Oecologia Montana 1997, **6**, 35 - 38

The structure of large soil invertebrate communities (Mesofauna) in the alpine ecosystems of the Teberda Reserve, the Northwestern Caucasus

V. G. ONIPCHENKO and O. E. ZHAKOVA
Department of Geobotany, Biological Faculty, Moscow State University, Moscow, 119899, Russia.

Abstract. The biomass and density of main groups of large soil invertebrates were investigated in four types of alpine ecosystems. Total dry biomass varied from 0.08 to 3.45 g/m^2 decreasing in the row from chionophobous to chionophilous ecosystems. *Lumbricidae, Aranei, Chilopoda, Curculionidae* - and *Diptera* - larvae were well represented. *Mollusca* and *Diplopoda* were practically absent apparently due to a Ca-deficiency of acidic alpine soils. Each ecosystem has a specific composition of soil invertebrates community. Communities studied differ from that of arctic tundras by smaller abundance of *Enchytraeidae* and *Tipulidae* and by the larger role of *Chilopoda* and *Curculionidae*.

Key words: Lumbricidae, Diptera larvae, *Aranei, Chilopoda, Staphylinidae, Curculionidae*

Introduction

Alpine ecosystems occur under severe climatic conditions. Because of the poor soils and the low rate of decomposition they have a slow biological turnover and a small production. Our knowledge about alpine soil invertebrates playing a significant role in decomposition of plant dead materials (Gilyarov and Chernov 1975, Striganova 1980) in the Caucasus is poorer than in the Alps (Franz 1979, 1981, Cuendet 1984, Dethier 1985).

The purpose of our study was to compare communities of large soil invertebrates ("mesofauna" according to Gilyarov 1975, or "macrofauna" according to Petersen and Luxton 1982) of several typical closed alpine ecosystems of the NW Caucasus in terms of density and biomass. This work is a part of a complex ecological research program of the Moscow University High Mountain Station, Teberda Natural reserve (Rabotnov 1987,Onipchenko 1994b).

Material and methods

The study area located on Mt Malaya Khatipara, Teberda State Reserve, Karachaevo-Cherkessian Republic, the NW Caucasus, Russian Federation. We investigated soil invertebrates communities in four alpine ecosystems with different snow cover depths and other features (Onipchenko 1994a,b).

Alpine lichen heaths (ALH) (Pediculari comosae -Eritrichietum caucasici oxytropidetosum kubanensis Minaeva 1987 in Onipchenko *et al.* 1987) are low productive communities with fruticose lichens as the main dominants (mostly *Cetraria islandica*). They occupy windward crests and slopes. The snow cover in winter is thin or practically absent, so soil freeze deeply and has great stony contents. Biological turnover is very slow although vegetative season is long (more than 5 months) (Voronina *et al.* 1986).

Grasslands with *Festuca varia* dominance (FVG) (Violo altaicae - Festucetum variae Rabotnova 1987 in Onipchenko *et al.* 1987) are firm-bunch grass communities with a great accumulation of dead plant material in the aboveground layer. These grasslands are floristic rich and similar to steppe plant ecosystems (Onipchenko and Semenova 1995).

Forb meadows with *Geranium gymnocaulon* and *Hedysarum caucasicum* dominance (GHM) (Hedysaro caucasicae-Geranietum gymnocauli Rabotnova in Onipchenko *et al.*1987) are the relatively fertile alpine meadows. They develop on sites with significant snow cover and short vegetation season(2.5-3 months).

Alpine snow bed ecosystems (SBC) (Hyalopoo ponticae - Pedicularietum nordmannianae Rabotnova 1987 in Onipchenko *et al.* 1987) occupying snow accumulating sites (depressions and bottoms of kars) are extremely chionophilous. Short rosette and draft trailing plants (*Sibbaldia procumbens, Taraxacum stevenii, Gnaphalium supinum*) dominates there. Vegetation season is less than 2 months.

We obtained invertebrates by means of handsorting the soil samples (Gilyarov 1975). The size of samples were 25 x 25 cm to depth of 20-30 cm. Twenty samples in each ecosystem were investigated. This work was done in August 1984 (for alpine lichen heaths) and in August 1987 (for other ecosystems). Animals were preserved in ethanol (70%) or formaldehyde according to standard methods (Balogh 1958, Striganova 1975). We determined the "fresh" mass of animals (for *Lumbricidae* without gut content) and calculated dry mass using the proportions published by Meyer (1981) and Petersen and Luxton (1982).

