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# SPECIES STRUCTURE OF ORIBATID MITE POPULATION (ACARI, ORIBATEA) IN THE FOREST FLOOR LITTER IN THE RECLAIMED TERRITORIES (UKRAINE)

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**Species Structure of Oribatid Mite Population (Acari, Oribatea) in the Forest Floor Litter in the Reclaimed Territories (Ukraine). Didur, O. O., Kulbachko, Yu. L., Pakhomov, O. Ye.** — The features of the structure of the population of oribatid mites (Oribatida) as primary destructors of dead plant material that provide such ecosystem service as improvement of soil fertility are considered. Studies were performed in various stratigraphic types of artificial edaphotopes in the reclaimed sites of "Pavlogradskaya" query (Pavlograd, Dnipropetrovsk Region, Ukraine), which were planted with eastern red cedar (*Juniperus virginiana* Linnaeus). The amount of oribatid mite species in the forest litter of studied forest plantation varied from 16 to 25. Minimal number of species (16) and minimal population density of oribatid mites (4720 ind./$m^2$) was established for calcic chernozem topsoil type with sand interlayer, which can be explained by lower thickness of the forest floor litter within this reclamation type.
Key words: ecological restoration, ecosystem services, pedogenesis, forest recultivation, red cedar (*Juniperus virginiana*), oribatid mites, forest litter, Ukraine.

## Introduction

In all industrially developed regions around the world, the structure of landscapes is under strong anthropogenic influence. At the same time, the share of anthropogenic landscapes, which appear mainly due to mining and enrichment activity, is constantly growing. As the result of such intensive industrial exploration of the territories, the morphology of natural landscapes had changed. Instead of natural habitats for biota, non-agricultural lands (industrial "badlands" and "deserts"). Intensification of erosion processes, hydrological regimes changes and ecological and hygienic status of water bodies, atmospheric pollution due to dust creation and burning (coal tails), soil contamination and other processes of soil degradation are directly associated with industrial landscapes (Lykholat, 1999; Chibrik et al., 2016) and negatively affect human health potential (Lykholat et al., 2016).

One of the possible ways of optimization of technogenic landscapes, in particular, re-vegetation, is forest recultivation. Animals, so called "ecosystem engineers" are the powerful agents of re-vegetation in forest ecosystems in the conditions of recultivation (Eisenhauer, 2010; Kulbachko et al., 2014) their activity is mainly attributed to provision of such regulating ecosystem service as formation of soil fertility and erosion prevention.

Soil fertility is directly connected to amount of organic matter and specialties of the processes of it's decomposition in the soil. Oribatid mite (Acari, Oribatea) community is an important constituent of soil biota supporting processes of soil formation (Behan-Pelletier, 1999; Kolodochka, Shevchenko, 2013). In world fauna, oribatid mites (Acariformes, Oribatida) comprise more than 10,000 named species representing 1240 genera and 165 families (Subías, 2012).

Due to their morphoecological specialties, they can dwell in forest floor litter, on the soil surface and in varies soil horizons. Active nutrition of oribatids in the litter and soil horizons provides it's enrichment with organic substances and products of decomposition, improving its water-air properties which also linked to ecosystem successional changes (Bird et al., 2004; Smrž, Norton, 2004; Gormsen, 2006). Such features of their trophical activity define their ecological importance as "ecosystem engineers" in natural disturbed biocenoses, especially in the steppe zone as tough hydrothermical conditions are typical for it, thus artificial forest plantations are put in conditions of evident geographical and ecological disparity to the growth conditions.

Western part of the Donets Basin is situated in the territory of the Dnipropetrovsk Region (fig. 1). In the region of the basin, there are over 40 mine seams with working thickness from 0.6 to 1.6 m, which lie in depth of 400 to 1800 m. Coal extraction is performed by the open-pit mining technique. Flat piles in the 11 mines of Western Donbas contain more than 70 million of tons of phytotoxic sulphur, organic-carbon-bearing and argillaceous shale, with high content of pyrite ($FeS_2$), troilite ($FeS$), and chalcopyrite ($CuFeS_2$). Movement of the deep sediments of the Cretaceous period onto the surface initiates the processes of physical weathering, oxidation, dissolution, hydrolysis, and burning. Other numerous negative factors may also induce such processes as high concentration of soluble toxic salts, rise in the alkalinity level, low absorbance and permeability, high soil density, low carbon and plant-available nitrogen concentrations (Novitskii, 2011).

