Praca zbiorowa pod redakcją naukową Mieczysława Kunza, Toruń 2020

Anna Geraskina, Nikolaj Shevchenko

Main forest types and distribution of earthworm in Arkhyz area of the Teberda Biosphere Reserve (Russia, North-Western Caucasus)

Introduction

High-altitude, slightly disturbed forests of the Arkhyz site of the Teberda Nature Reserve (North-West Caucasus) were selected to research (fig. 1). According to dendrochronological studies in the valley of the Kizgych River valley *Abies nordmanniana* (Steven) Spach and *Pinus sylvestris* L., with ages over 450 years, were detected (Solomina et al. 2012). Forests of the Arkhyz site are close in composition and structure to natural forests (figs. 2.1–2.5) and have a complex micromosaic organization, which in most communities is influenced by a free-living herd of bison. Therefore, the Arkhyz site of the Teberda Nature Reserve is of particular interest for studying the spatial and biotopic distribution of soil biota, i.e., distribution of soil animals on the main microsites in different types of forest.

The aim of the study – description of the main types of forests of the Arkhyz site of the Teberda Biosphere Reserve and assessment of the biotopic distribution of earthworms in main types of forest.

Materials and methods

The studies were carried out in Arkhyz area of the Teberda Biosphere Reserve (Russia, Republic of Karachay-Cherkessia) (fig.1).

Teberda Reserve consists of two sections: Teberda area (66 059 ha) and Arkhyz area (19 270 hectares), as well as a biosphere polygon with an area of 27 277 hectares, which connected two cluster sections of the reserve with each other and with the territory of the Caucasian Biosphere Reserve. Thus, the total area of the Teberda Biosphere Reserve is 112 606 hectares. In 1997, the reserve received the status of a Biosphere Reserve with inclusion in the world network of biosphere reserves.

The Arkhyz site of the Teberda Reserve is located in the valley of the Kizgych River. In the south, the border runs along the Greater Caucasus Mountain Range, in the north–along the Abishir-Akhub Ridge. In the west and east, there are

dividing ranges Chaget-Chat and Uzhum, respectively. The main type of relief is the morphostructures of the trough valleys and high mountain ranges, with a temperate continental climate. Precipitation mainly occurs during the warm period (65% of the annual value), with an annual amount of 800–850 mm. The strong ruggedness of the mountainous terrain and a significant difference in elevations (1500–2000 m) determine the vertical variability of all climatic indices (Shal'nev and Yurin 2015). The Arkhyz site is the area with the highest degree of protection. Since the 60s of the twentieth century, a free-living group of bison has been maintained in the Arkhyz area (Treboganova 2012), which has been replenished with new animals since 2013 (fig. 2.6).

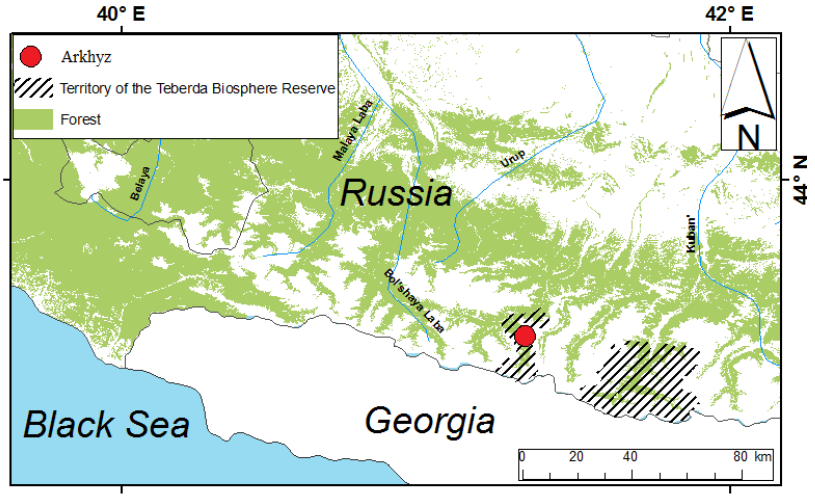

Fig. 1. Map of the Teberda Biosphere Reserve. Location point Arkhyz area – research region

The studies were carried out in the summer season of 2015. Description, collection and processing of geobotanical material obtained during route surveys were carried out according to generally accepted methods (Zaugol'nova and Braslavskaya 2010). The size of the test sites was 20 × 20 m; in total 124 descriptions were performed.

