

Spatial and Typological Organization of the Oribatid Mite Population in the Northeastern Altai

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Abstract—Major features of the spatial heterogeneity of the oribatid mite population in the Northeastern Altai are revealed from the data obtained in the field seasons of 2002 and 2006. The impact of environmental factors on the population appearance is evaluated.

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The spatial arrangement of animal communities in Northeastern Altai has been the subject of a number of publications [1–13]. But we were the first to apply this approach called factor zoogeography [14–16] to the study of oribatid mite communities on this territory [17, 18].

Oribatid mites are one of the most widespread groups of soil microarthropods. They play an important part in soil formation. Oribatids accelerate decomposition and mineralization of organic remains and humus formation. Many species are intermediate hosts of anoplocephalides, helminths of cattle and wild mammals. In anthropogenic landscapes, oribatid mites often remain the last relic of the initial natural population of soil and become especially valuable for bioindication, biogeography, and ecology [19].

The detected oribatid species number 179 in 104 genera and 51 families. Here, we analyze the results at the level of family.

AREA UNDER STUDY, MATERIALS AND METHODS

In comparison with Altai as a whole, the Northeastern Altai is characterized by a simpler structure of altitudinal belts, with a broad forest and a narrow alpine belts, and no steppe [20]. Small temperature gradients promote a gradual transition from one belt to another and their substantial width. The effect of exposure is weak because the ridges stretch, as a rule, submeridionally, thus exposed to uniform insolation.

The data were collected in June and August of 2002 and of 2006 in all altitudinal belts of the Northeastern Altai: in forest-steppe piedmont (200–500 m asl near the villages of Nizhnyaya Neninka and Saidyp), in for-

ests of low-height mountains (250–1200 m asl near the villages of Saidyp, Kebezen', Verkh-Biisk, and Yailyu and at the cordons of Bele and Suuchak), in taiga and subgoletz belts (900–2100 m asl at the Obogo cordon, Altyn-Tu Ridge, Mt. Archa and Mt. Evrichala), and in alpine tundra belts (2000–2500 m asl, in the Altyn-Tu Ridge).

The zones distinguished within the boundaries of the forest-steppe belt are forest-steppe and parvifoliate forest plains and lowland marshes. Soil was collected in six ecotopes (at the rank of landscape tract) (Table 1).

The forest belt occupies low- and medium-height mountainous regions. At low heights, 14 grounds were explored. Less wetted regions in the valleys of large rivers and the shores of Teletskoe Lake are covered with light coniferous and parvifoliate forest (250–1000 m). Mixed pine and parvifoliate-pine forests are much more widespread than pineries occurring only as small massifs. In warmer and wetter regions, dark forests prevail; they occupy the major part of the area under study (500–1200 m). Parvifoliate forest is represented by secondary aspen-birch and birch-aspen forests over large fire sites at the place of dark forests (500–900 m). In this belt, also marshes are distinguished; most of them are transient turf swamp with birch in the places with hindered drainage [21].

At medium heights, two types of landscape are distinguished: dark coniferous taiga and subgoletz zone bordering alpine landscapes. The taiga belt hosts dark coniferous forest, clearings, dark coniferous and parvifoliate forest in place of clearings and fire sites (900–1800 m). Here the oribatid population was examined at six grounds. Small forests and separate groups of trees alternate with regions of supalpine meadows

Table 1. Number of soil samples taken during the investigation

Belt, subbelt	Landscape tract	2002		2006		
		June	August	June	August	
Forest-steppe piedmont	Fields	10	—	—	10	
	Meadow copses	14	—	—	20	
	Valley meadow osiers	12	—	—	20	
	Lowland bogs, bushy	10	—	—	20	
	Birch-aspen forest	10	—	—	20	
	Inhabited areas at piedmont	10	—	—	20	
	Forest: low-height mountain	Forest: birch-pine	12	—	—	20
pine		14	—	—	20	
pine-birch, sparse		10	—	20	20	
pine-birch		12	—	—	20	
birch-aspen		12	—	—	20	
floodland osiers		10	—	20	20	
Forest on the shore of Teletskoe Lake:						
pine-birch		—	10	20	20	
larch-birch		—	10	20	20	
Fallow meadows		12	—	—	10	
Pine-abies-birch forest		12	—	—	20	
Low-mountain marshes, afforested		10	—	10	20	
Aspen-abies dark forest		12	—	20	20	
Birch-aspen forest over fire-sites		—	10	20	20	
Low-mountain inhabited areas		12	—	—	20	
medium-height mountain		Forest: birch-aspen	—	10	20	—
		birch-spruce	—	10	20	—
	Taiga: abies-cedar	—	10	20	—	
	fir-cedar	—	10	20	—	
	cedar	—	10	20	—	
	Clearings over abies-cedar taiga	—	10	20	—	
Subalpine	Sparse growth of trees: with meadows and yerniks	—	16	20	—	
	With yerniks on rocks	—	10	20	—	
Alpine	Tundra: yernik	—	10	20	—	
	stony	—	10	10	—	
	moss-lichen	—	—	20	—	
Total number of samples		194	136	340	380	

and mountain tundra (1800–2100 m). In this region, the data were collected at two grounds.

Three grounds were explored in the high-mountain goletz belt: yernik, stony, and moss-lichen kinds of tundra.

A reconnaissance examination was carried out in 2002: in the piedmont and low-height mountain part of the profile in June, and in the medium-height and alpine

part in August. Sampling was made in 30 grounds (10 to 18 samples in each of them). Soil samples were taken with a cylindrical bore 5 cm in both diameter and height.

These landscape tracts were examined in more detail in 2006. At the localities where in 2002 samples were taken in June, the new samples were taken in August, and vice versa. In addition, in 2006 we carried out an

additional investigation of alpine moss-lichen tundra. Soil samples were taken in each of 31 grounds in 20-fold replication; among them, 10 samples were mulch (taken with a 10 × 10 cm frame) and 10 were soil (taken with the same bore as described above). Forcing (extraction of mites from the samples) was carried out under stationary conditions according to the generally accepted procedure using modified Berlese funnels. Then the mites were poured into permanent preparations using Faure liquid [22]. The number of oribatids was calculated per 1 m², later the data were averaged over a landscape tract during the whole period of investigation.