The identification of different animals groups were made by: T.S.Perel (*Lumbricidae*); N.T. Zaslavskaya and L.P.Titova (*Chilopoda*); G.K.Mikhailov, A. V.Tanasevich, A.A..Zuzin and V.I.Ovcharenko (*Aranei*), K. Makarov (*Carabidae*), V.V. Zherihin (*Curculionidae*), A.B.Ryvkin, V.B.Semenov, I.A.Ushakov, E.N.Veselova (*Staphilinidae*), D.A.Scherbakov (other *Coleoptera*), N.T.Krivosheina (*Diptera* larvae).

Results and discussion

Total density and biomass. The general biomass of large soil invertebrates decreased in the row ALH-FVG-GHM-SBC from 14.2 to 0.4 g/m^2 ("fresh"mass) because of decreasing amount of *Lumbricidae* which dominates in ALH and FVG ecosystems (Table 1). The total density of the animals have the same tendency (Table 2). The maximal invertebrate biomass without *Lumbricidae* was in GHM which is the most productive ecosystem.

In all but FVG ecosystems more than 95% of individuals making more than 90% of the total biomass were found in upper 0-10 cm soil layer. In FVG these values are 92% and 77%, respectively. In SBC soil large invertebrates were not found deeper than 10 cm. Apparently, more frequent periods of soil desiccation in FVG lead to distributing of invertebrates in deeper soil layers.

The dominates of *Lumbricidae* in ALH and FVG communities is similar with temperate grasslands (Petersen and Luxton 1982) and alpine tundras of the North Urals (Olshwang and Fileva 1982, Fileva 1983). The invertebrate biomass in soils of alpine *Nardus-Poa* grassland of Karabach is similar with that of ALH but *Diplopoda* are dominant in the former community and absent in all our investigated communities (Striganova and Loginova 1984). Biomass of soil invertebrates in ALH and FVG exceeds that in high mountain steppes and deserts of West Tian-Shan but less than that in meadows of that region (Zlotin 1975).

Meyer (1981) investigated structure and biomass of soil invertebrate communities in two alpine ecosystems of the Austrian Alps: Curvuletum (ecological analogous to ALH) and a chionophilous ecosystem where *Salix herbacea* dominated (ecological analogous to SBC). The total biomass was estimated as 925 and 480 mg/m^2 (dry mass), respectively, so the difference between chionophobous and chionophilous communities were less than in our region. The density and biomass of *Coleoptera* were higher than in the Caucasus ecosystems, while the abundance of *Lumbricidae* was lower. Meyer (1981) did not found *Chilopoda* in alpine communities; although, this group is very common in our ecosystems. In general, data of invertebrate communities in high alpine soils are not very abundant, so a causal analysis of their structure-forming mechanisms is still a good distance in the future.

Lumbricidae. Only one widely distributed Caucasian species of *Lumbricidae* was found in our communities - *Dendrobaena schmidti* Michaelsen, 1907 (or *Dendrobaena adaiensis adaiensis* (Michaelsen, 1900) according to Easton 1983). The biomass of this species differs significantly between studied communities, being the highest in ALH. In GHM and SBC, on the other hand, earthworms are practically absent, probably due to too short of snow free seasons in these ecosystems. To complete the life cycle the earthworms need more time than the snow free season lasts in relatively cold alpine soils.

The abundance of *D.schmidti* in subalpine meadows of the Central Caucasus (Kazbegi) was not great and did not exceed the value for ALH (Kvavadze 1985). The high biomass of *Lumbricidae* distinguishes the ALH and FVG communities from typical lowland tundras, where the role of this group is not significant (Petersen and Luxton 1982). Five species of *Lumbricidae* were found in calcareous alpine areas of Switzerland where their density and biomass were much more than in our ALH (Cuendet 1984). *Lumbricidae* were found in Swiss snow bed alpine communities (Salicetum herbaceae) but with low abundance.

Enchytraeidae. Apparently, by handsorting we collected only a small proportion of individuals, predominantly from species with large body sizes. According to our incomplete data, the role of this group is most important in ALH community (Tables 1, 2).

Chilopoda. This group was the most abundant in FVG. In other communities the density and biomass of *Chilopoda* are similar to tundra soils (Petersen and Luxton 1982). The high mountain soils of Tian-Shan contain more *Chilopoda* (Zlotin 1975) in comparison with the Caucasian communities.

