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Articles

Water mites (Acariformes: Hydrachnidia, Halacaroidea) of the Visimsky Nature Reserve (Central Urals)

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Water mites of the Urals have been poorly studied. In 2019–2020, we studied water mites from the water bodies of the Visimsky State Nature Biosphere Reserve and its surroundings, as well as from the territory of the Chusovaya River Nature Park. Different sites of watercourse of the Sulyom River, its tributaries, spring, permanent and temporary ponds were investigated. In total, 64 species of water mites Hydrachnidia and 6 species of Halacaridae were revealed. The upper areas of the Sulyom River and its small tributary, the Kamenka River, were richest in species diversity and number of water mites. In these rivers, rhitrobiontic species prevailed. In the middle and lower course of the Sulyom River the number and quantity of mite species were significantly lower. The diversity of mites in the Chusovaya River, near the confluence of the Sulyom River was low however, the highest mite numbers were noted here. The most specific associations of mites were revealed in the helocrene spring and in the sphagnum bogs. At the same time, mites from the standing waters of the Visimsky Reserve neighborhood, provided by water reservoir, artificial ponds and ditches, had a rather poor species composition and a low number. According to the faunal composition and structure of the acarofauna of the Visimsky Nature Reserve and the Central Urals are similar to East European, however, it has both, Eastern Palearctic elements and species currently only known from the Urals.

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Keywords

Distribution, fauna, ecology, number, Ural Mountains, rivers

Introduction

Water mites are a large group of freshwater invertebrates numerous in all types of freshwaters. They reach a considerable diversity in lotic habitats (Di Sabatino et al. 2000) and in the small mountain rivers, where they can dominate other groups of aquatic organisms in terms of specific richness and number. At the same time, water mites, especially in mountain rivers, are very sensitive to anthropogenic pollution and can serve as good bioindicators of their habitat (Miccoli et al. 2013; Goldschmidt 2016).

So far, water mites of the Urals have been poorly studied. Special studies have been conducted only for the western slopes of the Northern and the Nether-polar Urals, where mites from benthos, drift and grayling feeding were investigated (Shubina & Tsember 2017). Fragmentary data are available for the Central Urals (vicinity of the Kamensk-Uralsky city (Prisadsky 1914)) and vicinities of the city of Perm (Sokolov 1924)) in which 36 species have been mentioned.

Special research of water mites of the Central Urals and Sverdlovsk Oblast was not carried out earlier. In hydrobiological research from Sverdlovsk Oblast, mites were usually specified only by genus, including two genera of mites, *Lebertia* sp. and *Hygrobates* sp. which are also found in the Sulyom River in the territory of the Visimsky Nature Reserve (Stepanov 2001).

Often, many studies on water mites come from anthropogenically disturbed areas (Goldschmidt 2016). Studying the fauna of reserves is important for understanding the natural state of water biocenoses and the biota inhabiting them. The Central Urals have historically been an industrial region, highly susceptible to anthropogenic pollution. In this regard, it is necessary to carefully study all biotas in the most untouched (pristine) places, including the territory of the Visimsky Nature Reserve. The purpose of this research was to study the species composition, abundance and biotopic distribution of water mites in the main types of water bodies of the Visimsky Nature Reserve.

Materials and methods

The material was collected in Sverdlovsk Oblast in the Central Urals. Most of the material was collected on the territory of Visimsky Nature Reserve and its buffer zone (Sverdlovsk Oblast, Kirovgrad Town District), hardly influenced by anthropogenic pollution.

The Visimsky State Nature Biosphere Reserve is in the low-mountain part of the Central Urals Mountains, on the western slope, at the heights of 360–390 m above sea level. It has a well-developed river system, represented by the upper course of the Sulyom River and its tributaries.

The Sulyom River (length of 87 km, the area of the basin - 609 km^2), the right tributary of the Chusovaya River, crosses the low-mountain part of the Ural Mountains in the width direction. It is a part of the Volga-Kama basin. The area of its drainage basin is located in the southern taiga zone, it is slightly boggy, the woodiness is about 92%. The water of the river is hydro-carbonate-calcium and ultrafresh. The low concentration of the major indicates the absence of chemical pollution in ground waters (Goskova & Smirnov 1990). The Sulyom River rises on the slope of the Vesyolye Gory ridgeline, flows from the southeast to the northwest, turns west in the middle course and flows into the Chusovaya River near the village of Sulyom. It has more than 50 tributaries, half of which are located in the Visimsky Nature Reserve in the upper course of the river.