In total the soil samples numbered 1050. About 51 thousand individuals were extracted and counted. About 2700 preparations were made.

Calculations were carried out using the software developed in the Laboratory of Zoological Monitoring of the Institute of Systematics and Ecology of Animals SB RAS. To classify the population and reveal its structure, we used methods of multivariate factor analysis. The Jacquard coefficient [23] in Naumov's modification [24] for quantitative indices served as a measure of similarity of the communities. The spatial and typological structure of the population was revealed by means of correlation pleiads [25] using the matrix of average similarity coefficients between the versions of population belonging to the taxa of classification of a certain rank. Estimation of the strength of influence and the similarity of display of the environmental factors determining heterogeneity of population was made with the help of the linear qualitative approximation, which is a qualitative analog of the regression model [26].

cluding the Central Altai [34–38]. The revealed regularities are the same: The mites reach the highest species diversity and the population level in the forest belt. With an increase in the absolute height of a location, the density and diversity of the oribatid population decrease. Fairly low diversity of oribatids is characteristic of the steppe belt. This completely fits the distribution of mites in the latitudinal natural zones [19]. In the Northeastern Altai, the density of oribatid population from belt to belt changes with small differences (Fig. 1). In the transition from the piedmont forest-steppe belt, where 18 thousand ind./m² were found, to the low-height mountain forest subbelt the total abundance increases reaching the maximum of 21 thousand ind./m². As the absolute altitude increases, this index decreases: by a factor of 1.5 in the medium-height mountain taiga and twice in the subgoletz belt. The figures of total abundance in the subalpine and alpine tundra belts are almost identical: 7.2 and 7.1 thousand ind./m². Changes of the density of oribatid population correspond to the rhomb-like type, which is characteristic of reptiles, birds, mammals, invertebrates of the grass cover, as well as for diurnal lepidopterans investigated previously on this territory [1–4, 8, 9, 13].

For separate grounds, the total abundance of oribatids is the highest in low-height mountain light coniferous—parvifoliate and piedmont—low-height mountain parvifoliate forests (Table 2). A similar picture was observed for ticks and fleas of small mammals [5–7]. Somewhat smaller number of oribatids occur in piedmont slope meadows, coppices and low-height mountain pine forests. A further decrease in the density of population is observed in low-height mountain afforested marshes, birch-aspen forests over fire sites and dark forests. Still smaller total abundance of oribatids is observed in low-height mountain pine-birch, larch-birch forests and alpine stony tundras, and especially in the medium-height mountain taiga and sparse growth

ALTITUDE-BELT CHANGES OF POPULATION

The vertical belt distribution of oribatid mites was studied in many mountainous locations [27–33], in-

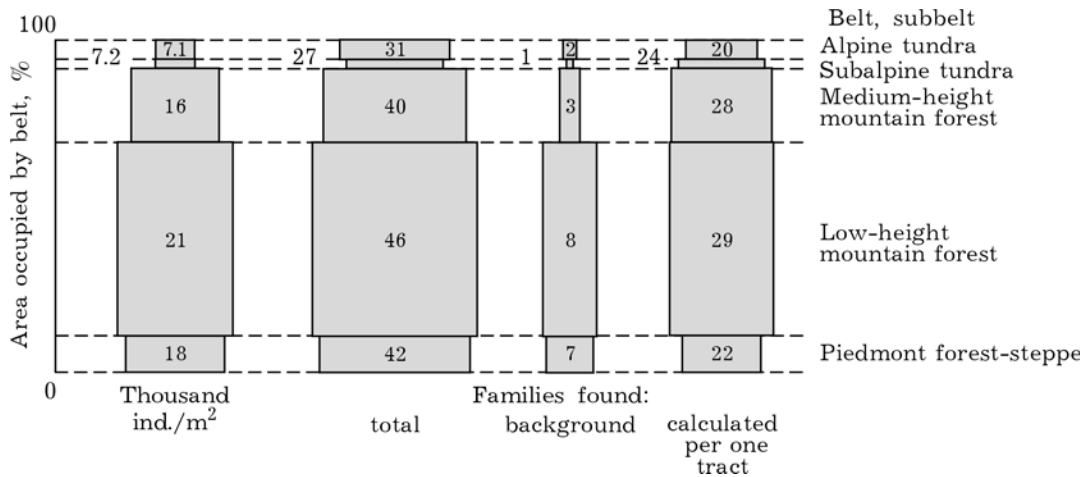


Fig. 1. Altitude-belt changes of the density and taxonomic richness of oribatid population of the Northeastern Altai, 2002 and 2006.

Table 2. Abundance of oribatids in landscape tracts and altitude belts of Northeastern Altai (after samplings of 2002 and 2006)

