



Faunistic review of oribatid mites (Acari: Oribatida) from Voronezh state nature biosphere reserve

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The study presents results on the analysis of faunistic complex of oribatid mites inhabiting the core zone of Voronezh state nature biosphere reserve named after V.M. Peskov. The number of taxa of oribatid mites from the reserve's core zone inhabiting green-moss pine forests, aspen forests and alder forests including 85 species, 59 genera and 33 family is presented for the first time. Results of the study show that core zone fauna mostly consists of Palaearctic and Holarctic mite species. Pine forests were dominated by the ecological group of mites living in soil pores, aspen and alder forests – mites dwelling in the litter layer. Greater number of primary-unspecialized and lower number of surface dwelling species were found in the core zone comparing with the zone of economic use of the reserve.

Keywords: oribatid mites, species list, core zone, Voronezhskaya oblast, morphoecological types, pine forests, alder forests, aspen forests, specially protected natural territories.

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Introduction

Oribatid mites (Acariformes: Oribatida) are numerous and widely distributed soil arthropods serving as convenient model objects for bioindication of transformation processes in the soil. The analysis of oribatid mites' fauna found in the specially protected nature territories (SPNT) many of which are insular zones surrounded by territories with high degree of anthropogenic transformation are of especial interest (Krivolutskiy, 1994).

Voronezh state nature biosphere reserve named after V.M. Peskov (hereinafter – Voronezh reserve) is an example of such SPNT. Its main task is to protect the natural complex of insular forest massif in the forest steppe zone. Territory of Voronezh reserve is an excellent model for research in the field of insular biogeography, functioning and conservation of metapopulations, development of practical recommendations for the organization of nature

conservation in densely populated regions of European Russia.

Voronezh reserve oribatid mites' fauna has been studied earlier by R.V. Kolycheva. These studies have been carried out from 1980's and allowed finding 103 species of oribatids (Kolycheva, 1994) however having been carried out only in the economic zone of the reserve not covering the core zone.

Aim of the present work was to analyze oribatid mites fauna in the Voronezh reserve core zone territory.

Material and methods

Nature reserve is located on the border between Voronezhskaya (Verkhnekhavsky rayon) and Lipetskaya (Usmanskyy rayon) oblasts, occupying the northern half of the insular forest massif – Usmanskyy bor. The geographical coordinates are in the range

N 51°52'–52°02' and E 39°21'–39°47'. On the southern border of the reserve is the village Krasnolesny (by rail – Grafskaya station), on the western side – settlement Ramon', on the northern – Usman' town, Lipetskaya oblast. 18 settlements are located on the perimeter. About 40 km south of the reserve is the city of Voronezh – industrial, scientific and historical and cultural center of the Chernozem region; 100 km to the north – large industrial city of Lipetsk. The reserve is connected with these regional centers by automotive roads and railways (Kadastryvye svedeniya..., 2014).

Material was collected in the summer (June–July) of 2013–2015. Sampling was performed on plots 202, 203, 221, 222, 340, 341, 342 according to the Voronezh reserve territory zoning (Fig. 1). Plots 202, 203, 221, 222 represent alder and aspen forests; undergrowth is dominated by black currant and the dense high herbage is made from a large number of herbaceous plants (common reed, meadowsweet, nettle, ostrich fern, etc.). Sod forest soils prevail. Plots 340, 341, 342 are green moss pine forests. The forest floor is dominated mainly by a moss pillow made of rugose fork-moss and red-stemmed feathermoss, in

the grassy layer there are one-sided wintergreen, round-leaved wintergreen, prince's pine, stiff clubmoss, common clubmoss and groundcedar. Sod forest soils prevail here as well, although with a high admixture of sand (Vengerov et al., 2009).

Soil samples were taken according to the standard method. Size of the soil sample was 10x10 cm. A total of 580 samples were taken. Mites were collected using Berlese-Tullgren funnels. Collected material was cleared in concentrated lactic acid. Species were identified according to "Die Tierwelt Deutschlands. Hornmilben" (Weigmann, 2006). Oribatid systematics are given according to Balogh (Balogh and Balogh, 1992a, b) and Subias (Subias, 2014) systems.