Density of the stand and the projective cover of plants of the ground cover is determined as a percentage (%) of the total area. The projective cover of species undergrowth of trees was determined according to the scale of J. Braun-Blanquet (Braun-Blanquet 1964, cited from Mirkin et al. 1989).

The names of forest types are given according to the *Guide of forest types in European Russia*, developed at the CEPF RAS (Zaugol'nova and Martynenko 2014), and nomenclature of plants follows *World Flora Online: An Online Flora of All Known Plants* [http://www.worldfloraonline.org].

Quantitative calculations of earthworms were carried out in five types of forest. Records of litter and soil were made by excavation and manual analysis of soil samples (Gilyarov 1975). The size of each separate sample was 25 x 25 cm, with a depth up to 30 cm. The worms were fixed in 4% formalin, weighed and determined using an inventory and identification guide of earthworms of the Russian fauna (Vsevolodova-Perel' 1997). Morpho-ecological groups are presented in accordance with the classification of Vsevolodova-Perel' (1997). The developmental stages were distinguished: cocoons, juvenile, submature and sexually mature worms (Fründ et al. 2010). In each type of communities, 20 soil samples were taken. In addition, deadwood and moss on rocks were examined (Geras'kina and Shevchenko 2019).

Fig. 2. The main forest types and large herbivores of the Arkhyz site (Teberda Biosphere Reserve) (photo: N. Shevchenko 2015)

Note: 1. grey alder nitrophilous floodplain forest with tall herbaceous plants in the ground layer, 2. birch-aspen nitrophilous forest with tall herb fringe communities in the ground layer, 3. beech-spruce-fir nemoral-boreal green moss forest, 4. spruce-fir nemoral-boreal green moss forest, 5. xero-mesophytic pine forest with spruce, fir and birch in the tree layer, 6. *Bison bonasus* on free grazing.

Results and Discussion

The main forest types of the Arkhyz site (Teberda Biosphere Reserve)

Grey alder nitrophilous floodplain forest with tall herbaceous plants in the ground layer occupied floodplain areas annually flooded during spring and summer floods (fig. 2.1). In the tree layer, *Alnus incana* (L.) Moench of overgrown origin was dominant. *Betula pendula* Roth, *Prunus padus* L., *Sorbus aucuparia* L. were also detected. Cover density varies from 50 to 90%; height 10–18 m. Natural seed regeneration due to developed herbaceous plants cover and permanent floods was absent and replaced by overgrowth. The shrub layer included bushy trees (*P. padus*, *S. aucuparia*, *Salix caprea* L.) and shrubs (*Corylus avellana* L., *Lonicera xylosteum* L.,

Ribes uva-crispa L., *Daphne mezereum* L., and others), the cover density was 20–50%. The projective cover of the herbaceous-shrub layer was 90–100%, height 1.0–2.0 (3.0) m. High mesophilic and meso-hygrophilous herbs determined the appearance of a multi-dominant herbaceous layer. There are three sub-layers in the layer. The sub-layer of tall herbaceous plants included: *Filipendula ulmaria* (L.) Maxim, *Angelica sylvestris* L., *Campanula latifolia* L., and others. In the second sub-layer *Persicaria bistorta* (L.) Samp., *Cardamine uliginosa* M. Bieb., *Carex sylvatica* Huds., *Equisetum pratense* Ehrh. and others were typical. The third sub-layer was represented by herbs: *Chrysosplenium alternifolium* L., *Galium odoratum* (L.) Scop., *Myosotis sparsiflora* J.C. Mikan ex Pohl, and others.

The upland part of the floodplain, remote from the riverbed, was occupied by **birch-aspen nitrophilous forest with tall herb fringe communities in the ground layer** (fig. 2.2)**.** These communities were flooded only in years with severe floods or after prolonged downpours in the mountains. *Populus tremula* L. dominated in the tree layer, sometimes – *B. pendula,* in admixture – *Acer platanoides* L., *Fagus orientalis* Lipsky, *S. caprea*, *Malus orientalis* Uglitzk ex Juz., and others. In the undergrowth layers, tree undergrowth occurred sporadically: *A. nordmanniana*, *A. platanoides* etc.) and shrubs (*C. avellana*, *L. xylosteum*, *R. uva-crispa* L., *Rhododendron luteum* Sweet), the degree of sheltering was 10–30%. In birch-aspen forest, as well as in gray alder forest, the projective cover of the herbaceous-shrub layer was about 100%, herbs height is 3.0 (4.0) m. In contrast to grey alder forest, mesophilic herb fringe communities with some presence of nitrophilous tall herbaceous plants predominated here. Typical species of the first sub-layer were: *Anthriscus sylvestris* (L.) Hoffm., *Delphinium schmalhausenii* Albov, *F. ulmaria, Symphytum asperum* Lepech., and others; second – *Geranium sylvaticum* L., *Poa nemoralis* L., *Vicia cracca* L., and others; third sub-layer – *Oxalis acetosella* L., *Stellaria nemorum* L., *Veronica filiformis* Sm., and others.

