Structural parameters and infection rate of the genus Littorina (Mollusca: Gastropoda) of the western and eastern Murman coast

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Abstract. There is information obtained on species composition, parasitofauna, and structural characteristics of periwinkles in autumn period in three areas (Abram-Mys settlement, Mishukovo settlement, Retinskaya bay) of western Murman coast, and was made a comparison of data with periwinkles of Eastern Murman. The eastern Murman coast is characterized by 6 species of periwinkles, with 5 species noted on the western Murman coast in this study, because the molluscs Littorina compressa have not been found. The infection rate of males L. saxatilis and L. obtusata in senior size classes of East Murman exceeds the infection rate of females what leads to the difference in the sex structure ratio of molluscs. This fact is also characteristic for periwinkles of Western Murman. Periwinkles of Eastern Murman significantly exceed periwinkles of Western Murman in shell height, shell width, and densities. The difference in maximum age is a one year for L. saxatilis molluscs of Western and Eastern Murman; there is no difference for L. obtusata. Maximum age for L. littorea is 13+, for Eastern Murman is 28+. The dominance of trematodes with a life cycle without a free-standing larval stage and a second intermediate host is typical for periwinkles of Western and Eastern Murman.

1. Introduction
Gastropods of the genus Littorina are large, common species, and periwinkles often uses as model objects in various fields of research because they play an important role in the coastal community as intermediate hosts of various trematode species [1], [2], [3].

Molluscs of the genus Littorina have been constantly studied for more than 100 years on the eastern Murman coast [4], [5], [6], [7], while researches are less frequent and represents a set of incomplete data for different time periods in the area of Western Murman.

This work is devoted to the study of structural parameters and infection rate with larval stages of trematodes in periwinkles in the southern (Abram-Mys and Mishukovo settlement) and the middle (Retinskaya bay) bends of the fjord type Kola Bay of the Barents Sea.

The aim of the work is to study species composition, structural parameters, and parasitofauna of actic molluscs of the genus Littorina in the areas of Western Murman in autumn, and to compare obtained data with data of Eastern Murman periwinkles.

2. Material and methods
This study was carried out in the littoral zone of Kola Bay of the Barents Sea. Snails were collected in the autumn period (end of October) in 2018 in the areas of Abram-Mys, Mishukovo and Retinskaya bay (Figure 1).

![Map of the study area of Western Murman.](image)

Three samples were taken with using a 50 x 50 cm frame from the high, middle, and low intertidal zones in Mishukovo settlement and Retinskaya bay. The area of 5x5 m was used for sampling in Abram-Mys.

The species and the age (number of annual growth rings on the shell, with accuracy to a one year) were determined for each mollusc in the laboratory. Subsequently, data on molluscs of the same age were combined. Gastropods with a damaged shell were assigned to the “X” group, that is, the age of which was not possible to count the number of annual growth rings.

Periwinkles were weighed and measured with a caliper for aperture width, shell height, and shell width. Sexually mature molluscs were dissected with pliers and the body was removed with preparation needles. Periwinkles were also examined for trematodes, and further after dissecting of molluscs, the species identity of the parasites was determined.

The sex was determined by the structural features of the reproductive system according to the monograph of Reed [8]. The structural features of the reproductive system of periwinkles were considered by means of binocular: in males – the features of the penis, in females – the features of the pallial oviduct.

3. Results

1668 molluscs were studied and 5 species of gastropods were identified during the work: *Littorina littorea*, *L. saxatilis*, *L. arcana*, *L. obtusata*, *L. fabalis* (Figure 2).

*L. compressa* was not found in any of the study areas. *L. arcana* was found in 2 specimens in the area of Abram-Mys settlement and Retinskaya bay; for *L. obtusata*, several individuals were found in the area of Abram-Mys and Mishukovo; for *L. fabalis* single individuals were also found in Retinskaya bay; subsequently, these species of periwinkles were not included in further analysis.
Figure 2. Percentage of the species composition of periwinkles in the study areas.

The sex ratio for males and females is about 1:1 of *L. saxatilis* molluscs in the littoral zone of Abram-Mys.

The sex ratio of males and females is 1:3 approximately for the remaining study areas (Figure 3).

Figure 3. Sex ratio of periwinkles in the study areas.

In examining the density and the biomass the genus *Littorina*, it was revealed that *L. saxatilis* gastropods have the lowest rates in the area of Abram-Mys: 4 specimens per square meter and 0.8 grams per square meter.

The density of *L. saxatilis* molluscs was: 516 ± 241 sp./m² with the biomass: 38.2 ± 0.3 g/m² in the area of Mishukovo settlement.