The aim of the study was to define the taxonomic composition and domination structure of oribatid mites in the floor litter under the red cedar within forest recultivation plot.

In soil ecosystems floor litter represents its special constituent, different from the mortmass. It had the number of vital ecological functions: regulation of soil air-water regime, termoisolation, protection of soil from water erosion and mechanical densification, enrichment with nutritive components and humus formation. Soil also represents life environment for varies animals, plants and microorganism, which amplifies its importance. During their nutrition process oribatid mites disperse dead plant material, contributing into main biochemical soil process — humification.

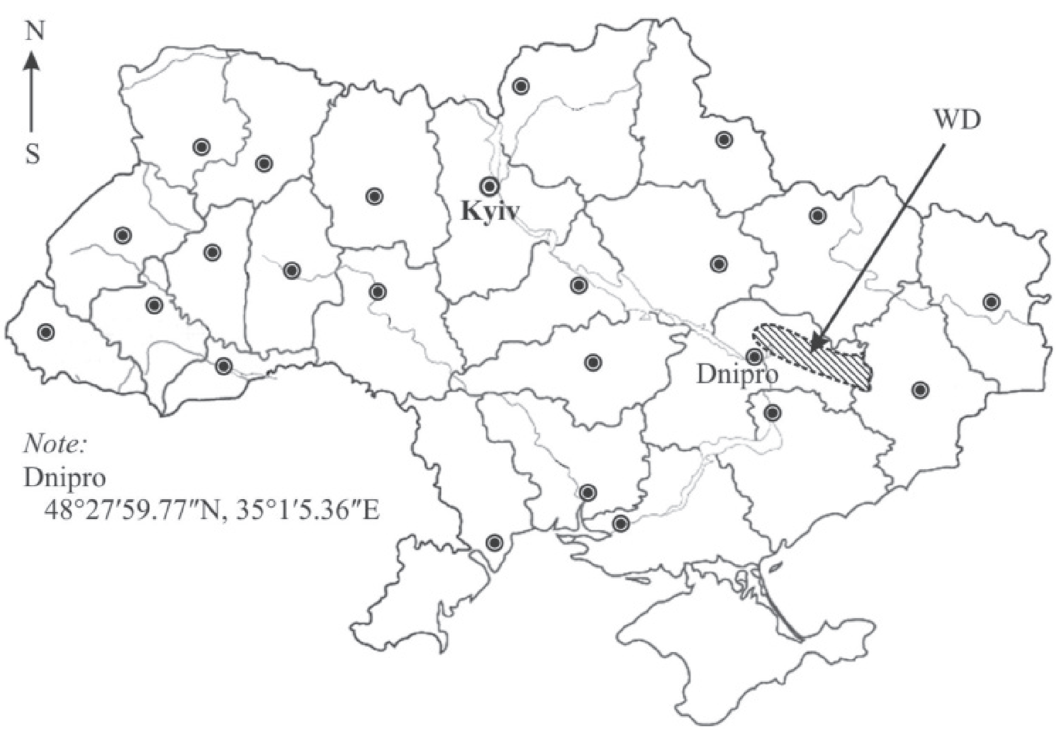


Fig. 1. Location of the Western Donbas coal basin in the Dnipropetrovsk Region, Ukraine: WD — Western Donbas.

**Material and methods**

Studied material was collected within the forest recultivation area in the territory of Western Donbas in the plantation of the red cedar (*Juniperus virginiana* L.). The experimental-production reclamation site was established in 1976 year and located in the mine-field zone of "Pavlogradskaya" query (48°33´32″ N, 35°59´13″ E), where five stratigraphic types of topsoil edaphotops with different depth of the reclaimed layer were distinguished (fig. 2).