Beech-spruce-fir nemoral-boreal green moss forest occupied a much larger area than spruce-fir (fig. 2.3). The litter is well developed and is represented mainly by litter of *F. orientalis*. In the tree layer in different proportions, they are co-dominated by *A. nordmanniana*, *Picea orientalis* (L.) Peterm. and *F. orientalis*. In the old sites, single *A. platanoides*, *B. pendula*, *S. caprea* and *S. aucuparia* with decreased and low vitality were detected. The degree of sheltering of the layer was 80–90% and the height of individual trees was 40–45 m. The degree of sheltering of the layer of undergrowth and shrub layer varied from 30 to 60%. The undergrowth of trees prevailed (immature and virgin specimens) with *A. nordmanniana* (cover abundance value 1–3 on the Braun-Blanquet scale), *P. orientalis* (1–4), and *F. orientalis* (1–2). Singular shrubs were found – *C. avellana*, *Lonicera caprifolium* L., *Rh. luteum*,

Vaccinium arctostaphylos L., and others. The projective cover of the herbaceous-shrub layer was 20–70%. The community was dominated by species of boreal short vegetation, typical were *O. acetosella*, *Circaea alpine* L., *Gymnocarpium dryopteris* (L.) Newman, and others; nemoral species were represented *G. odoratum*, *Geranium robertianum* L., *Lactuca muralis* (L.) E. Mey, *S. nemorum*, and others.

Characteristic feature of **spruce-fir nemoral-boreal green moss forest** was well-developed moss layer; projective cover was 40–100% (fig. 2.4). The litter mainly was formed by *A. nordmanniana* and *P. orientalis*. The dominant tree layer was *A. nordmanniana*, rarely *P. orientalis*. In the admixture in old sites, singular *A. platanoides*, *P. tremula*, *B. pendula* were present, while on the upper border of the dark coniferous belt, *Pinus sylvestris* L. were found. The degree of sheltering was 80–90%; the height of individual trees reached 50 m. In the shrub layer, undergrowth of different age was developed (immature and virgin specimens) of *A. nordmanniana* (cover abundance value 1–3) and *P. orientalis* (1–3). Single growth of trees (*A. platanoides*, *F. orientalis*) and shrubs (*C. avellana*, *D. mezereum*, *Rh. luteum* and others) was detected. The degree of sheltering was 20–60%. The projective cover of the herbaceous-shrub layer varied from 10 to 75%. Characteristic species were: *O. acetosella*, *G. dryopteris*, *Actaea spicata* L., *Clinopodium grandiflorum* (L.) Kuntze, *Solidago virgaurea* L., and others. Single undergrowth *A. nordmanniana*, *A. platanoides*, *P. orientalis* and *F. orientalis* were detected.

Xero-mesophytic pine forest with spruce, fir and birch in the tree layer were distributed along the upper border of the forest belt over dark coniferous nemoral-boreal green moss communities (fig. 2.5). The distribution boundary of the pine forest corresponded to the distribution boundary of regular ground fires, which is confirmed by the presence of numerous traces of burns on tree trunks and coal in the soil. Pine forests were distributed on granitic soil brown forest and mountain meadow soils, the closeness of the forest stand was 30–70%. *P. sylvestris* was dominant, sometimes *A. nordmanniana,* and *P. orientalis* were found as mixed species. Singular *P. tremula*, *B. pendula*, *F. orientalis* and *S. aucuparia* were detected. The height of the layer reached 30–35 m. The undergrowth layer was uneven and depended on the degree of sheltering of tree layer; the degree of sheltering varied in the range 50–60%. An *A. nordmanniana* undergrowth of different age (cover abundance value 1–3) and *P. orientalis* (1–2) was well developed in the layer. The high abundance and age composition of the latter confirmed that the periodic lower fires, to which dark coniferous tree species are sensitive, play a regulatory role in maintaining pine forests in the Arkhyz section of the Teberda Reserve. Singular growth of trees (*A. platanoides*, *B. pendula*, *F. orientalis*, *P. sylvestris*) and shrubs (*C. avellana*, *L. xylosteum*) was

detected, *Rh. luteum* (cover abundance value 3–4) was often abundant. The projective cover of the herbaceous-shrub layer was 10–40% (rarely 60%). Xero-mesophytic herbs prevailed in the layer, typical species were *Festuca drymeja* Mert. & W.D.J. Koch, *F. pratensis*, *Hieracium murorum* C.B. Clarke, *Lathyrus roseus* Steven, *Melampyrum pretense* L., *P. nemoralis*, *Vicia sepium* L., and others. The undergrowth (immature and juvenile specimens) of *A. nordmanniana* and *P. orientalis* was well developed. The layer of moss was located mainly on stones and near stem rises; the projective cover varied greatly from 15 to 70%.

