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Research Article

# Distribution and diversity of aquatic Oligochaeta in small streams of the middle taiga

Maria BATURINA*
Institute of Biology, Komi Scientific Center, Ural Branch of Russian Academy of Sciences, Syktyvkar 167982 - RUSSIA

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**Abstract:** The goal of the present study was to describe the fauna, community structure, distribution, diversity, abundance, and ecology of Oligochaeta in small streams of the Komi Republic. The work was performed in 13 streams located in the Vychegda River basin during the month of July, 2005-2008. During the study, 48 taxa from 7 families were collected. The habitat of each study stream was determined with respect to chemical water composition ($Na^+$, $Mg^{2+}$, $Ca^{2+}$, $Cl^-$, and total phosphorus ($P^{tot}$), among others) and some environmental factors: bottom structure (hard or soft), water temperature, depth, flow velocity, moss or algae cover, etc. The species composition, diversity, and determination of the small streams' aquatic Oligochaeta as well as the influence of different ecological factors on these characteristics were analyzed and discussed. The number of species, their composition, and the average abundance and biomass of Oligochaeta were found to depend upon bottom texture, current velocity, moss or algae cover, water temperature, and changes in the water chemicals ($Na^+$, $Mg^{2+}$, and $P^{tot}$ concentrations), as well as the nitrogen, carbon, and humus contents in the bottom sediments.

**Key words:** Oligochaeta, zoobenthos, ecology of northern fresh water streams

## Introduction

Water ecosystems are exposed to various environmental factors depending on the geology and morphology of the water body, climatic changes, human activity, etc. The Oligochaeta have a high rate of species diversity and ecological variety and also have a high significance in water ecosystems. They can be used as indicators of pollution or changes of conditions (e.g., Lafont, 1984; Milbrink, 1994; Särkkä, 1994; Finogenova, 1996).

The influence of stream hydrology and physical and chemical factors on aquatic Oligochaeta has been studied by many authors (Dumnicka and Pasternak, 1978; Verdonschot, 2001; Schenková and Helešic, 2006). In previous investigations, the question of the relationship between habitat environmental factors and the community structure of Oligochaeta in streams of the Komi Republic was examined.

There are 2 large basins located in the Komi Republic: the Pechora River (starting from the Ural Mountains and running into the Barents Sea) and the Vychegda River (running from the Timan Ridge into the North Dvina River). The Oligochaeta fauna of the Pechora River basin was recently studied (Baturina, 2007). The Vychegda River has many tributaries (Avdeev, 1964), all of which are located in the

* E-mail: baturina@ib.komisc.ru

middle taiga. The middle taiga is a dominant natural geographical belt running through the territory of the Komi Republic. It is represented mostly by spruce and pine forests growing in podzol and gley-podzol soils. These soil types are poor in humus and nutrients, and are highly acidic. Earlier information on the Oligochaeta of the Vychegda River basin was given by Lastochkin (1955) and Zvereva (1969). These authors provided data on oligochaete composition and abundance from riverbeds and floodplain pools, but presented no information on oligochaete fauna from small streams of the basin. This paper studies the distribution and diversity of Oligochaeta in streams of the Komi Republic (northeastern European Russia) in relation to different ecological factors.

## Materials and methods

The Vychegda River is 1130 km long (Avdeev, 1964). The river is divided into 3 zones: the Upper, the Middle, and the Lower Vychegda. We investigated small tributaries of different order of the Middle Vychegda River in July of 2005-2008 and in May-August of 2006. The study was performed in 13 small streams located in the middle taiga (Figure 1). Samples were also collected from the middle-sized rivers Sysola and Lokchim and also from different stagnant water bodies (reservoirs, flood pools, and shallow lakes).

The samples from sand and sand-gravel bottoms were collected using a Peterson dredge (2 replicates from each point; the sampling area was 0.040 $m^2$). Samples from cobble-boulder, cobble, gravel, and sand bottoms were collected using a hydrobiological scraper (S = 0.09 $m^2$). The scraper grasped the substrate 0.3 m down into the bottom. Boulders were lifted manually and a 230-μm mesh net was placed underneath them to prevent loss of organisms (Shubina, 1986).  The areas of boulders were defined by their projection onto the bottom. A kapron net with a mesh size of 230 μm was used to concentrate the samples. Samples were preserved in formalin solution (4%). The oligochaete biomass was determined as a wet weight using a torsion balance (WT-250, Techniprot, Poland). The worms were mounted in glycerin and identified to the species level under a light microscope, following the methods of Timm (2009). Some samples were unidentified, including members of the family Enchytraeidae and many juvenile individuals.