At the stage of biological reclamation, the site was planted with trees and bushes, in particular with red cedar, an evergreen coniferous plant of the Cypress family (Cupressaceae). This popular ornamental plant is often used for recreational areas, as well as for agromelioration and forestry.

Studies were performed within the reclamation plots with loess-like loam topsoil (2nd type) and with top layer of humified calcic chernozem (3rd type and 5th type). Types with calcic chernozem had different stratigraphic structure and were distanced from each other.

As the main mass of tree roots extending to the depth 20–60 cm in the soil layer, topsoil capacity is limited by half meter. According to objectives of the study, collection and withdrawal of oribatids, form the floor litter layer under the red cedar was performed according to the generally accepted method (Bulanova-Zakhvatkina, 1967) in fifteen repeats. Oribatids species identification was performed by microscopy, binocular microscopes PZO (Poland) and Zeiss Promo Star (Germany) were used. For the identification of mites, "Key of soil-inhabiting mites, Sarcoptiformes" (Giljarov, 1975), "A Guide to the ceratozetoid mites (Oribatei, Ceratozetoidea) of Ukraine" (Pavlichenko, 1994).

For the identification of the domination structure in mite communities, the Engelmann scale was used (Engelmann, 1978): E — eudominant (> 40 % of the total amount of individuals), D — dominant (12.5–39.9 %), SD — subdominant (4.0–12.4 %), R — recedent (1.3–3.9 %), and SR — subrecedent (< 1.3 %). Evaluation of the species variety index for oribatid mites was performed according to the Margalef index.

For identification of the qualitative species composition of the invertebrate communities in soil, the Jaccard coefficient of similarity was used. In the case of ultimate absence of common species, the meaning of the coefficient it is equal to zero and in the case of ultimate faunistic similarity it is equal to 100 %.

Mathematical processing of obtained data was performed with MS Excel Office program tool.

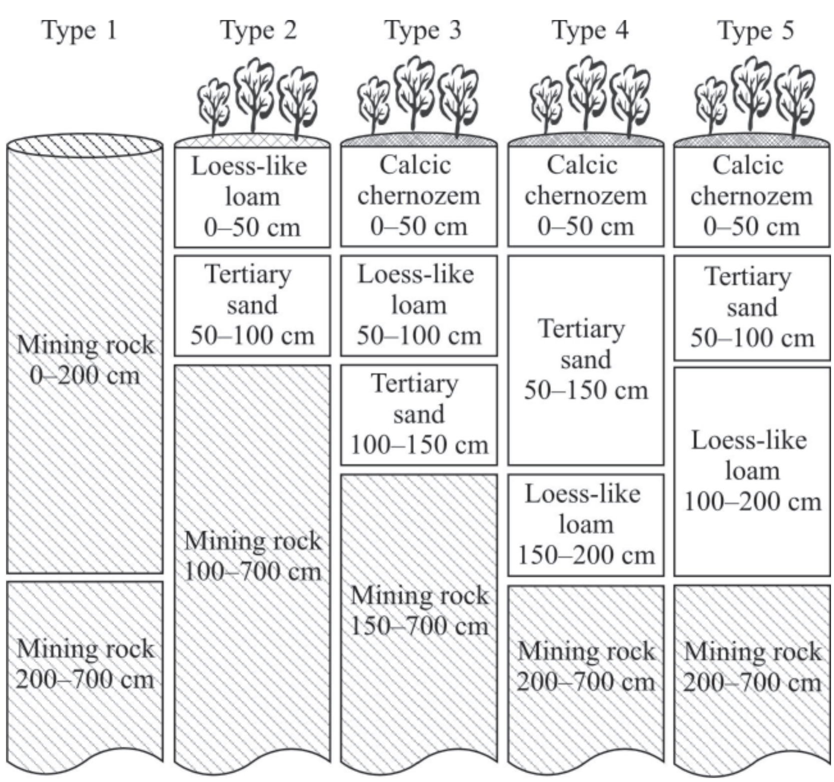


Fig. 2. Stratigraphic types of artificial edaphotopes within the experimental-production reclamation site.