Family	Piedmonts						Low-height mountain			
	1	2	3	4	5	6	7	8	9	10
Palaeacaridae	0	0	0	0	30	0	160	0	420	920
Hypochthoniidae	0	180	100	900	0	0	0	510	0	0
Heterochthoniidae	0	0	0	0	150	0	0	150	0	160
Brachychthoniidae	0	0	0	0	0	0	20	0	0	0
Phthiracaridae	0	1620	6680	480	2510	20	3680	2990	960	5490
Euphthiracaridae	0	160	250	0	230	110	500	1470	240	840
Oribotritiidae	0	10	10	0	250	0	0	20	0	150
Eulohmanniidae	0	40	20	0	50	0	0	0	0	20
Perlohmanniidae	0	0	0	0	0	0	0	0	0	110
Nothridae	0	0	0	80	0	0	780	330	0	20
Camisiidae	0	60	80	1970	670	0	600	1140	70	2090
Trhypochthoniidae	0	0	0	0	0	0	60	0	20	20
Malaco-nothridae	0	0	0	1480	0	0	0	0	3	0
Nanhermanniidae	0	0	0	30	0	0	0	20	0	110
Gymnodamaeidae	0	60	0	0	120	0	220	200	0	30
Damaeidae	80	760	800	230	2450	390	2370	920	1030	1610
Damaeolidae	0	0	0	0	0	0	0	0	0	0
Eremaeidae	0	0	0	0	0	0	0	0	0	0
Astegistidae	0	460	0	0	0	0	10	210	0	0
Gustaviidae	0	80	0	0	200	0	180	680	30	160
Liacaridae	30	350	530	5	580	70	760	470	120	480
Metrioppiidae	30	90	90	160	300	0	0	200	50	30
Xenillidae	0	130	150	0	1850	0	270	0	10	20
Carabodidae	0	0	0	0	70	0	2190	330	380	320
Niphocephidae	0	0	0	0	0	0	10	10	30	30
Tectocephidae	1070	1750	3070	130	2380	2200	1610	780	1000	2040
Otocephidae	0	0	0	0	0	0	0	0	0	0
Autognetidae	50	5280	30	0	5480	30	4320	1860	820	490
Oppiidae	920	4660	1010	5210	4030	1330	3120	4110	5030	4270
Quadropiidae	0	0	0	50	0	0	0	0	0	0
Suctobelbidae	30	1150	70	690	100	10	540	90	80	70
Thyrisomidae	30	180	0	180	0	0	30	0	0	130
Micreremidae	0	0	20	0	0	0	0	0	0	0
Licneremaeidae	0	0	0	0	0	0	0	0	0	0
Passalozetidae	0	20	0	50	0	0	0	0	0	0
Scutoverticidae	0	0	0	0	0	0	0	0	0	0
Haplozetidae	0	0	600	0	0	0	0	0	240	0
Oribatulidae	30	430	30	3050	80	90	2740	270	470	1590
Protoribatidae	0	1600	400	30	830	60	70	1150	830	460
Scheloribatidae	560	3150	1800	30	580	1280	6440	1960	1770	1850
Hemileidae	0	30	0	0	0	0	0	0	0	0
Parakalummidae	0	0	0	130	0	0	20	40	20	60
Ceratozetidae	50	6360	2300	1870	2160	340	2960	2690	2140	4230
Chamobatidae	0	0	50	10	250	0	0	0	30	500
Mycobatidae	950	1970	2090	510	980	200	50	630	190	20
Zetomimidae	0	0	0	30	0	0	0	0	0	0
Phenopelopidae	0	0	460	100	500	0	180	130	150	440
Oribatellidae	0	190	0	0	60	0	220	0	3	530
Achipteriidae	0	530	170	310	120	0	370	200	230	320
Tegoribatidae	0	0	0	0	0	30	570	110	10	300
Galumnidae	0	450	460	1210	430	390	1250	1020	670	1340
Total families	12	28	25	26	28	15	31	30	30	36
Density, ind./m ²	3830	31 750	21 270	18 930	27 440	6550	36 300	24 690	17 050	31 250

of trees. Minimal values are characteristic of the high-mountain yernik and moss-lichen tundra.

Among oribatids, small-sized forms (0.15 to 0.3 mm) belonging to the Oppiidae family are the most numerous. Almost all the found species are extremely

eurybiontic. Their percentage in the medium-height mountain taiga and alpine tundra belt are 30 and 36%, respectively. The representatives of Ceratozetidae and Phthiracaridae families should be related to the dominant groups of oribatids in the majority of altitudinal

Table 2. (Contd.)

Family	Low-height mountain									
	11	12	13	14	15	16	17	18	19	20
Palaeacaridae	60	50	230	20	0	360	40	0	0	530
Hypochthoniidae	0	10	0	0	2600	0	0	0	0	0
Heterochthoniidae	70	0	20	0	20	20	230	0	0	10
Brachychthoniidae	0	0	0	20	0	0	0	0	0	0
Phthiracaridae	5130	920	1390	510	4420	2240	7220	130	980	5050
Euphthiracaridae	630	60	150	100	30	890	560	270	0	490
Oribotritiidae	130	0	3	0	0	10	40	0	0	0
Eulohmanniidae	0	0	0	0	0	0	20	0	0	20
Perlohmanniidae	0	0	0	0	0	0	0	0	0	0
Nothriidae	330	370	30	80	170	70	170	0	0	190
Camisiidae	480	190	310	130	30	1490	650	60	30	470
Trhypochthoniidae	0	0	30	0	0	0	0	0	0	0
Malaconothridae	0	0	0	3	50	0	0	0	0	0
Nanhermanniidae	0	0	20	0	710	0	350	0	0	0
Gymnodamaeidae	60	0	30	80	0	70	0	0	0	0
Damaeidae	2990	220	1030	1140	20	1490	1820	140	100	1250
Damaeolidae	0	0	0	30	90	0	0	0	0	0
Eremaeidae	0	0	0	0	0	0	0	0	0	0
Astegistidae	180	120	20	80	0	250	0	30	0	980
Gustaviidae	170	100	180	0	1110	210	200	0	0	50
Liacaridae	620	50	200	1900	290	630	500	40	0	460
Metrioppiidae	60	120	10	730	190	250	270	0	0	190
Xenillidae	0	20	20	20	0	0	0	60	0	100
Carabodidae	50	0	170	190	40	60	420	0	0	200
Niphocephidae	10	30	10	3	20	80	80	0	0	60
Tectocephidae	970	600	910	1250	1570	700	210	2570	1180	1030
Otocephidae	0	0	0	0	0	200	0	0	0	0
Autognetidae	2300	390	830	2160	90	590	1420	50	30	2220
Oppiidae	6470	430	2450	2060	3340	3130	4040	1450	2390	6130
Quadropiidae	0	0	0	0	0	0	0	0	0	0
Suctobelbidae	80	20	40	130	20	40	110	0	0	0
Thyrisomidae	0	70	0	0	0	0	200	0	0	0
Micreremidae	0	0	0	0	0	0	0	0	0	0
Licneremaeidae	0	0	0	100	0	0	0	0	0	60
Passalozetidae	0	0	0	0	0	0	0	0	0	0
Scutoverticidae	0	0	0	90	0	0	0	0	0	0
Haplozetidae	0	0	0	420	0	10	20	20	0	0
Oribatulidae	5410	90	1090	1100	70	1410	420	50	0	350
Protoribatidae	950	430	370	410	1430	340	550	580	90	310
Scheloribatidae	1040	170	670	2240	960	2360	410	2710	130	5010
Hemileidae	0	0	0	0	0	10	0	0	0	0
Parakalummidae	5	10	0	0	0	20	100	40	0	0
Ceratozetidae	3070	1500	1780	2330	1620	3400	2400	210	440	1530
Chamobatidae	300	40	3	20	20	330	70	0	80	2400
Mycobatidae	40	370	20	3	4240	279	10	500	170	0
Zetomimidae	0	0	0	0	0	0	0	0	0	0
Phenopelopidae	210	10	190	440	20	250	540	30	0	340
Oribatellidae	90	20	60	20	0	30	490	5	0	1690
Achipteriidae	350	20	30	250	750	480	300	0	0	30
Tegoribatidae	30	20	50	1070	70	30	80	0	50	280
Galumnidae	440	610	270	340	1700	760	330	360	0	380
Total families	31	30	33	34	29	34	33	20	12	29
Density, ind./m ²	32 730	7060	12 620	19 470	25 710	22 490	24 270	9300	5670	31 810