The habitat at each study site was characterized by water chemical composition ($Na^+$, $Mg^{2+}$, $Ca^{2+}$, total phosphorus ($P^{tot}$), and $Cl^-$ concentrations, among others) and habitat environmental factors such as substratum (stones, pebbles, sand, or silt), water temperature, depth, flow velocity, and bottom texture (Table 1). In addition, the nitrogen, carbon,

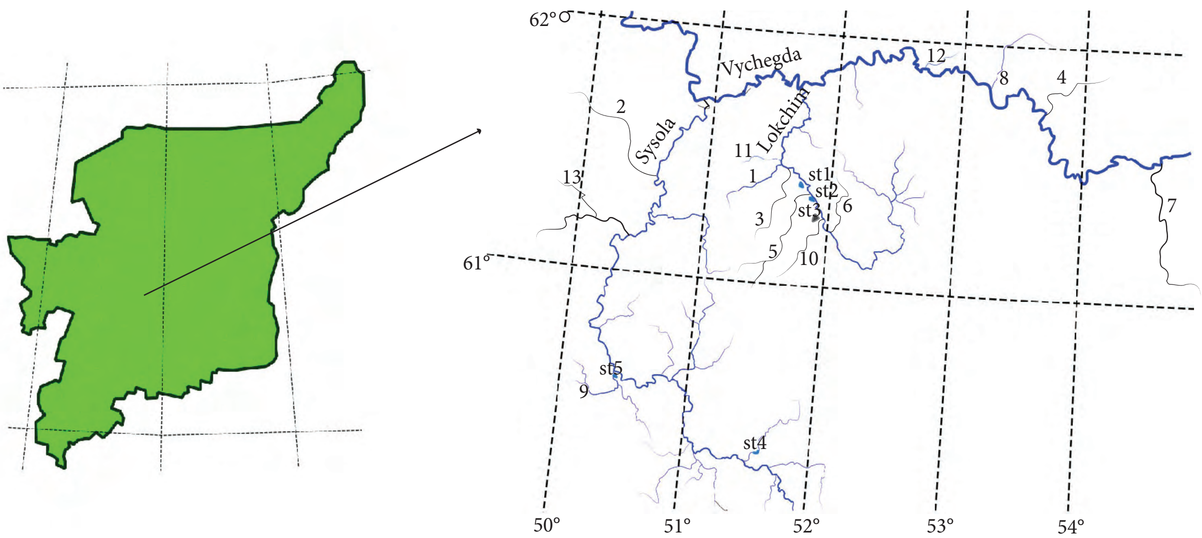


Figure 1. Map of the study region in the Komi Republic; 1-13 are small streams; st1-st5 are stagnant water bodies.

Table 1. Some major characteristics of the waters studied.

