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Myriapods (Myriapoda) occurring on plains and in mountain ecosystems on the Kola Peninsula (Russia)

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Abstract. Based on the literature there are five species of myriapod, four species of centipede (Chilopoda) and one symphylan (Symphyla) recorded on the Kola Peninsula. During research in different biogeographical subzones on the Kola Peninsula, only three species of centipede were found: *Lithobius curtipes* C. L. Koch, 1847, *Lithobius forficatus* (Linnaeus, 1758), and *Geophilus proximus* Koch, 1847. The polyzonal eurytopic species *L. curtipes* occurred widespread along a latitudinal gradient from the White Sea Islands to the tundra ecosystems on the coast of the Barents Sea and in all mountain belts on the Hibiny Mountain Massive up to the high-altitude rocky desert. *G. proximus* is rare on the Kola Peninsula and it is probable that the limit of its distribution coincides with the timberline on both the plains and in mountain habitats. *L. forficatus* was found only once in northern taiga forest in the continental part of the region. Millipedes (Diplopoda) were not recorded, although they occur in the neighbouring Republic of Karelia (Russia) and in northern areas of Scandinavian countries. The poverty of the myriapod fauna is due to the geographic position of this region inside the Arctic Circle, a cool, humid climate and acid podzol soils with low content of calcium. A map of the distribution of myriapod species on the Kola Peninsula is presented and the results of a six-year study of the altitudinal distribution of centipedes on the Hibiny Mountain Massive are summarized.

Key words. Distribution, density, latitudinal gradient, high-altitude gradient, soil parameters, Myriapoda, Russia, Kola Peninsula.

INTRODUCTION

Myriapod fauna of the Russian Federation includes at least 264 species in four classes: 180 millipedes (Diplopoda), 80 centipedes (Chilopoda), two pauropods (Pauropoda) and two symphylans (Symphyla) (Skarlato et al. 1994, Golovach 1995, Shileyko 1995). Five species are known from the Kola Peninsula. Four centipede species were noted at the beginning of the 20th century: two lithobiomorph species – *Lithobius* (*Monotarsobius*) *curtipes* Koch, 1847, and *Lithobius forficatus* (Linnaeus, 1758), and two geophilomorph species – *Geophilus proximus* Koch, 1847, and *Pachymerium ferrugineum* (Koch, 1835) (Palmen 1948). The occurrence of these species was confirmed during a ten-year study of the soil fauna on the White Sea Islands in the Kandalakša Nature Reserve in the southern part of the Kola Peninsula (Byzova et al. 1986, Tchesunov et al. 2008, Koryakin et al. 2009). In addition, one species belonging to the genus *Symphylella* (Symphyla) was found on these Islands (Byzova et al. 1986). Currently information about the distribution of species on the Kola Peninsula is fragmented, including the data on the ecology of *L. curtipes*. This species is known to occur in the tundra zone on the coast of the Barents Sea (69° N, 36° E; Striganova 1973, Evdokimova et al. 2006), in the Pasvik Nature Reserve on the border of northern taiga/forest-tundra (69° N, 29° E; Zenkova 2012) and in natural and industrially polluted forest soils in the central part of the region (Zenkova 1999, 2000, Evdokimova et al. 2002, 2005, Zenkova & Petrashova

2003, 2008a, b, Petrashova 2009, 2010). There is no information on the diversity and altitudinal distribution of myriapods in mountain ecosystems on the Kola Peninsula.

In the period 1996–2014 we studied the soil fauna in a wide range of natural and anthropogenic ecosystems from the northern taiga subzone on the Kola Peninsula to forest-tundra and tundra province on the coast of the Barents Sea, including mountain ecosystems on the alkaline Hibiny Mountain Massive and in the protected Pasvik Nature Reserve. The latitudinal distribution of myriapod species on the Kola Peninsula and an analysis of six-year research on the altitudinal distribution of centipedes in the mountains in this polar region are summarised in this article.

MATERIALS AND METHODS

Fifty-seven sites in northern taiga, forest-tundra and tundra subzones on the Kola Peninsula were investigated (Figs. 1, 2). Within the forest-tundra and tundra (68° 10' – 69° 19' N, 29° 36' – 34° 17' E), four sites along the Barents Sea coast were investigated: a plot of birch forest-tundra (T1), typical plain tundra (T2) and the littoral zone on the seashore (T3) in 2006, and several plots along low-level upland at Dal'nie Zelency (T4) in 2009. On the border between forest-tundra/northern-taiga a plain secondary birch forest (PRB) and nine mountain sites (PRM), including three rare pine forests, three birch tortuous forests and three mountain tundra sites were studied in the protected Russian area in the cross-border Pasvik Nature Reserve (69° 08–18' N, 29° 14–27' E) in 2010–2013. Within the northern taiga (66° 56'– 67° 35' N, 29° 36' – 34° 17' E), ten native forest sites were studied from 1996 to 2007, which included five spruce forests (S1–S5) and five