Water mite samples were collected in the Sulyom River basin from the source to the mouth: in different sites of the upper course within the Visimsky Nature Reserve (Fig. 1, points 1–4, 57.432000° N, 59.738472° E), the middle course lower than the dam in the village of Bol’shiye Galashki (point 5, 57.466056° N, 59.499306° E) and the lower course in the surrounding of the village of Sulyom (point 6, 57.541250° N, 59.139778° E). For comparison, samples were also collected in the Chusovaya River around the mouth of the Sulyom River (Fig. 1, point 7, 57.517750° N, 59.067556° E) in the territory of the River Chusovaya Nature Park. The Salyom River has a typical mountain character, rapid current and shallow depths. The bottom is sandy pebble in the upper reaches and rocky in the middle and the lower reaches. In the upper and middle reaches, the moss *Fontinalis antipiretica* Hedw. grows in large quantities, *Ranunculus* (*Batrachium*) spp. occurs less often, and in quiet sites of the current there are separate plants of *Sparganium* sp. In the lower reach, near the sampling place, higher aquatic plants were absent, and a small number of Chlorophyta grow on rocks. In the Chusovaya River near the confluence of the Sulyom River, *F. anipiretica* grow in large quantities on stones, was growing. The lower course of the Sulyom River and in the backwaters near the bank of the Chusovaya River have sites where *Petasites* sp. grew.

Samples were also collected from the tributaries of the upper course of the Sulyom River, from the small rivers Dudka (fig. 1, points 8–9), Medvezhka (point 10), Rasya (point 11), and Kamenka (points 12–13) within the Visimsky Reserve. These rivers are small, have insignificant depths, rocky, pebble or sandy pebble bottoms and clear water, except sites in the lower course of the Kamenka River and the Rasya River dammed by beavers, in which there was low speed of flow and silty-pebble bottom. Higher aquatic plants were represented by *Fontinalis antipiretica* and *Ranunculus* (*Batrachium*) sp. (most widespread in the Dudka River). The helocrene located in the upper course of the Sulyom River was also studied (point 14).

In addition, samples were collected from different standing water bodies in the basin of the upper course of the Sulyom River within the Visimsky Nature Reserve. Standing water bodies have an artificial origin and they are in the protected zone of the reserve. This is the large reservoir Sulyomsky (fig. 1, point 15) formed on the Sulyom River, abundantly overgrown with *Elodea canadensis* Michx., *Nuphar lutea* (L.) Sm. and *Equisetum* sp. The small artificial pond (point 16) located in the north of the territory of the Visimsky State Nature Reserve, with the depth of more than 1 m, transparent water, silty-pebble bottom with a large amount of detritus, completely overgrown with *Elodea canadensis*, *Potamogeton natans* L., *Carex* spp., mosses, Lemnoideae and filamentous Chlorophyta. We also studied the beaver pond on the Rasya River, having no current (point 17), and ditches along the road passing along the northern border of the Visimsky Nature Reserve (points 18–19). One of the ditches is in the open space, totally (100%) overgrowing (*Potamogeton natans*, mosses). At the same time, another one is shaded by wood and shrubby vegetation and there is no underwater vegetation.