| No. | Name | Main river name | Date | Mean depth, m (min-max) | Substrate type | Flow velocity, m $s^{-1}$ | Mean t, °C (min-max) |
|---|---|---|---|---|---|---|---|
| 1 | Bol'shoi Pevk | Lokchim | July 2007 | 1.3 (0.5-2.0) | sand | 0.2 | 14.3 (14.0-14.4) |
| 2 | Vazel'u | Sysola | July 2005, May-Aug 2006 | 0.4 (0.15-1.5) | sand, pebbles, gravel, silt | 0.15 | 19.0 (14.0-23.0) |
| 3 | El' | Lokchim | July 2007 | 0.7 (0.3-0.8) | gravel | 0.01 | 14.7 (14.5-14.8) |
| 4 | Kuzob'u | Vychegda | July 2007 | 1.5 (1.0-1.6) | sand | 0.2 | 13.3 (13.2-13.4) |
| 5 | Lek-shor | Lokchim | July 2007 | 0.23 (0.2-0.3) | sand | 0.2 | 11.2 (11.0-11.3) |
| 6 | Mor | Lokchim | July 2007 | 0.45 (0.2-0.7) | gravel, sand | 0.1 | 10.7 (10.6-10.8) |
| 7 | Nem | Vychegda | July 2007 | 2.0 (1.0-2.2) | sand | 0.2 | 16.3 (16.0-16.4) |
| 8 | Novik | Vychegda | July 2007 | 1.3 (1.0-1.5) | gravel, sand | 0.05 | 14.0 (13.9-14.1) |
| 9 | Tib'u | Sysola | July 2008 | 0.46 (0.3-0.8) | gravel, sand | 0.2 | 14.4 (14.0-15.2) |
| 10 | Sed-el | Lokchim | July 2007 | 0.5 (0.3-0.7) | sand, pebbles | 0.15 | 10.4 (10.3-10.5) |
| 11 | Sobinka | Lokchim | July 2007 | 0.6 (0.3-0.8) | silt, gravel | 0.1 | 15.9 (15.8-16.1) |
| 12 | Chortas | Vychegda | July 2007 | 0.5 (0.3-0.6) | gravel | 0.3 | 13.9 (13.8-14.1) |
| 13 | U-il | Sysola | July 2006 | 0.3 (0.2-0.4) | sand, gravel | 0.1 | 15.0 (14.8-15.1) |
| | Sysola | Vychegda | July 2008 | 0.6 (0.15-1.6) | sand, gravel | 0.1 | 17.3 (16.0-19.0) |
| | Lokchim | Vychegda | July 2007 | 1.4 (0.3-2.5) | sand, gravel, silt, clay | 0.25 | 14.9 (13.7-18.9) |
| st* 1 | Floodplain water 1 | Lokchim | July 2007 | 2.5 (0.4-2.6) | sand, silt | - | 16.9 (16.8-17.1) |
| st 2 | Shallow lake | Lokchim | July 2007 | 0.3 (0.1-0.4) | silt | - | 18.0 |
| st 3 | Floodplain water 2 | Lokchim | July 2007 | 0.7 (0.3-0.8) | sand, silt | - | 15.1 |
| st 4 | Kazim Reservoir (2 m from shore) | Sysola | July 2008 | 1.1 (0.1-2.5) | sand, silt | - | 17.0 (16.9-17.0) |
| st 5 | Tub'u Reservoir (2 m from shore) | Sysola | July 2008 | 0.7 (0.5-0.9) | sand, silt, clay | slow | 18.0 (17.8-18.1) |

st: stagnant water body.

and humus content in the bottom sediments were analyzed at several sites. Species composition, abundance, and biomass of oligochaetes were determined for each sample. Average abundance and Oligochaeta biomass were calculated for identified and unidentified immature individuals.

The oligochaete diversity per site in the small streams was calculated according to the Shannon index (H), Sørensen's similarity coefficient, and the Simpson dominance index (D). Species dominance was characterized using the Kownacki index (d) (Kownacka, 1971). All indexes were calculated for only identified individuals; unidentified individuals were excluded.

The similarity of the oligochaete assemblages was analyzed with cluster analysis based on Euclidean distance using Statistics 6.0 for Windows.

## Results

The frequency of occurrence of Oligochaeta in the zoobenthos samples from the small rivers was 90%, with an average abundance of 2467 ± 786 ind $m^{-2}$ (29% of total benthos) and an average biomass of 1 ± 0.1 g $m^{-2}$ (18% of total benthos). The total abundance of oligochaetes from small streams was higher than that from middle-sized rivers (225 ± 82 ind $m^{-2}$) as well as that from stagnant water bodies (1683 ± 712 ind $m^{-2}$). Oligochaete biomass was highest in the stagnant water bodies (1 ± 0.4 g $m^{-2}$), although only the average biomass in small streams was significantly higher in comparison to middle-sized rivers (0.1 ± 0.003 g $m^{-2}$).

All in all, 48 taxa belonging to 7 families, including 36 known nominal species and 12 forms not identified to the species level, were collected in this study. A total of 27 species and 11 forms not identified to the species level were identified in the small streams (Table 2), and 19 of the above species were found only in other water bodies. The species number was higher in small streams than in middle-sized rivers (27 and 14 species, respectively). Naididae was most dominant, with, on average, 13, 9, and 10 species in small streams, middle-sized rivers, and stagnant water bodies, respectively. Tubificidae was represented by a total of 10 species in all 3 types of water bodies. *Nais pseudobtusa* Piguet, 1906; *Uncinais uncinata* (Ørsted, 1842); *Limnodrilus hoffmeisteri* Claparède, 1862; *Tubifex tubifex* (Müller, 1774); and *Lumbriculus variegatus* (Müller, 1774) were collected most frequently. These species were also most dominant in some small streams (Table 2).

The Tubificidae were most dominant by count in the small upper courses, making up 90% of the total abundance of Oligochaeta. In comparison, the middle streams, Sysola and Lokchim, were inhabited by Tubificidae (54% of total abundance), Naididae (19%), and Propappidae (20%). The stagnant water bodies were inhabited by Tubificidae (75% of total abundance) and Naididae (24%) as the dominant groups.

