Conference Paper

Trematode Parthenitae Infection Rate and Distribution of Kola Bay Actic Molluscs of the Genus Littorina

Kseniia Kulesh, Petr Kravets, and Ivan Bacherikov

Department of Biology and Aquatic BioResources, Murmansk State Technical University, Murmansk, Russia

Abstract

The study was carried out in 2018 in the littoral zone of Kola Bay during the autumn period in the areas of Abram Mys Settlement, Mishukovo Settlement and Retinskaya Bay. Molluscs of the genus Littorina were collected from various substrates: stones, algae, metal construction and soil. In addition, samples were taken not from a particular substrate, but along the borders of the littoral zone to study species composition of molluscs and common level of infection rate in study areas. Our data showed that *L. saxatilis* infested by mature trematode parthenitae prefer being on the surface of algae, metal structure, stones at low tide instead of hiding under the stones, in the thickness of algae and in other possible shelters. The study of age distribution among infested Littorina molluscs living on different substrates showed that the ratio of age groups is different and varies from 1+ to 13+. Distribution data are established and considered for infested molluscs by trematode parthenitae of the group "pygmaeus": *Microphallus pygmaeus*, *M. piriformes*, which are characterized by the absence of free-living cercariae. Trematode parthenitae of other species which have a stage of free-living cercaria in their life cycle are absent in molluscs during the autumn period.

Keywords: periwinkle, distribution of periwinkles, molluscs of the genus Littorina, infection rate of periwinkles, Microphallidae

Corresponding Author:
Kseniia Kulesh
kmkulesh@gmail.com

Received: 24 December 2019
Accepted: 9 January 2020
Published: 15 January 2020

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the BRDEM-2019 Conference Committee.

1. Introduction

Parasites affect their host's mortality, fertility, growth, nutritional status, energy needs and population behavior [1, 2]. Thus the impact of parasites affects various spheres of the organism's vital activity.

Of the listed negative consequences, the behaviour of infected hosts is of particular interest, and gastropod molluscs of the genus Littorina are one of the convenient objects for studying this phenomenon. Periwinkles are widely distributed in the littoral zone and form clusters with high density and are readily available for research. The life cycles of various trematode species are carried out through the periwinkles as the first intermediate host [3, 4]. The final host in the life cycle is coastal birds or fish [5, 6].

The behaviour of infested hosts is one of peculiar interest among the other negative effects. One of the most convenient objects for studying this phenomenon is gastropod molluscs of the genus Littorina.

Distribution of the genus Littorina species through the intertidal zone has been successfully described by many authors. [7--9] However due to infestation of these molluscs, their distribution changes [10, 11]. This study considers the distribution features of infested periwinkles on different types of substrate and various age categories in Autumn in the littoral zone of Kola Bay.

2. Material and Methods

The study was carried out in the intertidal zone of Kola Bay (Barents Sea) in autumn period of 2018 in the areas of Abram Mys Settlement, Mishukovo Settlement and Retinskaya Bay. The map of study areas is shown in Figure 1.

Figure 1: Map of study areas.

Molluscs were collected by means of a frame 50x50 cm. in triple frequency from the top, average and lower horizons of intertidal zone from the surface of various substrates: stones, algae, metal (metal constructions in vertical position) and soil. This technique was also previously used by Galaktionov K.V., 1992 [12]. Samples were also additionally collected using the same method, but not from a specific substrate, but along the borders of the littoral zone to study species composition of molluscs and common level of infection rate in the study areas.

Molluscs were fixed in a 70% ethyl alcohol solution. During laboratory examination the age of one-year growth rings on the shell was previously set to 1 year accuracy. Then sexually mature periwinkles were dissected with pliers and the body was removed to determine species.

The species of molluscs was determined by the peculiarities of the sexual system structure according to the Reed monograph [9]. The body was also examined for trematode and in the event of infestation the species identity of parasites was determined.

3. Results and Discussion

The study identified 5 species of periwinkles: *Littorina littorea* (Linnaeus 1758), *L. saxatilis* (Olivi 1792), *L. arcana* (Hannaford Ellis 1978), *L. obtusata* (Linnaeus 1758), *L. fabalis* (W. Turton 1825). Among the molluscs of *L. arcana* and *L. fabalis*, single healthy individuals have been found and thus they are absent in further parasitological analysis.

While investigating molluscs for infestation with trematode parthenitae it should be noted that trematodes of the Microphallidae family of «pygmaeus» group have been detected for all studied areas, namely: mature parthenitae of *Microphallus pygmaeus* and *Microphallus piriformes*. Embryonal stages of these parthenitae are found in molluscs from areas of Abram Mys Settlement and Retinskaya Bay. Two molluscs *L. saxatilis* and one mollusc *L. littorea* are infested with *Notocotylus sp.* in Retinskaya Bay, but in further analysis these individuals will be absent due to insufficient quantity to study the distribution of infested molluscs.

Mollusks infection rate (extensity of invasion) in studied areas in Table 2 shows that extensity of invasion for molluscs *L. saxatilis* and *L. obtusata* increases from south to north and in Retinskaya Bay it reaches high values -- 72% and 60% respectively. Among molluscs L. littorea, infested individuals are found in Retinskaya Bay, where the extensity of invasion is low at 7%.

Such high values of extensity of invasion for molluscs *L. saxatilis* and *L. obtusata* in Retinskaya Bay are likely due to the fact that during this period of study (autumn) the level of infestation is inherent in a specific point of the littoral zone, despite annual fluctuations, where trematodes from the whole community interact actively and exclusively with its small part [13, 14].