Among *Lithobiomorpha* only one species (*Monotarsobius sseliwanoffi* Gard.) was found, being usual in all studied ecosystems. Among *Geophilomorpha* the most abundant species was *Strigamia acuminata* (Leach 1814) (found in ALH, FVG, GHM). *Fagetophilus elegans* Folk, 1956 also was usual (ALH, FVG), while *Geophilus* sp., founded only in FVG, was more rare.

Diplopoda. We have not found any *Diplopoda* in our samples. Although, this group is dominate in some soil invertebrate communities of alpine meadows of the Small Caucasus (Striganova and Loginova 1984), and it is common in subalpine meadows of Kazbegi (Kohia 1987). We suggest that the absence of *Diplopoda* is connected with the low level of Ca-content in alpine soils and in its parent materials (granites, biotite schists); because species of *Diplopoda* need significant amount of Ca for making their shells (Pokarzhevskiy 1985).

Aranei are very abundant and diverse in alpine communities. Using handsorting, however, we could not estimate correctly their density and biomass, because most of the large *Aranei* (especially *Lycosidae*) are very mobile. Apparently, the most underestimate density of *Aranei* was in ALH and SBC where plant height and protective properties of herb layer were small. The list of spiders is presented in Table 3. This group was the most diverse in dense FVG which occupied relatively warm sites. Species of *Linyphiidae* were more frequent, especially *Trichoncus hispidosus* Tanasevic, 1990 (Tanasevich 1990). Only *Erigonidae* species were founded in SBC.

Coleoptera. Various *Carabidae* are usual in all communities. As for *Aranei* we underestimated their biomass and density due to high mobility. *Carabus koenigi* Gglb. and *Pterostichus swaneticum* Rtt. are common species in our communities. Usual in soil samples also are: *Amara* sp. (ALH), *Amara (Lejocnemis) sabulosa* Dej. (GHM), and *Bembidion (Testedium) bipunctatum rugiceps* Chb. (SBC, more rare in GHM). More rare were *Bradycellus* sp. (FVG), *Dyschirius lederi* Rtt. (FVG), and *Calanthus (Neocalanthus) melanocephalus* L. (FVG).

Species of *Staphylinidae* were found in all communities. The following species were identified: *Geostiba (Ditroposipalia)* sp. *(betubereulata* group) (FVG), *Micralymma caucasicum* (Melichar) (FVG), *Philonthus frigidus svanetiensis* Coiffait. (FVG, GHM, SBC), *Geodromicus latiusculus* Eppelsheim (SBC), *Othius stenocephalus* Eppelsheim (FVG), *Tachyporus* sp. (ALH, FVG), *Mycetoporus ruficornis* Kraatz (FVG), and *Staphylinus* sp. (GHM).

Larvae of *Elateridae* were found with small density only in grassland ecosystems (FVG, GHM).

Among soil phytophagans (rhizophagans) the *Curculionidae* species were the most common. They occurred in all investigated ecosystems, being the

Ecosystems	ALH	FVG	GHM	SBC
Lumbricidae	13.6±4.3 *3.3*	2.9±1.0 *0.7*	0.3±0.3 *0.07*	-
Enchytraeidae	0.18±0.03 *0.03*	0.006±0.003 *0.001*	0.004±0.002 *0.001*	-
Aranei	0.017±0.007 *0.005*	0.34±0.10 *0.1*	0.29±0.08 *0.08*	0.009±0.003 *0.003*
Chilopoda	0.13±0.10 *0.02*	0.46±0.08 *0.08*	0.19±0.04 *0.03*	0.004±0.004 *0.001*
Coleoptera				
Carabidae	0.06±0.05 *0.02*	0.02±0.02 *0.006*	0.06±0.03 *0.02*	0.015±0.008 *0.005*
Staphylinidae	0.008±0.003 *0.003*	0.016±0.008 *0.006*	0.07±0.06 *0.03*	0.014±0.007 *0.006*
Elateridae	-	0.21±0.10 *0.08*	0.48±0.18 *0.19*	-
Tenebrionidae	-	-	0.04±0.04 *0.01*	0.10±0.07 *0.02*
Curculionidae	0.05±0.03 *0.01*	0.32±0.07 *0.06*	0.33±0.08 *0. 07*	0.15±0.06 *0.03*
Diptera	0.31±0.15 *0.06*	0.15 ±0.11 *0.03*	0.40±0.31 *0.08*	0.08±0.06 *0.016*
Lepidoptera	-	0.05±0.04 *0.005*	0.02±0.02 *0.002*	0.02±0.02 *0.002*
Hymenoptera	-	0.008±0.005 *0.002*	0.03±0.02 *0.01*	-
Total biomass	14.3+4.3 *3.45*	4.4±1.0 *1.07*	2.1±0.5 *0.59*	0.37±0.11 *0.08*
The sum without *Lumbricidae*	*0.15*	*0.37*	*0.52*	*0.08*