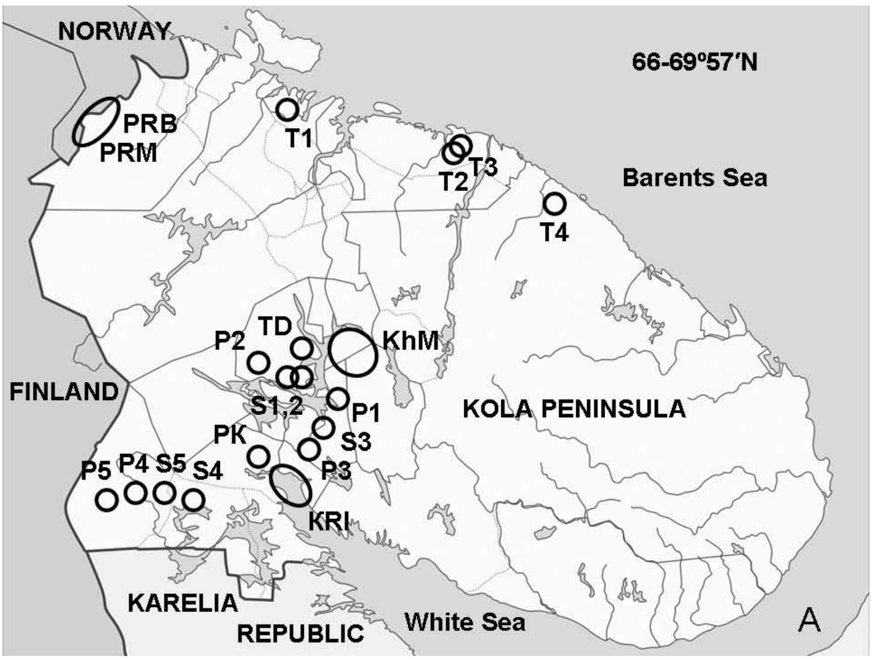

Fig. 1. Sites studied on the Kola Peninsula. Tundra and forest-tundra floristic province. T1 – Vidâevo, T2 – Teriberka, T3 – Barents Sea littoral zone, T4 – Dal'nie Zelency. Boundary between forest-tundra/northern taiga: PRB – Pasvik Nature Reserve plain birch, PRM – Pasvik Nature Reserve Mountains. Northern-taiga: P1–P5 – pine forests, S1–S5 – spruce forests, TD – technogenic desert resulting from industrial fall-out 5 km from the "Severonikel" plant, PK – damaged pine forest in the fall-out zone 2 km from the Kandalakša aluminium plant, KRI – White Sea Islands in the Kandalakša Nature Reserve, KhM – Hibiny Mountain Massive.

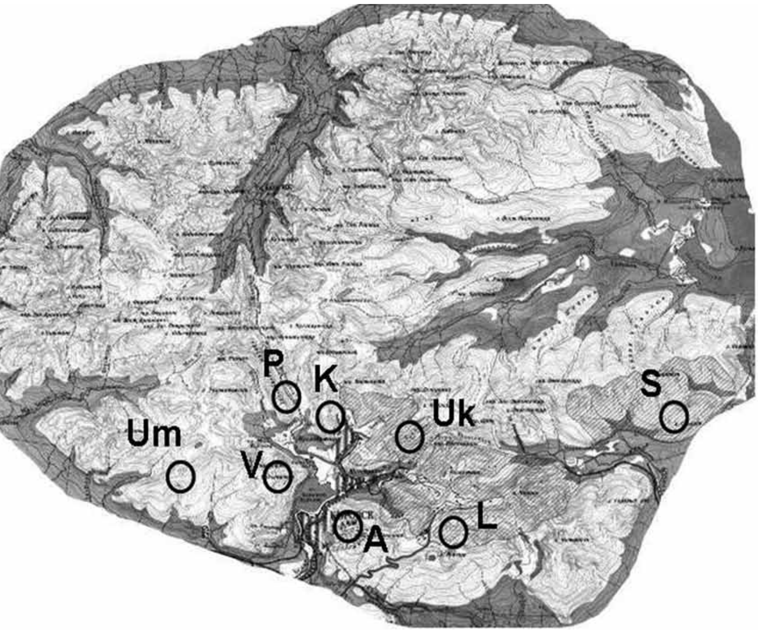

Fig. 2. Sites studied on the Hibiny Mountain Massive. L – Lovčorr Mt, Uk – Uksporr Mt, K – Kukisvumčorr Mt, Um – Umečorr Mt, A – Ajkâjvenčorr Mt, V – Vudjâvrčorr Mt, P – Poačvumčorr Mt, S – Suolaiv Mt.

