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AQUATIC FLORA AND FAUNA

Non-Metric Multidimensional Scaling Analysis of Composition of Trichopterofauna From Two Protected Areas (Republic of Mordovia, Russia)

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Abstract—The fauna of caddisflies was studied from two protected areas of federal significance such as Mordovia State Nature Reserve (Temnikov district, Republic of Mordovia) and National Park "Smolny" (Ichalki district and Bolshoe Ignatovo district, Republic of Mordovia). The material was collected from May to October 2008, 2009, 2013–2021. There were 677 specimens from 59 caddisfly species from 12 families. The largest family Limnephilidae includes 29 species, there were 9 species each in the families Phryganeidae and Leptoceridae. *Limnephilus sericeus* and *Holocentropus dubius* dominated in the collections (12 and 10% from the total amount respectively), *Hydropsyche angustipennis* (8.9%), *Hagenella clathrata* (8.7%), *Phryganea grandis* (7.5%), *Hydropsyche pellucidula* (7.1%), *Halesus tesselatus* (6.6%) were numerous. Eighteen species of caddisflies (*Rhyacophila fasciata, Holocentropus dubius, Agrypnia varia, Oligostomis reticulata, Anabolia concentrica, Anabolia furcata, Chaetopteryx villosa, Halesus digitatus, Limnephilus binotatus, Limnephilus extracatus, Limnephilus fuscicornis, Limnephilus ignavus, Limnephilus sericeus, Limnephilus sparsus, Limnephilus vittatus, Micropterna lateralis, Molanna albicans, Ceraclea excisa*) supplement the known information on the fauna of the Republic of Mordovia, where 73 species from 14 families are currently recorded. The species *Molanna albicans* is indicated for the first time for the fauna of the Middle Volga region. Non-metric multidimensional scaling analysis revealed similarities and differences in the composition of trichopterofauna among the study sites. There was the maximum similarity among the sites with more diverse biotopes. There were indicated preferred habitats of some species.

Keywords: insects, biodiversity, protected areas, rare species, Republic of Mordovia

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INTRODUCTION

Conservation of biological diversity is considered as one of the main global gpals of mankind and as the most important condition for the stability of ecological systems (Gray et al., 2016; Christie et al., 2021). Protected areas are the centers of biological diversity in moderate latitudes (Ruchin and Khapugin, 2019; Glotov and Hushtan, 2020; Ronquist et al., 2020; Cunningham et al., 2021; Polevoi, 2021; Sazhnev and Sergeev, 2021; Urbanavichus et al., 2021). Protected areas are gradually increasing in many countries. The expansion and strengthening of protected areas networks are at the forefront of efforts to preserve and restore global biodiversity. However, climate change and habitat loss (e.g., Chhetri et al., 2021) may interact synergistically, undermining the potential benefits of protected areas (Asamoah et al., 2021). In addition, in unprotected areas, the land is formed by human activity to such extent that animals are only able to live in protected areas (Ellis and Ramankutty, 2008; Gray et al., 2016; Sergeev, 2020; Fathima et al., 2021; Williams et al., 2021). Thus, ensuring the protection of the territory is a long-standing and current central element of the strategy for the conservation of species, populations and entire ecosystems, and the priority task is to study and preserve biological diversity in protected areas (Jenkins and Joppa, 2009; Ruchin and Kurmaeva, 2010; Geldmann et al., 2013; Tuniyev et al., 2021). It is the ecological systems preserved in their original form in these territories that are unique and have a high biological diversity, unlike adjacent territories that are usually subjected to anthropogenic pressure (Norris, 2012; Tantipisanuh et al., 2016; Ruchin and Grishutkin, 2018; Sinclair et al., 2018; Simonov and Matantseva, 2020).

Currently, the world fauna of caddisflies (Trichoptera) has 16.267 species (De Moor and Ivanov, 2007; Morse, 2022). More than 1700 species of caddisflies have been recorded in Europe and new species are regularly found (Previšić et al., 2014; Vitecek et al., 2015a, 2015b; Schmidt-Kloiber et al., 2017). The fauna of Russian caddisflies has 650 species from 28 families. At the same time, 235 species are observed in the European part of Russia (Ivanov, 2011; Melnitsky and Ivanov, 2017). In the Republic of Mordovia, the fauna of the dead has been specially studied only within the framework of hydrological studies, and imagos in a small area have been studied separately only in the current century (Plavilshchikov, 1964; Solntsev et al., 2006; Ruchin, 2014; Stoiko et al., 2014; Mey et al., 2017). As a result, according to the literature data, 55 species are known from the territory of the region (Solntsev et al., 2006; Borisova and Rushin, 2021b).