The substratum at the study sites consisted of either hard sediments like stones, pebbles, and gravel, or soft substrates like sand and silt. Oligochaetes from both substrate types were similar in number (2578 ± 1526 ind $m^{-2}$ and 2508 ± 928 ind $m^{-2}$), but differed in terms of biomass, which was, on average, 1 ± 0.2 g $m^{-2}$ on soft substrates and 0.2 ± 0.1 g $m^{-2}$ on hard substrates. Hard substrates were inhabited by Tubificidae (approximately 48% of total abundance) and Naididae (approximately 30%). The dominant (by numerical criteria) species were *Nais pseudobtusa*; *N. behningi* Michaelsen, 1923; and representatives of the family Tubificidae that were not determined to the species level due to their juvenile life stage. On soft substrates, most oligochaetes (87%) belonged to the family Tubificidae (*Tubifex tubifex* and *Limnodrilus hoffmeisteri*). Similarities between the oligochaete fauna of the 2 substrate types were low (35%).

The Shannon biodiversity index (SBI) was calculated only for the small streams studied (Figure 2). The highest oligochaete SBI (H = 2.3) was found in river 6, a small stream with a stony bottom (gravel and pebbles). The lowest SBI (H = 0.1) was found in streams 4 and 10, both with a sandy bottom. The Simpson dominance index was highest in water bodies with the lowest SBI. These water bodies hosted only 1-2 species or only 1 very dominant species together with several other less common species. The rivers with average Shannon and Simpson scores (for example, rivers 2, 3, 5, and 9) had a uniform species distribution without a clearly dominant species, and thus had an equal share of every species in the community composition.

Table 2. List of Oligochaeta collected in the water bodies studied. Kownacki index (d) (min-max)/*frequency of species in the zoobenthos samples (only for small streams)* are presented. (*: Present in the qualitative samples)