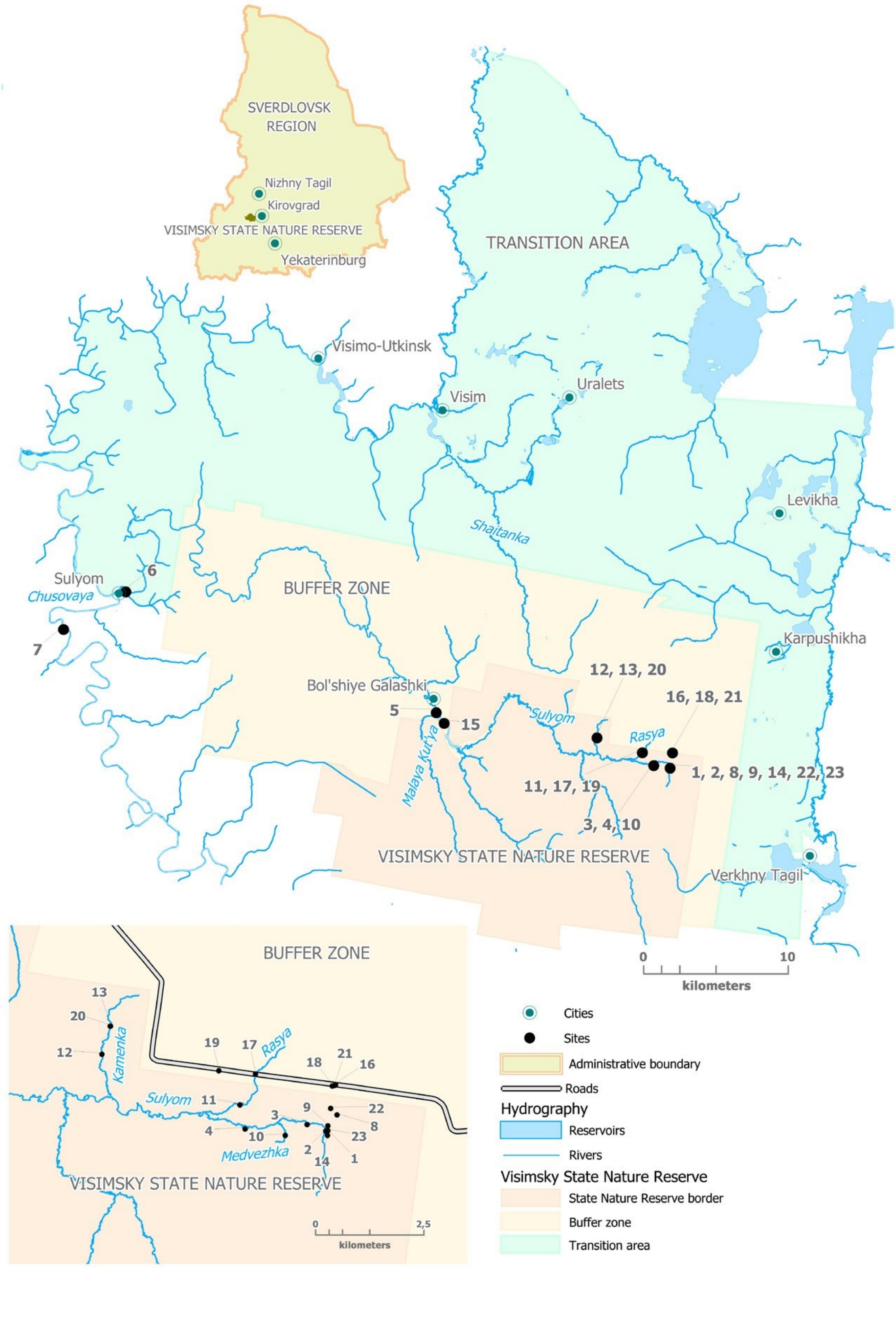
SVERDLOVSK REGION
Nizhny Tagil
Kirovgrad
VISIMSKY STATE NATURE RESERVE
Yekaterinburg
TRANSITION AREA
Visimo-Utkinsk
Visim
Uralets
Levikha
Shaitanka
Sulyom
Chusovaya
BUFFER ZONE
Karpushikha
Bol'shiye Galashki
Sulyom
Rasya
Malaya Kut'ya
VISIMSKY STATE NATURE RESERVE
Verkhny Tagil
12, 13, 20
16, 18, 21
1, 2, 8, 9, 14, 22, 23
11, 17, 19
3, 4, 10
0 10
kilometers
BUFFER ZONE
Kamenka
Sulyom
Rasya
Medvezhka
VISIMSKY STATE NATURE RESERVE
0 2,5
kilometers
Cities
Sites
Administrative boundary
Roads
Hydrography
Reservoirs
Rivers
Visimsky State Nature Reserve
State Nature Reserve border
Buffer zone
Transition area

Figure 1. *The map of sampling points in Visimsky State Nature Reserve.*

Temporary water bodies are represented by a very small pond in the floodplain of the Kamenka River, which almost dries up in summertime (point 20) and by the drying-up ditch in the protected zone of the Visimsky Nature Reserve (point 21). The bottom is covered with leaf litter, there are mosses (*Drepanocladus* spp.).

The last studied water body types are the small low-lying sedge sphagnum bogs located in the spruce forest (points 22–23). In these bogs, there were no sites with open water.

Samples were collected in July 2019 and in May 2020. Samples were collected with hydrobiological net from an approximately identical area (1 sq.m) to allow comparison of results. Biofouling was scraped from solid substrates (rocks, flooded tree branches) and washed out in the net. Macrophytes were selected from water from the thickets of higher aquatic plants and were further washed out in the net. Within one water body, samples were collected from several biotopes differing in bottom, current speed, quantity of the higher aquatic plants and other parameters.