Along with other amphibiotic insects, caddisflies represent one of the most significant and diverse groups in aquatic ecosystems. Caddisflies larvae are vital participants in food chains, and their presence and adaptability to certain types of habitats are used in biological assessment and monitoring of water quality (Habdija et al., 2004; Schmidt-Kloiber et al., 2017; Wissinger et al., 2018; Morse et al., 2019; Baturina, Efstifeeva, 2021; Ostrovsky, 2021; Pozojevic et al., 2021). A recent review has shown that the sensitivity of the preimaginal stages of Trichoptera to habitat imbalance, including urbanization and agricultural use of landscapes, leads to the extinction of a number of species of this order. The main causes of death are pollution with fertilizers and pesticides, the influence of pathogenic microorganisms and introduced species, as well as climate change (Sánchez-Bayo and Wyckhuys, 2019). In addition, an important task is the inventory of regional and local caddisfly farms, correction of errors and inaccuracies in old tables, addition of tables with new information (Ivanov and Melnitsky, 2011). The purpose of this work is to assess the species diversity of caddisflies on the territory of two protected areas of federal significance in the Republic of Mordovia (Mordovia State Nature Reserve and National Park "Smolny").

MATERIALS AND METHODS

The Mordovia State Nature Reserve is located in Temnikov district of the Republic of Mordovia. It covers an area of 321.62 km^2, 90% of the area is represented by forests. From the north, the border runs along the Satis River—the right tributary of the Moksha, along the Arga River, which flows into the Satis River. The western border follows the rivers Chernaya, Satis and Moksha. From the south there are forest-steppe biotopes. The territory is included in the zone of coniferous-deciduous forests on the border with the forest-steppe. The vegetation cover has a taiga character with a certain attraction to the immoral complex during successions. Pine (*Pinus sylvestris* L.) is the main forest-forming genus. It forms pure or mixed plant communities in the southern, central and western parts. Birch (*Betula pendula* Roth) and birch forests occupy the second place in terms of forest area. These are mainly secondary communities at the sites of cuttings and burnt pine forests (Ruchin et al., 2019). At the same time, plant communities from other small-leaved species (aspen, alder) are formed in some areas (Khapugin et al., 2016). Linden forests are located mainly in the northern part. These are plant communities that have arisen on the site of pine forests and linden-spruce forests. Oak forests occupy a relatively small area. Spruce forests and alder ones are located mainly in floodplains of rivers and streams and occupy small areas. The main areas of floodplain meadows are located along the Moksha River in the southwest. There are not many reservoirs on the territory of Mordovia State Nature Reserve. They are represented by small lakes in the south-western part and ponds in different places, mostly close to the cordons.

The National Park "Smolny" has an area of 363.85 km^2 and is located in Ichalki district and Bolshoe Ignatovo district of the Republic of Mordovia. About 95% of the territory is occupied by forests (a zone of broad-deciduous forests). Oak forests and linden trees are widespread. Forest-forming species are also represented by spruce and pine from conifers; norway maple, ash, oak, linden, alder, aspen, birch. In different parts of the park there are mainland (dry land) and floodplain meadows. The rivers belong to the basin of the Alatyr River (southern part). The largest rivers are the Yazovka and Kalysha. In the floodplain of the Alatyr River, there are numerous floodplain lakes. The southern part of the territory is lower and flatter, with wide watersheds. It occupies the terraces of the Alatyr River, small areas of the floodplain and almost all the depressions, as well as the southern part of the water-glacial plain (Chugunov and Khapugin, 2020; Kirillov and Kirillova, 2021).

We collected the material in 2008, 2009, 2013–2021 (from May to October) in the National Park "Smolny" (S1–S8) and Mordovia State Nature Reserve (S9–S17) (Table 1).

Adult caddisflies were caught at night by the light of lamps (DRL type), which were installed in different places, usually close to a reservoir, clearing, road, in a forest village or on the territory of a forest cordon. Single specimens were collected using crown fermental traps (Ruchin et al., 2020) and mowing. The material is identified according to the determinants of T.T. Macan (1973), V.D. Ivanova (1997), H. Malicky (2004), W. Tobias, D. Tobias, (2012), J. Salokannel, K. Mattila (2018). No special study of the hydrological characteristics of water bodies and their influence on the composition of the Trichoptera fauna has been carried out.

Table 1. Locality data for the 16 sampling stations of caddisflies at the Mordovia State Nature Reserve and National Park "Smolny"

Code	Sampling Stations	Water body type	Latitude, °N	Longitude, °E
		National Park "Smolny"		
S1	Mitryashki	Oxbow lake	54.7450	45.5020
S2	Lvovskoe foresty	Pond	54.8416	45.3816
S3	Malye Ichalki	River	54.7546	45.2304
S4	Lesnoi	Pond	54.8763	45.4758
S5	Barakhmany	River	54.7697	45.5654
S6	Rezovatovsky	Oxbow lake	54.7393	45.4741
S7	Obrezki	Pond	54.8337	45.3786
S8	Sanatorium	Oxbow lake	54.7396	45.3840
		Mordovia State Nature Reserve		
S9	Pushta	Pond	54.7199	43.2300
S10	Valzensky	Pond	54.7200	43.2352
S11	Steklyannyi	Pond	54.8951	43.6004
S12	Srednyaya Melnitsa	River	54.9020	43.2317
S13	Novenkovsky	River	54.9316	43.4215
S14	Pavlovsky	Pond	54.7541	43.4011
S15	Inorsky	Oxbow lake	54.7274	43.1512
S16	Taratinsky	River	54.7450	43.0876
S17	Novenky	Oxbow lake	54.7098	43.2058

The nomenclature is given according to the electronic database Fauna Europaea (https://fauna-eu.org). The volume of the material is 677 specimens (275 females, 402 males) and is stored in the collection of Mordovia State Nature Reserve (Pushta village) and the personal collection of the first author.