belts. The Ceratozetidae family is a leader in the alpine belt (15%). It is represented by two life forms. One of them includes the individuals of large size, strongly pigmented; they inhabit mainly the litter and the surface layer of the soil of forest biotopes (*Ceratozetes cis-*

alpinus Berlese, 1908, *Ceratozetes peritus* Grandjean, 1951). Other individuals are medium in size and moderately pigmented. They belong to the nonspecialized life form, that is, inhabit both the surface layers of the soil and deeper ones. They prefer open biotopes and micro-

Table 2. (Contd.)

Family	Medium-height mountain								Alpine		
	21	22	23	24	25	26	27	28	29	30	31
Palaeacaridae	100	150	30	130	80	0	50	30	0	50	0
Hypochthoniidae	0	0	0	0	80	0	0	0	0	0	150
Heterochthoniidae	0	580	0	410	140	40	290	30	0	100	0
Brachychthoniidae	0	0	0	0	0	0	890	30	10	0	0
Phthiracaridae	1740	1980	100	1640	30	1800	100	60	30	1020	0
Euphthiracaridae	10	130	20	10	0	100	0	0	0	0	0
Oribotritiidae	0	0	0	0	0	0	0	0	0	0	0
Eulohmanniidae	200	30	0	30	0	30	40	0	0	0	0
Perlohmanniidae	0	0	0	0	0	0	0	0	0	0	0
Nothridae	270	0	0	0	0	130	110	50	90	460	100
Camisiidae	50	940	280	930	390	990	530	1350	110	1320	0
Trhypochthoniidae	0	0	0	0	0	0	10	0	230	30	90
Malaconothridae	0	0	0	20	5	0	0	0	0	0	0
Nanhermanniidae	0	1090	90	1300	50	5	10	30	20	30	0
Gymnodamaeidae	0	0	0	830	0	0	0	0	0	0	0
Damaeidae	1130	1170	1090	590	30	510	70	30	10	410	10
Damaeolidae	0	0	0	0	0	0	0	0	0	0	0
Eremaeidae	30	510	80	30	0	0	0	0	30	180	0
Astegistidae	0	1220	30	30	50	0	0	0	0	250	0
Gustaviidae	270	0	5	0	0	160	0	0	0	0	0
Liacaridae	460	450	700	680	490	200	170	30	20	50	50
Metrioppiidae	320	180	40	270	100	200	190	30	80	180	0
Xenillidae	0	0	0	0	0	0	0	0	0	0	0
Carabodidae	30	80	130	0	0	60	0	0	20	180	0
Niphocephidae	0	30	40	40	5	0	0	200	0	330	0
Tectocephidae	230	1310	20	110	180	5	110	1300	90	2140	0
Otocephidae	0	1220	200	190	0	0	0	0	0	0	0
Autognetidae	380	600	60	20	0	360	10	5	0	100	50
Oppiidae	2650	9750	3950	5350	6810	1250	2780	530	1500	6130	60
Quadropiidae	0	0	0	0	0	0	0	0	0	0	0
Suctobelbidae	80	100	0	90	20	0	5	0	0	0	10
Thyrisomidae	110	30	80	220	180	130	380	50	200	30	0
Micreremidae	0	0	0	30	0	0	0	0	0	0	0
Licneremaeidae	50	110	0	5	0	0	0	0	0	0	0
Passalozetidae	0	0	0	0	0	0	0	0	0	0	0
Scutoverticidae	0	0	0	0	0	0	0	0	0	0	0
Haplozetidae	0	0	0	0	0	0	0	0	0	0	0
Oribatulidae	70	840	650	510	740	260	210	70	60	130	30
Protoribatidae	1060	630	350	1110	5	960	250	0	3	0	0
Schelorbitidae	50	1840	2320	1240	0	90	0	30	0	0	0
Hemileidae	0	0	0	260	0	0	0	0	0	0	0
Parakalummidae	120	40	5	160	0	40	40	50	10	0	0
Ceratozetidae	2210	3870	560	920	350	1130	920	1070	430	1730	980
Chamobatidae	0	0	0	30	0	0	0	0	0	0	0
Mycobatidae	460	0	5	5	5	300	30	1000	180	1350	30
Zetomimidae	0	0	0	0	0	0	0	0	0	0	0
Phenopelopidae	600	50	280	250	30	990	150	150	30	180	0
Oribatellidae	70	480	890	80	0	150	0	0	0	30	0
Achipteriidae	0	30	20	0	0	290	60	20	30	0	10
Tegoribatidae	700	930	200	520	110	2060	90	860	20	360	30
Galumnidae	330	590	70	0	0	350	0	0	10	0	0
Total families	28	31	29	34	22	27	25	23	23	24	13
Density, ind./m ²	14 410	30 960	12 300	18 040	9880	12 590	7500	7000	3210	16 770	1600