## Results and discussion

For biological community existence, not only amount of individuals is important, but also species variety, which is the basis of biological diversity in nature. Amount of species dwelling in a biocenosis and their numerical ratio define its species structure. For each particular species in the biocenosis the indicators of significance are: its abundance (number of individuals per unit of area of occupied space); frequency of occurrence (percentage of samples where species was identified to the total number of samples or studied plots); rate of domination (ratio between number of individuals of certain species and all studied group). These indicators have great importance for evaluation of structural and functional characteristics of animals' communities.

Taxonomic composition, the amount of species and the domination structure of oribatid mites samples from the forest floor litter under the red cedar within three different stratigraphic types of forest recultivation plots were defined within this study (tables 1–3). Due to that recultivation plot represents itself artificial forest ecosystem on the on the mine rock, thus species composition of oribatids' community is poor. In studied red cedar floor litter on the loess-like loam topsoil (2nd stratigraphic type), 18 species of oribatid mites were found, on the calcic chernozem (3rd and 5th topsoil types) 25 and 16 species were identified accordingly.

**Table 1. Species structure of oribatid mite community collected from the coniferous litter under red cedar plantation on the loess-like loam with sand interlayer (2nd stratigraphic type)**

| Species | Number of ind. | Domination percentage | Domination class |
|---|---|---|---|
| *Belba dubinini* Bulanova-Zachvatkina, 1962 | 5 | 0.27 | SR |
| *Rhinoppia obsoleta* (Paoli, 1908) | 8 | 0.44 | SR |
| *Metabelba papillipes* (Nicolet, 1855) | 57 | 3.13 | R |
| *Multioppia glabra* (Mihelčič, 1955) | 448 | 24.6 | D |
| *Ramusella mihelcici* (Pérez-Íñigo, 1965) | 35 | 1.92 | R |
| *Scheloribates laevigatus* (Koch, 1835) | 65 | 3.57 | R |
| *Suctobelbella* sp. Jacot, 1937 | 85 | 4.66 | SD |
| *Suctobelbella subtrigona* (Oudemans, 1900) | 20 | 1.10 | SR |
| *Galumna dimorpha* Krivolutskaja, 1952 | 490 | 26.9 | D |
| *Gymnodamaeus bicostatus* (Koch, 1835) | 172 | 9.43 | SD |
| *Pilogalumna crassiclava crassiclava* (Berlese, 1914) | 28 | 1.54 | R |
| *Liacarus punctulatus* Mihelčič, 1956 (L.) | 5 | 0.27 | SR |
| *Protoribates capucinus* Berlese, 1908 | 2 | 0.11 | SR |
| *Punctoribates liber* Paulitchenko, 1991 | 145 | 7.95 | SD |
| *Suctobelbella acutidens acutidens* (Forsslund, 1941) | 90 | 4.94 | SD |
| *Tectocepheus velatus velatus* (Michael, 1880) | 156 | 8.56 | SD |
| *Trichoribates trimaculatus* (C. L. Koch, 1836) | 7 | 0.38 | SR |
| *Liochthonius lapponicus* (Trägårdh, 1910) | 5 | 0.27 | SR |
| Number, ind. | 1823 | – | – |
| Number of species | 18 | – | – |
| Average density, ind./m$^2$ | 12 153 | – | – |

Note. Domination scale: E — eudominant (> 40 % of the general amount of individuals), D — dominant (12.5–39.9 %), SD — subdominant (4.0–12.4 %), R — recedent (1.3–3.9 %), and SR — subrecedent (< 1.3 %).