pine forests (P1–P5). All coniferous forests were approximately 100-150 years old with a well-developed vegetative cover, including shrubs, grasses, mosses and lichens in different proportions. Several disturbed sites were investigated along two gradients of soil pollution: (1) – at distances of 5, 15 and 30 km from the Severonikel copper-nickel plant in 1996–2000, and (2) – at distances of 2, 5, 10 and 20 km from the Kandalakša aluminium plant in 2000–2005. On the Hibiny Mountain Massive (KhM; 67° 35–49' N, 33° 14' – 34° 11' E) 26 sites, including rare spruce, pine and birch tortuous forests, high-mountain tundra and rocky desert were studied on the slopes of eight different mountains (Fig. 2). In addition, literature data of a ten-year soil zoological research on 21 White Sea Islands in the Kandalakša Nature Reserve (KRI) in the south of the Kola Peninsula were taken into consideration (Byzova et al. 1986).

Hydromorphic peat soils and semi-hydromorphic peat podzol soils are typical for lowland and mountain tundra on the Kola Peninsula (Pereverzev 2004, 2010, 2013). Shallow iron-illuvial podzols on a sandy moraine prevail in coniferous forests in the Pasvik Nature Reserve. Al-Fe-humus podzol (or humus-illuvial podzol) on sandy moraine deposits is a predominant soil type in the northern taiga, except on the Hibiny Mountain Massive. Dark humus-illuvial podzols (or high-humus podzols) developed on alkaline nepheline syenite rocks rich in minerals under mountain forests and podbur soils with a large amount of organic material under mountain tundra.

Two methods were used to study of invertebrates on the sites: litter sampling and 500 ml Barber traps containing 4% formaldehyde (Barber 1931, Ghilarov 1975). The litter samples, each 25×25 and up to 7(9) cm deep, were collected monthly after the snow melted, beginning in May or June and continuing to September. At each site not less than 5 litter samples and 20–40 traps were used, depending on the heterogeneity of the vegetation cover. The period of the traps set was 2–3 months during the growing season from May–June to August–September. Hand sorting was used to find animals in the litter samples and trap catches, following the electric heating of the litter in the laboratory. All groups of invertebrates were counted in soil samples and trap catches, including myriapods. Centipedes were identified using the keys by Zalesskaja (1978) and Andersson et al. (2005).

The coordinates of the sites, the exposure of the slopes and altitude above sea level were measured using a satellite navigator Garmin eTrex-30. Humidity, acidity (pH H_2O), the ratio of the concentration of humic acids and fulvic acids (Ha/Fa), ash and organic matter content (loss after the burning, %) were determined for litter, using the methods of Arinushkina (1970). Descriptive statistics of the data were calculated using Statistica 6.0 software.

RESULTS

Latitudinal gradient in plain ecosystems

Only three species of centipedes were found in northern taiga forests during this study: *Lithobius curtipes* (several hundred specimens), *Lithobius forficatus* (single specimen), and *Geophilus proximus* (five specimens), but only *L. curtipes* was common in various types of natural and industrially polluted pine and spruce forests growing on a wide range soils (Table 1). In natural ecosystems the highest abundance and biomass of *L. curtipes* were recorded in pine litter (P1) with low acidity and a fulvo-humatic type of soil humus, and the lowest number in water-logged dwarf shrub-green moss spruce forest (S4).

Along the latitudinal gradient only *L. curtipes* occurred up to 69° 19' N in tundra ecosystems on the coast of Barents Sea. In iron-illuvial podzol soils in shrub-grass birch forest in the Pasvik Nature Reserve and in illuvial-humus and peat podzols of typical tundra (sites T1, T2, and T4), the number of *L. curtipes* do not exceed 2–3 ind.m^{-2}. In the sandy littoral zone (T3) it was more numerous and dominated in the littoral fauna of both numbers (18%) and biomass (70%).

In polluted soils in northern taiga subzone *L. curtipes* was less abundant than in natural forest podzols but more abundant than in tundra subzone (Table 1).

In contrast, *L. forficatus* was recorded only once in the continental part *of the region,* in wet blackberry spruce (S1, 67° 35' N, 32° 59' E), on the NE slope of a moraine ridge at an altitude 125 m a. s. l. Several specimens of *G. proximus* were found in different months from the middle of May to the end of September in pine forest automorphic sandy soils in different stages of leaching with the following range of parameters: pH 4.3–4.8, depth 4.5–9.2 cm and soil temperature 5–13 °C. The northernmost record of *G. proximus* was in black crowberry pine at site P2 (67° 34' N).