Table 1. Biomass of large soil invertebrates in alpine ecosystems (g/m[2] "fresh" mass, average and stantard error, italic values represent dry mass)

Ecosystems	ALH	FVG	GHM	SBC
Lumbricidae	39±10	25±6	2±2	-
Enchytraeidae	338±52	7±4	4±1	-
Aranei	5±2	72±21	36±7	10±3
Chilopoda	23±19	100±17	46±9	2±2
Coleoptera				
Carabidae	3±2	4±2	4±2	3±1
Staphylinidae	5±2	10±3	3±1	3±1
Elateridae	-	4±2	8±3	-
Tenebrionidae	-	-	2±2	2±1
Curculionidae	7±4	35±7	29±5	12±4
Diptera	190±136	12±4	81±64	5±2
Lepidoptera	-	4±2	1±1	1±1
Hymenoptera	-	2±1	2±1	-
sum	610±148	275±30	218±67	38±6

Table 2. Density of large soil invertebrates in alpine ecosystems (individuals/m[2], mean ± SE, n=20)

most abundant in alpine meadows (FVG, GHM). All of them were identified as members of genus *Otiorrhynchus: O.carbonarius* Reitt.(ALH, more rare in GHM), *O.circassicus* Reitt. (FVG, more rare in GHM), *O.bidentatus* Tourn. (FVG, GHM), and *O.cinereus* Stierl. (rare in GHM, SBC). Their density and biomass are represented in Table 1 and 2 as total for all life stages (larvae, pupae, imago).

The total density and biomass of *Coleoptera* in alpine grasslands (FVG, GHM) exceeds those for *Curvuletum* in Tirol Alps (Schatz 1981).

Diptera. Larvae occurred in soils of all studied communities (Table 4). *Sciaridae* had the highest density. As these species have extremely aggregate distribution, the precise data are difficult to obtain.

	ALH	FVG	GHM	SBC
*Salticidae**	-	1	2	-
*Gnaphosidae**	1	12	5	-
Gnaphosa sp.	-	1	1	-
Thomisidae (incl. *Philondromidae*)*	1	1	2	-
Oxyptila sp.	2	2	-	-
O. balkarica Ovtsharenko, 1979	-	2	-	-
Xysticus sp.	-	6	7	-
X. bacurianensis Mcheidze,1971	-	1	1	-
Clubionidae (incl. *Zoridae*)				
Clubiona sp.	-	1	2	-
C.diversa O.Pickard-Cambridge,1862	-	1	-	-
Zora sp.	-	1	-	-
*Lycosidae**	1	2	8	-
Tarentula sp.	-	1	-	-
Linyphiidae (incl. *Erigonidae*)*	1	6	2	11
Agyneta sp.	-	4	3	-
Agyneta rurestris (C.L. Koch, 1936)	-	-	2	-
Trichoncus sp.	-	2	-	-
T. hispidosus Tanasevitch,1990	-	17	1	-
Macrargus carpenteri (O.Pickard-Cambridge,1862)	-	2	-	-
Tiso diclivitalis Tanasevitch	-	-	2	-
Silometopus elegans (O.Pickard-Cambridge,1972)	-	2	-	-
Scotinotylus evansi (O.Pickard-Cambridge,1894)	-	1	-	1

Table 3. *Aranei* in alpine ecosystems (number of individuals found in 20 soil samples for each stands), *not identified in detail.

We found two aggregations in ALH and one in GHM. *Empididae* larvae were the most frequent in investigated soils, while *Tipulidae* were relatively rare.