Earthworm population of the Arkhyz site (Teberda Biosphere Reserve)

In the selected forest types, 16 species of Lumbricidae family were found: *Aporrectodea caliginosa caliginosa* (Savigny, 1826), *A. jassyensis* (Michaelsen 1891), *A. rosea* (Savigny 1826), *Dendrobaena attemsi* (Michaelsen 1902), *D. mariupoliensis* (Wyssotzky 1898), *D. shmidti* (Michaelsen 1907), *D. octaedra* (Savigny 1826), *D. tellermanica* (Perel 1966), *D. veneta* (Rosa 1886), *Dendrodrilus rubidus tenuis* (Eisen 1874), *Eiseniella tetraedra tetraedra* (Savigny 1826), *Esenia fetida* (Savigny 1826), *Lumbricus castaneus* (Savigny 1826), *L. rubellus* (Hoffmeister 1843), *L. terrestris* (Linnaeus 1758), and *Octolasion lacteum* (Örley 1885). Detected species belong to four morpho-ecological groups. One species of earthworm *D. shmidti* is polymorphic and includes three forms: epigeic, endogeic and epi-endogeic which differ in size, pigmentation and habitat horizons (Rapoport 2009). Currently, the taxonomic status of these forms is being studied in detail by molecular methods (Shekhovtsov et al. 2020).

In **grey alder nitrophilous floodplain forest with tall herbaceous plants in the ground layer**, maximum abundance (146±18.2 ind./m^2), biomass (89±10.9 g/m^2) and species diversity of Lumbricidae were noted. They were inhabited by 12 species of earthworms (fig. 3). The found species belong to 4 morpho-ecological groups.

Epigeic species *Dr. rubidus tenuis* and *D. attemsi* out of all microsites more often inhabit in fallen trees. *Lumbricus castaneus,* a rare species in the Caucasus, was found only in the gray alder litter. For a long time, there was no data on the habitat of this species in the Caucasus before the finds of I.B. Rapoport (2005) in floodplain communities of the steppe zone of Kabardino-Balkaria. Due to the frequent flooding of soils, the epigeic amphibiotic species *E. tetraedra* are present here.

Out of epi-endogeic species *L. rubellus, D. veneta, D. shmidti* and *E. fetida* were found. All four species inhabited places where traces of bison life were noted: tree gnaws, push cars for bison, and bison excrement, which can serve as a source of nutrition for *D. veneta* and *E. fetida* – species used in vermicomposting and

processing of various organic substrates, including animal manure (Wang et al. 2007). In a number of studies, confinement of *L. rubellus* to manure of cattle and other large mammals (Seeber et al. 2005) was also noted. Findings of *E. fetida* were described earlier on the Arkhyz site of the reserve in alder-mixed herbaceous communities (Rapoport 2014). In our findings, *E. fetida* was detected only in the fallen trees beneath the *Alnus incana* bark. *D. veneta* inhabits forest litter, river sediments, and rotting fallen trees (Vsevolodova-Perel' 1997); in our records, worms of this species were found in waterlogged soil and in fallen trees.