Note: 1, fields; 2, meadow copses; 3, valley meadow osiers; 4, birch-aspen forest; 5, lowland bogs, bushy; 6, inhabited areas at pidmont; 7, birch-pine forest of the middle reaches of the Biya; 8, pine forest; 9, pine-birch sparse forest; 10, pine-birch forest; 11, birch-aspen forest; 12, floodland osiers; 13, pine-birch forest on the shore of Teletskoe Lake; 14, larch-birch forest on the shore of Teletskoe Lake; 15, low-height mountain bogs, afforested; 16, aspen-abies dark forest; 17, birch-aspen forest over fire-sites; 18, low-height mountain inhabited areas; 19, fallow-land meadows; 20, pine-abies-birch forest; 21, birch-aspen forest; 22, birch-spruce forest; 23, abies-cedar taiga; 24, spruce-abies-cedar taiga; 25, cedar taiga; 26, clearings over abies-cedar taiga; 27, sparse growth of trees with meadows and yerniks; 28, sparse growth of trees with yerniks over rocks; 29, yernik tundra; 30, stony tundra; 31, moss-lichen tundra.

stations with grass vegetation (*Ceratozetella sellnicki* (Rajski, 1958). The largest participation of the Phthiracaridae family was detected in the low-height mountain forest subbelt (14%). The species especially abundant in all landscapes is the meadow-forest species *Atropacarus striculus* (C. L. Koch, 1836) and the forest species of the *Phthiracarus* genus. Up the profile, the Phthiracaridae family is replaced by Camisiidae (subgoletz belt) and Tectocephidae (goletz belt). The representatives of the former family are large wedge-shaped oribatids of *Nothrus* and *Camisia* genera inhabiting friable substrates and litter. They are able to separate rather large particles of the substrate. The latter family is represented by the only species *Tectocephus velatus* (Michael, 1880). This is a small-sized litter-soil eurybiont of global distribution. One more life form of oribatids should be mentioned though it did not get into the group of leaders. These are representatives of the Damaeidae family. They are large in size, globular in shape, with long wide-spaced legs; they move only along the surface but do not penetrate deep into soil. As a rule, all of them belong to forest species. Our data also clearly indicate that they are confined to forest grounds: in all kinds of forest, they account for 4–5% of the total abundance of oribatids. In open nonforest tracts where the litter is not pronounced, their abundance is much lower.

The diversity of oribatid families changes over the belts in a similar manner but, unlike population density, with smaller differences in values. Forty-two families were detected in the forest-steppe piedmont; among them, seven families are background. The background families distinguished by analogy with background species [39] are those whose abundance is more than 1000 ind./m² (below the numbers of background families are given in parentheses). The number of families in the low-height mountain forests increase to 46 (8). It is this part of the forest belt that exhibits the highest taxonomic richness of oribatids, as well as many groups of invertebrates. Further ascent to medium heights is accompanied by a decrease in the number of families to 40 (3) in the forest belt and to 27 (1) in the subgoletz belt. However, the number of families detected in the goletz region is 31 (2), which exceeds their number in the subgoletz medium-height mountains. This may be explained by the diversity of suitable ecological niches. Such a regularity was discovered for oribatids in the mountains of Mongolia [30].

Over separate ecotope grounds, the largest number of oribatid families was found in the low-height mountain pine-birch forests; somewhat smaller number was detected in the other landscape tracts at low heights and in dark coniferous taiga and dark coniferous-parvifoliate forests at medium heights. The smallest number of families was recorded in the piedmont fields and inhabited areas, fallow-land meadows at low heights, as well as in alpine moss-lichen tundras.

Since the number of tracts explored in the altitudinal belts varies (from 2 to 14), the amount of data collected in these tracts is different, too. This affects the general picture of altitude-belt changes of the taxonomic composition. In this connection, we recalculated the total number of families recorded in a belt as an average for one ground. Comparison of the obtained data shows that the maximal number of families is found in the forest belt. With an increase in the absolute height of a locality, the taxonomic richness gradually decreases.

Thus, the results obtained depict a general trend of spatial changes of the density and taxonomic richness of oribatid depending on the absolute height of a locality (the rhomb-like type). The maximum values were detected in forest low-height mountain regions. The values decrease in belts below and above. Such a distribution is due to the hydrothermal conditions at low heights, which is optimal in the heat-to-moisture ratio, and to the landscape diversity of this territory.

CLASSIFICATION OF THE POPULATION

This idealized classification scheme depicts the heterogeneity of oribatid population density. It is based on the grouping of similar communities with all the versions of population. After the first fragmentation as a result of automatic classification, we obtained seven groups of population; four of them comprise several versions and three, one version each. Usually a type unites the groups distinguished during the first fragmentation by cluster analysis. On idealization, the community of medium-height mountain sparse growth of trees with yerniks over rocks and the similar population of alpine yernik tundras were united into one group. One of the types including 19 versions of population was subdivided into eight subtypes using the same program.

As a result, the classification of oribatid population in the Northeastern Altai is represented by six types. This idealization is aimed at matching the classification to our actual representations, level of understanding and explanation of the revealed heterogeneity of population [16].

Classification of the oribatid communities (in abundance) is as follows.

Types of population of the grounds:

1. Optimal ecotopes (leading in abundance, %: Oppiidae 18, Phthiracaridae 12, Ceratozetidae 10; density of population, thousand ind./m² 24; total number of families recorded: 49/ including background with the abundance not less than 1000 ind./m²: 7; below these indices are listed without units).