Results

We have collected 85 species belonging to 59 genera and 33 families from the studied plots in the Voronezh reserve. 54 species were common for our research and materials of R.V. Kolycheva, while 49 more species indicated in her review have not been found. At the same time, 31 species among those that we

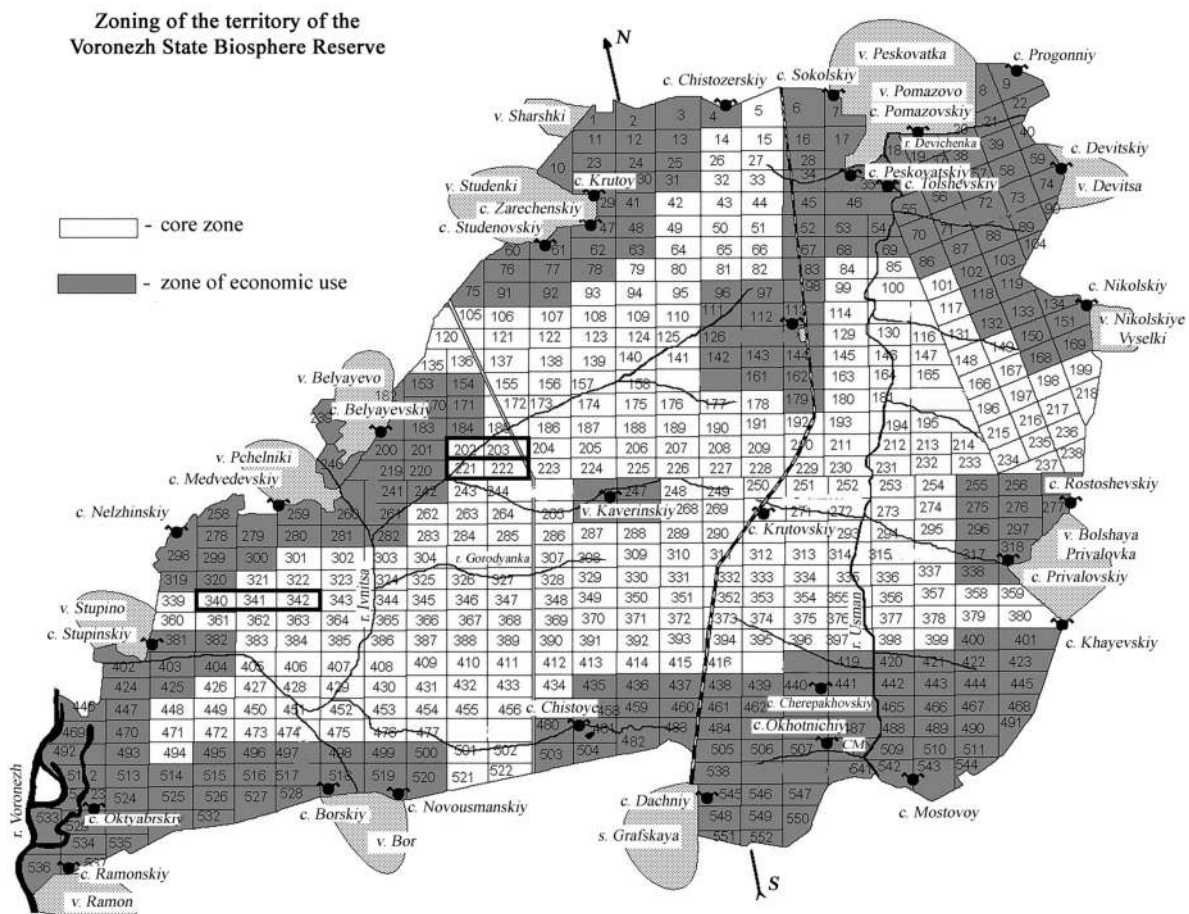


Figure 1. The zoning of Voronezh state nature biosphere reserve (from <http://zapovednik-vrn.ru/o-zapovednike1/dokumenty1/kadastryvye-svedeniya/>, with changes). The zones of sampling plots are marked by a box.

collected have not been found previously on the territory of Voronezh reserve. Of particular interest are 17 species, new to the fauna of the Voronezh region, including one family (Mesoplophoridae Ewing, 1917) and three genera (*Mesoplophora* Niedbala, 1985, *Furcoppia* Mahunka, 1983, *Suctobelba* Paoli, 1908).