Analysis of the dominance structure of oribatid mites in the floor litter under the red cedar in planted on the loess-like loam (2nd stratigraphic type), indicated that two species were dominating: *Multioppia glabra* (Mihelčič, 1955) (24.6 % of the total number of individuals found) and *Galumna dimorpha* Krivolutskaja, 1952 (26.9 %) (fig. 3). There were 5 species classified as subdominant, among which general species such as *Tectocepheus velatus, Punctoribates liber*, which were occurring in red cedar

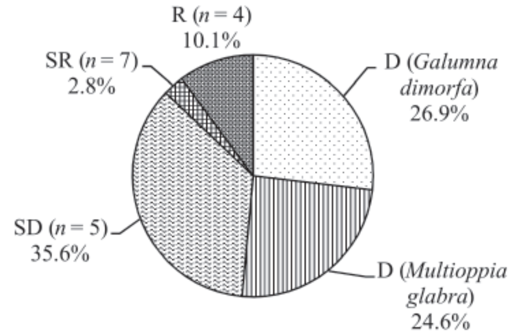


Fig. 3. Dominating structure of oribatid mite community on the 2nd stratigraphic type (forest floor litter).

**Table 2. Species structure of oribatid mite population, collected from coniferous floor litter within red cedar plantation on the humified calcic chernozem layer with loess-like loam interlayer (3rd stratigraphic type)**

| Species | Number of ind. | Domination percentage | Domination class |
|---|---|---|---|
| *Belba dubinini* Bulanova-Zachvatkina, 1962 | 6 | 0.17 | SR |
| *Rhinoppia obsoleta* (Paoli, 1908) | 2 | 0.06 | SR |
| *Metabelba papillipes* (Nicolet, 1855) | 36 | 1.01 | SR |
| *Multioppia glabra* (Mihelčič, 1955) | 449 | 12.6 | SD |
| *Multioppia wilsoni laniseta* Moritz, 1966 | 5 | 0.13 | SR |
| *Oppiella nova* (Oudemans, 1902) | 14 | 0.39 | SR |
| *Ramusella mihelcici* (Pérez-Íñigo, 1965) | 213 | 5.99 | SD |
| *Suctobelbella* (*Flagrosuctobelba*) *alloenasuta* Moritz, 1971 (S.) | 54 | 1.52 | R |
| *Suctobelbella acutidens acutidens* (Forsslund, 1941) | 192 | 5.40 | SD |
| *Suctobelbella* sp. Jacot, 1937 | 377 | 10.6 | SD |
| *Suctobelbella subtrigona* (Oudemans, 1900) | 45 | 1.27 | SR |
| *Galumna dimorpha* Krivolutskaja, 1952 | 195 | 5.48 | SD |
| *Galumna lanceata* (Oudemans, 1900) | 3 | 0.08 | SR |
| *Galumna alata* (Hermann, 1804) | 179 | 5.03 | SD |
| *Gymnodamaeus bicostatus* (Koch, 1835) | 248 | 6.98 | SD |
| *Microzetorchestes emeryi* (Coggi, 1898) | 3 | 0.08 | SR |
| *Pilogalumna crassiclava crassiclava* (Berlese, 1914) | 60 | 1.69 | R |
| *Acrotritia hyeroglyphica* (Berlese, 1916) | 14 | 0.39 | SR |
| *Liacarus punctulatus* Mihelčič, 1956 (L.) | 2 | 0.06 | SR |
| *Punctoribates liber* Paulitchenko, 1991 | 839 | 23.6 | D |
| *Scheloribates laevigatus* (Koch, 1835) | 8 | 0.23 | SR |
| *Tectocepheus velatus velatus* (Michael, 1880) | 594 | 16.7 | D |
| *Trichoribates trimaculatus* (C. L. Koch, 1836) | 6 | 0.17 | SR |
| *Oribatula frisiae* (Oudemans, 1900) | 6 | 0.17 | SR |
| *Liochthonius lapponicus* (Trägårdh, 1910) | 6 | 0.17 | SR |
| Number, ind. | 3556 | – | – |
| Number of species | 25 | – | – |
| Average density, ind./m$^2$ | 23707 | – | – |

See note for table 1.

