

## Spatial distribution of spiders (Aranei) and other groups of soil macrofauna in the arctic tundra of northeastern Taimyr, Russia

### Пространственное распределение пауков (Aranei) и других групп почвенной мезофауны в арктических тундрах северо-восточного Таймыра (Россия)

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КЛЮЧЕВЫЕ СЛОВА: Российская Арктика, хорология, почвенные беспозвоночные, список видов.

**ABSTRACT.** Numerous materials have been processed on soil invertebrates collected by the International Arctic Expedition of the Institute for Evolutionary Morphology and Animal Ecology, Russian Academy of Sciences in 1991 in arctic tundra of eastern Taimyr, near Pronchishchev Lake. The samples revealed six spider species of the only family Linyphiidae, all of them being typical purely arctic. The most common species were *Erigone psychrophila* Thorell, 1872, *Hilaira gertschi* Holm, 1960 and *Semljicola arcticus* (Eskov, 1989). The first two species inhabited all the studied biotopes, whereas *E. psychrophila* was superdominating in each of these biotopes. The fauna of spiders of zonal communities was poorer than that in intrazonal ones (3–4, vs 4–6 species). Spiders play the main role in the structure of the soil macrofauna population of arctic tundra of eastern Taimyr. This group is the most diverse, is the most vast component of the macrofauna, and most earlier in the activity after the winter diapause. The second important group are the beetles (Carabidae and Staphylinidae). While spiders are primary in abundance and the share in the total macrofauna in zonal communities, the intrazonal biotopes are characterized by approximate parity of these groups. The share of spiders in the macrofauna decreases during the summer due to diapause end in other invertebrate groups: the soil samples show a decrease from 38% in June to 30% in July, the data from pitfall traps show a decrease from 75% to 38%. In soil samples, spiders comprised 23–50% of the number of all soil macrofauna in the beginning of vegetation season (June), while declining to 18–36% in the mid-season (July). The total number of soil macrofauna in zonal communities is about twice lower on the average than that in intrazonal ones (82, vs 149 spms/m<sup>2</sup>); the number of spiders is 1.5 times lower (31, vs 48 spms/m<sup>2</sup>), that of beetles is almost 4 times lower (16, vs 62

spms/m<sup>2</sup>). The share of spiders in the macrofauna of zonal communities is considerably higher than that of beetles (39, vs 19%), whereas their shares are approximately the same in intrazonal communities (36, vs 38%). According to data of pitfall traps, the share of spiders is high during the whole season and comprises 50–89%, the share of beetles is much inferior to that of spiders: 8–44%. In the zonal composition, both spiders and other groups of macrofauna are represented by arctic species. A list of spider species is provided for vicinities of Pronchishchev Lake and the nearby Maria Pronchishcheva Bay. The species *Hilaira gertschi*, *H. nivalis* Holm, 1937 and *S. arcticus* are for the first time registered in the fauna of eastern Taimyr, and Pronchishchev Lake is the northernmost locality (75.287026°N) of the presently known species distribution. The data on number and the population density are for the first time provided for various groups of soil macrofauna in arctic tundra.

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**РЕЗЮМЕ.** Обработаны многочисленные материалы по почвенным беспозвоночным, собранные Международной арктической экспедицией института эволюционной морфологии и экологии животных РАН в 1991 г. в арктических тундрах восточного Таймыра, в районе оз. Прончищева. В сборах обнаружено 6 видов пауков одного семейства Linyphiidae, среди которых все являются типичными арктическими элементами. Наиболее массовыми видами оказались *Erigone psychrophila* Thorell, 1872, *Hilaira gertschi* Holm, 1960 и *Semljicola arcticus*

(Eskov, 1989). Первые два населяли все обследованные биотопы, причём *E. psychrophila* в каждом являлся супердоминантом. Фауна пауков зональных сообществ беднее интразональных (3–4, vs 4–6 видов). Основную роль в структуре населения почвенной мезофауны зональных сообществ арктических тундр восточного Таймыра играют пауки. Эта группа наиболее разнообразна, является самым обильным компонентом мезофауны и ранее других начинает свою активность после зимней диапаузы. Второй по значимости группой являются жуки (Carabidae и Staphylinidae). Если в зональных сообществах первенство по обилию и доли в общей мезофауне принадлежит паукам, то в интразональных биотопах у этих групп наблюдается примерный паритет. Доля пауков в мезофауне в течение лета снижается за счёт выхода из диапаузы других групп беспозвоночных: по данным почвенных проб с 38% в июне, до 30% в июле, по данным ловушек: с 75 до 38%. В почвенных пробах пауки составляли 23–50% от численности всех групп почвенной мезофауны в начале вегетационного сезона (июнь), и 18–36% в середине сезона (июль). Общая численность почвенной мезофауны в зональных сообществах в среднем примерно вдвое ниже, чем в интразональных (82, vs 149 экз./кв.м.); численность пауков ниже 1.5 раза (31, vs 48 экз./кв.м.), жуков — почти в 4 раза (16, vs 62 экз./кв.м.). Доля пауков в мезофауне зональных сообществ существенно выше, чем жуков (39, vs 19%), в интразональных сообществах их доли примерно одинаковы (36, vs 38%). По материалам почвенных ловушек доля пауков во всех биотопах в течение всего сезона велика и составляла 50–89%, доля жуков существенно уступала паукам — 8–44%. По зональному составу как пауки, так и остальные группы мезофауны представлены арктическими видами. Приведён список видов пауков окрестностей оз. Прончищева и расположенной неподалёку бухты Марии Прончищевой. Виды *Hilaira gertschi*, *H. nivalis* Holm, 1937 и *S. arcticus* впервые указаны для фауны восточного Таймыра, а оз. Прончищева является самой северной из известных точек (75.287026°N) находок этих видов. Впервые приведены данные по численности и динамической плотности населения различных групп почвенной мезофауны в арктических тундрах.