The collected material was fixed in 70% alcohol. Then mites were mounted on slides in Hoyer's medium. The water mites were determined in the laboratory using modern keys (Bartsch 2007; Davids et al. 2007; Di Sabatino et al. 2010; Gerecke et al. 2016).

The analysis of the material included the expected frequency of occurrence (O), absolute and average (by 1 sq.m) number (N) of mites, the index of dominance (D) (the ratio of number of mite specimens from one species to the total number of all species in the sample). The index of dominance (D) was calculated using formula $D_i = N_i / N_s$ (N_i – number of individuals of the i-th species, N_s – total number of individuals in the biocenosis). For the analyze of dominance structure, Engelmann scale was used (eudominants (40-100%), dominants (12.5–39.9%), subdominants (4.0–12.4%), precedents (1.3–3.9%), subprecedents (<1.3 %) (Engelmann 1978)). The analysis of fauna similarity of water mites was calculated on the basis of the Bray-Curtis index (Ricotta and Podani 2017), using hierarchical clustering (grouping by the algorithm of the single linkage method) by the Biodiversity Pro v. 2 software (McAleece et al. 1997).

Result

A total of 70 species of mites were revealed, including 64 species of Hydrachnidia from 16 families and six species of Halacaroidea (Suppl. material 1: Table 1). The fauna of water mites in lotic and lentic habitats sharply differed, with practically no common species. The typical rheobiontic fauna was found in the rivers.

On different sites along the course of the Sulyom River and at the confluence of the Sulyom River with the Chusovaya River, 31 species of water mites were revealed. On all sites of the course of the Sulyom River, species composition was similar, while the number of mites and the structure of dominance was considerably different.

Sperchonopsis verrucosa (Protz, 1896) was the most prevalent species, found in all samples on all sites along the river's course. *Torrenticola amplexa* (Koenike, 1908) and *Sperchon clupeifer* Piersig, 1896 were the only other species found on all studied sites. Some species were noted only in the upper course of the Sulyom River. There are stenothermal rithrobiontic species, including *Hygrobates foreli* (Lebert, 1874), *Aturus scaber* Kramer, 1875, *Ljania bipapillata* Thor, 1898, *Ocybrachypoda celeripes* (Viets, 1910) and *Lebertia glabra* Thor, 1897. Conversely, *Atractides pavesii* Maglio, 1905, *Hydrodroma reinhardi* Pešić, 2002 and *Mideopsis roztoczensis* Biesiadka et Kowalik, 1979 were collected only in the lower course of the River Sulyom and the River Chusovaya.

The highest indexes of species richness were revealed in the upper course, where 23 species of mites were noted. In the middle reaches of the river behind the reservoir dam Sulyomsky, the number and species richness sharply decreased with only 8 species revealed. In the lower reaches, on the site without macrophytes, a low number of mites was noted, although the number of species (13) was twice as high as in the middle reaches. The highest indexes of the average number of mites were in the Chusovaya River, which considerably exceeds those on different sites of the Sulyom River. Additionally, a large number of species (15) were identified.

The dominant composition differed on different sites of the course, only *Sperchonopsis verrucosa* was among the dominating species on each of the sites (Fig. 2). In the upper reaches, *Lebertia fimbriata* Thor, 1899 prevailed (34.7%), while only a single specimen of this species was found in the lower reaches. On this site there was the highest number of the species. In the middle course, representatives of the family Sperchontidae and the genus *Atractides* prevailed. *Sperchon clupeifer* which shares 48.2% of all mites here was eudominant. In this site, located after the dam of the Sulyomsky reservoir, the temperature in water was increased. That's why, probably, the number and species diversity of water mites were low.

In the lower course of the Sulyom River and in the Chusovaya River the composition of dominant species had change. Representatives of the genus *Torrenticola* and *Hygrobates* dominated in numbers. In the lower reaches of the Sulyom a River and in the Chusovaya River the number and occurrence of representatives of the subgenus *Pilolebertia* was much higher. *Torrenticola amplexa* dominated in the lower course of the Sulyom River (38.8%), *Hygrobates calliger* Piersig, 1896 was eudominant in the Chusovaya River with a proportion 59.1% of all mites.