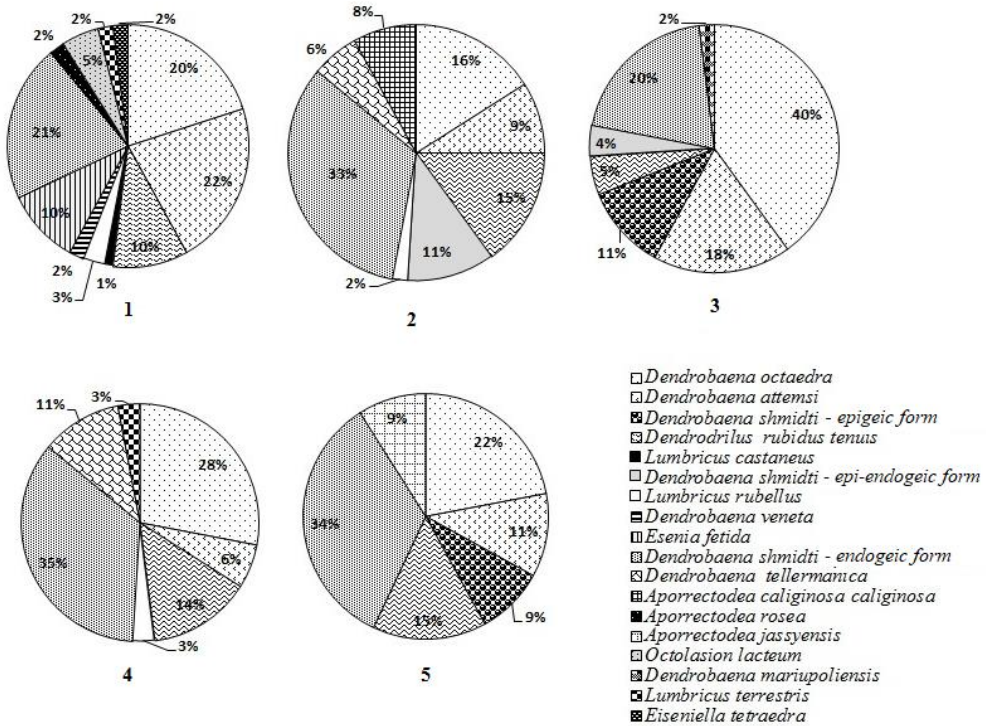

Fig. 3. Proportion (%) by number of earthworm species in the main forest types of the Arkhyz site (Teberda Biosphere Reserve). Note. 1–5 forest types as fig. 2.

In terms of abundance and biomass, the main species out of the group of endogeic species was *D. shmidti*. This species dominates in many communities of the mountain regions of the Caucasus (Geraskina 2019, Rapoport and Tsepkova 2019, etc.). Only in the riverbed nitrophilous tall herbs in grey alder forest *A. rosea* and *O. lacteum* were found. Rapoport (2014) noted the exceptional biotopic confinement of these species to grey alder forest in the studied area. From the group of anecic species, *L. terrestris* was found in soil at shallow depths due to severe waterlogging of the soil, as well as several sexually mature worms were found in the fallen trees.

In **birch-aspen nitrophilous forest with tall herb fringe communities in the ground layer,** the diversity (7 species), abundance (85±9.12 ind./m^2) and biomass (56±6.14 g/m^2) of earthworms were lower than in the grey alder nitrophilous floodplain forest. The detected species belong to 3 morpho-ecological groups. Epigeic species *D. octaedra*, *D. attemsi* and *Dr. rubidus tenuis* were found more often in fallen trees, and the highest number of specimens was found in rotting *Betula pendula* trunks under poorly decomposed bark in raw decaying wood. Out of the group of epi-endogeic species, *D. shmidti* and *L. rubellus* (singular specimens found in aspen) were detected. Out of the group of endogeic species, the most numerous was *D. shmidti* (65±6.6 ind./m^2), which is 33% of the total number of worms (fig. 3). Large, mature specimens of endogeic and epi-endogeic form *D. shmidti* were more often found in mosses on stones, in a well-moistened litter and moss cover on the fallen trees *Populus tremula* and *Acer* sp. of 2–3 stages of decomposition. In soil singular *D. tellermanica* and *A. caliginosa caliginosa* specimens were detected. *Dendrobaena tellermanica* characteristic species of the Arkhyz site of the Teberda Reserve (Rapoport and Tsepkova 2015).

In **beech-spruce-fir nemoral-boreal green moss forest**, 7 species of Lumbricidae were found. The number (78±4.1 ind./m^2) and biomass (41.7±5.3 g/m^2) of worms in the soil correspond to data for beech-dark coniferous forests (Perel' 1979, Scheu and Falka 2000, Rapoport et al. 2017). The found species belong to 4 morpho-ecological groups. From the group of epigeic species *D. octaedra* was detected in litter and this species is 40% of the total number of worms (fig. 3), *D. attemsi* was found more often in fallen trees, less often in mosses on stones, not found in the soil and *Dr. rubidus tenuis* was detected only in fallen trees. The only representative of the epi-endogeic group *L. rubellus* was found in the soil of the forest part where traces of bison activity were noted; in the same part of the forest, at a greater depth, anecic species *L. terrestris* was found. Out of the group of endogeic species *D. shmidti* dominated – 20% of the total number of worms (fig. 3). *D. tellermanica* was found singularly.