High-altitude gradient in mountain ecosystems

The species *L. curtipes* and *G. proximus* were both recorded on the Hibiny Mountain Massive in the northern taiga subzone, and only *L. curtipes* was recorded in the mountains in the Pasvik Nature Reserve on the border between northern taiga and forest-tundra. In the Pasvik Nature Reserve *L. curtipes* inhabit the pine forest belt but its density in shallow iron-illuvial podzols did not exceed 2 ind.m^{-2}. In the upper birch forest-tundra belt at an altitude 200–250 m a. s. l. this species occurred only on southern slopes at densities up to 4 ind.m^{-2}, which is similar to the density recorded in plain birch forest at an altitude 45 m a. s. l. Centipedes were not found in hydromorphic podzolic podbur soils in the tundra belt in the mountains at an altitude 270–300 m a. s. l. (Table 2).

In contrast, on the Hibiny Mountain Massive *L. curtipes* occurred in all areas in coniferous spruce and pine forests up to the rocky desert with fragmentary moss and lichen cover on the mountain plateau at an altitude of about 1000 m a. s. l. The density and biomass of *L. curtipes* recorded in open habitats in areas of high mountain tundra and rocky desert were comparable and even exceeded those in northern-taiga coniferous forests on the plain (Tables 1 and 2). *L. curtipes* was most numerous (up to 144 ind.m^{-2}) in intrazonal plant communities on warm and wet S and SE facing slopes. Based on the soil analysis, the layers of debris at these sites were less acidic (pH 5.3–5.6) and contained more organic matter (60–80%). Single individuals of *G. proximus* were recorded at such sites only (Fig. 3).

DISCUSSION

Kola Peninsula is an arctic region interesting from a geographical point of view because of the presence of a high diversity of different zones both in terms of latitude and altitude. Along the latitudinal gradient there is a succession of coniferous northern taiga, birch forest-tundra and typical tundra. At high-altitudes there are gradients in climatic and edaphic factors. As a result,

Table 1. Density and biomass of *Litobius curtipes* in the plain ecosystems studied on the Kola Peninsula

site	coordinates	altitude m a. s. l.	soil type and litter properties	year studied	no. samples	density ind.m^{-2}	biomass mg.m^{-2}
tundra and forest-tundra on the coast of the Barents Sea							
T1 – lichen-shrub, shrub, moss-shrub forest-tundra; Vidâevo settlements (*Betula pubescens*, *Empetrum hermaphroditum*, *Arctous alpina*)	69° 19’ N 32° 52’ E	60	hydromorphic peat soils, semi-hydro-morphicpeat-podzol soils; depth up to 22 cm; ash content 9–15%; pH 4.2	2006	15	1±1* 0–16**	1±1 0–7
T2 – shrub-lichen tundra; Teriberka settlements (*Vaccinium vitis-idaea*, *V. myrtillus, Empetrum hermaphroditum*, *Chamaepericlymenum suecicum*)	68° 10’ N 35° 08’ E	45	humus-illuvial podzols on sandy moraine; depth up to 7–8 cm; pH 4.3–5.4		15	1±1 0–16	1±1 0–19
T3 – littoral zone (*Leymus arenarius*)		≤5	fine-grained sea sand deposits; pH 7.2		5	6±3 0–16	29±15 0–50
T4 – shrub, lichen-shrub tundra in a low altitude catena; Dal’nie Zelency settlements	69° 06’ N 36° 04’ E	55–85	peat podzol soils	2009	40	1±1 0–16	not measured
northern taiga / forest-tundra border (Pasvik Nature Reserve)							
PRB – plain shrub-grass birch forest (*Betula pubescens* f. *subarctica*)	69° 08’ N 29° 14’ E	45	iron-illuvial podzols on sandy moraine; depth 2–5 cm; pH 5.1–5.6	2011	10	3±2 0–16	5±4 0–46
northern taiga natural forest ecosystems							
spruce forests (*Picea obovata*): S1 – blackberry, S2 – shrub humid, S3 – green moss, S4 – shrub-green moss, S5 – lichen	66° 56’ – 67° 35’ N 29° 36’ – 32° 60’ E	125–330	humus-illuvial podzols on sandy moraine; ash content 7–10%; pH 3.7–4.3; humate-fulvatic type of soil humus, Ha/Fa<1.0	2005 –2007	40 on each site	2±1 –13±3 0–80	0.2±0.1 –97±28 0–774
		148–230				4±1 –12±3 0–48	5±4 –50±15 0–215
pine forests (*Pinus sylvestris*): P2 – black crowberry, P3 – shrub, P4, P5 – lichen, P1 – blackberry	67° 34’ N 33° 17’ E	155	humus-illuvial podzols on lake-glacier sand sediments; ash content 30%; pH 5.5–6.0; fulvo-humatic type of soil humus, Ha/Fa≥1.0	1996 –2007	220	32±3 0–304	120±12 0–845
northern taiga polluted ecosystems							
TD – technogenic desert 5 km from the “Severonikel” copper-nickel plant	67° 34’ N 34° 17’ E	80	eroded humus-illuvial peat-podzols; concentration mg/kg: Ni 2600, Cu 1280, Co 350, sulphate 400–600; ash content 80–90%; pH 3.5; Ha/Fa 0.9–1.0	1996 –2000	55	7±1	53±20
PK – shrub pine forest (*Empetrum herma-phroditum*); fall-out zone 2 km from Kandalakša aluminium plant	67° 20’ N 33° 20’ E		humus-illuvial podzols on a moraine consisting of large boulders; fluorine concentration 1200 mg/kg; ash content 60%; pH 4.9–5.7	2000 –2005	110	9±1	30±5