In the tributaries of the upper course of the Sulyom River the fauna of water mites was similar to acarofauna from the headwaters of the river (Table 1). The diversity of mite species was low in rivers with low flow (Medvezhka, Rasya). In each river only 2 species, in low numbers were collected. Only in the Rasya River, along the whole length of the river dammed by beavers, the eurybiontic species *Hydrodroma despicien*s (Müller, 1776) found. In all other rivers an exclusively rheobiont mite's fauna was present. In the Dudka, a small and slow flowing river, 9 species were found with a rather high abundance. All species that were collected in this river, inhabited the headwaters of the Sulyom River as well *Hygrobates foreli*, *Lebertia fimbriata* and *Feltria minuta* Koenike, 1892 predominated.

The number and species richness were high in the Kamenka River, a larger and faster watercourse than the Dudka River. In the Kamenka River, 20 species of mites are found, with an average total number of 58.8 mites per 1 m2. Species composition was similar to the upper course of the Sulyom River, with *Sperchonopsis verrucosa*, *Lebertia porosa* Thor, 1900 and *L. fimbriata* prevailed in abundance (100%) and number. In one of the samples the most numerous were nymphs of the genus *Hygrobates*. In the only studied helocrene spring, three species of crenobiont water mites were recorded with the dominance of *Panisus michaeli* Koenike, 1896 (72.2% of total number of collected individuals).

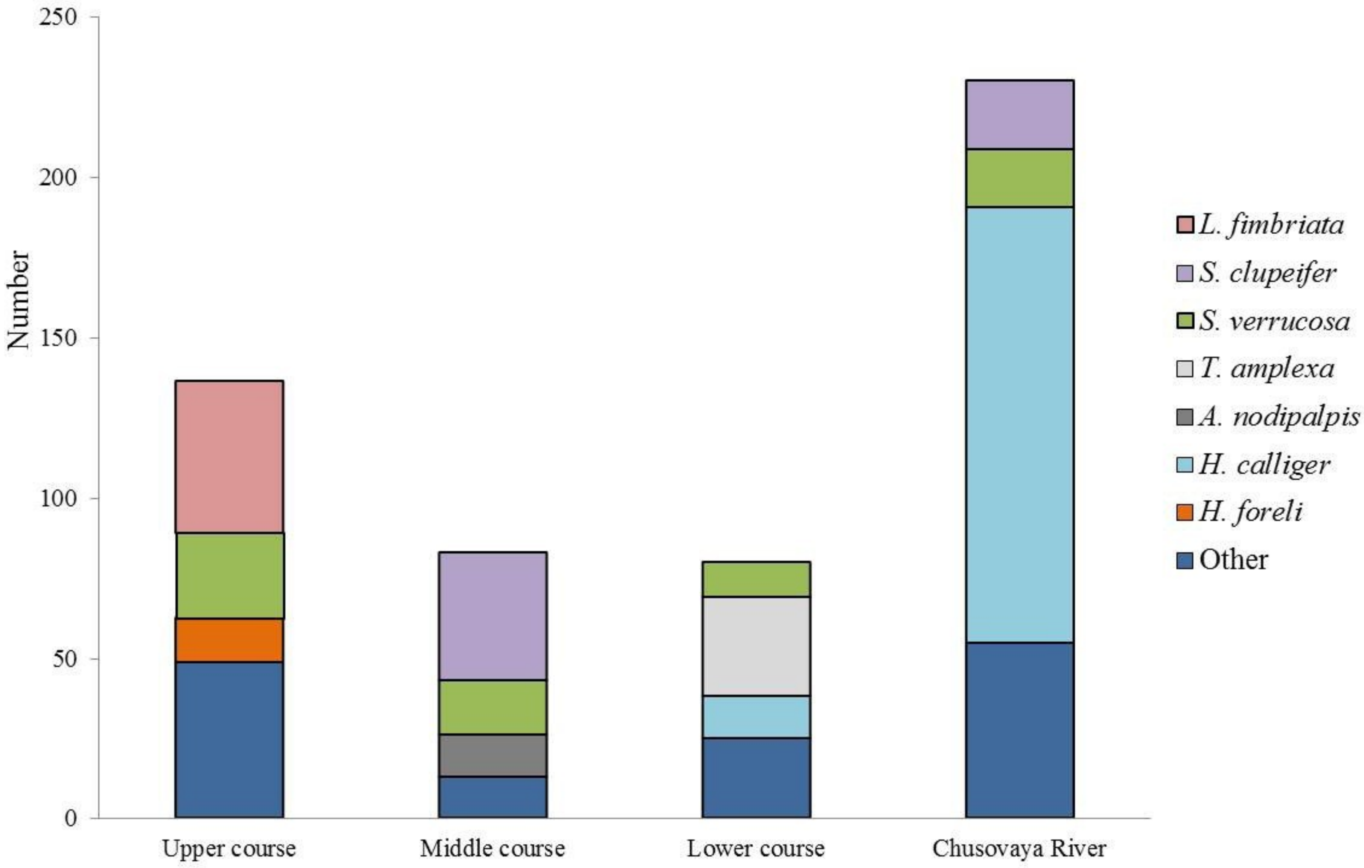

Figure 2. *The average number of specimens and the dominant structure of water mites on different sites of the Sulyom River and Chusovaya River.*