## Introduction

In 1991, Valery Chesnokov (Moscow) has participated in the summer field studies in arctic tundra of eastern Taimyr in vicinities of Pronchishchev Lake, which were within the framework of the International Arctic Expedition of the Institute for Evolutionary Morphology and Animal Ecology RAS. He collected a rich material on soil invertebrates, particularly on spiders. This material is of considerable interest not only because it has been collected in a hard-to-reach region of the Arctic, but it also allows, besides the soil arthropod

species diversity estimation, to study the peculiarities of their spatial distribution and to reveal the role and position of the main invertebrate groups in the structure of soil macrofauna in tundra communities.

## Regional and climatic peculiarities in 1991

Pronchishchev Lake is located in the NE part of the Taimyr Peninsula, 30 km S of Maria Pronchishcheva Bay and 30 km W of the Laptev Sea coast. The research area is a flat-hilly plain at W of Pronchishchev Lake (75.287026°N, 112.430524°E), which is occupied by various variants of arctic tundra communities of the Laptev Sea basin. The zonal type of vegetation is represented here by undershrub-grass-moss and moss-grass-undershrub arctic tundra [Matveeva, 1979].

The snow melting in the area of studies in 1991 proceeded as follows: on June 15 snow covered 95% of the area, in a week — 90%, and only by the early July the area of snow cover decreased to 10%. The soil frost was not recorded after July 2. The year 1991 was a period of lemming abundance, with the population density comprising 100 to 392 spms per 1 hectare in various variants of plant communities (see Underhill *et al.* [1993]). The high population density of lemmings affected not only the state of predator population but also, probably, the abundance of large arthropods including spiders.

## Material, methods and sampling

The present paper is based on the material collected by Valery Chesnokov in 1991 from the eastern part of the Taimyr Peninsula, on the western bank of Pronchishchev Lake (see Map), and kept at the Zoological Museum of the Moscow State University, Moscow, Russia (ZMMU). Spiders were collected from June 16 to July 15, by soil sampling and pitfall trapping. Vegetation period is short in arctic tundra, with considerable variations of climatic characteristics and with a change of phenophases in vegetation, which reflects in the composition and, especially, abundance of soil population. Therefore, the series of soil samples were taken twice during the season (in June and July). Soil samples (total of 88) for macrofauna were taken at the size of 0.25 x 0.25cm, by layers, 6–8 samples per a plot. The first series of samples (61 samples) was taken at 8 plots in the late June, and the second series of samples (27 samples) was taken at 5 sites in the middle July. Pitfall traps (200 ml plastic cups, filled on 2/3 by 2% of formaldehyde) were set in eight biotopes in lines of 10 traps and exposed for 10 days.

The text below provides information on adult spiders. Immature individuals were taken into account in the total number (in soil samples) or dynamic density (pitfall traps). In total, 841 spider specimens were gained by pitfall traps, of these 353 adults were examined.

Abbreviations used in the text: MPB — Maria Pronchishcheva Bay; PL — Pronchishchev Lake; TPCD — total projective cover degree.

## Typification of plant communities

The scheme proposed by Yuri I. Chernov [1978] for classifying plant communities of the Arctic has been used



Map. IA — investigated area (red spot); PL — Pronchishchev Lake.

Карта. IA — территория исследований (красный круг); PL — оз. Прончищева.

for the analysis of zonal-landscape distribution of tundra spiders. Based on this classification, there are three main zonal-landscape types of plant communities in the tundra: zonal, intrazonal and azonal (for details see Tanasevitch & Rybalov [2015], Tanasevitch & Nekhaeva [2016] and Tanasevitch & Khruleva [2017]). This study does not consider the azonal biotopes due to their regular flooding.

#### Zonal communities (Zonal in the text below).

Plot 1. Hummocky sedge-undershrub-lichen-moss stony tundra on upper parts of gentle slopes on watersheds [1]. Total projective cover degree (TPCD) — ca. 95%. Mosses: *Hylocomium splendens* var. *alaskanum*, *Tomentypnum nitens* — 90%, *Salix polaris* — 2–3%, *Alopecurus alpinus* — 1–2%, *Carex stans* — 1–2%, lichens — *Cetraria nivalis*, *C. cucullata* — 1–3%.

Plot 2. Spotty undershrub-moss-*Dryas* medallion tundra on flat, well-drained watersheds [2]. TPCD — 40–50%. *Dryas punctata* — 20–25%, *Salix polaris* — 5–7%, *Novosieversia glacialis* — 2%, mosses: *Hylocomium splendens* var. *alaskanum*, *Tomentypnum nitens* — 10%. Medallion spots of bare ground — 50%.

Plot 3. Nano-polygonal moss-grass-sedge-undershrub stony tundra on low and flat hills on well-drained watersheds [3]. TPCD — 40–45%. *Dryas punctata* — 15–20%, *Myosotis asiatica* — 3–5%, *Salix polaris* — 2–3%, *Alopecurus alpinus* — 2–3%, *Carex stans* — 2–3%, *Novosieversia glacialis* — 3%, *Hylocomium splendens* var. *alaskanum* — 5%, *Tomentypnum nitens* — 2–3%. Spots of bare ground — 55–60%.