The study of periwinkles abundance (density and biomass) in Retinskaya Bay revealed (Figure 4):

- Means of the density and the biomass for *L. saxatilis* molluscs are 30.6 sp. and g/m².
- For *L. obtusata* molluscs the biomass on average is 28 g/m² with the density of 120 ± 42 sp./m².
- *L. littorea* molluscs have the highest biomass: 123 ± 69 g/m² and at the same time the lowest density: 47 ± 5 sp./m².

Figure 4. Biomass and density of periwinkles in the study areas.

1 - the biomass and the density of *L. saxatilis* in the area of Abram-Mys, 2 – the biomass and the density of *L. saxatilis* in the area of Mishukovo, 3 – the biomass and the density of *L. littorea* in Retinskaya bay.

The error bars on the graph show the mean ± standard error of the mean.

Thus, the dominance of *L. saxatilis* molluscs by the density is typical for the area of Mishukovo, and, certainly, it is the biomass for *L. littorea*.

In this study of dimensional and weight parameters for the study areas, the following was found (Table 1):


- *L. saxatilis* molluscs have the greatest parameters in the area of Abram-Mys.
- *L. obtusata* molluscs in the area of Retinskaya bay are characterized by higher values compared to *L. saxatilis* molluscs.
- Size and weight parameters of *L. littorea* molluscs were calculated only for the lower intertidal zone of Retinskaya bay and, certainly, this species is characterized by the highest values.

Table 1. Dimensional and weight parameters of periwinkles in the study areas

| Study area       | Mean of periwinkle parameter ± standard error of the mean |
|------------------|-----------------------------------------------------------|
| Abram-Mys settlement | *L. saxatilis*                                          |
|                  | Shell height, mm, 9.07 ± 0.16                             |
|                  | Shell width (diameter), 8.17 ± 0.14                       |
|                  | Aperture width, mm, 5.99 ± 0.10                           |
|                  | Weight, g, 0.22 ± 0.01                                    |
| Mishukovo settlement | *L. saxatilis*                                         |
|                  | Shell height, mm, 6.90 ± 0.13                             |
|                  | Shell width (diameter), 6.07 ± 0.10                       |
|                  | Aperture width, mm, 4.58 ± 0.07                           |
|                  | Weight, g, 0.10 ± 0.01                                    |
| Retinskaya bay   | *L. saxatilis*                                           |
|                  | Shell height, mm, 7.29 ± 0.09                             |
|                  | Shell width (diameter), 6.31 ± 0.07                       |
|                  | Aperture width, mm, 4.60 ± 0.05                           |
|                  | Weight, g, 0.11 ± 0.001                                   |
|                  | *L. obtusata*                                             |
|                  | Shell height, mm, 9.59 ± 0.21                             |
|                  | Shell width (diameter), 8.96 ± 0.19                      |
|                  | Aperture width, mm, 6.53 ± 0.13                           |
|                  | Weight, g, 0.27 ± 0.01                                    |
|                  | *L. littorea*                                             |
|                  | Shell height, mm, 17.85 ± 0.49                            |
|                  | Shell width (diameter), 15.94 ± 0.46                      |
|                  | Aperture width, mm, 11.25 ± 0.32                          |
|                  | Weight, g, 1.53 ± 0.14                                    |

Note: *a* - mean of parameters for *L. littorea* in Retinskaya bay is calculated only for the low intertidal zone.

In terms of the age structure of periwinkles, it was revealed that presence of juveniles is typical for the molluscs *L. saxatilis* and *L. obtusata*.

The following features were noted for the age structure of *L. saxatilis* molluscs (Figure 5):
- Dominant age groups: 0+, 1+ years (juveniles and younger age groups) and older groups: 5+ and 6+ years in the area of Abram-Mys.
- Molluscs of age 1+ and 2+ are dominated in the area of Mishukovo, with the result that *L. saxatilis* possess the smallest dimensional, and weight parameters in this littoral zone.
- Juveniles and younger age groups are prevailed in Retinskaya bay.

![Figure 5. Age structure of *L. saxatilis* molluscs in the study areas](image-url)
The dominance of *L. obtusata* molluscs is typical for the older age groups: from 4+ to 7+ years (Figure 6).

![Figure 6. Age structure of L. obtusata molluscs in Retinskaya bay](image)

The older age group is dominated among *L. littorea* molluscs – from 5+ to 7+ years (Figure 7). Molluscs of the younger age groups were not found, due to the low density of this species and, accordingly, the insufficient number of samples.

![Figure 7. Age structure of L. littorea molluscs in Retinskaya bay](image)

The prevalence of the "X" group molluscs is typical for *L. saxatilis* and *L. obtusata* in Retinskaya bay, indicating a high degree of damage in this study area. Also it was revealed that dominant species of trematodes is *Microphallus pygmaeus* for *L. saxatilis* molluscs in the study areas, and for *L. obtusata* in Retinskaya bay (Figure 8, 9). The only one *L. obtusata* mollusc was infected by *M. pygmaeus* in the area of Mishukovo, and also, there was found only 10 molluscs; therefore they were not included in further analysis.