* mean ± standard error recorded at each site; ** spatial variation in density or biomass (variation between soil samples).

there are several types of soil in this region with different thermal and hydrological regimes from automorphic to semi-hydromorphic and hydromorphic (Pereverzev 2004, 2010, 2013). In addition, agriculturally and industrially polluted soils, and technogenic substrates are present with physical and chemical properties that differ from native soils. Despite these factors, there are only five myriapod species recorded in the literature for the Kola Peninsula and only three species of which, *L. curtipes*, *L. forficatus* and *G. proximus*, were repeatedly recorded in this study.

In northern Norway, at the same latitude, the fauna includes not less than eight species of centipedes and seven species of millipedes and along the southern border of Northern Norway, four species of pauropods and three species of symphylans occur (Bergersen et al. 2006). For the whole of Norway, 111 myriapod species are recorded, and for Sweden, approximately 80 species (Table 3). As on the Kola Peninsula, in Northern Norway myriapod diversity decreases northwards from 12 species (seven centipedes and five millipedes) in Nordland (65° N) to 5–6 species in Tromsø and Finnmark (68–70° N), mainly because of the absence there of millipedes. Common in all these counties are species that also are typical for the Kola Peninsula: *L. forficatus* in Nordland, *G. proximus* in Nordland and Tromsø, and *L. curtipes* in Finnmark (Bergersen et al. 2006).

Both *L. forficatus* and *L. curtipes* are widely distributed in Europe and very common in Nordic countries. The holarctic *L. forficatus* is a ubiquitous and synanthropic species. Due to good osmoregulation, it inhabits both xeromorphic and hydromorphic soils (Fairhurst et al. 1978). Obviously, the occurrence and abundance of *L. forficatus* gradually decrease from taiga to forest-tundra

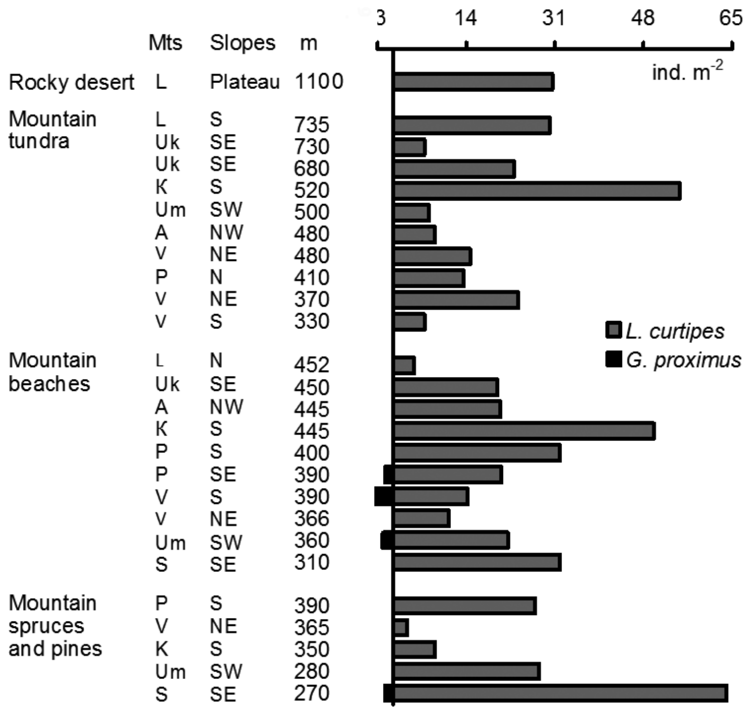

Fig. 3. Numbers of centipedes (ind.m^{-2}) recorded on the Hibiny Mountain Massive. For abbreviation of mountain names see Fig. 2.