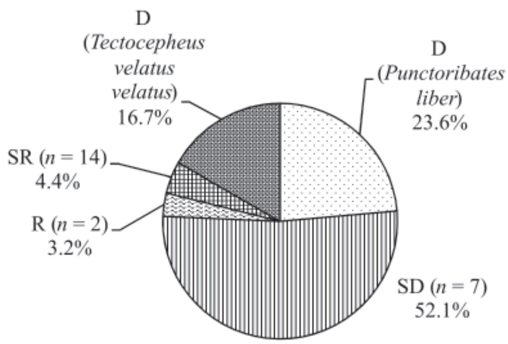


Fig. 4. Dominating structure of oribatid mites community on the 3rd stratigraphic type (forest floor litter).

litter within plots with calcic chernozem top layer. 4 species were defined as recedent (10.1 %), subrecedents — 7 species (2.8 %).

In the population of the mites, dwelling in the litter covering calcic chernozem with loess-like loam interlayer (3rd type), two species were found to be dominating, *Tectocepheus velatus velatus* (Michael, 1880) (16.7 %) and *Punctoribates liber* Paulitchenko, 1991 (23.6 %) (fig. 4). 7 species (52.1 %) could be defined as subdominants, recedents — 2 species (3.2 %), subrecedents 14 species (4.4 %).

In the community of mites inhabiting litter on the calcic chernozem with sand interlayer (5th type) following species were found to be dominating: *Tectocepheus velatus velatus* (Michael, 1880) (39.7 %), *Punctoribates liber* Paulitchenko, 1991 (21.2 %), *Pilogalumna crassiclava crassiclava* (Berlese, 1914) (16.7 %). Subdominant species was *Oribatula frisiae* (Oudemans, 1900) (6.1 %), 6 species were defined as recedents — *Trichoribates trimaculatus* (C. L. Koch, 1836) (3.7 %), *Metabelba papillipes* (Nicolet, 1855) (3.1 %) and six — subrecedents (2.5 %). No eudominants species were found in red cedar floor litter (fig. 5).

**Table 3. Species structure of oribatid mite population, collected from coniferous floor litter within red cedar plantation on the humified calcic chernozem layer with sand interlayer (5th stratigraphic type)**

| Species | Number of individuals | Domination percentage | Domination class |
|---|---|---|---|
| *Metabelba papillipes* (Nicolet, 1855) | 22 | 3.11 | R |
| *Multioppia glabra* (Mihelčič, 1955) | 15 | 2.12 | R |
| *Suctobelbella acutidens acutidens* (Forsslund, 1941) | 6 | 0.85 | SR |
| *Suctobelbella* sp. Jacot, 1937 | 2 | 0.28 | SR |
| *Suctobelbella subtrigona* (Oudemans, 1900) | 2 | 0.28 | SR |
| *Galumna alata* (Hermann, 1804) | 10 | 1.41 | R |
| *Galumna dimorpha* Krivolutskaja, 1952 | 13 | 1.84 | R |
| *Galumna lanceata* (Oudemans, 1900) | 4 | 0.56 | SR |
| *Gymnodamaeus bicostatus* (Koch, 1835) | 13 | 1.84 | R |
| *Microzetorchestes emeryi* (Coggi, 1898) | 2 | 0.28 | SR |
| *Pilogalumna crassiclava crassiclava* (Berlese, 1914) | 118 | 16.7 | D |
| *Xenillus tegeocranus* (Hermann, 1804) | 2 | 0.28 | SR |
| *Punctoribates liber* Paulitchenko, 1991 | 150 | 21.2 | D |
| *Tectocepheus velatus velatus* (Michael, 1880) | 280 | 39.5 | D |
| *Trichoribates trimaculatus* (C. L. Koch, 1836) | 26 | 3.67 | R |
| *Oribatula frisiae* (Oudemans, 1900) | 43 | 6.07 | SD |
| Number, ind. | 708 | – | – |
| Number of species | 16 | – | – |
| Average density, ind./m$^2$ | 4720 | – | – |

See note for table 1.

Increase in the total share of rare species (sum of shares for R and SR categories) could be observed in the floor litter samples collected on 2nd (loess-like loam topsoil) and 5th (calcic chernozem on the sand interlayer) — 13.0 % and 16.5 % in comparison with floor litter covering calcic chernozem with loess-like loam interlayer (3rd type) — 7.6 %.