Population subtypes:

1.1: piedmont valley osier meadows (Phthiracaridae 31, Tectocephidae 14, Ceratozetidae 11; 21; 25/6);

1.2: piedmont sloping meadow copse (Ceratozetidae 20, Autognetidae 17, Oppiidae 15; 32; 28/9);

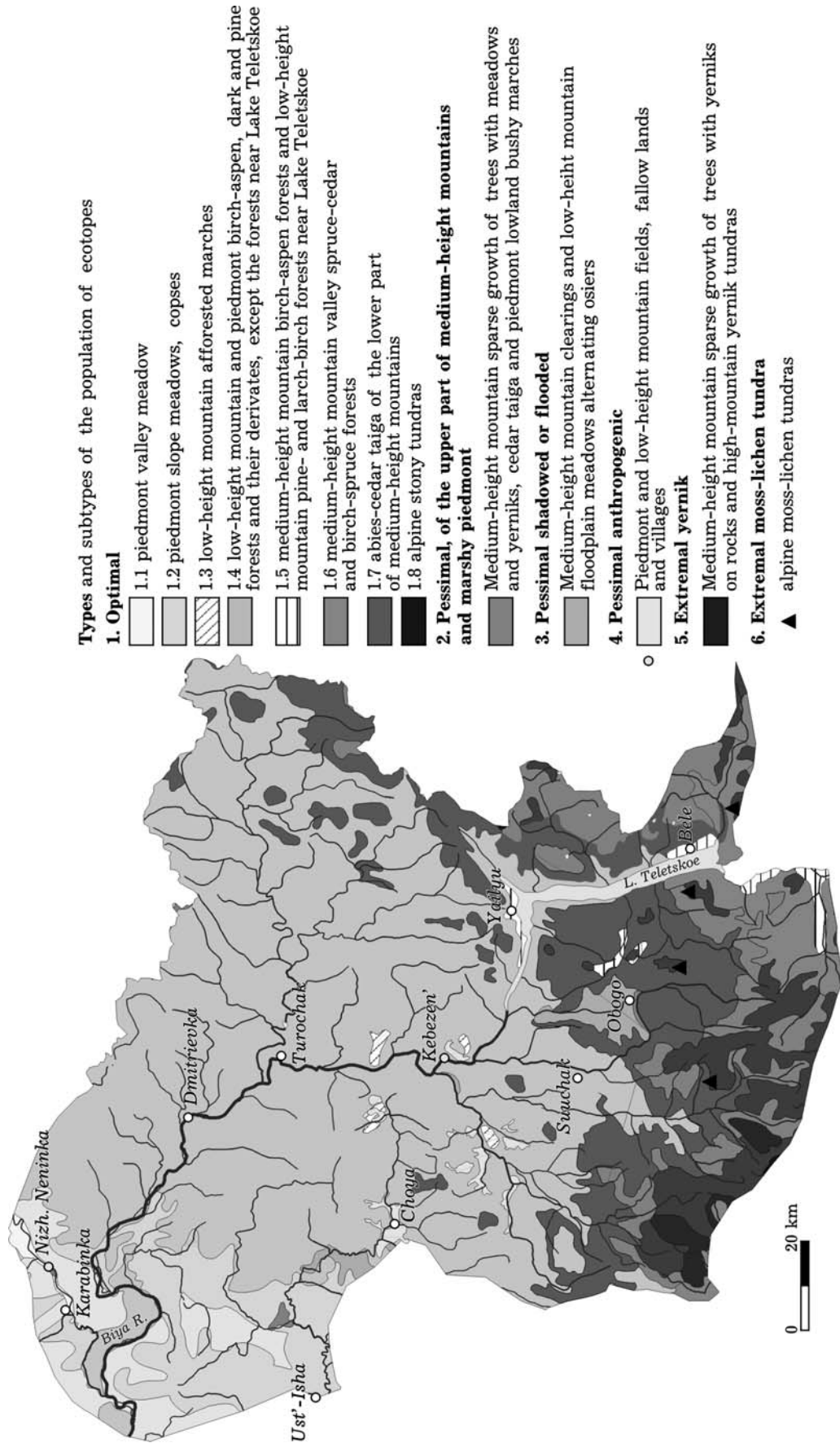


Fig. 2. Oribatid mites population of the Northeastern Altai.