Plot 4. Nano-polygonal moss-sedge stony tundra with sparse vegetation on brook terrace [4]. TPCD — 40–50%, grasses and sedges: *Carex stans* — 10–15%, *Festuca brachyphylla* — 3–5%, *Draba* spp. — 3–5%, *Saxifraga* spp. — 1–2%, mosses: *Polytrichum strictum* — 15–20%, *Tomentypnum nitens* — 3–5%. Spots of bare ground — 50–60%.

#### Intrazonal communities (Intra in the text below).

Plot 5. Grass-*Dryas* tundra on flat, well-drained watersheds [5]. TPCD — 60–70%; *Dryas punctata* — 50%, *No-*

*vosieversia glacialis* — 10–15%, *Saxifraga* spp. — 3–5%). Spots of bare ground ca. 30–40%.

Plot 6. Sedge-lichen-moss-*Dryas* tundra on low, flat hills on watersheds, with small, shallow, wet depressions [6]. TPCD — 50–60%. *Dryas punctata* — 15–20%, *Carex stans* — 5–7%, *Alopecurus alpinus* — 2–3%, mosses: *Hylocomium splendens* var. *alaskanum*, *Tomentypnum nitens* — 20%, lichens — 10%. Spots of bare ground — 20–30%.

Plot 7. Wet cotton-grass tundra on flat depression on lake bank [7]. TPCD — 80–90%. *Eriophorum scheuchzeri* — 50%, *Juncus biglumis* — 5–10%, *Dipontia fisheri* — 5–7%, *Arctagrostis latifolia* — 2–3%, *Calligonum* sp. — 2–3%.

### List of spiders of environs of Pronchishchev Lake and Maria Pronchishcheva Bay

NOTES. Maria Pronchishcheva Bay (see Map) is situated ca. 30 km NE of investigated area, and is located at the same, arctic, subzone of the tundra belt. At present, the fauna of this local arctic tundra is known to contain five spider species only [Chernov, 1978; Eskov, 1985, 1986, 1988; Tanasevitch, 2010], and the information on their biotopical distributions is practically absent. The list of species collected in the area of Pronchishchev Lake includes also species recorded in vicinities of Maria Pronchishcheva Bay, to get a more complete representation of araneofauna of local arctic tundra of eastern Taimyr.

#### Family Linyphiidae

##### *Diplocephalus barbiger* (Roewer, 1955)

1985 *Diplocephalus barbatus*. — Eskov: 123.

1986 *D. barbatus*. — Eskov: 177.

1988 *D. barbatus*. — Eskov: 16.

REMARKS. This species is known from MPB, from dwarf willow-grass-sedge tundra [Eskov, 1985, 1986, 1988]. Not represented in our material.

RANGE. Siberian-Nearctic, arctic.



*Erigone arctica sibirica* Kulczyński, 1908

1978 *Erigone sibirica*. — Chernov: 28.

REMARKS. This species is known from MPB from “arctic tundra”, without precise locality [Chernov, 1978]. Maria Pronchishcheva Bay is the northernmost locality of the presently known species distribution. Not represented in our material.

RANGE. Siberian arcto-boreal.

*Erigone psychrophila* Thorell, 1872

1985 *Erigone psychrophila*. — Eskov: 124.

1986 *E. psychrophila*. — Eskov: 177.

MATERIAL. **Zonal. Pitfall traps.** 26 ♂♂ & ♀♀, hummocky sedge-undershrub-lichen-moss stony tundra [1], 17–27.IV.1991; 13 ♂♂ & ♀♀, spotty undershrub-moss-*Dryas* medallion tundra [2], 17–27.IV.1991; 21 ♂♂ & ♀♀, nano-polygonal stony moss-grass-sedge-undershrub tundra [3], 19–29.VI.1991; 15 ♂♂ & ♀♀, nano-polygonal moss-sedge stony tundra [4], 19–29.VI.1991. **Soil samples.** 5 ♂♂ & ♀♀, [1], 21.VI.1991; 11 ♂♂ & ♀♀, [1], VII.1991; 8 ♂♂ & ♀♀, [2], 15.VII.1991; 2 ♂♂ & ♀♀, [2], VII.1991; 6 ♂♂ & ♀♀, [3], 13.VII.1991; 4 ♂♂ & ♀♀, [3], VII.1991; 10 ♂♂ & ♀♀, [4], VI.1991; 2 ♂♂ & ♀♀, [4], VII.1991.

**Intra. Pitfall traps.** 46 ♂♂ & ♀♀, grass-*Dryas* tundra [5], 16–26.VI.1991; 43 ♂♂ & ♀♀, sedge-lichen-moss-*Dryas* tundra [6], 17–27.VI.1991; 34 ♂♂ & ♀♀, cotton-grass wet tundra [7], 19–29.VI.1991. **Soil samples.** 11 ♂♂ & ♀♀, [5], VI.1991; 14 ♂♂ & ♀♀, [5], VII.1991; 16 ♂♂ & ♀♀, [6], VI.1991; 16 ♂♂ & ♀♀, [7], VI.1991; 7 ♂♂ & ♀♀, [7], VII.1991.

REMARKS. This species was recorded from MPB, from stony dwarf willow-moss tundra, and from dwarf willow-grass-sedge tundra [Eskov, 1985, 1986].

RANGE. Holarctic, arctic.

*Halorates spetsbergensis* (Thorell, 1872)

1985 *Collinsia spetsbergensis*. — Eskov: 123.

1986 *C. spetsbergensis*. — Eskov: 177.