Table 2. Density and biomass of *Litobius curtipes* recorded in the mountain ecosystems on the Kola Peninsula. nm = not measured

belts	coordinates	altitude m a. s. l.	soil type	year studied	no. samples	no. ind./m²	biomass mg/m²
northern taiga / forest-tundra border, mountains of the Pasvik Nature Reserve (PRM)							
lichen-shrub tundra	69° 14–18’ N 29° 22–27’ E	273–303	podzolic podburs with cryogenic spots; pH 4.4–5.7	2010–2013	30	0	0
shrub, grass, moss, birch tortuous forests (*Betula pubescens tosrtuoa*)		200–250	hydromorphic and semi-hydromorphic peat-podzols; depth up 10–13 cm; pH 4.5–5.1		30	1±1 0–16	not measured
shrub, lichen-shrub pine sparse forests (*Pinus sylvestris laponica*)		125–155	humus-illuvial and iron-illuvial podzols; depth 1.5–5 cm; pH 4.5–5.1		30	1±1 0–16	not measured
northern taiga, Hibiny Mountain Massive (KhM)							
rocky desert on high-mountain plateau with fragmentary lichen-shrub cover	67° 35–49’ N 33° 14’ – 34° 11’ E	1100	rocky bedrock; ash content 70–90%; pH 5.5–6.0	2008–2013	20	31±7 0–144	125±35 0–680
shrub, lichen-shrub, lichen-shrub-moss tundra		330–735	podzolic podburs; ash content 33–84%; pH 4.4–5.9		105	19±2 0–150	125±30 0–1680
shrub, grass and moss-grass birch (*Betula tortuosa*) forests		310–450	high-humus illuvial podzol soils on alkaline nepheline syenites; ash content 20–86%; pH 4.2–5.9		115	20±3 0–160	60±16 0–730
shrub-grass-moss spruce (*Picea obovata*) and pine (*Pinus sylvestris*) sparse forests		270–390			55	17±3 0–80	65±21 0–475

and tundra both in Scandinavia and Russia (on, for example, the Kola Peninsula and in the Ural Mountains). In Fennoscandia this species is distributed very widely south of the Arctic Circle, but rare in Northern Finland; it is not recorded in Northern Sweden, several times recorded in Southern Iceland and only once in Greenland (Palmen 1949, Eason 1970, Jensen & Christensen 2003, Andersson et al. 2005). In Northern Norway it occurs further north than in Northern Sweden, is common in Nordland, but there are no recent records from Finnmark (Bergersen et al. 2006). On the Kola Peninsula, *L. forficatus* was recorded by Palmen (1949) but is not included in more recent faunistic publications. Its presence on the White Sea Islands in the Kandalakša Nature Reserve was queried (Byzova et al. 1986) and it was not included in the "Catalogue of Biota" of the White Sea Biological Station on the north coast of the Karelia Republic, Russia (Tchesunov et al. 2008). During this long-term study, *L. forficatus* was never caught in traps and only one specimen was found in litter collected from a spruce forest at site S1 (67° 35' N). This is the only record that confirms its occurrence on the Kola Peninsula.

In contrast, *L. curtipes* is widespread in natural and anthropogenic ecosystems on the Kola Peninsula. According to our data, this centipede occurs along the latitudinal gradient up to tundra ecosystems along the coast of the Barents Sea. This was also noted by Striganova (1973) at several tundra sites in the vicinity of the Biological Station in Dal'nie Zelency. Lower values of density and biomass of *L. curtipes* in tundra in comparison with northern taiga is in accordance with this centipede being a forest floor species (Zalesskaja 1978, Andersson et al. 2005) and with the latitudinal increase in the harshness of environmental conditions. Foremost, the total sum of the average daily air temperatures (ADAT) is about 1100 °C in the southern part of the Kola

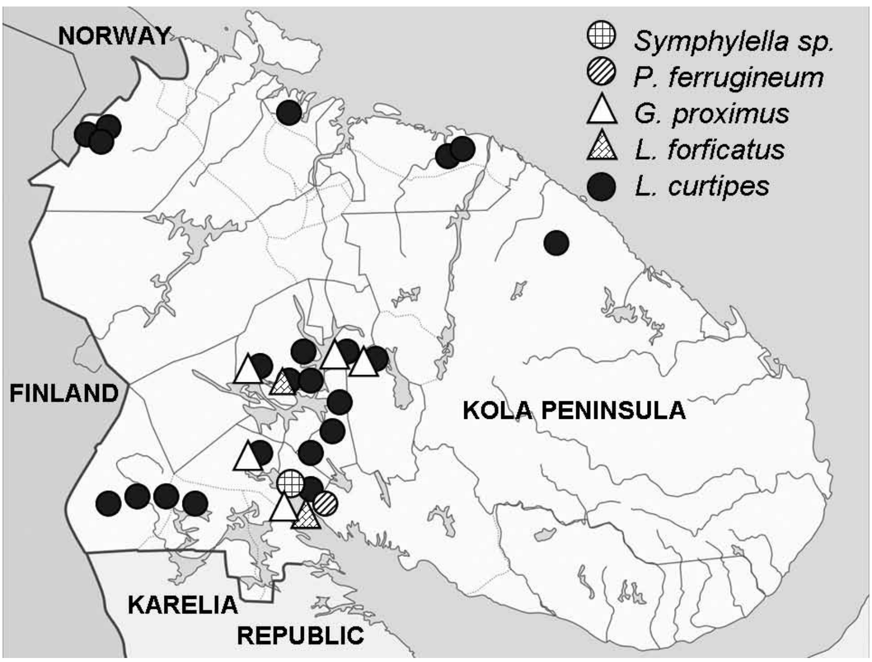

Fig. 4. Map showing the occurrence of myriapods on the Kola Peninsula.