| | Small streams | Mid-sized rivers | Stagnant water bodies |
|---|---|---|---|
| **Naididae** | | | |
| *Arcteonais lomondi* (Martin, 1907) | | 1.1 | |
| *Chaetogaster diaphanus* (Gruithuisen, 1828) | 0.004-0.4 /*3.8* | | 3.1-12 |
| *Chaetogaster diastrophus* (Gruithuisen, 1828) | 0.002-8.8/*5.8* | | |
| *Haemonais waldvogeli* Bretscher, 1900 | | | 1.6 |
| *Nais alpina* Sperber, 1948 | 0.09/*1.9* | | |
| *Nais barbata* Müller, 1774 | 8.3/*1.9* | | |
| *Nais behningi* Michaelsen, 1923 | 0.02-6.7/*3.8* | | |
| *Nais communis* Piguet, 1906 | 0.01-10.3/*3.8* | | 4.1 |
| *Nais elinguis* Müller, 1774 | 0.4/*1.9* | 0.09 | 2.1 |
| *Nais pseudobtusa* Piguet, 1906 | 0.03-89.3/*19.2* | * | 3.0-7.0 |
| *Nais variabilis* Piguet, 1906 | | | 6.3 |
| *Paranais litoralis* (Müller, 1784) | | 0.05 | |
| *Piguetiella blanci* (Piguet, 1906) | 0.12-5.0/*5.8* | 0.9-100 | |
| *Ripistes parasita* (Schmidt, 1847) | | 0.42 | * |
| *Slavina appendiculata* (Udekem, 1855) | 0.07-6.7/*7.8* | | 2.0-9.5 |
| *Specaria josinae* (Vejdovský, 1884) | 0.2-8.3/*5.8* | 11.1 | |
| *Stylaria lacustris* (Linnaeus, 1767) | | * | * |
| *Uncinais uncinata* (Ørsted, 1842) | 0.02-50/*17.3* | 0.09 | |
| *Vejdovskyella comata* (Vejdovský, 1884) | 0.05/*1.9* | | 18.5 |
| **Pristinidae** | | | |
| *Pristina aequiseta* Bourne, 1891 | 0.004-0.5/*5.8* | | |
| *Pristina* sp. | * | * | |
| *Pristina* sp. [? *P. rosea* (Piguet, 1906)] | * | | |
| **Tubificidae** | | | |
| *Aulodrilus pluriseta* (Piguet, 1906) | * | | 1.6 |
| *Isochaetides michaelseni* (Lastočkin, 1936) | 0.1-100/*3.8* | 0.1 | 23.6 |
| *Limnodrilus* sp. juv. | | | |
| *Limnodrilus claparedeanus* Ratzel, 1868 | | 0.04 | |
| *Limnodrilus hoffmeisteri* Claparède, 1862 | 2.5-4.0/*11.5* | 0.5-8.4 | 20.8-93.7 |
| *Limnodrilus udekemianus* Claparède, 1862 | 0.08/*3.8* | 0.2 | |
| *Potamothrix hammoniensis* (Michaelsen, 1901) | 1.6/*1.9* | | |
| *Spirosperma ferox* Eisen, 1879 | 0.3-15.0/*7.8* | | |
| Tubificidae gen. sp. juv. without hair chaetae | * | * | * |
| Tubificidae gen. sp. juv. with hair chaetae | * | * | * |
| ? *Aulodrilus limnobius* Bretscher, 1899 | | * | |
| *Tubifex newaensis* (Michaelsen, 1903) | | | 5.1 |
| *Tubifex ignotus* (Štolc, 1886) | 0.06/*7.8* | | |
| *Tubifex tubifex* (Müller, 1774) | 8.8-80/*34.6* | | 4.1-33.3 |
| **Propappidae** | | | |
| *Propappus volki* Michaelsen, 1916 | 16.8/*1.9* | 14.0 | |
| **Enchytraeidae** | | | |
| *Enchytraeidae* gen. sp. | * | * | * |
| *Fridericia* sp. | * | | |
| *Cernosvitoviella* sp. | * | | |
| *Cognettia* sp. | * | | |
| *Cognettia glandulosa* (Michaelsen, 1888) | 5.9-50/*9.6* | | |
| *Cognettia sphagnetorum* (Vejdovský, 1878) | 0.05/*1.9* | | |
| **Lumbriculidae** | | | |
| *Lumbriculus variegatus* (Müller, 1774) | 0.04-100/*13.5* | | 1.5-8.7 |
| ? *Stylodrilus heringianus* Claparède, 1862 | * | | |
| Lumbriculidae gen. sp. juv. | * | | |
| *Stylodrilus heringianus* Claparède, 1862 | 0.3-3.3/*7.8* | | |
| **Lumbricidae** | | | |
| *Eiseniella tetraedra* (Savigny, 1826) | 0.002-5.0/*1.9* | | |
| Total number of species and forms | 38 | 19 | 19 |

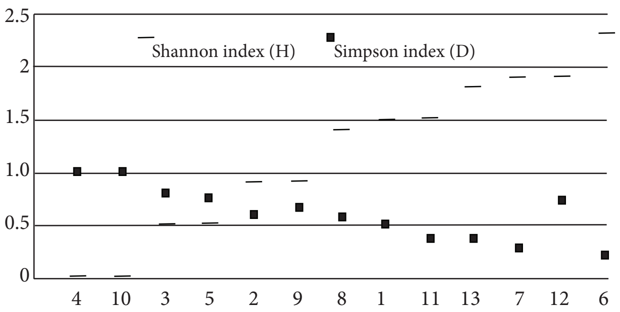


Figure 2. The scores of both the Shannon index and the Simpson dominance index for 13 small streams in the Vychegda River basin.

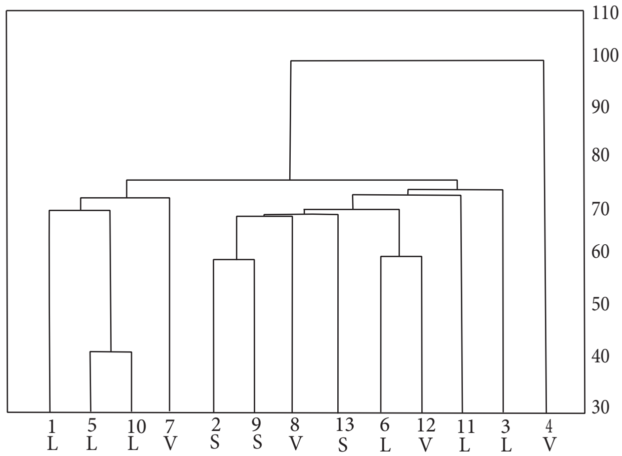


Figure 3. Tree diagram based on single linkage and Euclidean distance for the 13 small tributaries. L = Lokchim River tributaries, S = Sysola River tributaries, V = Vychegda River tributaries.