![Figure 8. Infection rate of L. saxatilis molluscs in the study areas](image)
In general, the feature of “pygmaeus” microphallides group is the absence of a free-living cercaria. The completion of the life cycle is associated with ingestion of infected molluscs by the final host (bird) and, as a rule, this group of trematodes occupies the dominant position of the most common trematodes in the genus Littorina in the Barents and also White Seas [9]. The dominance of Notocotylus sp. trematodes is typical for L. littorea molluscs; the trematodes M. pygmaeus are subdominant (Figure 10). The life cycle of these trematodes is simple and does not include a free-living cercaria.

4. Discussion
The presence of 6 species of periwinkles is typical for East Murman [10], while 5 species were found in our study on the coast of Western Murman, considering the absent L. compressa snails in the samples. According to data of 2014, L. compressa molluscs were found in the area of Teriberka village (East Murman). These periwinkles inhabit the macrophyte zone, as well as L. obtusata (Figure 11).

Perhaps, competitive relations are possible between these species, according to Granovitch A. I. et al. [10]. This fact is also evidenced by our data (Figure 12).
However, more researches of the species composition are needed to address the issue related to the lack of *L. compressa* molluscs in the areas of Western Murman.

It should be noted that the extensity of invasion (prevalence) of males *L. saxatilis* and *L. obtusata* in senior size classes of Eastern Murman significantly exceeds the infection rate of females [11]. This fact leads to a higher mortality rate of males, and therefore to the difference in the sex ratio of molluscs. This situation is typical for periwinkles of Western Murman in the area of Mishukovo settlement and Retinskaya Bay, where the ratio of males to females is 1:3. The infection rate is lower in the area of Abram-Mys, than in the remaining areas, and the sex ratio is approximately 1:1.

Densities and morphometric parameters are different for periwinkles of Eastern and Western Murman: molluscs of the east coast significantly exceed molluscs of the western coast in shell height, width (diameter), and population density [10]. This fact is probably due to the more favorable conditions for the growth and the reproduction of gastropods in the areas of Eastern Murman. Regarding the age structure of periwinkles, the following can be noted:

- The maximum age is 12+ for *L. saxatilis* molluscs in the southern and middle bends of western Murman coast. The maximum age of *L. saxatilis* is 11+, where the littoral is represented as rocky sprouts and silted-sandstone beaches based on landlocked sites of bays in the areas of Eastern Murman [12], as well as the littoral zone of the western Murman areas we explored.

- The maximum age is 7+ for *L. obtusata* molluscs, where the littoral zone is represented as stony sprouts based on landlocked sites of bays of Eastern Murman [11], the maximum age for this species is also 7+ in our study of the western Murman areas.

- It is known that the maximum age is 13+ for *L. littorea* molluscs of Western Murman, for Eastern Murman it is 28+ [12]. The maximum age for this species is also 13+ in our study areas of Western Murman.

Thus, there is a significant difference in a maximum age for *L. littorea* molluscs of Western and Eastern Murman; the difference in a maximum age is insignificant and it is 1 year for *L. saxatilis*; and there is no age difference for *L. obtusata*.

When the data for the fauna of trematodes and the infection rate were compared, the following features were found:

- The dominance of trematodes with a life cycle without a free-standing larval stage and a second intermediate host is typical for periwinkles of Western and Eastern Murman [13]. Trematodes with a life cycle with presence of a larval free-living stage are not found in our study. One of the reasons can be attributed to the fact that the study was conducted in autumn (October). V. V. Kuklin and M. M. Kuklina (2018) found that the larvae and parthenites of Echinostomatidae family completely disappear in autumn from parasitofauna of *Littorina saxatilis* gastropods in the area of Abram-Mys settlement. These authors attribute this circumstance to probability of birds flying away for wintering and, as a consequence, parasite eggs cease to dispersion in the external environment [14]. However, additional monitoring studies are needed to address this issue.

![Figure 12. Population density of *L. obtusata* and *L. compressa* molluscs in the area of Teriberka village](image-url)
The dominance of trematodes *Microphallus pygmaeus* is typical for *L. saxatilis* and *L. obtusata* molluscs of Western and Eastern Murman [13], as in our study. Trematodes with a dixenic life cycle are better adapted to intertidal conditions of sub-Arctic and Arctic seas comparing trematodes with a tricenx life cycle [9].

Summarizing our data, it should be noted that additional monitoring studies are needed in the field of parasitology, species composition, etc. during summer and autumn in the areas of Western Murman; considering these periwinkles are studied more thoroughly in the areas of Eastern Murman.

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