Principal Component Analysis (PCA) was performed to find the association of the most abundant caddisfly species with certain water bodies in the study area based on the distance for these objects. To obtain environmental gradients, average abundance values were plotted onto the PCA ordination diagram as supplementary environmental variables. PCA analysis was performed using PAST v. 4.09 (Hammer et al., 2001). For estimation of similarity and differences of caddisfly composition among the sampling stations, the NMDS analysis was used. Similarity among the sampling stations was determined using the Bray-Curtis similarity index through the PRIMER6 software package (Clarke and Warwick, 2001).

RESULTS

The main core of the fauna consists of species with high ecological plasticity to habitat conditions. The analysis of the relative abundance of caddisflies revealed the ratio of species in the collections (Table 2). The dominant ones are *Limnephilus sericeus* and *Holocentropus dubius* (12% and 10% respectively of all collected individuals), the numerous ones are *Hydropsyche angustipennis* (8.9%), *Hagenella clathrata* (8.7%), *Phryganea grandis* (7.5%), *Hydropsyche pellucidula* (7.1%), *Halesus tesselatus* (6.6%). The mentioned species, with the exception of *Hagenella clathrata*, are common in the studied ecoregion and actively fly to the light. *Hagenella clathrata* shows only daytime activity and is collected exclusively with fermental traps. Eighteen species of caddisflies (*Rhyacophila fasciata, Holocentropus dubius, Agrypnia varia, Oligostomis reticulata, Anabolia concentra, Anabolia furcata, Chaetopteryx villosa, Halesus digitatus, Limnephilus binotatus, Limnephilus extracatus, Limnephilus fuscicornis, Limnephilus ignavus, Limnephilus sericeus, Limnephilus sparsus, Limnephilus vittatus, Micropterna lateralis, Molanna albicans, Ceraclea excisa*) supplement the known information on the fauna of the Republic of Mordovia, where 73 species from 14 families are currently recorded. The *Molanna albicans* species is noted for the first time for the fauna of the Middle Volga region.

Taking into account the original and literary data (Plavilshchikov, 1964; Solntsev et al., 2006; Ruchin, 2014; Stoiko et al., 2014; Mey et al., 2017), the fauna of protected areas of federal significance of the Republic of Mordovia has 65 species of caddisflies from 12 families, 59 species were collected by the authors. The species *Agrypnia obsoleta, Semblis phalaenoides, Lenarchus bicornis, Parasetodes respersellus, Setodes viridis,*

Table 2. List of caddisflies species from Mordovia State Nature Reserve and National Park "Smolny" by collections (2008, 2009, 2013–2021)