The fauna of mites that has been found in standing water bodies that are represented in the explored area by exclusively artificial ponds and ditches along the road was significantly poorer than in the rivers. In these water bodies, widespread eurybiont species were found, mites from Pionidae, Limnesiidae and Arrenuridae families prevailed. Mites reached rather high specific diversity and number only in the large Sulyomsky reservoir that has extensive warmed-up shallow water which is completely covered by aquatic vegetation. There were 14 species of mites, and *Limnesia maculata* (Müller, 1776) prevailed. In small artificial ditches and a pond, both overgrown with macrophytes and lacking macrophytes, mites were rare and were represented by a few individuals (from 1 to 5 species per sample). *Piona alpicola* (Neuman, 1880) and *Neumania limosa* (Koch, 1836) were most abundant, except in one sample in which *Arrenurus forpicatus* Neuman, 1880 dominated.

In small temporary ponds, located in the floodplain of the Kamenka River and in the shaded ditch, typical representatives of vernal fauna were found. Members of the Hydryphantidae family and *Hydrachna incognita* (Wainstein, 1976) prevailed. The number and species richness of mites in temporary ponds were low, and only 5 species were noted. The temporary ponds on the territory of the Visimsky reserve had very limited distribution.

Finally, in the small sedge-sphagnum bogs located in the upper reaches of the Sulyom River the Halacaridae dominated with 88.7% of all mites collected. The family was represented by 5 species, the few Hydrachnidia only by 2 species. The dominant halacarid species were *Porolohmanella violacea* (Kramer, 1879) and *Parasoldanellonyx parviscutatus* (Walter, 1917). All mites were found in sphagnum bogs only during the spring period. In the summer, these bogs almost completely dried up, and mites in them did not find.

The ecological structure of water mites from the studied water bodies was divided into 4 groups: the rheobiont species inhabiting the rivers, crenobionts inhabiting the spring, stagnobionts inhabiting standing reservoirs, and the species that are specific to temporary ponds and bogs. In the lotic habitats of the Visimsky Nature Reserve, much greater species diversity and abundance of water mites were revealed compared to lentic ones.

The similarity of mite's fauna in the studied water objects was in general low (Fig. 3). At the same time, a cluster of rivers was clearly identified, between which there were the highest indicators of faunal similarity. The highest similarity by composition of acarofauna was found between the headwaters of the Sulyom River and the small Rivers Dudka and Kamenka, which share similar environmental conditions, i.e., the high speed of the current, the low temperature, presence of *Fontinalis antipiretica*. All those parameters affect formation of a similar mite fauna represented mainly by rheobiontic species.

Among other types of water bodies, indicators of fauna similarity were very low (Fig. 3). The helocrene spring had the most unique composition of acarofauna, which had 0% similarity with other types of water bodies.

Discussion

Thus, in the water bodies of the Visimsky Nature Reserve and its vicinities, 70 species of water mites were revealed. For comparison, in the rivers and lakes of the Northern Urals studied by Shubina and Tsember (2017) 87 species are noted, while in Nether-polar Urals 33 species were noted. At the same time, the fauna of water mites of different parts of the Urals was very similar: in the rivers were dominated by representatives of three main families, Sperchontidae, Lebertiidae and Hygrobatidae. Most species are common inhabitants of waters in Central and Northern Urals.