Table 3. Comparison of the numbers of myriapod species recorded in different regions at northern latitudes. Sources of data: [1] Minelli (2013), [2] Golovach (1995), [3] Ghilarov (1986), [4] Starobogatov (1991), [5] Mikhaljova (2004), [6] Shileyko (1995), [7] Skarlato et al. (1994), [8] Palmen (1948), [9] Byzova et al. (1986), [10] Bergersen et al. 2006

	fauna (no. species)	Diplopoda	Chilopoda	Pauropoda	Symphyla
world	~16,000[1]	>12,000	3,149[1]	700	200
former USSR	719	400[2]	315[3]	2[4]	2[4]
Russia	264	180[2] / 103[5]	80[6]	2[7]	2[7]
Kola Peninsula	5	0	4[8,9]	0	19
northern Norway	15[10]	7	8	4	3
Norway	111[1]	49	38	16	8
Sweden	>80[1]	43	32	11	?

Peninsula and decreases to 800–900 °C in the central and western part and to 500–700 °C in the NW, NE and eastern parts of the region. The period with ADAT ≥ +5 °C decreases on the Kola Peninsula from 130 to 90 days, and with ADAT ≥ +10 °C – from 80 to 45 days (Yakovlev 1961, Anonymous 1971, Semko 1982).

A similar density of *L. curtipes* (3.4 ind.m^{-2}) was recorded in birch forest-tundra in Finnish Lapland, in the vicinity of the Kevo Research Station (69° 45' N; Koponen 1987). In sand in the littoral zone (T3) its density (7 ind.m^{-2}) was comparable with that recorded on the White Sea Islands in the Kandalakša Nature Reserve (KRI) (Byzova et al. 1986).

On the Hibiny Mountain Massive, in the high mountain rocky desert with fragmentary moss and lichen cover at an altitude of more than 1000 m a. s. l., the density of *L. curtipes* is higher than in most lowland forest ecosystems. It is noteworthy, that at this altitude air temperatures above 0 °C are recorded on less than 40 days a year and the precipitation is 1200–1500 mm per year compared to 800–900 mm in the forest belts at lower altitudes and the 400–700 mm in the rest of the region (Yakovlev 1961, Anonymous 1971, 2008). The greater numbers of centipedes in mountain ecosystems than on the plains was also recorded for the Northern Ural Mts (Russia) with six species on the plains and only *L. curtipes* in the mountain tundra. In all mountain communities in the Northern Ural Mts *L. curtipes* was abundant (Farzalieva 2008, Farzalieva & Esyunin 2008).

The history of the discovery of this Panpalaearctic species is associated with the polar regions: described for the first time in 1847 by Koch, then ten years later *L. curtipes* was discovered in Finnmark and was the first myriapod recorded in northern Norway (Koch 1847, Palmberg 1866). Later it was reported that *L. curtipes* is common in Sweden, Finland, on the Kola Peninsula and in NE Russia (Palmberg 1866, Tobias 1975). In 1875 *L. curtipes* was recorded as common on Vajgač (Waigatsch) Island, located in the Arctic Ocean on the border between Barents and Kara Seas at 69–70° N and 76–77° E (Stuxberg 1876). At present, the records of *L. curtipes* on Vajgač Island and in Finnmark are the northernmost records for centipedes (Bergersen et al. 2006). It is the only species of myriapods found in arctic Finnish Lapland (69° 45' N): it inhabits mountain birch forest-tundra in 70 km from the Arctic Ocean, where the average annual temperature is +2.5 °C and the lowest temperature, recorded by the local Weather Stations, is –48 °C (Koponen 1987). Of the 28 species of myriapods recorded in the Ural Mts, located in Russia between the two largest East European and West Siberian plains, only *L. curtipes* is common in all mountain provinces (South, Middle, North, Subpolar, and Polar Ural) and also occurs in Arctic tundra (Farzalieva 2008). The ecology of this species on the Kola Peninsula is now well-studied (Zenkova 2003, Zenkova & Petrashova 2003, 2008a, b, Petrashova 2009, 2010, Zenkova et al. 2011).

Summarizing the literature and the present results allow us to conclude that this species is highly successful in colonizing the northern periphery of the area.