MATERIAL. **Zonal. Pitfall traps.** 1 ♀, spotty undershrub-moss-*Dryas* medallion tundra [2], 17–27.VI.1991. **Soil samples.** 1 ♀, [2], VI.1991; 4 ♂♂ & ♀♀, [2], VII.1991; 1 ♂, nano-polygonal moss-grass-sedge-undershrub stony tundra [3], VI.1991; 1 ♀, [3], VII.1991; 1 ♂, nano-polygonal moss-sedge stony tundra [4], VI.1991; 1 ♂, 1 ♀, [4], VII.1991.

**Intra. Pitfall traps.** 3 ♀♀, sedge-lichen-moss-*Dryas* [6], 17–27.VI.1991; 4 ♀♀, cotton-grass wet tundra on flat depression on lake bank [7], 17–27.VI.1991. **Soil samples.** 1 ♀, [6], VI.1991; 2 ♀♀, [7], VI.1991; 2 ♂, 1 ♀, [7], VII.1991.

REMARKS. This species was recorded from MPB, from dwarf willow-moss tundra, and from dwarf willow-grass-sedge tundra [Eskov, 1985, 1986].

RANGE. Holarctic, arctic.

*Hilaira gertschi* Holm, 1960

MATERIAL. **Zonal. Pitfall traps.** 7 ♂♂ & ♀♀, hummocky sedge-undershrub-lichen-moss stony tundra [1], 17–27.IV.1991; 7 ♂♂ & ♀♀, spotty undershrub-moss-*Dryas* medallion tundra [2], 17–27.IV.1991; 7 ♂♂ & ♀♀, nano-polygonal moss-grass-sedge-undershrub stony tundra [3], 19–29.VI.1991; 4 ♂♂ & ♀♀, nano-polygonal moss-sedge stony tundra [4], 19–29.VI.1991. **Soil samples.** 2 ♂, hummocky sedge-undershrub-lichen-moss stony tundra [1], VI.1991; 1 ♀, [1], VII.1991; 2 ♀♀, [2], VI.1991; 1 ♂, [2], VII.1991; 1 ♀, nano-polygonal moss-grass-sedge-undershrub stony tundra [3], VI.1991; 1 ♀, [3], VII.1991; 1 ♂, [3], VII.1991; 1 ♀, nano-polygonal moss-sedge stony tundra [4].

**Intra. Pitfall traps.** 30 ♂♂ & ♀♀, grass-*Dryas* tundra [5], 16–26.VI.1991; 15 ♂♂ & ♀♀, sedge-lichen-moss-*Dryas* tundra [6], 16–

26.VI.1991; 1 ♀, cotton-grass wet tundra on flat depression on lake bank, [7], 19–29.VI.1991. **Soil samples.** 1 ♂, 1 ♀, [5], VI.1991; 2 ♀♀, [6], VI.1991; 1 ♂, [7], VI.1991; 1 ♀, [7], VII.1991.

REMARKS. Pronchishchev Lake is the northernmost locality (75.287026°N) of the presently known species distribution.

RANGE. Siberian-Alaskan, arctic.

*Hilaira nivalis* Holm, 1937

MATERIAL. **Intra. Pitfall traps.** 1 ♀, sedge-lichen-moss-*Dryas* tundra [6], 17–27.VI.1991.

REMARKS. Pronchishchev Lake is the northernmost locality (75.287026°N) of the presently known species distribution.

RANGE. West Siberian, arctic.

*Hybauchenidium aquilonare* (L. Koch, 1879)

1985 *Hybauchenidium aquilonare*. — Eskov: 126, examined.

1986 *H. aquilonare*. — Eskov: 177, examined.

2010 *H. aquilonare*. — Tanasevitch: 276.

MATERIAL RE-EXAMINED. 3 ♂♂, 4 ♀♀ (ZMMU), eastern Taimyr, Maria Pronchishcheva Bay, *Salix* stands on slope with *Carex* & graminoids, 20–25.VII.1973, leg. Yu.I. Chernov.

MATERIAL. **Zonal. Pitfall traps.** 1 ♀, hummocky sedge-undershrub-lichen-moss stony tundra [1], 17–27.IV.1991; 1 ♂, spotty undershrub-moss-*Dryas* medallion tundra [2], 17–27.IV.1991; 1 ♀, nano-polygonal moss-grass-sedge-undershrub stony tundra [3], 19–29.VI.1991; 1 ♀, nano-polygonal moss-sedge stony tundra [4], 19–29.VI.1991. **Soil samples.** 1 ♀, [2], VI.1991.

**Intra. Pitfall traps.** 1 ♂, 1 ♀, grass-*Dryas* tundra [5], 16–26.VI.1991; 1 ♂, 1 ♀, sedge-lichen-moss-*Dryas* tundra [6], 17–27.VI.1991. **Soil samples.** 1 ♂, [5], VI.1991; 1 ♂, 1 ♀, [6], VI.1991.

REMARKS. This species was recorded from MPB, from dwarf willow-grass-sedge tundra [Eskov, 1985, 1986; Tanasevitch, 2010].

RANGE. Siberian-West Nearctic, arctic.

*Semljicola arcticus* (Eskov, 1989)

MATERIAL. **Zonal. Pitfall traps.** 4 ♂♂ & ♀♀, hummocky sedge-undershrub-lichen-moss stony tundra [1], 17–27.IV.1991; 7 ♂♂ & ♀♀, nano-polygonal moss-grass-sedge-undershrub stony tundra [3], 19–29.VI.1991; 8 ♂♂ & ♀♀, nano-polygonal moss-sedge stony tundra [4], 19–29.VI.1991. **Soil samples.** 1 ♂, [1], VI.1991; 1 ♂, [1], VII.1991; 1 ♂, [4], VI.1991; 1 ♀, [4], VII.1991.

