) suggested that rare

Table 4: Percentage representation of the dominant species in the studied sub-regions (only species with percentages greater than 5 % in one of the sub-regions are considered.) Sub-regions. N = Numrug, MT = Menengiin Tal, L = Lkhachinvandad, SB = Shiliin Bogd, Y = Yazaar.

Species	N	MT	L	SB	Y
Proteremaeus punctulatus	2.6	-	3.3	3.2	13.7
Astegistes pilosus	5.8	-	-	-	-
Tectocepheus velatus	12.9	14.6	6.3	3.6	12.3
Banksinoma sp.	-	26.5	-	-	-
Bipassalozetes gobiensis	7.4	-	0.1	-	0.3
Hypovertex laticuspis	0.5	4.6	0.7	0.6	15.1
Peloribates angulatus	5.0	18.1	4.4	25.3	4.2
Eporibatula prominens	0.3	-	2.2	3.0	16.4
Zygoribatula frisiae	7.4	0.8	2.3	1.1	2.1
Liebstadia similis	0.8	-	0.2	10.7	2.6
Scheloribates latipes	6.8	0.5	60.8	0.2	0.5
Ceratozetoides aokii	5.8	-	-	-	-
Punctoribates punctum	5.3	0.3	-	0.2	0.6
Eupelops mongolicus	0.8	4.1	0.7	6.0	1.0
Tectoribates mongolicus	0.3	13.3	-	-	3.7
Lepidozetes conjunctus	0.3	-	-	9.0	1.4
Galumna rossica	7.9	1.9	-	4.8	0.2

species may be competitively excluded by abundant generalist species, or species may simply be rare because they occupy a rare habitat or are highly specialized in their feeding habits.

Thus, the different communities of oribatid mites of each studied sub-regions might be considered as potential indicators for the differences of the habitat diversity and conditions in various landscapes. Di Castri & Vitali-di Castri (1981), and Spain & Hutson (1983) suggested that one of the most important determinants of soil faunal abundances is annual precipitation, and faunal abundances can be shown to decrease with increasing aridity. This concept may be considered for the oribatid communities of our study sites since the study areas differ from one another in the annual precipitation which fluctuates between 201 mm and 381 mm (Batdelger et al., 2001). Soil organic carbon levels and soil temperature have also been identified as significant determinants of population density, species composition, and diversity in semi-arid to arid communities (Loots & Ryke, 1967; Santos et al., 1978; Franco et al., 1979 and MacKay et al., 1987). Other investigators have observed that moisture, soil type, pH, C:N ratio, nutrient concentrations and various other factors can trigger increased abundance or compositional changes in oribatid communities.

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