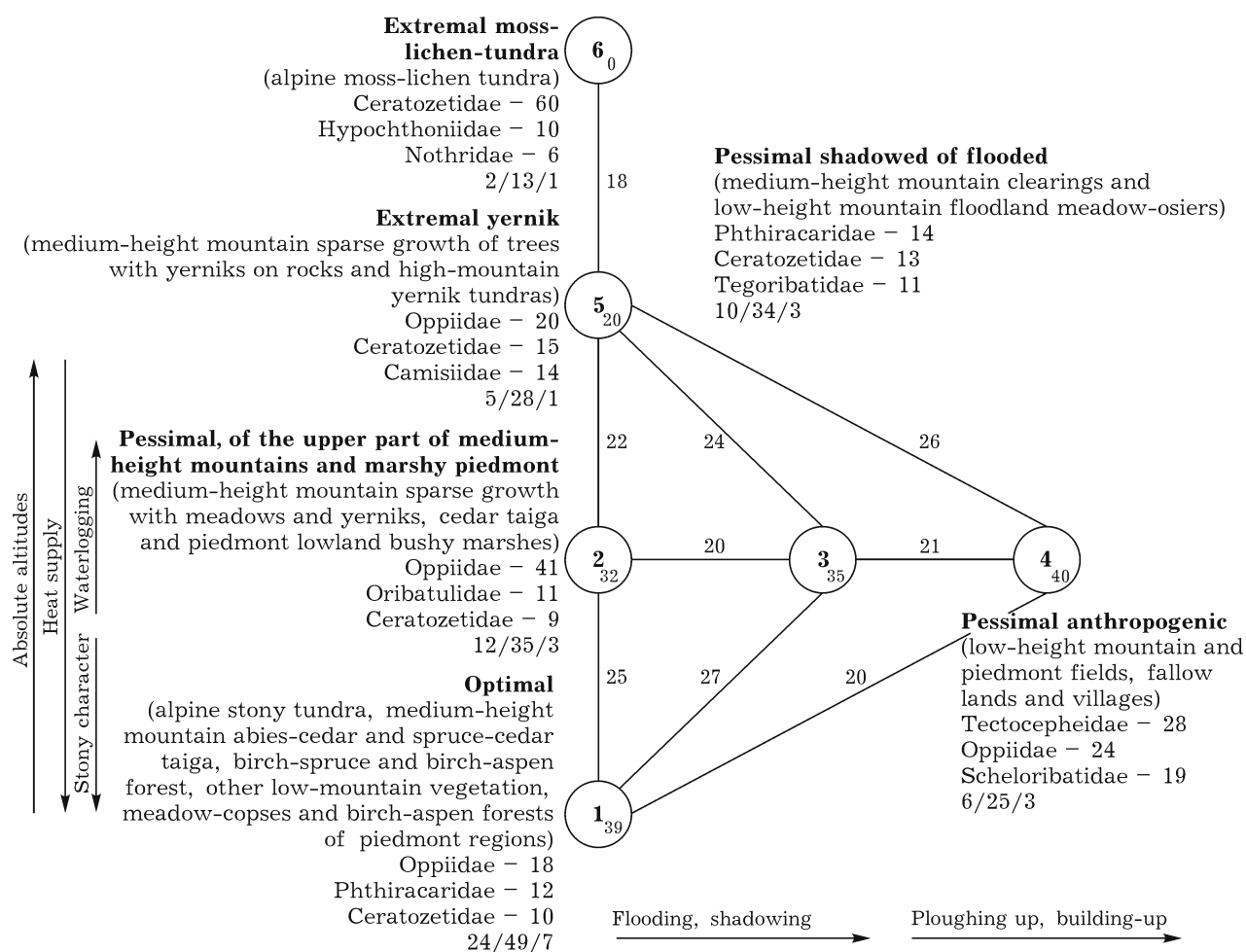


Fig. 3. Spatial and typological structure of the oribatid population of the Northeastern Altai, 2002 and 2006. Each symbol corresponds to a population type; the main figure means type number, the index means the intragroup similarity. Figures at the lines that connect the symbols are estimations of the intergroup similarity. Arrows at the scheme are directed towards an increase in the manifestation of environmental factor. Symbols are accompanied by: a short list of ecotopes whose population belongs to this type of population, three most abundant families (%), population density (thousand ind./m²), total number of detected families and the number of background ones among them.

1.3: low-height mountain afforested marshes (Phthiracaridae 17, Mycobatidae 16, Oppiidae 13; 26; 29/9);

1.4: low-height mountain and piedmont birch-aspen, dark and pine forests and their derivatives, except those near Lake Teletskoe (Oppiidae 16, Phthiracaridae 14, Ceratozetidae 10; 28; 44/8);

1.5: medium-height mountain birch-aspen and low-height mountain pine-birch and larch-birch forests near Teletskoe Lake (Oppiidae 15, Ceratozetidae 14, Phthiracaridae 8; 15; 43/5);

1.6: medium-height mountain spruce-cedar and birch-spruce valley forests (Oppiidae 31, Ceratozetidae 10, Phthiracaridae 7; 24; 37/5);

1.7: abies-cedar taiga of the lower part of medium-height mountain regions (Oppiidae 32, Scheloribatidae 19, Damaeidae 9; 12; 29/3);

1.8: alpine stony tundra (Oppiidae 37, Tectocephidae 13, Ceratozetidae 10; 17; 24/6).

2. Pessimal of the upper part of medium-height mountain and marshy piedmont (medium-height mountain sparse growth of trees with meadows and yerniks, cedar taiga, and piedmont lowland bushy marshes; Oppiidae 41, Oribatulidae 11, Ceratozetidae 9; 12; 35/3).

3. Pessimal shadowy or floodable (medium-height mountain clearings and low-height mountain floodland meadows alternating with osiers; Phthiracaridae 14, Ceratozetidae 13, Tegoribatidae 11; 10; 34/3).

4. Pessimal anthropogenic (piedmont and low-height mountain fields, fallow lands, and villages; Tectocephidae 28, Oppiidae 24, Scheloribatidae 19; 6; 25/3).

5. Extremal yernik (medium-height mountain sparse growth of trees with yerniks on rocks and high-mountain yernik tundras; Oppiidae 20, Ceratozetidae 15, Camisiidae 14; 5; 28/1).

6. Extremal alpine moss-lichen tundra (Ceratozetidae 60, Hypochthoniidae 10, Northridae 6; 2; 13/1).

Thus, the spatial heterogeneity of oribatid population is determined by the optimality of conditions with respect to a number of factors. The taxa of oribatid community classification, like the communities of ticks, fleas and poikilothermal vertebrates (amphibians and reptiles), are marked not with respect to separate landscape-physiognomic indices of territories but with respect to the general integral evaluated degree of the optimality of environment. It was determined on the basis of the abundance of oribatids, which depends on a number of factors. The classification reveals the influence of the same factors as those affecting ticks and fleas. The major ones are heat supply connected with the absolute altitude of a locality and shadowing determined by the composition of forest-forming species. Less significant is the negative effect of excess wetting, flood during high-water period, and the economical activities of humans.

A substantial part of the Northeastern Altai is occupied by the population of optimal ecotopes (Fig. 2). Such a trend was also observed for the reptile population. A smaller part is occupied by pessimal and especially extremal ecotopes. This proves that the territory of the Northeastern Altai is more favorable for oribatids than for poikilothermal vertebrates, ticks and fleas, because oribatids live in soil. All the ecotopes are favorable for one or another species of different families. Extremal territories are generally characterized by the minimal values for oribatids, ticks and fleas, as well as for reptiles. Pessimal and extremal ecotopes for reptiles occupy the largest area in the Northeastern province of the Altai.