**Intra. Pitfall traps.** 34 ♂♂ & ♀♀, grass-*Dryas* tundra [5], 16–26.VI.1991; 9 ♂♂ & ♀♀, sedge-lichen-moss-*Dryas* tundra [6], 17–27.VI.1991. **Soil samples.** 2 ♀♀, [5], VI.1991; 1 ♂, [6], VI.1991.

REMARKS. Pronchishchev Lake is the northernmost locality (75.287026°N) of the presently known species distribution.

RANGE. Siberian, arctic.

## Results and Discussion

## Taxonomic composition of the soil macrofauna

The araneofauna of the local tundra in vicinities of Pronchishchev Lake is represented by the family Linyphiidae only. Spiders were collected by pitfall traps and soil samples during virtually the entire the snowless season, but species of other families characteristic of continental tundra, like as Lycosidae, Thomisidae, Tetragnathidae, have not been found even as juveniles.

Table 1. The population density of spiders, beetles, and other groups of macrofauna as accounted by soil samples in June, 1991 (spms per 1 m<sup>2</sup>).  
 Таблица 1. Плотность населения пауков, жуков и других групп мезофауны по данным учёта почвенными пробами в июне 1991 года (в экз. на 1 м<sup>2</sup>).

	Types of plant communities						
	Zonal				Intrazonal		
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7
<b>Date</b>	21.VI	28.VI	30.VI	26.VI	29.VI	30.VI	27.VI
<b>TAXA</b>	<b>Number or % of collected specimens</b>						
<b>Spiders (total)</b>	36±4.7	32±4.5	24±2.9	31±4.3	51±5.6	46±6.4	46±6.9
% of total macrofauna	31	46	42	37	33	23	50
<b>Beetles (imago+larvae)</b>	29±3.5	11±1.6	10±1.4	15±2.0	64±8.3	99±11.9	22±3.1
% of total macrofauna	25	16	18	18	42	50	23
Carabidae imago	11±1.4	2±0.3	5±0.6	6±0.8	5±0.7	10±1.4	6±0.8
% of total macrofauna	9	3	9	7	3	5	6
Staphylinidae (imago+larvae)	18±2.3	9±1.4	5±0.8	9±1.1	59±7.7	89±12.5	16±2.6
% of total macrofauna	15	13	9	11	39	45	17
<b>Other groups of macrofauna</b>							
Enchytraeidae*	38±4.6	2±0.3		9±1.3	8±1.1	32±4.8	7±1.0
Lumbricidae (adults+juv.)	3±0.3	9±1.2	8±1.1	11±1.4	8±0.9	9±1.1	5±0.7
Homoptera (imago)					11±1.2		
Tipulidae (imago)	3±0.3	11±1.6	5±0.6	14±1.6		5±0.5	7±0.9
Tipulidae (larvae)	5±0.6		5±0.8	2±0.3		7±0.8	2±0.3
Limoniidae (larvae)		5±0.7					
Diptera (imago)				2±0.3	3±0.3		
Hymenoptera (imago)	3±0.4				3±0.4	2±0.3	2±0.3
Lepidoptera (larvae)			5±0.7		5±0.6		2±0.4
<b>Macrofauna (total)</b>	117±14.0	70±10.5	57±7.9	84±13.2	153±18.4	200±27.5	93±13.9

\* Visually recorded in soil samples.

Despite the relatively high abundance of spiders in practically all biocenoses in vicinities of Pronchishchev Lake, their species diversity is very low. Only six spider species have been recorded during the whole period of investigations. The species composition of zonal communities is poorer than that of intrazonal ones: the four different zonal plots were inhabited by 3 to 4 spider species, whereas the fauna of 3 intrazonal ones included 4–6 species (Tables 2 & 3). In the nearby region, near Maria Pronchishcheva Bay, besides six species from the Table 2, the two additional have been found: *Diplocephalus barbiger* and *Erigone arctica sibirica* (see above in the List).

The taxonomic poorness of araneofauna indicates the very pessimal conditions of local arctic tundra. The pooriness of the fauna was recorded also in other mass groups of macrofauna. For example, among the fauna of Carabidae and Staphylinidae beetles, only two species were found in each of these families: *Cryobius*

*pinquedineus* and *C. ventricosus*, and also *Tachinus* (s.str.) *arcticus* and *Micralymma brevilingue*, respectively. The macrofauna composition in almost all biocenoses included single specimens of Lumbricidae (*Eisenia nordenskioldi*), Tipulidae (larvae and imago), Lepidoptera (larvae), and Hymenoptera imago. In general, the taxonomic structure of macrofauna of local tundra is corresponding well with data of Yu.I. Chernov and N.V. Matveeva [1979], who mentioned that arctic tundra are characteristic by a drastic impoverishment in the fauna species composition resulted in representation of each large taxa by only single species.

As concerns the zonal composition of the soil arthropods, practically all groups are represented by arctic species. For example, out of spider species (including two from Maria Pronchishcheva Bay area) the seven ones are purely arctic, and only one, *Erigone arctica sibirica*, is an arcto-boreal element, probably found at the northernmost border of its distribution.

Table 2. Data on records of spiders and beetles by pitfall traps in June, 1991 (spms per 100 pitfall traps/day).  
Таблица 2. Данные учёта пауков и жуков почвенными ловушками в июне 1991 (в экз. на 100 лов./сут.).