In **spruce-fir nemoral-boreal green moss forest**, 5 species of earthworms were found. The detected species belong to 4 morpho-ecological groups. Abundance (72±12.0 ind./m^2) and biomass (54.6±8.76 g/m^2) do not differ significantly from the previous forest type. But the species composition has its own characteristics. Only in this forest type, three *D. shmidti* forms were found. Epigeic species *D. octaedra, D. attemsi, Dr. rubidus tenuis* and *D. shmidti* inhabited mainly fallen trees. *D. octaedra* was also common in litter, upper soil, and moss on stones. *D. attemsi* in addition to fallen trees was found in mosses on stones.

From the epi-endogeic group, only *D. shmidti* was detected. The endogeic group also was represented by one species *D. shmidti*. But this species made up 35% of the total number of earthworms (fig. 3). Only in this type of forest a large anecic worm the Crimean-Caucasian subendemic *D. mariupoliensis* was found in the soil.

In **xero-mesophytic pine forest with spruce, fir and birch in the tree layer**, the lowest values of the abundance (30±2.5 ind./m^2) and biomass (17.8±6.1 g/m^2) of Lumbricidae were noted. Five species were found. Discovered species belong to two morpho-ecological groups: epigeic and endogeic groups. From the group of epigeic species, *D. octaedra* dominated – 22% of the total number of earthworms (fig. 3). *D. attemsi*, *Dr. rubidus tenuis* and the epigeic form *D. schmidti* were found only in fallen trees. From the endogeic group, two species were found: *D. schmidti* and *A. jassyensis*. The endogeic form *D. schmidti* was found not only in soil, but mainly in mosses on rocks and in wet fallen trees *Picea orientalis* and was 22% of the total number of earthworms (fig. 3). *Aporrectodea jassyensis* was found in a small number of soil samples at a depth of 10–15 cm, and singular specimens were found in the fallen trees of *Abies nordmanniana* of the latest stage of decomposition.

Conclusion

Five main types of forest of the Arkhyz area of the Teberda Biosphere Reserve were identified and described: grey alder nitrophilous floodplain forest with tall herbaceous plants in the ground layer, birch-aspen nitrophilous forest with tall herb fringe communities in the ground layer, beech-spruce-fir nemoral-boreal green moss forest, spruce-fir nemoral-boreal green moss forest, xero-mesophytic pine forest with spruce, fir and birch in the tree layer.

In the forests, 16 species of earthworms were found. The greatest abundance, diversity, and biomass of Lumbricidae were noted in communities with a high gradient of soil moisture, among which the near-channel grey alder nitrophilous floodplain forest are characterized by the maximum indicators. With an increase in the xerophyticity of communities, the diversity and quantitative characteristics of the population of Lumbricidae naturally decrease, which reach the lowest values in the upper border of the forest in xero-mesophytic pine forest with spruce, fir and birch in the tree layer. In the dark coniferous forest that make up the bulk of the forest belt of Arkhyz area is inhabited by 7 species of earthworms, among which the group of litter species dominates numerically, soil-litter and burrowing species are rare, the group of soil species itself is represented mainly by *Dendrobaena schmidti*, which constitutes the main biomass of the entire complex of Lumbricidae.

Acknowledgements

The scientific materials were collected by of state assignment "Methodical approaches to the assessment of the structural organization and functioning of forest ecosystems" No. AAAA-A18-118052400130-7 and results of the study were processed and supported by the Russian Science Foundation (project 16-17-10284).

References

Fründ H.-C., Butt K., Capowiez Y., Eisenhauer N., Emmerling C., Ernst G., Potthoff M., Schädler M., Schrader S., 2010, Using earthworms as model organisms in the laboratory: recommendations for experimental implementations, *Pedobiologia* 53 (2): 119–125.

Geraskina A.P., 2019, Transformations of earthworm communities during post-logging successions in the forests of the Northwest Caucasus, *Forest science issue* 2 (2): 1–14.

Geraskina A.P., Shevchenko N.E., 2019, Biotopic Association of Earthworms in Intact Forests of Teberda Nature Reserve, *Contemporary Problems of Ecology* 12 (7): 731–742.

Gilyarov M.S., 1975, *Metody pochvenno-zoologicheskih issledovanij* [*Methods of soil and zoological research*], Nauka, Moscow: pp. 304.

Mirkin B.M., Naumova L.G., Solomeshch A.I., 1989, Metodicheskie ukazaniya dlya praktikuma po klassifikacii rastitel'nosti metodom Braun-Blanke [Methodological guidelines for the practical course in plant classification by the Braun-Blanquet method], *Ufa*:1–37.