In terms of taxonomy, higher oribatid mites (Brachypylina) form the basis of the oribatofauna of the region. Their share in the total taxonomic list is 73% for genera and 75% for species. The share of the lowest mites is 27 and 25%, respectively.

In zoogeographical terms the overwhelming majority are Palaearctic (43%) and Holarctic (30%) species. The proportion of cosmopolitans is 21%. About 6% are European species.

In terms of morphoecology the population of oribatid mites of the core zone is distributed as follows: only 33% are secondary non-specialized types, while 30% are inhabitants of the surface layer, 26% are inhabitants of minute pores and 13% are primary non-specialized species with soft outer covers.

When comparing the generalized data with the results of Kolycheva's study (1994), it is evident that the share of surface-dwelling species in the core zone is much lower (30 versus 52% noted for the zone of economic use), which is presumably due to the low thickness of the litter layer. At the same time, the share of primary non-specialized species and inhabitants of pores is significantly higher in the core zone territory (13 and 26 against 8 and 17%, respectively). This difference, in our opinion, can be explained primarily by the absence of anthropogenic load on the soil of the core.

It should be noted that two groups of plots (202, 203, 221, 222 and 340, 341, 342) have some differences in the species composition of mites, which is probably due to varying environmental conditions. Thus, plots 202, 203, 221, 222 are dominated by species preferring the litter layer of broad-leaved trees (species of genera *Nothrus*, *Hermannella*, *Cepheus*, *Carabodes*, family Oribatellidae, etc.) and the presence of a dense network of small roots in the soil (for example, genera *Ramusella*, *Berniniella* and *Furcoppia*). At the same time, there are almost no moss-dwelling mites, except for the species that inhabit moss growing on tree trunks (*Poroliodes farinosus* and *Fosseremus laciniatus*).

Species that prefer loose sandy soils (small-size inhabitants of soil pores, for example, species of the family Brachychthoniidae, *Liebstadia pannonica*, *Licnodamaeus pulcherrimus*, etc.), as well as the inhabitants of the above-ground moss (in particular species of the genus *Furcoribula* and *Eremaeus*) are abundant on plots 340, 341, 342. Despite these differences, many species are found in both groups of plots. These are, first of all, secondary unspecialized species from the families Euphthiracaridae, Phthiracaridae, Achipteriidae, Ceratozetidae,

Schelorbitidae and Galumnidae. A number of species from other ecological groups, such as primary unspecialized species (families Hypochthoniidae and Eniochthoniidae), the inhabitants of soil pores (family Oppiidae, Suctobelbidae, etc.) are also characterized by a very uniform distribution.

Below is a general taxonomic list of oribatid mites from the core zone of Voronezh Reserve.

Annotated list of oribatid mites of the core zone of Voronezh Reserve

An asterisk (*) marks the species first recorded for the Voronezh Region, the grating (#) – the species first recorded on the territory of the Voronezh Reserve. The figures indicate the number of the reserve plot in which the species was found (Fig. 1).

Superfam. Hypochthonioidea Berlese, 1910

(2 families, 2 genera, 2 species)

Fam. Hypochthoniidae Berlese, 1910

Genus *Hypochthonius* Koch, 1835

Hypochthonius rufulus Koch, 1835 202, 203, 221, 222, 340, 341, 342

Fam. Eniochthoniidae Grandjean, 1947

Genus *Hypochthoniella* Berlese, 1910 (=Eniochthonius Grandjean, 1933)

Hypochthoniella minutissima (Berlese, 1904) 202, 203, 221, 222, 340, 341, 342

Superfam. Brachychthonioidea Thor, 1934

(1 family, 3 genera, 8 species)

Fam. Brachychthoniidae Thor, 1934

Genus *Brachychthonius* Berlese, 1910

Brachychthonius impressus Moritz, 1976 #340, 341, 342

Brachychthonius hirtus Moritz, 1976 **340, 341, 342

Genus *Liochthonius* Hammen, 1959

Liochthonius (Liochthonius) plumosus Mahunka, 1969 #202, 203, 221, 222, 340, 341, 342