	Types of plant communities Типы растительных сообществ						
	Zonal Зональные				Intazonal Интразональные		
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7
<b>Date / Дата</b>	17- 21.VI	17- 27.VI	19- 29.VI	19- 29.VI	16- 26.VI	17- 27.VI	19- 29.VI
<b>TAXA</b>	Number or % of collected specimens Количество или % пойманных экземпляров						
<b>Spiders (total)</b>	113	79	77	80	222	186	84
% of total macrofauna	79	82	88	71	89	67	50
Species of spiders							
<i>Erigone psychrophila</i>	26	13	21	15	46	43	34
<i>Halorates spetsbergensis</i>		1				3	4
<i>Hilaira gertschi</i>	7	7	7	4	30	15	1
<i>Hilaira nivalis</i>						1	
<i>Hybauchenidium aquilonare</i>	1	1	1	1	4	5	
<i>Semljicola arcticus</i>	4		7	8	34	9	
Total adult specimens	38	22	36	28	114	76	39
Total species of spiders	4	3	4	4	4	6	4
<b>Beetles</b>							
Carabidae *	18	7	11	9	19	28	21
<i>Cryobius pinquedineus</i>	18	7	11	9	17	28	21
<i>Cryobius ventricosus</i>					2		
Staphylinidae (im.+larvae)	10	1	7	17	5	38	53
<i>Tachinus</i> (s.str.) <i>arcticus</i> (im.)	8	1	5	14	4	10	13
<i>Micralymma brevilingue</i> (im.)	2		1	3	1	1	2
Carabidae & Staphylinidae	28	8	18	26	24	66	74
% of total macrofauna	19	8	20	23	10	24	44
<b>Macrofauna (total)</b>	145	96	88	112	249	277	167

\* Carabidae were represented only by imago.

### Spiders and beetles in the structure of soil macrofauna

**Soil samples.** The studies have shown that in local arctic tundra the spiders comprise 23–50% in the number of all groups of the soil macrofauna in June (Table 1) and 18–36% in the mid-season, in July (Table 4). The share of beetles was, correspondingly, 16–50% in June and 15–26% in July.

Spiders dominated among all the groups of the soil macrofauna in the beginning of vegetation period (June) in all variants of zonal communities. The intrazonal communities showed a somewhat different pattern: in two of the three localities beetles dominated, while the spiders were prevalent in only one: 42; 50 and 23%, vs 33; 23 and 50% in spiders.

The total mean number of soil macrofauna in zonal communities appeared to be about twice lower than in

intrazonal ones (82, vs 149 spms/m<sup>2</sup>), the spider abundance was 1.5 times lower (31, vs 48 spms/m<sup>2</sup>), that of beetles — almost 4 lower (16, vs 62 spms/m<sup>2</sup>).

The share of spiders in the macrofauna of zonal communities is considerably higher than that of beetles (39, vs 19%), in intrazonal communities their shares are approximately the same (35, vs 38%). This probably indicates that beetles are either less adapted to extremal arctic living conditions than the spiders, and prefer intrazonal vegetative communities with more favourable environment, or the intrazonal biotopes provide a more vast food supply, which allows ground beetles and rove beetles to realize their reproductive potential more effectively in these conditions.

In July, in the vegetation mid-season, the share of spiders in the composition of inhabitants was also rather high: 18–36%, the share of beetles comprising 15–

Table 3. The population density of spiders, beetles, and other groups of macrofauna as accounted by soil samples in June, 1991 (spms per 1 m<sup>2</sup>).  
 Таблица 3. Плотность населения пауков и массовых видов жуков по данным учета почвенными пробами в июне 1991 (в экз. на 1 м<sup>2</sup>).

	Type of plant communities						
	Zonal				Intrazonal		
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7
<b>Date</b>	21.VI	28.VI	30.VI	26.VI	29.VI	30.VI	27.VI
<b>TAXA</b>	<b>Number or % of collected specimens</b>						
<b>Spiders (adults+juv.)</b>	36±4.7	32±4.5	24±2.9	31±4.3	51±5.6	46±6.4	46±6.9
% of total macrofauna	31	46	42	37	33	23	50
Spiders juv.	9±1.3	9±1.4	8±1.1	9±1.3	16±2.2	3±0.4	5±0.7
Species of spiders							
<i>Erigone psychrophila</i>	23±3.2	18±2.9	13±2.1	19±2.7	24±3.6	32±5.4	36±5.8
<i>Halorates spetsbergensis</i>		1±0.14	1±0.16	1±0.12		1±0.2	3±0.5
<i>Hilaira gertschi</i>	3±0.4	3±0.5	2±0.3	2±0.3	4±0.6	5±0.9	2±0,3
<i>Hybauchenidium aquilonare</i>		1±0.2			2±0.3	3±0.5	
<i>Semljicola arcticus</i>	1±0.2			3±0.5	5±0.8	2±0.3	
Total species of spiders	3	4	3	4	4	4	3
<b>Beetles</b>							
Carabidae							
<i>Cryobius pinquedineus</i> (im.)	11±1.7	2±0.2	5±0.7	6±0.9	5±0.7	5±0.7	6±0.9
Carabidae (larvae)						5±0.6	
Staphylinidae							
<i>Tachinus</i> (s.str.) <i>arcticus</i> (im.)	4±0.6	7±1.1	4±0.6	8±1.1	42±6.3	48±7.7	14±2.2
<i>Micralymma brevilingue</i> (im.)	1±0.2	2±0.3	1±0.2	1±0.2	6±0.9	9±1.4	2±0.3
Staphylinidae (larvae)	13±1.4				11±1.4	32±3.8	
<b>Macrofauna (total)</b>	117±14.0	70±8.5	57±7.9	84±13.2	153±18.4	200±27.5	93±13.9

26% (Table 4). Regretfully, two of the three intrazonal areas appeared out of study due to flooding in July, and therefore we cannot reliably estimate and compare the data on the abundance of macrofauna in intrazonal and zonal communities.