SPATIAL AND TYPOLOGICAL STRUCTURE OF POPULATION

By the spatial and typological structure of animal population is meant the general character of its territorial changes revealed from the morphological similarity of communities, without taking into account their conjugation at the locality [40].

The structure of oribatid population (Fig. 3) is governed by the main trend matching the heat supply determined by absolute altitudes of a locality and by deviations from it. The main trend comprises four types (1, 2, 5, 6), and deviations, two (3, 4). A deviation from the mainstream is determined by the degree of shadowing with tree crowns, flood during high water, and human activities such as ploughing and building up.

The highest density of population and taxonomic diversity of oribatids are characteristic of the type of population of optimal ecotopes (24 thousand ind./m²/49 families), which is due to high heat supply, afforestation, and favorable microclimatic conditions of stations. This type unites the versions of the population of medium-height mountain abies-cedar and spruce-abies

taiga, birch-spruce and birch-aspen forests, other low-height mountain regions, meadow copses and birch-aspen forests of piedmont. It also includes stony tundras whose soil is able to conserve heat due to the stones heated with the sun; in combination with wetting this soil creates favorable conditions for oribatids, similarly to diurnal lepidopterans. The internal similarity of the versions included in this type reaches the maximum, 39%.

Passing to the next type of pessimal upper part of medium-height and marshy piedmont regions (25% similarity) we observe a decrease in the density and taxonomic richness (12/35). These regions include the communities of medium-height mountain sparse growth of trees with meadows and yerniks, cedar taiga and piedmont lowland bushy marshes. A decrease in population density and diversity is due to the negative effect of marshlands and low heat supply. The internal similarity is 32%.

The types of population of extremal yernik and moss-lichen tundra regions have lower indices of total abundance and taxonomic richness: 5/28 and 2/13, respectively. This is due to a decrease in heat supply with an increase in absolute altitudes.

A deviation from the main trend of oribatid communities in pessimal regions is represented by the versions of medium-height mountain clearings and low-height mountain floodland meadow osiers (internal similarity 35%). It is connected with flood during high water periods and shadowing with tree crowns. These factors decrease the density and taxonomic richness (10/34).

The effect of ploughing and building on the density and taxonomic richness in low-height mountain and piedmont fields causes depletion of the communities (6/25). For this type, we observed a high internal similarity of the versions incorporated in it: 40%.

So, the spatial heterogeneity of oribatid population is determined by the effect of heat supply, which is due to the absolute altitudes of the territory and the degree of shadowing determined by the composition of forest-forming species and cedar reforestation, flood during high water periods, and the economical activities of man.

SPATIAL AND TYPOLOGICAL ORGANIZATION OF POPULATION

The spatial and typological organization of population is understood as the general character of its territorial heterogeneity (spatial structure), as well as a set and the strength of environmental factors conjugated with the spatial changes of the appearance of population [25]. The largest estimate of the connection (the fraction of accounted variance in the matrix of the coefficients of similarity of communities) between the heterogeneities of population and the environment (Table 3) is inherent to the belt structure (38%), a smaller value relates to heterogeneity in heat supply determined

Table 3. Estimation of the strength and commonness of the relationship between environmental factors and heterogeneity of the oribatid population in the Northeastern Altai

Factor, regime	Accounted variance, %, in abundance
Belt structure	38*
Afforestation	35
Composition of forest-forming species	28
Absolute altitudes	25
Shadowing	20
Bushing	13
Pattern	7
Anthropogenic influence	3
Flooding	2
Moisture	0.9
Waterlogging	0.8
Stony character	0.6
All the factors	68
Regimes: structural	65
classification	54
All regimes	71
All factors and regimes	85
Correlation coefficient	0.92

* Basic (the first in significance) structure-forming factors are marked with bold type.

by absolute altitudes and shadowing (25% and 20%). The effect of other factors is much smaller. Thus, the effect of bushy growth accounts for 13% of the population variance. In the force of correlation the distributional pattern is twice weaker than the variability of oribatid population. Anthropogenic impact and wetting are much inferior to these factors. All the structure-forming factors account for 68% of variance. Taken together, the structure and classification provide for 71% of information about the population, while all the factors and regimes provide for 85% of information (the multiple correlation coefficient is 0.92).

The heterogeneity of environment on a specific territory is responsible for changes in the animal population, so the set of factors determining the spatial heterogeneity of oribatid population is similar to that over all the invertebrates where the three most significant factors are belt structure, composition of forest-forming species, and absolute altitudes of the territories; however, the strength of manifestation of these factors differs [16]. Afforestation is also significant for oribatid and bird populations. The largest effect of the belt structure was also revealed for poikilothermal vertebrates [4] and diurnal lepidopterans [8, 9]. For mammals [3], the effect of shadowing and the composition of for-

est-forming species is significant; for ticks and fleas [5–7] the effect of the absolute height of the territories and the belt structure are significant, for diurnal lepidopterans, ground beetles [11, 12], ants [10] and poikilothermal vertebrates the composition of forest-forming species and belt structure are significant.

Oribatids depend on the environmental factors more heavily than reptiles, ground beetles, chortobionts and diurnal lepidopterans but to a lesser extent than ticks, fleas, and other vertebrates.

CONCLUSIONS

The performed investigations allowed us to make the following conclusions.

1. The altitudinal-belt changes of the density of population, taxonomic and background richness of oribatids in the Northeastern Altai have a rhomb-like character. At first, the indices increase from the piedmont forest-steppe belt to the low-height mountain forest subbelt, then decrease to the alpine tundra.

2. The spatial heterogeneity of the oribatid population is due to the changes of absolute altitudes of the territories and related heat supply, the degree of shadowing which is determined by the composition of forest-forming species, flood during high-water periods, and the economical activities of man.

3. The main structure-forming factors are belt sequence, afforestation, and the composition of forest-forming species. The set of the revealed factors may be considered as full because the informative knowledge of structure-forming factors and natural regimes in general accounts for 85% of population variance, which corresponds to the multiple correlation coefficient equal to 0.92.

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