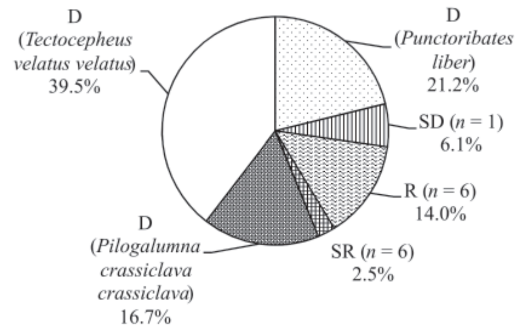


Fig. 5. Dominating structure of oribatid mite community on the 5th stratigraphic type (forest floor litter).

Population density of oribatid mites can be considered as the measure for population state evaluation. Comparison of average oribatid mite population density in the coniferous litter of the red cedar plantation from different stratigraphic recultivation types indicated that maximal density in the red cedar litter on the 3rd type (calcic chernozem with loess-like loam interlayer) — 23,707 ind./m$^2$, minimal density was found for 5th recultivation type (calcic chernozem with sand interlayer) — 4720 ind./m$^2$ (fig. 6).

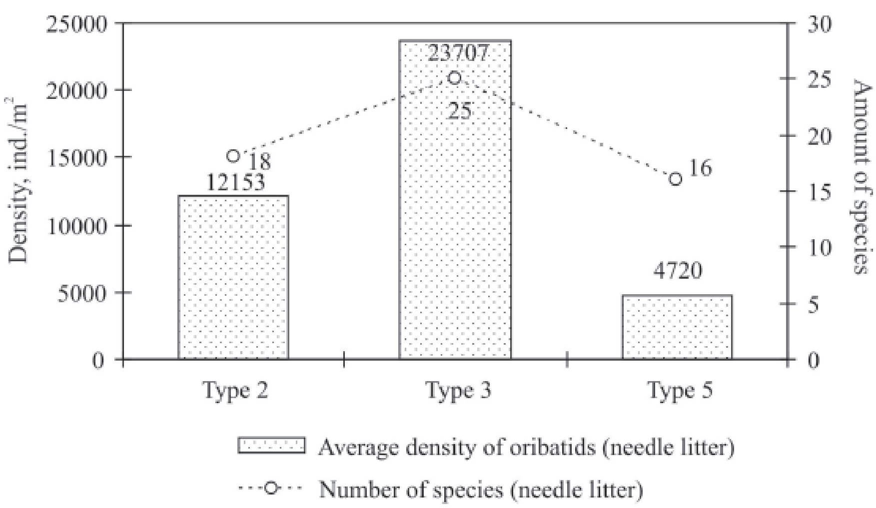


Fig. 6. Average population density and species richness of oribatid mites on different recultivation types within red cedar plantation.

**Table 4. Qualitative identity of oribatid mite populations dwelling in red cedar litter within forest recultivation plot**

| Stratigraphic type of the topsoil | Loess-like loam (2nd type) | Calcic chernozem with loess-like loam interlayer (3rd type) | Calcic chernozem with sand interlayer (5th type) |
|---|---|---|---|
| Loess-like loam (2nd type) | 18 | 14* | 17* |
| Calcic chernozem with loess-like loam interlayer (3rd type) | 65,4 % | 26 | 10* |
| Calcic chernozem with sand interlayer (5th type) | 47,8 % | 51,9 % | 25 |

Note. Total amounts of species identified in community are marked in diagonal; * amount of general species for two communities.

In the litter from the 5th recultivation type (loess-like loam topsoil) average oribatid density was found to be 12,153 ind./m$^2$. Average density decrease observed for 5th recultivation type could be explained by lower thickness of cedar litter layer down to 0.5 cm, which is linked to anthropogenic activity.

Maximal meaning for species richness (Margalef index) for oribatids was defined for 3rd stratigraphic type of chernozem topsoil with loess like loam interlayer (DMg = 2.38). In the litter collected from 2nd and 5th types same index was estimated 1.81 and 1.77 accordingly.