The Sørensen index of similarity varied from 0 to 0.67 in the streams studied (Table 3). Rivers 10 and 5 had the highest similarity coefficient (0.67). Several other rivers had no similarity (Sørensen index of similarity = 0). The streams were combined into several clusters by index values (Figure 3). One cluster (streams 1, 5, 7, and 10) was grouped according to a few Tubificidae and Enchytraeidae species. Naididae were found sparsely in this cluster. These streams were characterized by very low or average SBI values (from 0 to 1.9). A second cluster unified all other small streams belonging to the different river basins. The number of Oligochaeta species was higher in this cluster (from 8 to 12 species of Tubificidae, Naididae, Enchytraeidae, and Lumbriculidae). These streams were characterized by average or high SBI values (up to 2.3). The third cluster isolated stream 4, because only *Isochaetides michaelseni* was found in this stream.

Table 3. Sørensen's similarity coefficient (small streams only).

| No. of small streams | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.18 | 0 | 0 | 0.44 | 0.27 | 0.36 | 0.13 | 0.29 | 0.25 | 0.2 | 0.27 | 0.31 |
| 2 | | 1 | 0.15 | 0 | 0.15 | 0.18 | 0.14 | 0.24 | 0.39 | 0.08 | 0 | 0.36 | 0.19 |
| 3 | | | 1 | 0 | 0 | 0 | 0 | 0.2 | 0.09 | 0 | 0 | 0.4 | 0.25 |
| 4 | | | | 1 | 0 | 0 | 0 | 0 | 0.09 | 0 | 0 | 0 | 0 |
| 5 | | | | | 1 | 0.2 | 0 | 0.2 | 0.17 | **0.67** | 0 | 0.2 | 0 |
| 6 | | | | | | 1 | 0.33 | 0 | 0.28 | 0.22 | 0.36 | 0.5 | 0 |
| 7 | | | | | | | 1 | 0 | 0.16 | 0 | 0 | 0.16 | 0.2 |
| 8 | | | | | | | | 1 | 0.34 | 0 | 0 | 0.13 | 0.33 |
| 9 | | | | | | | | | 1 | 0.09 | 0.008 | 0.21 | 0.22 |
| 10 | | | | | | | | | | 1 | 0 | 0 | 0.22 |
| 11 | | | | | | | | | | | 1 | 0.22 | 0 |
| 12 | | | | | | | | | | | | 1 | 0.14 |
| 13 | | | | | | | | | | | | | 1 |

The study showed that the diversity and abundance of single Oligochaeta species depend on different environmental factors. The correlation analyses showed a significant, positive correlation between the total number of Oligochaeta in the small streams and the bottom texture and the nitrogen, carbon, and humus contents (Table 4). The total Oligochaeta biomass in these streams showed a positive correlation with the depth of the water. Correlation between the average Oligochaeta biomass and water temperature was significant, but this correlation is not conclusive, as additional research on the seasonal dynamics of Oligochaeta development in small streams was not performed. A positive correlation with bottom texture was noted for *Tubifex tubifex*, *T. ignotus* (Štolc, 1886), *Nais pseudobtusa*, *Chaetogaster diastrophus* (Gruithuisen, 1828), and *Stylaria lacustris* (Linnaeus, 1767). Other species (*C. diaphanus* (Gruithuisen, 1828) and *Uncinais uncinata*) were positively correlated with flow velocity. The species *Arcteonais lomondi* (Martin, 1907); *Spirosperma ferox* Eisen, 1879; *Nais pseudobtusa*; *N. behningi*; *N. alpina* Sperber, 1948; and *Stylodrilus heringianus* were positively correlated with algal cover.

The correlation and regression analyses between the total number of oligochaetes and abundance of single species in the studied small streams, and the chemical water composition (about 20 characteristics), showed that the abundance of oligochaetes strongly correlated with Na and Mg content (Table 5). Regression analysis

Table 4. Correlation coefficients between environmental factors and oligochaete abundances. Only significant ($P < 0.05$, $n = 65$) values are shown.