Data on trophic groups. Among trophic groups saprotrophs were dominated in terms of biomass

Ecosystems	ALH	FVG	GHM	SBC
Sciaridae	200	-	80	-
Tipulidae	1	1	1	-
Empididae	15	4	17	2
Brachycera				
-Cyclorrhapha	7	2	-	2
Therevidae	1	-	-	-
Dolychopodidae	2	-	-	-
Cecidomyidae	-	2	-	-
Tabanidae	-	-	-	1

Table 4. *Diptera* larvae in alpine soils (total number for 20 samples)

because of high abundance of *Lumbricidae* (Fig. 1). Dominance of saprotrophs were noted for high mountain communities in Tirol Alps (Schatz 1981, Meyer 1981). The most significant number of phytophagous were recorded for GHM. In this ecosystem the ratio of plant necromass to plant biomass was the least, so a biological turnover is the most intensive here. The proportion of phytophages is great in chionophilous SBC, but the total invertebrates biomass is extremely low there. Similar peculiarity was noted for analogous communities in the Swiss Alps (Dethier 1985). The proportion of carnivores is relative great in grasslands (FVG, GHM).

Conclusions. Total dry biomass of large soil invertebrates varied from 0,08 to 3,45 g/m[2] decreasing in the row from chionophobous to chionophilous ecosystems. Each ecosystem has a specific composition of soil invertebrate community. Alpine communities differ from that of arctic tundras by a smaller abundance of *Enchytraeidae* and *Tipulidae* and by a larger abundance of *Chilopoda* and *Curculionidae*.

The composition of soil invertebrate community of ALH is similar to that of plain meadows and Ural alpine tundras. The community of alpine grasslands (FVG, GHM) is closer to alpine communities of Tian-Shan and Alps. Apparently, the type of parent soil materials (silicate or carbonates) have a strong influence on the composition of soil invertebrate communities, especially for such Ca-demanding groups as *Diplopoda* or *Mollusca*.

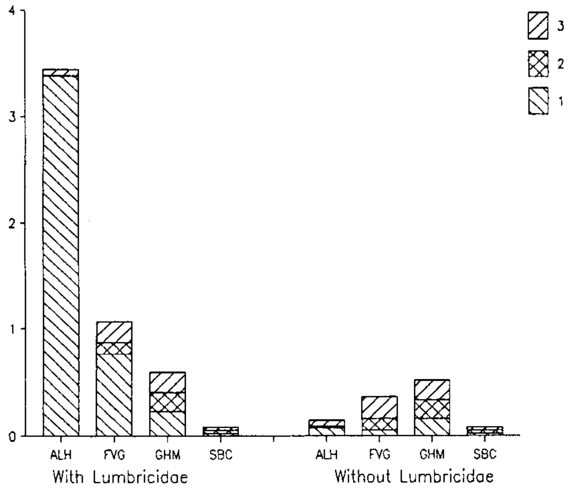

Fig. 1. Trophic composition of the total large soil invertebrate biomass (g/m^2 dry mass). Trophic groups: 1 - saprothrops, 2 - phytophages, 3 - carnivores.

Acknowledgments

We thank all colleagues who identified species. We also appreciate the efforts of A.D.Petrova, T.V.Dobrolubova, and others who took part in the field work. Thanks also are expressed to Prof. B.R.Striganova and Prof. A.S.Kondrashov for reading the manuscript and helpful notes.

References

Balogh, J. 1958: Lebensgemeinschaften der Landtiere. Akademie-Verlag, Berlin.

Cuendet, G. 1984: Les peuplements lombriciens des pelouses alpines du Mont La Schera (Parc national suisse). *Rev. suisse zool.*, **91**: 217-228.

Dethier, M. 1985: Distribution des larves d'Insectes Pterygotes dans une pelouse alpine. *Bull. Soc. Linneenne de Lyon*, **54**: 64-76.

Easton, E.G. 1983: A guide to the valid names of *Lumbricidae (Oligochaeta)*. In *Earthworm Ecology* (ed. J.E.Satchell), pp. 475-485. London, New York.

Fileva, O.N. 1983: Investigation of the mountain tundra invertebrates communities in the North Urals. In *Fauna and ecology of insects in the Urals* (ed. I. A. Bogacheva), pp. 55-56. Sverdlovsk (in Russian).

Franz, H. 1979: Ökologie der Hochgebirge. Ulmer, Stuttgart.

Franz, H. (ed.) 1981: Bodenbiologische Untersuchungen in den Hohen Tauern 1974 - 1978. Veroff. des Österreich. MaBHochgebiergsprogramms Hohe Tauern. Innsbruck, 4.