Geophilomorph centipedes are rare on the Kola Peninsula. Only two species of European origin are known to occur in the southern part of the region (KRI) and it is evident that they occupy different ecological niches near the northern borders of the area. *P. ferrugineum* is a specialized inhabitant of rocks with various plant associations and the endogeic *G. proximus* prefers meadow soils under grass growing along the coast (Byzova et al. 1986). In accordance with this, *G. proximus* was recorded mainly in the well-developed humus debris layer under herbaceous birch and spruce forests on the S and SE slopes of the Hibiny Mountain Massive. Such communities are also characterized by a high diversity and abundance of earthworms (Zenkova & Rapoport 2013). *P. ferrugineum* was not recorded at any of the sites studied in the northern taiga, forest--tundra and tundra subzones.

In Nordic countries *G. proximus* is the most common geophilid occurring in the far north, especially in Norway, where it inhabits forests, open land and mountains at an altitude of up to 600 m a. s. l. Northern populations are repeatedly recorded as being parthenogenetic races, which vary in body length, number of body segments and pairs of legs (Palmen 1948, Meidell 1969, Barber & Jones 1999, Andersson et al. 2005, Bergersen et al. 2006). This species is not recorded in Finnish Lapland. On the Kola Peninsula it probably occurs only within the forest zone both on plains and in mountains. In this research, the sites where *G. proximus* was recorded, occur at similar latitudes of 67° 34' N on the plain and 67° 38–42' N on the Hibiny Mountain Massive.

P. ferrugineum is a cosmopolitan species which has been introduced into Japan, Taiwan, Hawaii, Juan Fernandez Island and Mexico (Edgecombe & Giribet 2007, Zapparoli & Iorio 2012). Its distribution is determined by its physiological adaptations to arid conditions and ability to survive for long time in sea water. Folkmanova (1950) classifies this species as a steppe chilopod because of its greater resistance to desiccation than other centipedes. In Russia its abundance is greater in dry areas than in wet forests. It is common in open habitats, meadows and pastures than in forests. It is typical for virgin steppes and saline semi-deserts, the first geophilomorph species in natural and man-made sandy substrates (Gilyarov & Folkmanova 1957). In Northern Europe and Asia (Japan, Taiwan, South Korea) it is a littoral (thalassobiont) species widespread on seashores and islands (Barber 2009). Specimens from Southern Finland can survive in sea water for 68–178 days at 6–12 °C and for 24–95 days at 19–27 °C (Palmen & Rantala 1954). In Fennoscandia *P. ferrugineum* is the only species of this genus. It prefers open habitats and is less common than *G. proximus*. In terms of latitude *P. ferrugineum* occurs at approximately 66° N and is not found in the northernmost parts of Norway, Sweden and Finland (Andersson et al. 2005, Bergersen et al. 2006). Rare records of this species on KRI at 66° 34' N, correspond to a warmer temperature regime (namely greater amount of solar radiation and longer frost-free season) in the Kandalakša Nature Reserve than on the rest territory of the Kola Peninsula (Anonymous 1971).

Only one specimen of *Symphylella* sp. juv. was recorded on White Sea Islands studied by Byzova et al. (1986). A map of myriapod occurrences on the Kola Peninsula is presented in Fig. 4.

CONCLUSION

Five species of myriapods are recorded in the literature from the northern-taiga subzone on the Kola Peninsula (*L. curtipes*, *L. forficatus*, *G. proximus*, *P. ferrugineum* and *Symphylella* sp.). This research confirms the occurrence of the first three species in coniferous and deciduous forests. The latitudinal and high-altitude distributions of the species are similar. The panpalearctic polyzonal litter-dwelling lithobiomorph centipede *L. curtipes* is common and wide spread in typical tundra on the coast of the Barents Sea and present in the high-altitude rocky desert on the plateau of the

Hibiny Mountain Massive. It is the only species of myriapod recorded in Finnmark (Norway), subarctic Finnish Lapland, tundra zones in NE Russia, such as those on the Kola Peninsula, Vajgač Island and Polar Ural Mts. The European endogeic geophilomorph centipede *G. proximus* is the second frequency of occurrence after *L. curtipes*. Its distribution on plain and in mountains on the Kola Peninsula is probably limited to the of forest zone. In general, there is a decrease in myriapod diversity the further north one goes, with only a single species *L. curtipes* recorded in the far north of Scandinavia and Russia.

Millipedes were not recorded in permanently frozen soils on the Kola Peninsula although they inhabit similar habitats in Northern Norway, the Karelia Republic. The absence of millipedes and the poor myriapod fauna can be explained in terms of the geographic position of the Kola Peninsula inside the Arctic Circle, it's cool, humid climate and acidic podzol soils with a low content of calcium.

It should be emphasized that these are the results of long-term studies in the most heterogeneous W, NW and SW parts of the Kola Peninsula with complicated relief. The large eastern part of the region remains unknown from a soil-zoological viewpoint because land is inundated, the population is low and lines of communication are poorly developed.

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