№	Taxa	Collection sites	Number		Share of total numbers of species, %	Occurence		Collectors
			♀♀	♂♂		MSNR	NPS	
	Fam. **Rhyacophilidae**							
1	!*Rhyacophila fasciata* Hagen, 1859	1		1	0.1		+(*)	AR
	Fam. **Glossosomatidae**							
2	*Agapetus ochripes* Curtis, 1834	1, 9		5	0.7	+(*)	+(*)	AR, GS
	Fam. **Hydroptilidae**							
3	*Agraylea multipunctata* Curtis, 1834	9		1	0.1	+(*)		AR
4	*Hydroptila tineoides* Dalman, 1819	1, 11			0.1	+(*)		GS
5	*Oxyethira* sp.	1	3		0.4		+(*)	GS
	Fam. **Psychomyiidae**							
6	*Tinodes waeneri* (Linnaeus, 1758)	9	1	1	0.3	+(*)		AR
	Fam. **Ecnomidae**							
7	*Ecnomus tenellus* (Rambur, 1842)	9, 12	2	4	0.9	+(*)		AR, GS
	Fam. **Polycentropodidae**							
8	*Cyrnus flavidus* McLachlan, 1864	9	5	1	0.9	+		AR
9	!*Holocentropus dubius* (Rambur, 1842)	2, 9, 13,	49	19	10.0	+(*)	+(*)	AR, GS
10	*Neureclipsis bimaculata* (L., 1758)	9, 12	7		1.0	+(*)		GS
11	*Polycentropus flavomaculatus* (Pictet, 1834)	1, 9, 13	10	8	2.7	+(*)	+(*)	AR, GS
	Fam. **Hydropsychidae**							
12	*H. angustipennis* (Curtis, 1834)	1, 2, 3, 9, 10, 11, 12, 13, 14, 15	50	10	8.9	+(*)	+(*)	AR, GS
13	*H. bulgaromanorum* Malicky, 1977	10, 12		3	0.4	+(*)		AR, GS
14	*H. contubernalis* Mclachlan, 1865	11	2	1	0.4	+		GS
15	*H. pellucidula* Curtis, 1834	1, 2, 5, 9, 11, 12, 13	42	6	7.1	+	+(*)	AR, GS
	Fam. **Phryganeidae**							
16	*Agrypnia pagetana* Curtis, 1835	5, 9	1	1	0.3	+(*)	+(*)	AR, GS
17	!*A. varia* (Fabricius, 1793)	9, 14		2	0.3	+(*)		GS
18	*Hagenella clathrata* (Kolenati, 1848)	12	31	28	8.7	+		AR
19	!*Oligostomis reticulata* (L., 1761)	9, 12		4	0.6	+(*)		AR
20	*Phryganea bipunctata* Retzius, 1783	6, 9, 12	5	10	2.2	+	+(*)	AR, GS
21	*Ph. grandis* L., 1758	1, 2, 5, 6, 9, 11, 12, 14	12	39	7.5	+	+(*)	AR, GS
22	*Trichostegia minor* (Curtis, 1834)	9, 12, 14	6	1	1.0	+		GS
	Fam. **Brachycentridae**							
23	*Brachycentrus subnubilus* Curtis, 1834	9, 13		2	0.3	+(*)		AR, GS
	Fam. **Limnephilidae**							
24	*Anabolia brevipennis* (Curtis, 1834)	1, 2, 9, 10, 13	8	5	1.9	+	+(*)	AR, GS
25	!*A. concentrica* (Zetterstedt, 1840)	1, 8		3	0.4		+(*)	GS
26	!*A. furcata* Brauer, 1857	1, 9		2	0.3	+(*)	+(*)	GS
27	*A. nervosa* (Curtis, 1834)	3	1		0.1		+(*)	GS
28	!*Chaetopteryx villosa* (Fabricius, 1798)	10		1	0.1	+(*)		AR
29	*Glyphotaelius pellucidus* (Retzius, 1783)	2, 3, 9	2	18	3.0	+	+(*)	AR, GS
30	*Grammotaulius nitidus* (Müller, 1764)	3	1		0.1	+	+(*)	GS
31	!*Halesus digitatus* (von Paula Schrank, 1781)	1, 9		2	0.3	+(*)	+(*)	AR

Table 2. (Contd.)

№	Taxa	Collection sites	Number		Share of total numbers of species, %	Occurence		Collectors
			♀♀	♂♂		MSNR	NPS	
32	*Halesus radiatus* (Curtis, 1834)	1, 9		2	0.3	+(*)	+(*)	AR, GS
33	*H. tesselatus* (Rambur, 1842)	1, 2, 8, 9, 10, 12, 13, 14	8	37	6.6	+(*)	+(*)	AR, GS
34	!*Limnephilus binotatus* Curtis, 1834	9	2		0.3	+(*)		AR
35	*L. decipiens* (Kolenati, 1848)	9		1	0.1	+(*)		AR
36	!*L. extricatus* McLachlan, 1865	16		2	0.3	+(*)	+(*)	GS
37	*L. flavicornis* (Fabricius, 1787)	3, 4, 9, 11, 12, 15	2	7	1.3	+(*)	+(*)	AR, GS
38	!*L. fuscicornis* Rambur, 1842	2, 4, 9, 12, 13	2	7	1.3	+(*)	+(*)	AR, GS
39	*L. griseus* (L., 1758)	1, 2, 9, 10, 11, 12, 13, 17	6	17	3.4	+	+(*)	AR, GS
40	!*L. ignavus* Mclachlan, 1865	1, 13	1	1	0.3	+(*)	+(*)	GS
41	*L. lunatus* Curtis, 1834	10		1	0.1	+(*)		AR
42	*Limnephilus nigriceps* (Zetterstedt, 1840)	1		1	0.1	+	+(*)	GS
43	*L. politus* McLachlan, 1865	2, 11		3	0.4	+(*)	+(*)	GS
44	*L. rhombicus* L., 1758	1, 2, 3, 9, 12, 13, 14		21	3.1	+	+	AR, GS
45	!*L. sericeus* (Say, 1824)	1, 2, 9, 10, 11, 12, 13, 14	7	74	12.0	+(*)	+(*)	AR, GS
46	!*Limnephilus sparsus* Curtis, 1834	1, 2, 3, 9, 11, 12	1	18	2.8	+(*)	+(*)	AR, GS
47	*L. stigma* Curtis, 1834	9, 12	1	2	0.4	+(*)		AR
48	!*L. vittatus* (Fabricius, 1798)	9		1	0.1	+(*)		AR
49	!*Micropterna lateralis* (Stephens, 1837)	2, 3, 4	3	1	0.6		+(*)	AR, GS
50	*Potamophylax latipennis* (Curtis, 1834)	7	1	5	0.9		+(*)	GS
51	*P. rotundipennis* (Brauer, 1857)	2, 9		5	0.7	+(*)	+(*)	AR, GS
	Fam. **Molannidae**							
52	*Molanna angustata* Curtis, 1834	2		1	0.1	+	+(*)	GS
53	!!*M. albicans* (Zetterstedt, 1840)	12, 13	1	2	0.4	+(*)		GS
	Fam. **Leptoceridae**							
54	*Ceraclea albimacula* (Rambur, 1842)	11		1	0.1	+		GS
55	*C. dissimilis* (Stephens, 1836)	9, 11, 12		7	1.0	+		AR, GS
56	!*C. excisa* (Morton 1904)	12		3	0.4	+(*)		GS
57	*C. senilis* (Burmeister, 1839)	11		1	0.1	+		GS
58	*Leptocerus tineiformis* Curtis, 1834	9		1	0.1	+(*)		AR
59	*Mystacides azureus* (L., 1761)	9, 13	2	1	0.4	+(*)		AR, GS
	In total:		275	402	100	53	33	