Most mite species are widely distributed in Holarctic, Palaearctic and Western Palaearctic areas. Several species, such as *Mesobates forcipatus* Thor, 1901 and *Mixobates processifer* (Thor, 1905) are, however, known mainly from Scandinavia and from the North and the East of Russia (Gerecke et al. 2016). The same species also were noted in the rivers of Northern and Nether-polar Urals (Shubina & Tsember 2017). Another species, *Ocybrachypoda celeripes*, which is rare in Europe and known in Northern Germany and Ireland (Gerecke et al., 2016), was widespread in the rivers of the Visimsky Nature Reserve. This species is abundant in the small clean rivers of the neighboring region, in the South of Western Siberia (our unpublished data). Also, in the rivers of the Visimsky Nature Reserve *Sperchon distans* (Scheffler, 1972) and *Sperchonopsis minutiporus* Tuzovskij, 1990 were found. Until now they were known only from Eastern Siberia and from the Far East of Russia (Tuzovskij 2002; Semenchenko 2008). *Sperchon distans* was also noted in the rivers of Northern and Nether-polar Urals previously (Shubina & Tsember 2017). Possibly, across the Urals there is the western border of distribution of these species. Finally, *Protzia uralensis* Tuzovskij, 2021 and *Atractides teneroides* Tuzovskij, 2023, in the upper course of the Rivers Sulyom and Kamenka were described by P.V. Tuzovskij as a species new to science (Tuzovskij 2021, 2023).

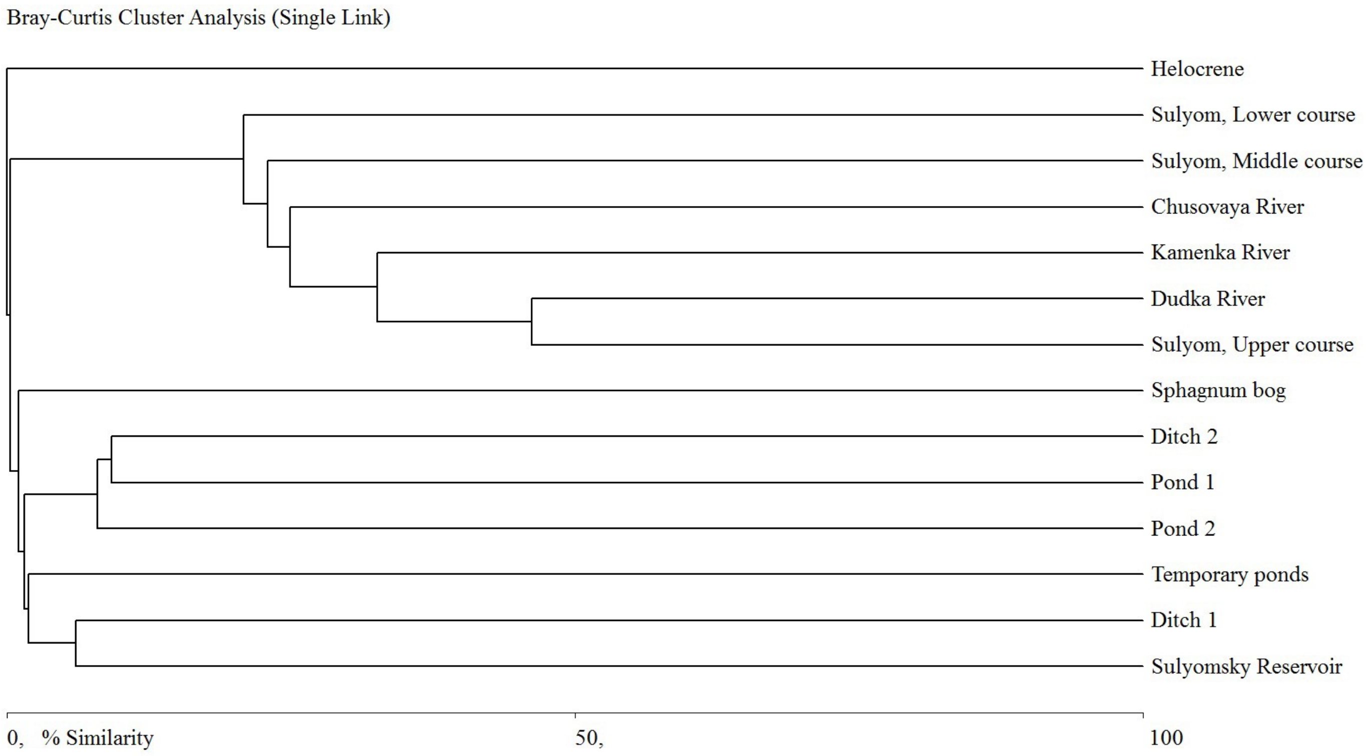

Figure 3. *The Bray-Curtis similarity analysis of water mites fauna of the studied water bodies of the Visimsky State Nature Reserve*

In the studied water bodies, a high species diversity of Halacarid mites was noted. In total, 6 species from this family were found in the Visimsky reserve. At the same time, with the exception of *Porohalacarus alpinus* (Thor, 1910), which was sporadically recorded in the upper course of the Sulyom River, all species of Halacarid mites were found in sedge-sphagnum bogs. Similar species composition of Halacarid mites with high abundance, was previously observed in the neighboring region, Western Siberia, in sphagnum bogs (Stolbov et al. 2018).