Genus *Sellnickochthonius* Krivolutsky, 1964

Sellnickochthonius cricoides (Weis-Fogh, 1948) 340, 341, 342

Sellnickochthonius rostratus hungaricus (Balogh, 1943) #340, 341, 342

Sellnickochthonius suecicus (Forsslund, 1942) 202, 203, 221, 222, 340, 341, 342

Sellnickochthonius zelawaiensis (Sellnick, 1928) 202, 203, 221, 222, 340, 341, 342

Sellnickochthonius jacoti (Evans, 1952) **340, 341, 342

Superfam. Epilohmannioidea Oudemans, 1923

(1 family, 1 genus, 1 species)

Fam. Epilohmanniidae Oudemans, 1923

Genus *Epilohmannia* Berlese, 1910

Epilohmannia cylindrica (Berlese, 1904) #221

Superfam. Mesoplophoroidea Ewing, 1917

(1 family, 1 genus, 1 species)

Fam. Mesoplophoridae Ewing, 1917

Genus *Mesoplophora* (*Parplophora*) Niedbala, 1985
Mesoplophora (*Parplophora*) *pulchra* Sellnick, 1928
 *#202, 203, 221, 222

Superfam. Euphthiracaroidae Jacot, 1930

(1 family, 3 genera, 3 species)

Fam. Euphthiracaridae Jacot, 1930

Genus *Acrotritia* Jacot, 1923 (= *Rhysotritia* Märkel et Meyer, 1959)

Acrotritia ardua (Koch, 1841) 202, 203, 221, 222, 340, 341, 342Genus *Euphthiracarus* Ewing, 1917*Euphthiracarus* (*Euphthiracarus*) *reticulatus*

(Berlese, 1913) *#203, 221

Genus *Microtritia* Märkel, 1964*Microtritia minima* (Berlese, 1904) 340, 341, 342**Superfam. Phthiracaroidae Perty, 1841**

(1 family, 3 genera, 5 species)

Fam. Phthiracaridae Perty, 1841Genus *Atropacarus* Ewing, 1917*Atropacarus* (*Atropacarus*) *striculus* (Koch, 1835)
202, 203, 221, 222, 340, 341, 342Genus *Phthiracarus* Perty, 1841*Phthiracarus* (*Phthiracarus*) *globosus* (Koch, 1841)
#202, 203, 221, 222*Phthiracarus* (*Phthiracarus*) *laevigatus* (Koch, 1841)
#340, 341, 342*Phthiracarus* (*Phthiracarus*) *longulus* (Koch, 1841)
#202, 203, 221, 222Genus *Steganacarus* Ewing, 1917*Steganacarus* (*Tropacarus*) *carinatus* (Koch, 1841)
#340**Superfam. Crotonioidea Thorell, 1876**

(2 families, 2 genera, 3 species)

Fam. Nothridae Berlese, 1896Genus *Nothrus* Koch, 1836*Nothrus pratensis* Sellnick, 1928 203*Nothrus pulchellus* (Berlese, 1910) 203 (= *Nothrus parvus* Sitnikova, 1975)**Fam. Camisiidae Oudemans, 1900**Genus *Camisia* Heyden, 1826*Heminothrus* (*Platynothrus*) *peltifer* (Koch, 1839) 202, 203, 221, 222, 340, 341, 342 (= *Platynothrus grandjeani* Sitnikova, 1975)**Superfam. Hermannielloidea Grandjean, 1934**

(1 family, 1 genus, 2 species)

Fam. Hermanniellidae Grandjean, 1934Genus *Hermanniella* Berlese, 1908*Hermanniella dolosa* Grandjean, 1931 221, 222*Hermanniella septentrionalis* Berlese, 1910 221, 222**Superfam. Neoliodoidea Sellnick, 1928**

(1 family, 1 genus, 1 species)

Fam. Neoliodidae Sellnick, 1928Genus *Poroliodes* Grandjean, 1934*Poroliodes farinosus* (Koch, 1839) 221, 222**Superfam. Plateremaeoidea Trägårdh, 1926**

(1 family, 1 genus, 1 species)