Designations. !—new species for the fauna of the Republic of Mordovia; !!—a species first observed in the Middle Volga region, (*)—species new to a specific protected areas according to our data; (+)—collections taking into account the literature data; (AR) – initials of collector A.B. Ruchin, (GS)—initials of collector G.B. Semishin.

Triaenodes bicolor were noted only according to literature data (Plavilshchikov, 1964; Solntsev et al., 2006; Ruchin et al., 2007; Ruchin, 2014; Stoiko et al., 2014; Mey et al., 2017). The largest family Limnephilidae includes 29 species, there are 9 species each in the families Phryganeidae and Leptoceridae, and one species has been registered in four families (Rhyacophilidae, Glossosomatidae, Psychomyiidae, Ecnomidae) (Fig. 1). Taking into account previously published data, 58 species were identified on the territory of the Mordovia State Nature Reserve, 34 species on the territory of National Park "Smolny". 27 species of caddisflies are common to both faunas.

Non-metric multidimensional scaling (MDS) analysis revealed similarities and differences in the composition of the caddisfly fauna among the study sites. Several sampling stations were grouped together with the greatest similarity into one cluster (S13, S6, S14, S15, S7, S4, S16, S9 and S2). The most similar to this cluster were the S3 trapping stations and three sta-

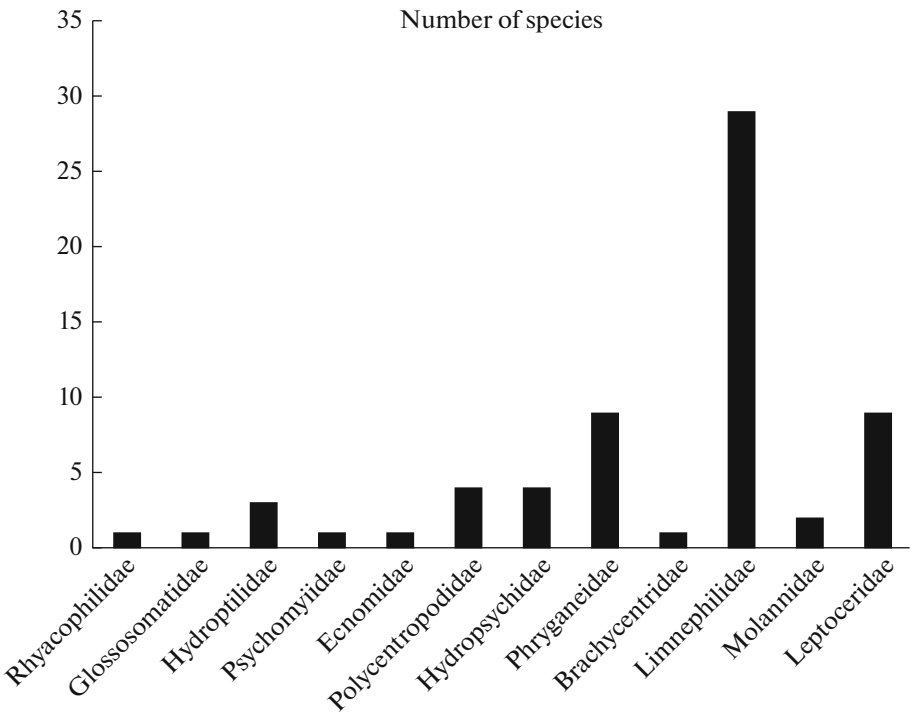

Fig. 1. The ratio of the number of species in the families of the caddisfly fauna living on the territory of Mordovia State Nature Reserve and National Park "Smolny".

tions (S5, S1 and S11), which also differed little from each other. The other three sampling stations (S8, S12, and S10) are identified as the most dissimilar stations based on their caddisfly fauna (Fig. 2). We have not found any regularities in the clusterization in relation neither to geographical position of trapping stations (Mordovia State Nature Reserve vs. National Park "Smolny"), nor to the water body type (pond, oxbow lake, river, brook). Based on this result, we believe that additional further investigations will contribute to answer the question on relationships between Trichoptera species composition and certain environmental factors.