It should be noted that, according to the research of DNA barcoding (using the COX1 barcoding locus) of water mites conducted earlier (Klimov et al. 2022), six species (*Hydrodroma pilosa*, *Lebertia fimbriata*, *L. inaequalis*, *Sperchonopsis verrucosa*, *Ljania bipapillata*) from the Visimsky Nature Reserve are possibly cryptic species, with large interspecific COX1 K2P distances. Many species of water mites, including those revealed in our research, are likely to have high cryptic diversity. This has been shown by numerous studies conducted in Europe in recent years (eg., Blattner et al. 2019; Pešić et al. 2021a, b).

The upper course of the Sulyom River and its tributaries are similar to some clean small lowland rivers of Eastern Europe by the structure of water mite fauna and dominating species. For example, there are similarity with the rivers of the North of the European part of Russia (Shubina & Tsember 2017), the River Kamenka of the Yaroslav Oblast of Russia (Tuzovsky, 1997), tributaries of the River Neman in Belarus (Biesiadka et al. 2004), the River Krapiel in Poland (Zawal et al. 2017) etc. At the same time, in the rivers of the Visimsky Nature Reserve the share of the rheobiont species was much higher, there were practically no lentic species, and there was much less share of species of subgenus *Piloleberia* which were steadier against environmental factors. However, in comparison with the rivers of mountainous areas of Eastern Europe, for example, Pieniny Mts. in Poland (Biesiadka 1979), in the rivers of Visimsky Nature Reserve much less species from the Aturidae and Feltriidae and a smaller species diversity of rhitrobiontic water mite species were found.

The number of mites was rather high in most of the studied rivers, the highest species diversity and abundance were found on stony sites, often overgrown by *Fontinalis antipiretica*. Similar data was noted for other groups of aquatic organisms of the Visimsky Nature Reserve too. For example, the highest rates of biomass of zoobenthos were representative of moss overgrowing of stony and pebble bottom of upper course of the Sulyom River (Stepanov 2001).

At the same time in the Rasya River, which is completely dammed by beavers, the number of mites was very low. Species tolerating pollution were only found here. We can speculat that in the absence of anthropogenic influence, activity of beavers might be important in the distribution of mites in the small rivers of the Visimsky Nature Reserve.

The mite fauna in the middle and lower course of the Rivers Sulyom and Chusovaya are considerably different from the upper course and tributaries by the species composition. At the same time, different sites of the watercourses of the Sulyom River had a low degree of similarity to each other. The site of the middle course, located behind the dam of the Sulyomsky reservoir was the poorest in the terms of species richness. This may be due to the influence of the dam.

The only helocrene studied by us revealed three species which were typical crenobionts and were not found in other types of water bodies. It is known that in springs there forms a very rich and specific fauna of water mites (Di Sabatino et al. 2003).

A very specific fauna was found in sedge-sphagnum bogs in which Halacaridae dominate by species diversity and number. Also very specific, but poor species composition mite fauna was revealed in temporary water reservoirs where typical spring species were found.

In our study species that are common for standing and low-flowing water bodies were found in permanent standing waters. At the same time, although these water reservoirs are located at a small distance from each other, mites species composition in each of them strongly differed and the number of common species was low. In general, permanent standing water bodies are not typical of this area. All studied water bodies had artificial origins and rather small age (the water reservoir and all other artificial water bodies were created in the mid-eighties), and, perhaps due to this, they have quite poor water mite fauna.

Conclusion

Our research showed that there exists a rich and diverse water mite fauna in the water bodies of the Visimsky Nature Reserve. The structure and composition of the acarofauna are similar to East European, however, it has both East Palearctic elements and species currently only known from these territories. At the same time, the composition of the water mite fauna of the Visimsky Nature Reserve, located in the Central Urals is very similar to the acarofauna from lakes and rivers of the Northern and Nether-polar Urals. Because the territory of the Visimsky Nature Reserve is not affected by anthropogenic influence, the upper course of the Sulyom River and small tributaries of the river dominate species with high requirements for quality of the environment, which can be considered an index of good ecological condition of water bodies.

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Supplementary material 1

Table 1. Number, frequency of occurrence (O, %) and dominance index (D, %) of water mites in water bodies of the Visimsky Nature Reserve and its surroundings

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Data type: table

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