| | Current velocity | Main bottom textures | Amount of elements in sediment | Total bottom texture | Silt | Algae | Mosses | Water depth | Carbon (%) | Nitrogen (%) | Humus (%) | Temperature (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oligochaeta abundance | | 0.45 | 0.29 | | | | | | 0.85 | 0.85 | 0.84 | |
| Oligochaeta biomass | | | | | | | | 0.84 | | | | –0.70 |
| *Potamothrix hammoniensis* | | | | | 0.26 | | | 0.50 | | | | |
| *Spirosperma ferox* | | | | | | 0.31 | 0.69 | | | | | |
| *Tubifex tubifex* | | | 0.53 | 0.35 | | | | | | | | |
| *Tubifex ignotus* | | | 0.27 | | | | | | | | | |
| *Cognettia glandulosa* | | | | | | | | 0.30 | | | | |
| *Arcteonais lomondi* | | | | | | | 0.26 | | | | | |
| *Chaetogaster diastrophus* | | | 0.31 | 0.30 | | | | | | | | |
| *Chaetogaster diaphanus* | 0.55 | | | | | | | | | | | |
| *Nais pseudobtusa* | | 0.53 | | | | 0.40 | | | | | | |
| *Nais behningi* | | | | | | 0.69 | | | | | | |
| *Nais alpina* | | | | | | 0.39 | 0.43 | | | | | |
| *Pristina aequiseta* | | | | | | 0.25 | | | | | | |
| *Ripistes parasita* | | | | | 0.29 | | | | | | | |
| *Specaria josinae* | | | | | | | | 0.46 | | | | |
| *Stylaria lacustris* | | | | 0.29 | | | | | | | | |
| *Uncinais uncinata* | 0.26 | | | | | | | | | | | |
| *Stylodrilus heringianus* | | | | | | 0.69 | | | | | | |

Table 5. The relationship based on stepwise regression of the total abundance (ind $m^{-2}$) of oligochaetes and of *Tubifex tubifex* with chemical parameters.

| Group (dependent values) | Factor (independent values) | Step | Multiple | $R^2$ (%) | F | P |
|---|---|---|---|---|---|---|
| Oligochaeta, ind $m^{-2}$ | $Na^{+}$, mg/dm$^3$ | 1 | 0.6 | **42** | 14.3 | 0.001 |
| | $Mg^{2+}$, µg/dm$^3$ | 2 | 0.8 | **25** | 14.4 | 0.001 |
| | $Ca^{2+}$, mg/dm$^3$ | 4 | 0.9 | **14** | 15.1 | 0.001 |
| | Cr, µg/dm$^3$ | 3 | 0.8 | 4 | 2.5 | 0.129 |
| | $Fe^{2-}$, mg/dm$^3$ | 5 | 1.0 | 8 | 17.6 | 0.001 |
| | $NO_3$, mg/dm$^3$ | 6 | 1.0 | 3 | 7.9 | 0.013 |
| | $PO_4^{2-}$, mg/dm$^3$ | 7 | 1.0 | 1 | 4.6 | 0.049 |
| | $Mn^{+2}$, mg/dm$^3$ | 8 | 1.0 | 1 | 7.7 | 0.016 |
| | Nitrogen, % | 9 | 1.0 | 1 | 11.4 | 0.005 |
| | $Cu^{2-}$, mg/dm$^3$ | 10 | 1.0 | 0.4 | 5.2 | 0.043 |
| *Tubifex tubifex*, ind $m^{-2}$ | $Cl^{-}$, mg/dm$^3$ | 1 | 0.6 | **37** | 11.7 | 0.003 |
| | P, mg/dm$^3$ | 2 | 0.8 | **32** | 19.1 | 0.0003 |
| | Cr, µg/dm$^3$ | 3 | 0.9 | 6 | 4.5 | 0.05 |
| | $Mn^{+2}$, µg/dm$^3$ | 4 | 0.9 | 5 | 4.4 | 0.05 |
| | $SO_4^{2-}$, mg/dm$^3$ | 5 | 0.9 | 5 | 5.8 | 0.03 |
| | $PO_4^{2-}$, mg/dm$^3$ | 6 | 1.0 | 6 | 11.9 | 0.004 |
| | $K^{+}$, mg/dm$^3$ | 7 | 1.0 | 2 | 4.2 | 0.06 |
| | oil products, mg/dm$^3$ | 8 | 1.0 | 1 | 2.0 | 0.2 |
| | Zn, µg/dm$^3$ | 9 | 1.0 | 2 | 4.6 | 0.05 |
| | Cu, µg/dm$^3$ | 10 | 1.0 | 1 | 1.7 | 0.2 |

showed that the abundance of the dominant species *Tubifex tubifex* was related to chloride, calcium, and phosphorus concentrations. Only small streams were used for analysis.