Among all the species, *Limnephilus flavicornis, Limnephilus fuscicornis* have the least attraction to lakes, being more abundant near other types of reservoirs. *Glyphotaelius pellucidus* and *Holocentropus dubius* avoid rivers, gravitating more towards ponds and streams. *Limnephilus sparsus* also has a greater affinity for streams and ponds. The remaining species did not show a pronounced attraction to one or another type of reservoir in the studied territories (Fig. 3).

To obtain environmental gradients, average abundance values were plotted onto the principal component analysis ordination diagram as supplementary environmental variables.

DISCUSSION

The caddisflies of the protected areas of the Republic of Mordovia have not been studied specifically before. Information about the species composition of this group of insects is extremely limited and is of a fragmented nature. According to the available literature data, 23 species of caddisflies have been previously observed in federal protected areas (Plavilshchikov, 1964; Kamenev, 1989; Kameev and Kuznetsov, 1999; Solntsev et al., 2006; Ruchin, 2014; Stoiko et al., 2014; Bayanov et al., 2015; Mey et al., 2017; Sazhnev, 2017, 2018; Borisova and Ruchin, 2020, 2021). It is well known that the biodiversity of protected areas is usually much greater than in adjacent territories. There are important factots such as the relief, the different preservation of landscapes, the age of protected areas, the uniqueness of ecosystems, the absence of anthropogenic impact and other factors (Cardoso et al., 2011; Françoso et al., 2015; Robinson et al., 2016; Tantipisanuh et al., 2016; Bukhtiyarova, 2021). For example, in Belarus, the fauna of the 13 protected areas accounted for 97 caddisfly species from 12 families (Czachorowski and Moroz, 2007). At the same time, 310 species of caddisflies were identified on the territory of 10 nature reserves and national parks of the Russian Far East, characterized by high endemism and diversity of fauna, as well as mountainous terrain and unique ecosystems (Potikha and Vshivkova, 2016). This number significantly exceeds the species richness of the ecoregion (214 species), which includes Mordovia State Nature Reserve and National Park "Smolny" (Schmidt-Kloiber et al., 2017).

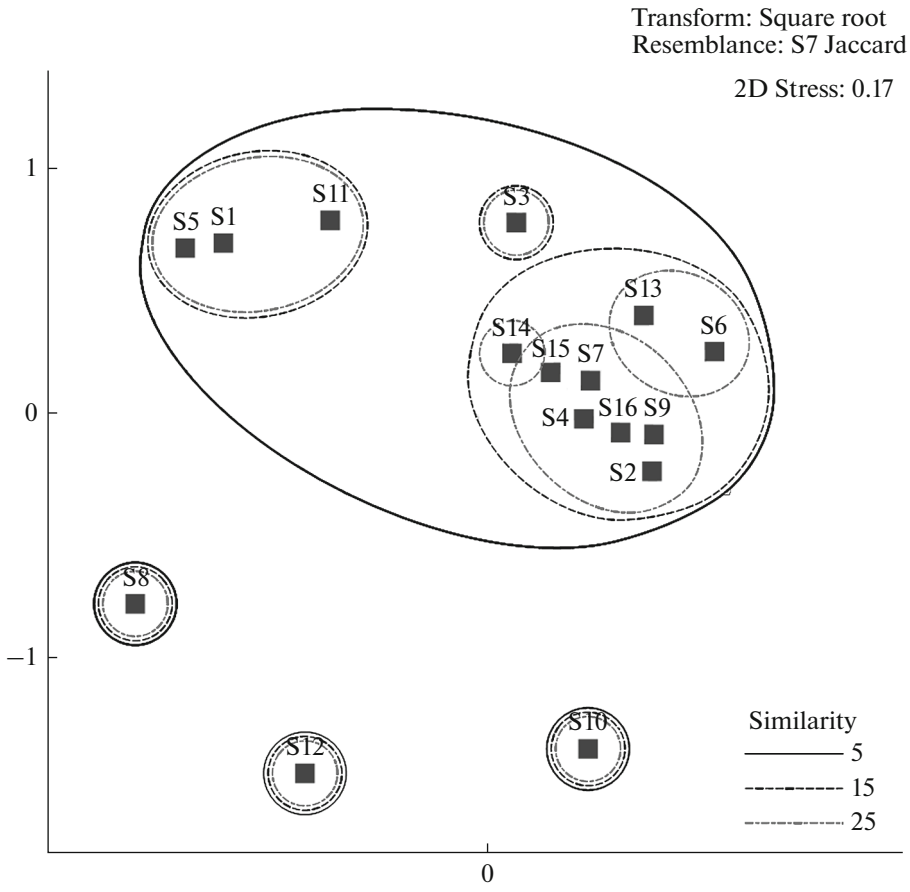

Fig. 2. NMDS analysis of the 16 sampling stations based on the caddisfly fauna composition. Abbreviations of the sampling sites are given in Table 1.