Gilyarov, M.S. 1975: Investigations of large soil invertebrates (mesofauna). In *Methods of soil zoological investigations* (ed. M.S.Gilyarov), pp. 12-29. Nauka, Moscow (in Russian).

Gilyarov, M.S. and Chernov, J.I. 1975: Soil invertebrates in communities of the temporal zone. In *Resources of the biosphere* (eds. L.E.Rodin and N.N.Smirnov), pp. 218-240. Nauka, Leningrad, 1 (in Russian).

Kohia, M.S. 1987: A role of the *Diplopoda* in cellulose destruction and their energetic needs on the subalpine meadows of the Great Caucasus. In *Soil fauna and soil fertility* (ed. B.R.Striganova), pp. 358-359. 9th Int. soil zool. Colloq., Moscow, Aug. 16-20, 1985. Moscow, (in Russian).

Kvavadze, E.S. 1985: Earthworms (*Lumbricidae*) of the Caucasus. Metsniereba, Tbilisi (in Russian).

Meyer, E. 1981: Abundanz und Biomasse von Invertebraten in zentralalpinen Boden (Hohe Tauern,Österreich). In *Bodenbiologische Untersuchungen inden Hohen Tauern 1974 - 1978.* (ed. H. Franz), pp. 153-178. Veroff. des Österreich. MaBHochgebiergsprogramms Hohe Tauern. Innsbruck, 4.

Olshwang, V.N. and Fileva, O.N.: 1982. Investigation of invertebrates in the tundras of the Northern Urals. In *Problems of animal ecology.* (ed.S.N.Postnikov), p.9. Sverdlovsk (in Russian).

Onipchenko, V.G. 1994a: Study area and general description of the investigated communities. In *Experimental investigation of alpine plant communities in the Northwestern Caucasus* (eds. V.G. Onipchenko, M.S. Blinnikov), pp.6-22. Veröffentlichungen des Geobotan. Institutes der ETH, 115, Stiftung Rübel, Zürich.

Onipchenko,V.G. 1994b: The structure and dynamics of alpine plant communities in the Teberda Reserve,the Northwestern Caucasus. *Oecol. Montana*, **3**:40-50.

Onipchenko, V.G., Minaeva T.Yu. and Rabotnova M.V. 1987: Syntaxonomy of the alpine plant communities of the Teberda reserve. Moscow, VINITI (in Russian).

Onipchenko, V.G. and Semenova, G.V. 1995: Comparative analysis of the floristic richness of alpine communities in the Caucasus and the Central Alps. *Journal of Vegetation Science*, **6**: 299-304.

Petersen, H. and Luxton M. 1982: A comparative analysis of soil fauna populations and their role in decomposition processes. *Oikos*, **39**: 288-388.

Pokarzhevskiy, A.D. 1985: Geochemical ecology of terrestrial animals. Nauka, Moscow, (in Russian).

Rabotnov, T.A.(ed.) 1987: Biogeocoenoses of alpine heaths (NW Caucasus).Nauka, Moscow (in Russian).

Schatz, H. 1981: Abundanz, Biomasse und Respirationsrate der Arthropoden-Mesofauna im Hochgebirge (Obergurgl,Tiroler Zentralalpen). *Pedobiol.*,**22**:52-70.

Striganova, B.R. 1975: Methods of soil invertebrates conservation. In *Methods of soil zoological investigations* (ed. M.S.Gilyarov), pp. 49-53. Nauka, Moscow, (in Russian).

Striganova, B.R. 1980: Nutrition of soil saprophages. Nauka, Moscow (in Russian).

Striganova, B.R. and Loginova, N.G. 1984: The role of *Diplopoda* in biological turnover of alpine meadows ecosystems of the Small Caucasus. *J.General Biology (Zh. obschei biologii)*, **45**: 196-202 (in Russian).

Tanasevich, A.V. 1990. Spiders of *Linyphiidae* of the Caucasus (*Arachnida, Aranei*). In *Fauna and ecology of the terrestrial invertebrates of the Caucasus* (ed.B. R.Striganov), pp.5-114. Nauka, Moscow (in Russian).

Voronina, I. N., Onipchenko V.G. and Ignaťeva, O.V., 1986: Components of the biological cycle in alpine lichen barrens of the Northwestern Caucasus. *Sov. Soil Sci.*, **18**: 20-29.

Zlotin, R.I., 1975: Life in high mountains. Mysĺ, Moscow (in Russian).

Received 21 August 1996; accepted 14 October 1997