**Pitfall traps.** According to data from pitfall traps which primarily estimate the dynamic density of population, the share of spiders in macrofauna was much higher as compared to samples in most areas. In June, the share of spiders was 50–89%, and that of beetles was only 8–44% (Table 2). In zonal communities, the share of spiders on the average increased that of beetles by 4 times (80, vs 18%), in intrazonal — by 3 times (70, vs 26%).

The data of account by soil samples and pitfall traps definitely indicate that spiders play the main role in the structure of soil fauna of zonal communities of arctic tundra. The second in importance group are beetles, Carabidae and Staphylinidae in this case, with

share the first place with spiders in intrazonal communities.

#### Dominance in spiders

The area of Pronchishchev Lake is the northernmost (75.28°N) territory of Russian Arctic where faunal-ecological studies of spiders were performed on the basis of zonal-landscape approach (after Chernov [1978]). Other areas of studies based on such an approach are situated much southward: Kola Peninsula — 69.11–69.15°N [Tanasevitch, Rybalov, 2010], Amderma, Arkhangelsk Area — 69.75°N [Tanasevitch, Khruleva, 2017], northern Yamal Peninsula — 70.47–71.49°N [Tanasevitch, Rybalov, 2015], Kharaulakh, Yakutia — 71.63–72.19°N [Tanasevitch, Nekhaeva, 2016], and Sibiryakova Island, Krasnoyarsk Area — 72.73°N [Tanasevitch *et al.*, 2020]. The dominant spiders on the listed areas are (in alphabetic order): *Erigone arctica palaeartica* Brøndegaard, 1934, *E. a. si-*

Table 4. The population density of spiders and mass beetles from the data of accounting by soil samples in July, 1991 (spms per 1 m<sup>2</sup>).  
Таблица 4. Плотность населения пауков и массовых видов жуков по данным учета почвенными пробами в июле 1991 г. (в экз. на 1 м<sup>2</sup>).

	Types of plant communities				
	Zonal				Intrazonal
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 7
<b>Date</b>	10.VII	15.VII	13.VII	12.VII	11.VII
<b>Taxa</b>	<b>Number or % of collected specimens</b>				
<b>Spiders (adults &amp; juv.)</b>	34±5.5	17±2.4	15±2.4	11±1.9	29±4.6
% of total macrofauna	36	30	29	18	36
Spiders juv.	7±1.1				4±0.6
Species of spiders					
<i>Erigone psychrophila</i>	24±3.8	5±0.8	10±1.5	5±0.8	17±2.9
<i>Halorates spetsbergensis</i>		10±1.7	3±0.5	4±0.7	7±1.0
<i>Hilaira gertschi</i>	1±0.2	2±0.3	2±0.3	1±0.2	1±0.2
<i>Semljicola arcticus</i>	2±0.3			1±0.2	
<b>Beetles (imago)</b>	14±1.8	13±1.9	13±1.7	16±2.4	14±1.8
% of total macrofauna	15	23	25	26	18
Carabidae					
<i>Cryobius pinquedineus</i>	5±0.7	8±1.2	7±0.9	5±0.7	5±0.8
Staphylinidae	9±1.5	5±0.9	7±1.0	11±1.8	9±1.3
<i>Tachinus (s.str.) arcticus</i>	7±1.1	4±0.7	6±0.8	9±1.5	8±1.1
<i>Micralymma brevilingue</i>	2±0.3	1±0.2	1±0.2	3±0.5	1±0.2
<b>Macrofauna (total)</b>	94±13.1	57±6.8	52±7.3	61±7.9	81±11.3

*birica* Kulczyński, 1908, *E. psychrophila*, *Halorates holmgreni* (Thorell, 1871), *H. spetsbergensis* (Thorell, 1872), *Hilaira incondita* (L. Koch, 1879), and *Masikia indistincta* (Kulczyński, 1908). From the south to the north, from southern tundra to arctic ones, the importance of *E. psychrophila*, as dominant in the spider population, is increasing, and here, in northeastern Taimyr, in the northernmost of studied regions, this species becomes the only superdominant in all types of vegetative communities, as based on data of both soil samples and pitfall traps (Tables 2, 3).

#### Types of spider population

Based on data from soil samples and pitfall traps in local arctic tundra, two types of spider population groups can be recognized in both zonal and intrazonal vegetative communities.