Perel' T.S., 1979, *Rasprostranenie i zakonomernosti raspredeleniya dozhdevykh chervei fauny SSSR* [*Distribution Pattern of Earthworms in Fauna of USSR*], Nauka, Moscow, pp. 273.

Rapoport I.B., 2005, Novyj dlja fauny Kavkaza vid roda *Lumbricus* (L., 1758) (Oligochaeta, Lumbricidae) [A new species of the genus *Lumbricus* (L., 1758) (Oligochaeta, Lumbricidae) in Caucasus], *Zoologicheskij zhurnal* 84 (8): 1015–1016.

Rapoport I.B., 2009, Morpho-ecological forms of Dendrobaena schmidti Michaelsen, 1907 (Oligochaeta, Lumbricidae) of North Caucasus, [in:] *Fourth International Oligochaete Taxonomy Meetings: Book of Abstracts*, Diyarbakir: 39.

Rapoport I.B., 2014, Biotopicheskoe raspredelenie dozhdevyh chervej (Oligochaeta, Lumbricidae) v Teberdinskoj zapovednoj territorii s naibolee vysokoj stepen'ju ohrany (Arhyzskij uchastok, Severo-Zapadnyj Kavkaz) [Biotopic distribution of earthworms (Oligochaeta, Lumbricidae) in Teberda Nature Reserve with high protection level (Arkhyz site, Northwestern Caucasus)], *Modern problems of strictly protected regional nature areas and their solution*, Voronezhskij gosudarstvennyj universitet, Voronezh: 214–218.

Rapoport I.B., Tsepkova N.L., 2019, Earthworm Populations (Oligochaeta, Lumbricidae) in the Basin of the Middle Reaches of the Bol'shaya Laba River (Northwestern Caucasus, Buffer Zone of Caucasian Nature Reserve), *Biology Bulletin* 46 (9): 1012–1029.

Rapoport I.B., Zenkova I.V., Tsepkova, N.L., 2017, Earthworm (Oligochaeta, Lumbricidae) populations of the Karasu River basin (Central Caucasus), *Biology Bulletin* 44 (8): 941–951.

Scheu S., Falca M., 2000, The soil food web of two beech forests (*Fagus sylvatica*) of contrasting humus type: stable isotope analysis of a macro-and a mesofauna-dominated community, *Oecologia* 123 (2): 285–296.

Seeber J., Seeber G.U.H., Kössler W., Langel R., Scheu S., Meyer E., 2005, Abundance and trophic structure of macro-decomposers on alpine pastureland (Central Alps, Tyrol): effects of abandonment of pasturing, *Pedobiologia* 49 (3): 221–228.

Shal'nev V.A., Yurin D.V., 2015, Drevnie oledenenija i paleogljacial'nyj rel'ef Arhyza [Ancient glaciation and paleoglacial relief of Arkhyz], *Nauka. Innovatsii. Tehnologii* (1): 127–136.

Shekhovtsov S.V., Rapoport I.B., Poluboyarova T.V., Geraskina A.P., Golovanova E.V., Peltek S.E., 2020, Morphotypes and genetic diversity of Dendrobaena schmidti (Lumbricidae, Annelida), *Vavilov Journal of Genetics and Breeding* 24 (1): 48–54.

Solomina O.N., Dolgova E.A., Maksimova O.E., 2012, *Rekonstruktsiya gidrometeorologicheskikh uslovii poslednikh stoletii na Severnom Kavkaze, v Krymu i na Tyan'-Shane po dendrokhronologicheskim dannym* [*Reconstruction of Hydrometeorological Conditions of Last Centuries in North Caucasus, Crimea, and Tian Shan According to Dendrochronological Data*], Nestor-Istoriya, St. Petersburg, pp. 253.

Treboganova N., 2012, An importance of protected areas for European Bison Reintroduction in Russia. European Bison Conservation Newsletter 5: 103-112.

Vsevolodova-Perel T.S., 1997, *Dozhdevye chervi fauny Rossii: kadastr i opredelitel' [Earthworms of the fauna of Russia: Cadastre and determinant*], Nauka, Moscow, pp. 101.

Wang L.K., Hung Y.-T., Li K.H., 2007, Vermicomposting proces, [in:] *Biosolids Treatment Processes*. *Totowa*, *Humana*: 689–704.