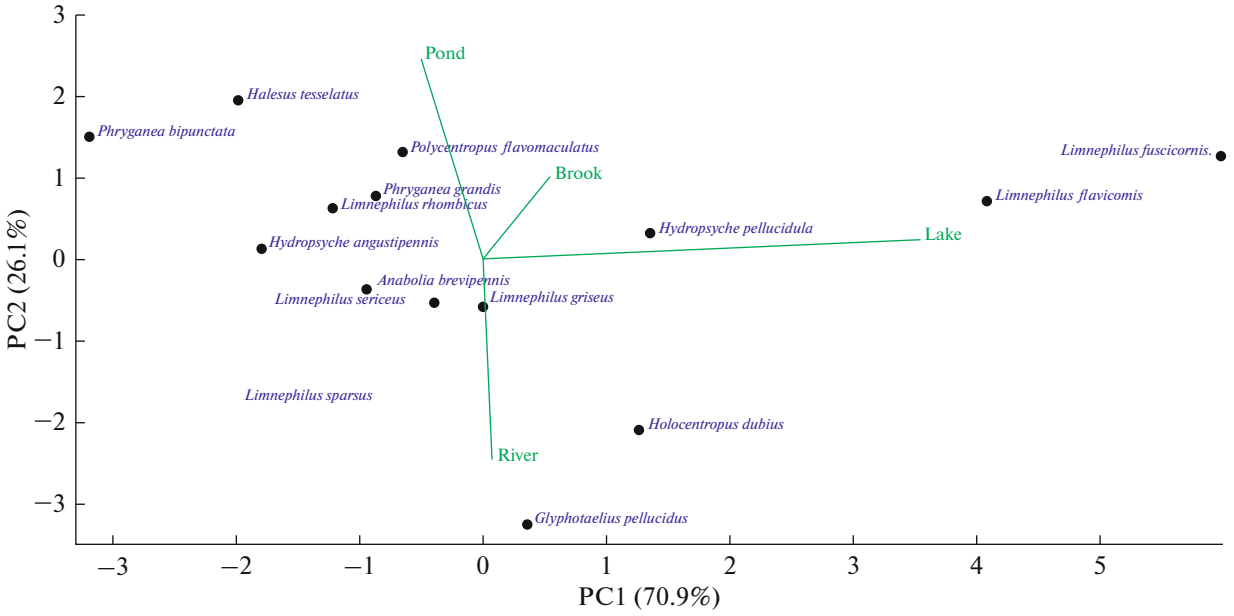

Fig. 3. Ordination diagram of the principal component analysis (PCA) of the dominant species in Protected Areas (Mordovia State Nature Reserve, National Park "Smolny") of the Republic of Mordovia, European Russia. Biplot arrows designate a distance from certain water bodies. To obtain environmental gradients, average abundance values were plotted onto the principal component analysis ordination diagram as supplementary environmental variables.

Table 3. Comparative species richness of Trichoptera in some protected areas of European Russia

Protected areas	Region	Number of species	References
National Park "Khvalynsky"	Saratov region	22	Mey and Anikin, 2015
National Park "Mari Chodra"	Republic of Mari El	12	Zaburdaeva, 2004a, 2004b
National Park "Chavash varmane"	Chuvash Republic	4	Borisova and Egorov, 2021
National Park "Smolny"	Republic of Mordovia	34	Our data
Kenozero National Park	Arkhangelsk region	15	Melnitsky and Ivanov, 2012
Oka State Nature Reserve	Ryazan region	47	Ivancheva, 2000
Prisursky State Nature Reserve	Chuvash Republic	38	Borisova, 2021
Kerzhensky State Nature Reserve	Nizhny Novgorod region	21	Anufriev and Bayanov, 2002
Nurgush State Nature Reserve	Kirov region	17	Kochurova, 2014
Privolzhskaya Lesostep State Nature Reserve	Penza region	10	Ivanovskiy, 2009
Bolshaya Kokshaga State Nature Reserve	Republic of Mari El	2	Bedova, 2008
Mordovia State Nature Reserve	Republic of Mordovia	58	Our data

The results obtained on the diversity of the caddisfly fauna of the protected areas of the Republic of Mordovia can be compared, and in many cases, they are more relevant, compared with the somolar data on some other nature reserve and national parks of the European part of Russia (Table 3).