##### 1. Zonal communities.

a) Basically, this spider group is rather homogeneous in abundance and composition. It inhabits tundra with large areas of exposed surface (plots 2, 3, 4). All the three plots have lower abundance of spiders, as compared to intrazonal communities, — 24–36 spms/

m<sup>2</sup> (Table 1) and lower dynamic density — 77–80 spms/100 traps per day. (Table 2). Besides, all the three plots are similar in abundance of main species: *Erigone psychrophila* is dominating, with abundance of 13–19 spms/m<sup>2</sup>; *Hilaira gertschi* — 2–3 spms/m<sup>2</sup>; *Halorates spetsbergensis* — 1 spm/m<sup>2</sup> (Table 3). The reason of relative poverty of these three zonal communities is that 50–60% of their area consist of lifeless spots of exposed surface. Let us mention that the main competitor of spiders, i.e. the ground beetle *Cryobius pinquedineus* also had a rather low abundance in all the three plots — 2–6 spms/m<sup>2</sup> and a rather low dynamic density — 7–11 spms/100 traps per day.

b) The second zonal group of spiders (plot 1) lives in quite moistened moss-lichen tundra with virtually complete covering of vegetation (TPCD — 95%). This community is characterized by more numerous population, as compared to the previous group, — 36 spms/m<sup>2</sup>, 113 spms/100 traps per day. The dominating species *E. psychrophila* has also a higher abundance here — 24 spms/m<sup>2</sup> and the dynamic density — 26 spms/100 traps per day. It is characteristic that this community possess 2–3 times higher abundance of both all



beetles (29 spms/m<sup>2</sup>, vs 10–15 spms/m<sup>2</sup>), and the main species of ground beetle, *Cryobius pinquedineus* (11 spms/m<sup>2</sup>, vs 2–6 spms/m<sup>2</sup>) (Table 3).

#### 2) Intrazonal communities.

a) Spider groups inhabiting the meadow tundra with domination of dryads and relatively good drainage (plots 5 & 6). The fauna composition of these tundra communities is much diverse than in zonal ones, and the spider abundance is on average twice higher of that in zonal formations (46–51 spms/m<sup>2</sup>, vs 24–36 spms/m<sup>2</sup>) (Tables 1–3). These plots, besides the superdominant *E. psychrophila*, are inhabited also by subdominants *Hilaira gertschi* and *Semljicola arcticus*, as indicated by data from both soil samples and pitfall traps. The population of sedge-lichen-moss-*Dryas* tundra (plot 6) is the most diverse. All the six spider species of local fauna are recorded here because this plot, besides grassland-dryad parcels, includes wet depressions with additional microconditions for spiders.

b) Group inhabiting wet cotton-grass tundra (plot 7). This boggy community, as everywhere, is dominated by *E. psychrophila* — 34 spms/100 traps per day, and a subdominant — 4 spms/100 traps per day (Table 1) is hydrophilic species *Halorates spetsbergensis*, which is rather few in other biocenoses. *Hilaira gertschi* is a rare species here. The samples, as compared to data from traps, are characterized by even stronger dominating of *E. psychrophila* — 36 spms/m<sup>2</sup> (79% of all spiders).

#### Dynamics of spider population (June–July)

In mid-July, the samples were again taken in five biocenoses (zonal plots 1–4 & intrazonal plot 7) (Table 4). Since only one plot was studied in intrazonal communities in July, we cannot reliably compare the population of two different landscape-zonal types of communities.

The share of spiders and beetles in the soil population of tundra somewhat decreases during the summer: that of spiders on average from 38% of the total macrofauna in June to 30% in July; that of beetles from 27 to 21%, respectively. The share of spiders decreases due to lesser number of dominants. For example, the number of the main dominant *Erigone psychrophila* and the subdominant *Hilaira gertschi* decreased twice in July as compared to June: from 24 to 12 spms/m<sup>2</sup> and from 3 to 1.4 spms/m<sup>2</sup>, respectively (Tables 1 & 3). On the contrary, the scanty in June species *Halorates spetsbergensis* increased its density from 1 to 4.8 spms/m<sup>2</sup> (Tables 1 & 3) in July. It can be suggested that one of the reasons of diminished number of large-sized spiders *E. psychrophila* was the outbreak of the number of lemmings which comprised from 100 to 392 spms per 1 hectare, the diet of lemmings includes this spider (see Underhill *et al.* [1993]).

#### Conclusions

Arctic tundra of eastern Taimyr in vicinities of Pronchishchev Lake possess a very poor spider fauna con-

taining only six species of linyphiids, plus two additional species of linyphiids have been found in nearby area of Maria Pronchishcheva Bay. The number of species in other main groups of soil macrofauna appeared to be also very low: two species were found in both ground beetles and rove beetles. All species of both spiders and beetles are purely arctic. The only species, *Erigone arctica sibirica*, known from Maria Pronchishcheva Bay, is arcto-boreal and was probably found at the northern border of its distribution.

Spiders play the main role in the structure of the soil macrofauna population in zonal communities of arctic tundra of eastern Taimyr. This group is the most diverse and the most numerous in the soil macrofauna population. It also begins the activity after the winter diapause earlier than other groups. The second in importance group is beetles (Carabidae and Staphylinidae). Whereas the spiders take the first place in abundance and the share in the total macrofauna in zonal communities, there is an approximate parity of spiders and beetles in intrazonal biotopes. Among spiders, *Erigone psychrophila* is an absolute dominant in all studied biotopes, irrespective of their zonal-landscape category, and it reaches in some biotopes the density of 32–36 spms/m<sup>2</sup>. The most abundant beetles were *Cryobius pinquedineus* (Carabidae) and *Tachinus* (s.str.) *arcticus* (Staphylinidae).

Intrazonal vegetative communities possess not only the most taxonomic diversity of spiders but they have more abundant population of the soil macrofauna: the data on population density and the trap catches are on average twice higher than in the zonal biotopes.

Our data support the statements of Yu.I. Chernov and N.V. Matveeva [1979] that there is a sharp decline in the species composition in the fauna of arctic tundra, which results in representation by single species in each large taxon. Also, the same species can inhabit a wider range of biotopes in arctic tundra because of the general pessimal conditions. This is well demonstrated by the spider *Erigone psychrophila*.

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