Zaugol'nova L.B., Braslavskaya T.Yu. (eds), 2010, *Metodicheskie podkhody k ekologicheskoi otsenke lesnogo pokrova v basseine maloi reki* [*Methodological Approaches to Ecological Evaluation of Forests in the Small River Basin*], KMK, Moscow, pp. 383.

Zaugol'nova L.B., Martynenko V.B., 2014, *Opredelitel' tipov lesa Evropejskoj Rossii* [*Guide of forest types in European Russia*] online version at http://cepl.rssi.ru/field-guide-of-forest-types-european-russia.

Summary

On the basis of the ecological-cenotic classification, five main types of forest of the Arkhyz area of the Teberda Biosphere Reserve were identified and described: grey alder nitrophilous floodplain forest with tall herbaceous plants in the ground layer, birch-aspen nitrophilous forest with tall herb fringe communities in the ground layer, beech-spruce-fir nemoral-boreal green moss forest, spruce-fir nemoral-boreal green moss forest, xero-mesophytic pine forest with spruce, fir and birch in the tree layer. It was established that the main forest species have a high ecological and ecological-floristic diversity and are characterized by a well-defined altitudinal zonation. The population of earthworms was studied in five types of forests, 16 species of the family Lumbricidae were found. The greatest abundance, diversity and biomass of earthworms were found in grey alder nitrophilous floodplain forest with tall herbaceous plants in the ground layer, the smallest – in xero-mesophytic pine forest with spruce, fir and birch in the tree layer. In the prevailing in area beech-spruce-fir forest 7 species of earthworms was found, among which the group dominates numerically epigeic species, epi-endogeic and anecic species are very rare, group of endogeic species represented mainly *Dendrobaena schmidti.* Species diversity, abundance and biomass of earthworms in beech-spruce-fir forest higher than in spruce-fir forest.

Key words: Teberda Biosphere Reserve, Caucasus, Russia, high mountain forests, soil, dead wood, microsites, soil macrofauna

Główne typy lasu i rozmieszczenie dżdżownic na powierzchni badawczej Arkhyz w Rezerwacie Biosfery Teberda (Rosja, północno-zachodni Kaukaz)

Streszczenie

Na podstawie klasyfikacji ekologiczno-cenotycznej, przeprowadzonej na powierzchni badawczej Arkhyz w Rezerwacie Biosfery Teberda wyróżniono pięć typów lasu: zalewowy, nitrofilny borealny las z olszą szarą i wysokim runem, brzozowo-osikowy nitrofilny las z runem ziołoroślowym, bukowo-świerkowo-jodłowy las borealno-nemoralnej strefy przejściowej z runem mszystym, świerkowo-jodłowy las borealno-nemoralnej strefy przejściowej z runem mszystym, bór sosnowy strefy umiarkowanie suchej ze świerkiem, jodłą i brzozą w drzewostanie. Stwierdzono, że w tych pięciu głównych typach lasu występuje wysoka ekologiczna i florystyczna różnorodność gatunkowa oraz zaznacza się wyraźna zonacja wysokościowa. W badaniach populacyjnych dżdżownic zanotowano występowanie ogółem 16 gatunków z rodziny Lumbricidae. Największa liczebność, różnorodność gatunkowa i biomasa dżdżownic wystąpiła w zalewowym, nitrofilnym borealnym lesie z olszą szarą i wysokim runem, najmniejsza – w borze sosnowym strefy umiarkowanie suchej ze świerkiem i jodłą w drzewostanie. W lesie bukowo-świerkowo-jodłowym, zajmującym największy obszar na powierzchni badawczej, znaleziono 7 gatunków dżdżownic. Dominujące wśród nich ilościowo gatunki epigeiczne, epiendogeiczne i aneciczne, to gatunki rzadkie. Grupa gatunków endogeicznych była reprezentowana głównie przez *Dendrobaena schmidti*. Różnorodność gatunkowa, liczebność i biomasa dżdżownic w lesie bukowo-świerkowo-jodłowym z runem mszystym była wyższa niż w lesie świerkowo-jodłowym z podobnym typem runa.

Słowa kluczowe: Rezerwat Biosfery Teberda, Kaukaz, Rosja, gleba, lasy wysokich gór, martwe drewno, makrofauna glebowa, mikrosiedliska

Contact to authors:

Anna Geraskina
Center for Forest Ecology and Productivity
Russian Academy of Sciences, Moscow, Russian Federation
e-mail: angersgma@gmail.com

Nikolaj Shevchenko
Center for Forest Ecology and Productivity
Russian Academy of Sciences, Moscow, Russian Federation
e-mail: neshevchenko@gmail.com