Fam. Licnodamaeidae Grandjean, 1954Genus *Licnodamaeus* Grandjean, 1931*Licnodamaeus pulcherrimus* (Paoli, 1908) #340, 341, 342**Superfam. Gymnodamaeoidae Grandjean, 1954**

(1 family, 2 genera, 3 species)

Fam. Gymnodamaeidae Grandjean, 1954Genus *Adrodamaeus* Paschoal, 1984*Adrodamaeus rossicus* (Bulanova-Zachvatkina, 1967) *#340, 341, 342*Gymnodamaeus barbarossa* Weigmann, 2006 *#340, 341, 342Genus *Gymnodamaeus* Kulczynski, 1902*Gymnodamaeus bicostatus* (Koch, 1835) #340, 341, 342**Superfam. Damaeoidae Berlese, 1896**

(1 family, 4 genera, 5 species)

Fam. Damaeidae Berlese, 1896Genus *Damaeus* (*Epidamaeus*) Bulanova-Zachvatkina, 1957*Damaeus* (*Epidamaeus*) *bituberculatus* (Kulczynski, 1902) *#202, 203, 221Genus *Damaeus* (*Spatiodamaeus*) Bulanova-Zachvatkina, 1957*Damaeus* (*Spatiodamaeus*) *kamaensis* (Sellnick, 1926) *#202, 203, 221, 342Genus *Porobelba* Grandjean, 1936*Porobelba spinosa* (Sellnick, 1920) #202, 203, 221, 222, 340, 341, 342Genus *Metabelba* Grandjean, 1936*Metabelba* (*Neobelba*) *pseudopapillipes* (Bulanova-Zachvatkina, 1967) #202, 203, 221, 222, 340, 341, 342*Metabelba* (*Metabelba*) *papillipes* (Nicolet, 1855)
*#202, 203, 221, 222**Superfam. Niphocephoidea Trav, 1959**

(1 family, 1 genus, 1 species)

Fam. Compactozetidae Luxton, 1988(= *Cepheidae* Berlese, 1896)Genus *Cepheus* Koch, 1835*Cepheus cepheiformis* (Nicolet, 1855) #221**Superfam. Gustavioidea Oudemans, 1900**

(2 families, 4 genera, 4 species)

Fam. Astegistidae Balogh, 1961Genus *Cultroribula* Berlese, 1908*Cultroribula bicultrata* (Berlese, 1905) #202, 340, 341, 342

Genus *Furcoppia* (*Mexicoppia*) Mahunka, 1983
Furcoppia (*Mexicoppia*) cf. *vtorovi* (Krivolutsky, 1971) *#202, 203, 221, 222

Genus *Furcoribula* Balogh, 1943
Furcoribula furcillata (Nordenskiöld, 1901) ³⁴²

Fam. Liacaridae Sellnick, 1928

Genus *Liacarus* Michael, 1898
Liacarus (*Dorycranosus*) *acutus* Pschorn-Walcher, 1951 ³⁴¹

Superfam. Eremaeioidea Oudemans, 1900

(1 family, 1 genus, 1 species)

Fam. Eremaeidae Oudemans, 1900

Genus *Eremaeus* Koch, 1835
Eremaeus hepaticus Koch, 1835 ^{340, 341}

Superfam. Ameroidea Bulanova-Zachvatkina, 1957

(1 family, 1 genus, 1 species)

Fam. Damaeolidae Grandjean, 1965

Genus *Fosseremus* Grandjean, 1954
Fosseremus laciniatus (Berlese, 1905) ^{#202, 203, 221, 222}

Superfam. Oppidea Sellnick, 1937

(2 families, 8 genera, 9 species)

Fam. Oppiidae Sellnick, 1937

Подсем. Multioppiinae Balogh, 1983

Genus *Multioppia* Hammer, 1961
Multioppia glabra (Mihelcic, 1955) ^{202, 340, 341, 342}
Multioppia wilsoni laniseta Moritz, 1966 *#221, 222
 Genus *Ramusella* Hammer, 1962
Ramusella (*Insculptoppia*) *furcata* (Willmann, 1928) *#202, 203, 221, 222