The greatest similarity based on NMDS analysis was found in six stations—S2, S4, S7, S9, S15, and S16. These are stations near which there is a maximum of diverse ecological (large ponds, floodplain lakes) and lottic ecosystems (rivers, streams). The closest to this cluster is the fauna of caddisflies at station S14 since there are no flowing reservoirs, and the fauna of stations S13 and S6, which have both large flowing lakes and small rivers. Three stations (S1, S5 and S11) grouped into one cluster differed from the others by the presence of ponds and lakes and the absence of large rivers near them. Three more sampling stations (S8, S10 and S12), which as a result of NMDS analysis were identified as the most dissimilar stations based on their fauna of caddisflies, are located on the territory of Mordovia State Nature Reserve. Their ecosystems have common features with other trapping stations. Therefore, it is possible that the differences between these stations and others are due to the insufficiency of the sample of caddisflies on them.

According to our data, two species *Limnephilus flavicornis* and *Limnephilus fuscicornis* can be found near small watercourses. In Europe, larvae of these species inhabit coastal zones of small rivers and streams (Ibrahimi et al., 2019; Slavevska-Stamenković et al., 2021). Thus, our data on the imago *Limnephilus flavicornis* and *Limnephilus fuscicornis* coincide with the data on the biology of larvae.

Larvae of two species *Glyphotaelius pellucidus* and *Holocentropus dubius* mainly inhabit various lentic ecosystems. Larvae of the first species can be found both in clean, well-warmed ponds and lakes, and in temporary spring puddles along rivers and streams abounding with a huge amount of decomposing organic matter (Szivák et al., 2011). The second type is more common in lakes (Ungermanová et al., 2014). According to our calculations, *Limnephilus sparsus* is more confined to streams and ponds. This is consistent with the literature data that indicate the habitation of larvae of this species in lakes, temporary small ponds and streams (Williams et al., 2004; Olafsson and Gíslason, 2010; Ibrahimi et al., 2019).

As we have already mentioned above, a rare species *Molanna albicans* is given for the first time for the fauna of the Middle Volga region. It is found in the Holarctic region, and in Europe, mainly in the northern part. It lives in slow-flowing streams and stagnant reservoirs with a sandy shore, in lakes, sometimes completely frozen in winter. Larvae live on sandy-detritus or sandy-silty soils (Solem, 1983; Otto, 1994; Boonstra and Wiggers, 2014). It was found on the territory of cordons near small rivers (Satis, Arga). There are no non-flowing reservoirs nearby.

A rare (tyrphophilic) species (*Hagenella clathrata*) was found locally on the territory of the Mordovia State Nature Reserve—exclusively on the sites of the area burnt in 2010. The larvae live in swampy areas, often in raised bogs (Czachorowski and Moroz, 2007; Kubiak and Peters, 2010; Buczynska et al., 2012). After the 2010 fires in the Mordovia State Nature Reserve, many swampy ecosystems appeared on the territory of the mountain ranges in small lowlands. Apparently, they are the habitats of *Hagenella clathrata*. This species also occurs sporadically in many countries from the West Europe to Kamchatka (Czachorowski and Moroz, 2007).

The larvae of a number of species (*Agapetus ochripes, Molanna angustata Polycentropus flavomaculatus, Potamophylax latipennis, Potamophylax rotundipennis*, etc.) are indicators of water quality and are considered in calculating the majority of the biotic indices (Lavrov, 2009; Skuja and Spuņģis, 2010).

It should be mentioned that there was only find in protected areas of a rare species—the butterfly-shaped caddisfly (*Semblis phalaenoides*), listed in the Red Books of a number of northern regions of the Russian Federation and recommended in the new edition of the Red Book of the Chuvash Republic (Borisova and Egorov, 2021). The species is distributed in the northern regions of the Eastern and Central Palearctic. Larvae live in shallow stagnant and slow-flowing flowing reservoirs, prefer small rivers and streams (Berglin et al., 1999; Borisova and Egorov, 2021). The imago of the species was caught on the bank of the Kalysha River. This is a small and shallow river 4m wide with a sandy bottom (at the point of imago observation). It is recommended to include this species in the Red Book of Mordovia.

CONCLUSIONS

Based on the results of studies conducted on the territory of Mordovia State Nature Reserve and National Park "Smolny" and comparative analysis with other European protected areas of Russia, it can be concluded that the fauna of the protected areas of Mordovia is relatively diverse. It includes both common and fairly rare species. A total of 65 species from 12 families were identified. The dominant ones are *Limnephilus sericeus, Holocentropus dubius*, and the numerous ones are *Hydropsyche angustipensis, Hagenella clathrata, Phryganea grandis, Hydropsyche pellucidula, Halesus tesselatus*. Eighteen caddisfky species were recorded for the first time for the Republic of Mordovia. *Molanna albicans* was recorded for the first time for the fauna of the Middle Volga region. Protected areas play an important role in maintaining the species diversity of the region's ecosystems.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interests.The authors declare that they have no conflicts of interest.

Statement on the welfare of animals. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

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