## Discussion

The oligochaete fauna of the small streams in the middle taiga zone is similar to the common oligochaete fauna in fresh waters all over northeasten European Russia (e.g., Popchenko, 1988; Baturina, 2007). The high diversity of Naididae in small streams is explained by the presence of moss and algae on the hard substrates. In the current study, the correlations between some species of Naididae and moss or algal cover were significant. The dominance of the algae-eating Naididae in streams with moss or algae was also shown by Dumnicka (1994). The majority of Naididae belong to the phytophages with a broad feeding spectrum (e.g., Smith and Kaster, 1986; Monakov, 1998). The positive correlation between *Stylodrilus heringianus* and the presence of algae was unexpected. This species has been described as a strictly aquatic detritophagous species by many authors (Monakov, 1998; Dumnicka, 2000; Schenková and Kroča, 2007). Furthermore, the studied stream bottoms, along with being covered by algae, are also coated by detritus, so we suggest that the appearance of *Stylodrilus heringianus* is connected with the detritus component. Tubificidae had a high abundance in studied small streams rich in degradable organic matter and detritus. Some species of the family Tubificidae showed a significant positive correlation with bottom texture. Many authors have described the relationship between the abundance of Tubificidae and soft substrates (e.g., Slepukhina, 1984; Schenková et al., 2001; Nijboer et al., 2004).

The nonsignificant differences in oligochaete species diversity, abundance, and biomass between soft and hard substrates were not reflected in the small tributaries in which both substrate types occurred. Therefore, substrate type was not the only explanatory environmental factor. Only a few species, mainly Tubificidae, had a positive correlation between abundance, substrate type, and grain size in the studied small streams.

Many authors have shown that water depth is one of the most important factors in the distribution of oligochaete species, especially in the largest lake ecosystems (e.g., Wiederholm, 1980; Martinez and Prat, 1984). However, our research showed 4 species that were positively correlated with water depth. Similar results have been published (Marchese, 1987; Popchenko, 1988) reporting species that preferred different depths of water. In the present study, the measured depths were similar, and we suggest that the mentioned correlation is also connected with other ecological factors, due to the very limited absolute depth of our study sites.

Water temperature is also a major factor for oligochaete species distribution and diversity (Nijboer et al., 2004). In the studied region, the difference in winter and summer water temperature is high. Nevertheless, the relationship between oligochaete diversity and temperature should be studied further. Here, only the total biomass of Oligochaeta showed a significant negative correlation with temperature. Only 2 species (*Nais behningi* and *Stylodrilus heringianus*) are known as stenothermic cold-water species (Popchenko, 1988). Their temperature tolerance is limited by an upper temperature of 12 °C.

The rivers and streams of the middle taiga have a hydrocarbonate-calcium water composition. Some species (for example, *Tubifex tubifex*) significantly change in abundance when $Na^{+}$, $Mg^{2+}$, $Ca^{2+}$, total phosphorus ($P^{tot}$), and $Cl^{-}$ concentrations change. Some authors have pointed out this relationship between species abundance and chemical water composition (Dumnicka and Pasternak, 1978; Martinez-Ansemil and Collado, 1996). The increase of the Na and Mg concentrations as well as chloride and phosphorus content usually indicates pollution. Water pollution is often further characterized by an accumulation of organic matter. The observed increases in oligochaete numbers seem to be related to organic matter accumulation. Increasing numbers of *Tubifex tubifex* were related to their high tolerance of chemical disturbances (Milbrink, 1983; Casellato and Caneva, 1994). Many authors (e.g., Slepukhina, 1984; Lauritsen et al., 1985; Monakov, 1998) have indicated that Tubificidae use organic material as food.

## Conclusion

The Oligochaeta fauna in the studied streams is characterized by high diversity. The highest diversity was found in small streams with stony bottoms covered by algae or mosses and with high flow velocity. The oligochaete diversity was lowest in streams with sandy bottoms, but the oligochaete abundance and biomass were quite similar in small rivers with different bottoms. Oligochaete diversity, differences in composition, and abundance were dependent on different environmental and ecological factors (i.e. bottom characteristics, flow velocity, algae or moss cover, and temperature), chemical water composition ($Na^{+}$, $Mg^{2+}$, $Ca^{2+}$, $Cl^{-}$, and total phosphorus ($P^{tot}$), among others), and nitrogen, carbon, and humus content in the bottom sediments. However, according to the data of Schenková and Helešic (2006), the numbers of oligochaete species showing wide ecological valences and habitat preferences are not significant when comparing relatively close sampling points in streams.

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