Подсем. Medioppiinae Subías et Minguez, 1985

Genus *Micropoppia* Balogh, 1983
Micropoppia minus (Paoli, 1908) ^{202, 203, 221, 222, 340, 341, 342} (= *Oppia minutissima* Sellnick, 1950)
 Genus *Rinoppia* Balogh, 1983 (= *Medioppia* Subías et Minguez, 1985)
Rinoppia subpectinata (Oudemans, 1900) ³⁴⁰ (= *Medioppia tuberculata* Bulanova-Zachvatkina, 1964)

Подсем. Oppiellinae Seniczak, 1975

Genus *Berniniella* Balogh, 1983
Berniniella bicarinata (Paoli, 1908) ²²¹
 Genus *Moritzoppia* Subías et Rodriguez, 1988
Moritzoppia unicarinata (Paoli, 1908) ^{202, 203, 221, 222, 340, 341, 342}
 Genus *Oppiella* Jacot, 1937
Oppiella nova (Oudemans, 1902) ^{202, 203, 221, 222, 340, 341, 342}

Fam. Quadropiidae Balogh, 1983

Genus *Quadropia* Jacot, 1939
Quadropia (*Quadropia*) *quadricarinata* (Michael, 1885) ^{202, 203, 221, 222, 340, 341, 342}

Superfam. Trizetoidea Ewing, 1917

(1 family, 2 genera, 8 species)

Fam. Suctobelbidae Jacot, 1938

Genus *Suctobelbella* Jacot, 1937
Suctobelbella (*Suctobelbella*) *acutidens sarekensis* (Forsslund, 1941) ^{#202, 203, 221, 222}
Suctobelbella (*Suctobelbella*) *longicuspis* Jacot, 1937 ^{#340, 341, 342}
Suctobelbella (*Suctobelbella*) *opistodentata* (Golosoova, 1970) ^{#202, 203, 221}
Suctobelbella (*Suctobelbella*) *subcornigera subcornigera* (Forsslund, 1941) ^{#202, 203, 221, 222, 340}
Suctobelbella (*Suctobelbella*) *subcornigera vera* (Moritz, 1964) ^{#340, 341, 342}
Suctobelbella (*Flagrosuctobelba*) *alloenasuta* Moritz, 1971 ^{#203}
Suctobelbella (*Flagrosuctobelba*) *forsslundi* (Strenzke, 1950) ^{#221, 222, 340}
 Genus *Suctobelba* Paoli, 1908
Suctobelba aliena Moritz, 1970 *#340, 341

Superfam. Carabodoidea Koch, 1837

(1 family, 1 genus, 3 species)

Fam. Carabodidae Koch, 1837

Genus *Carabodes* Koch, 1835
Carabodes (*Carabodes*) *subarcticus* Trägårdh, 1902 ^{221, 222}
Carabodes (*Carabodes*) *areolatus* Berlese, 1916 ^{221, 222, 340, 341, 342}
Carabodes (*Carabodes*) *femoralis* (Nicolet, 1855) ^{221, 340, 341, 342}

Superfam. Tectocephoidea Grandjean, 1954

(1 family, 1 genus, 1 species)

Fam. Tectocephidae Grandjean, 1954

Genus *Tectocephus* Berlese, 1896
Tectocephus velatus sarekensis Trägårdh, 1910 ^{203, 221, 222, 340, 341}

Superfam. Achipterioidea Thor, 1929

(1 family, 2 genera, 2 species)

Fam. Achipteriidae Thor, 1929

Genus *Achipteria* Berlese, 1885
Achipteria (*Achipteria*) *nitens* (Nicolet, 1855) ^{202, 203, 221, 222, 340, 341, 342}
 Genus *Campachipteria* (*Triachipteria*) Subías, 2017
Campachipteria (*Triachipteria*) *fanzagoi* (Jacot, 1929) *#202, 203, 221 (= *Parachipteria willmanni* Hammen, 1952)

Superfam. Oribatelloidea Jacot, 1925

(1 family, 2 genera, 2 species)

Fam. Oribatellidae Jacot, 1925

Genus *Oribatella* Banks, 1895
Oribatella (*Oribatella*) *sexdentata* Berlese, 1916 ^{#203, 221, 222}

Genus *Ophidiotrichus* Grandjean, 1953
Ophidiotrichus tectus (Michael, 1884) ^{221, 222}
 (= *Notaspis borussicus* Sellnick, 1908)