Jaccard coefficient of species similarity is widely used for comparative analysis of the groups of terrestrial animals. In our study Jaccard coefficient of species similarity, calculated for oribatid mite population, dwelling in the floor litter of 2nd, 3rd and 5th types within red cedar plantation was varying from 47.8 % to 65.4 % (table 4). Comparison of identity of oribatid mite populations dwelling in the floor litter of studied types revealed more species identity for mite populations of neighboring 2nd and 3rd types (65.4 %).

It was established, that on studied types of forest recultivation in oribatid mite populations, collected from red cedar litter species with large number of individuals are prevailing. Their share was quite large and was varying from 83.5 % to 92.4 %. Maximal total share of specie with large number of individuals (dominants and subdominants) was typical for red cedar litter covering calcic chernozem topsoil with loess-like loam interlayer (3rd stratigraphic type) — 92.4 %, smaller share — 87.1 % — for red cedar litter covering loess-like loam (2nd stratigraphic type), even smaller — 83.5 % — for red cedar litter covering calcic chernozem with sand interlayer (5th stratigraphic type). Due to that red cedar plantation on the 5th stratigraphic type had formed not thick enough layer of litter (in some spots litter was almost absent) share of species with maximal number of individuals was lower, at the same time the share of species with low number of individuals grows (16.5 %) compared to loess-like loam type (2nd recultivation type) — 12.9 % and calcic chernozem topsoil on the loess-like loam interlayer (3rd type) — 7.6 %.

It should be noted that in oribatid mite population three common species with low number of individuals were identified — *Metabelba papillipes* (Nicolet, 1855), *Suctobelbella subtrigona* (Oudemans, 1900), *Trichoribates trimaculatus* (C. L. Koch, 1836). Their total share among all species with low number of individuals was 35.6 % (loess-like loam type) and 31.4 % (calcic chernozem with loess-like loam interlayer type), 43.0 % (calcic chernozem with sand interlayer type).

Among oribatid mite species with high number of individuals, two common species were identified in the litter from all studied types — *Punctoribates liber* Paulitchenko, 1991, *Tectocepheus velatus velatus* (Michael, 1880). Their total share among all species with high number of individuals was 19.0 % (loess-like loam type), 44.0 % (calcic chernozem topsoil with loess-like loam interlayer), 73.0 % (calcic chernozem with sand interlayer).

## Conclusion

The activity of oribatid mites in terrestrial ecosystems preserves stability of ecological properties of the soil (fertility and structure), which corresponds to the groups of ecosystem services — pedogenesis and soil quality regulation. Species structure of oribatid mites is an integral component of biological diversity in soil. During our study it was established that amount if species of oribatid mites in the floor litter under red cedar planted within studied stratigraphic types varies from 16 to 25. At the same time population density of oribatid mites varies between 4720 and 23,707 ind./m$^2$. In the floor litter covering calcic chernozem type with sand interlayer amount of species was found to be minimal (16) as well as density 4720 ind./m$^2$.

Possibly this is due to presence of sand interlayer under calcic chernozem in 5th stratigraphic type which influences hydrothermal conditions of environment of oribatid mites and, ultimately, vertical migration of motes is limited by half meter layer of chernozem. From the other side this is related to low thickness of cedar litter layer. In general, this is confirmed by Margalef index of species richness.

In the domination structure of oribatid mite population in the litter under red cedar plantation within studied recultivation types, two dominating species — *Punctoribates liber* Paulitchenko, 1991 and *Tectocepheus velatus velatus* (Michael, 1880) were present, for which conditions of recultivation plot were the most favorable. High number of individuals for these species influence general oribatid mite population density within recultivation plot while recedent and subrecedent species had insignificant density, which is typical for anthropotechnogenic ecosystems.

Fauna composition of oribatid mites found in the floor litter of red cedar plantation is more identical for loess-like loam topsoil and calcic chernozem with sand interlayer types (Jaccard index 65,4 %), which can be explain by thick layer of the floor litter within these types.

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