Superfam. Ceratozetoidea Jacot, 1925

(3 families, 5 genera, 7 species)

Fam. Ceratozetidae Jacot, 1925

Genus *Ceratozetella* Shaldybina, 1966
Ceratozetella (Ceratozetella) sellnicki (Rajski, 1958)
^{202, 203, 221, 222, 340, 341, 342}

Genus *Ceratozetes* Berlese, 1908
Ceratozetes (Ceratozetes) gracilis (Michael, 1884)
^{202, 203, 221, 222, 340, 341, 342}

Ceratozetes (Ceratozetes) peritus Grandjean, 1951
^{202, 203, 221, 222, 340, 341, 342}

Genus *Euzetes* Berlese, 1908
Euzetes globulus (Nicolet, 1855) ^{202, 203, 221, 222, 340, 341, 342}

Fam. Chamobatidae Thor, 1937

Genus *Chamobates* Hull, 1916
Chamobates (Chamobates) cuspidatus (Michael, 1884) ³⁴¹
Chamobates (Chamobates) subglobulus
 (Oudemans, 1900) ^{*#221, 222}

Fam. Punctoribatidae Thor, 1937

Genus *Punctoribates* Berlese, 1908
Punctoribates (Semipunctoribates) zachvatkini
 Shaldybina, 1969 ^{202, 221, 222, 341, 342}

Superfam. Oripodoidea Jacot, 1925

(3 families, 4 genera, 6 species)

Fam. Oribatulidae Thor, 1929

Genus *Oribatula (Zygoribatula)* Berlese, 1916
Oribatula (Zygoribatula) exilis (Nicolet, 1855) ^{340, 341, 342}

Genus *Phauloppia* Berlese, 1908
Phauloppia lucorum (Koch, 1841) ^{*#341, 342}

Fam. Liebstadiidae J. et P. Balogh, 1984

Genus *Liebstadia* Oudemans, 1906
Liebstadia similis (Michael, 1888) ^{202, 203, 221, 222, 340, 341, 342}

Liebstadia pannonica (Willmann, 1951) ^{#341, 342}

Fam. Scheloribatidae Jacot, 1935

Genus *Scheloribates* Berlese, 1908
Scheloribates (Scheloribates) pallidulus pallidulus
 (Koch, 1841) ^{202, 203, 221, 222, 340, 341, 342}
Scheloribates (Scheloribates) pallidulus latipes
 (Koch, 1844) ^{202, 203, 221, 222, 340, 341, 342}

Superfam. Galumnoidea Jacot, 1925

(2 families, 3 genera, 5 species)

Fam. Parakalummidae Grandjean, 1936

Genus *Neoribates* Berlese, 1914
Neoribates (Neoribates) gracilis Travé, 1970 ^{*#340, 341}
Neoribates (Neoribates) aurantiacus (Oudemans, 1914) ^{202, 203, 221, 222, 340, 341, 342}

C□□. Galumnidae Jacot, 1925

Genus *Galumna* Heyden, 1826
Galumna (Galumna) lanceata (Oudemans, 1900)
^{202, 203, 221, 222, 340, 341, 342}

Genus *Pergalumna* Grandjean, 1936
Pergalumna nervosa (Berlese, 1914) ^{202, 203, 221, 222, 340, 341, 342}

Pergalumna willmanni (Zachvatkin, 1953) ^{#203, 221, 222}

Conclusion

Palearctic and Holarctic species with inclusions of European fauna represent the faunistic complex of oribatid mites in the Voronezh state nature biosphere reserve. At the moment, we have not found any noticeable endemism or intersection with non-European endemic complexes. At the same time, the fauna of the oribatid mites of Voronezh Reserve can not be considered fully studied. So far, there are no detailed data on such plant complexes as oak forests, linden trees, maple tree forests, blueberry beds, lichen pine forests, birch forests, grass and sedge marshes, sphagnum bogs and meadow complexes. The arboreal fauna of the reserve and local destructive systems, such as decomposing wood residues, also remain unexplored.

All morphoecological types of mites are fairly uniformly represented in the fauna, which can be explained by the absence of any anthropogenic load on soil complexes.

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