Our data on extensity of invasion by mature and embryonal stages of trematode parthenitae show that infection rate of periwinkles with embryonal stages is significantly lower in comparison with that by mature stages of *Microphallus spp.* This is probably due to the fact that the peak of trematode infection rate in molluscs occurs during the spring-summer period. These studies are reflected in Tables 3, 4.

It should be noted that the present study was carried out in the autumn period and therefore trematodes of "pygmaeus" group are found in molluscs and characterized by

Table 1: The extensity of invasion (EI,%) and the number of dissected molluscs (DM, specimen) of the genus Littorina infested with trematode parthenitae of *Microphallus pygmaeus* and *Microphallus piriformes* in study areas.

Study area	The extensity of invasion and the number of dissected molluscs of the genus Littorina					
Abram Mys Settlement	*L. saxatilis*		*L. obtusata*		*L. littorea*	
	EI, %	DM, spc.	EI, %	DM, spc.	EI, %	DM, spc.
	10	373	0	16	0	4
Mishukovo Settlement	26	227	17	6	-	-
Retinskaya Bay	72	363	60	141	7	29

Note to the table: "-" - missing value.

Table 2: The extensity of invasion (EI,%) and the number of dissected molluscs (DM, specimen) of the genus Littorina infested with mature stages of trematode parthenitae of *Microphallus pygmaeus* and *Microphallus piriformes* on various substrates of the littoral zone within the study areas.

Study area	The extensity of invasion and the number of dissected molluscs of the genus Littorina					
Abram Mys Settlement	*Microphallus pygmaeus + M. piriformes* (mature stages)					
	L. saxatilis		*L. obtusata*		*L. littorea*	
	EI, %	DM, spc.	EI, %	DM, spc.		
Stone surface	14	221	-	-	-	
Mishukovo Settlement						
Algae surface	83	6	-	-	-	
Stone surface	47	111	*	1		
Retinskaya Bay						
Algae surface	74	255	60	140	20	10
Stone surface	63	8	-	-	-	-
Soil surface	75	35	*	1	-	-
Metal construction surface	61	64	-	-	-	-

Note to the table: * - calculating the extensity of invasion is impossible due to having only 1 animal in this group (EI = 100%).

Table 3: The extensity of invasion (EI,%) and the number of dissected molluscs (DM, specimen) of the genus Littorina infested with embryonal stages of trematode parthenitae of *Microphallus sp.* on various substrates of the littoral zone in study areas.

Study area	The extensity of invasion and the number of dissected molluscs of the genus Littorina	
Abram Mys Settlement	*Microphallus sp.* (embryonal stages)	
	L. saxatilis	
	EI, %	DM, spc.
Stone surface	5	152
Retinskaya Bay		
Metal construction surface	13	46

the absence of free-living cercaria and characterized by life cycle, where the final stage is eating infested mollusc by the final host -- birds [15].

Trematode parthenitae of other species, which have a stage of free-living cercaria in their life cycle are absent in molluscs of the genus Littorina during the autumn period, which is probably due to the migration of birds carrying such species of trematodes during this period.

The dominance of the "pygmaeus" group over trematode parthenitae with a free-living stage is generally characteristic of the Barents Sea region as this group is better adapted to constantly changing northern environmental conditions [16].

With reference to distribution of periwinkles infested with mature stages of *Microphallus spp.* on different substrates, Table 3 shows a curious picture:

1. In the areas of Abram Mys and Mishukovo a significant part of molluscs *L. saxatilis* is concentrated on the stone surfaces, periwinkles were not found on the algae surface in the area of Abram Mys Settlement. In Mishukovo Settlement only 6 molluscs were found, of which 5 were infested (EI - 83%). *L. obtusata* found in Mishukovo Settlement -- a single infested specimen, infested molluscs *L. littorea* are not found in Abram Mys Settlement and no common periwinkles *L. littorea* were found in Mishukovo Settlement.

2. The greatest extensity of invasion depending on substrate is observed for molluscs *L. saxatilis* in Retinskaya Bay from the algae, metal construction, stone and soil surfaces. Compared to other surfaces a relatively small number of *L. obtusata* had been found on the surface of algae and characterized by high infection rate -- 60%, there is 1 infected mollusc on the soil surface, on the surface of metal and stones this species was absent. Molluscs *L. littorea* were observed only on the surface of algae in amount of 10 specimen with EI -- 10%.

Normally, during low tide, periwinkles take refuge from a negative factors of the littoral zone --drying and overheating -- by placing themselves in the thickness of algae, where relatively constant temperature and humidity are maintained. This ability is suppressed in infested molluscs and for the period of drying, they remain where they were found by the high tide [17]. This is clearly observed in Retinskaya Bay, where most of infested molluscs from the community at low tide were found on the algae and metal construction surfaces.

The analysis of the age structure of infested molluscs of the genus Littorina in autumn period showed that:

1. Infection rate with embryonal stages of *Microphallus sp.* is low in comparison with infection rate with mature trematode parthenitae and is typical for molluscs *L. saxatilis*

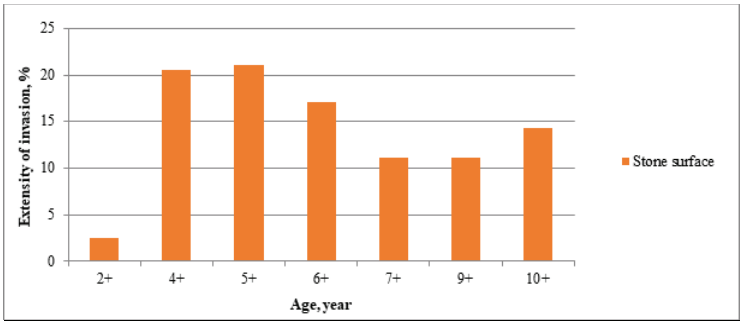
of older age categories: from 3+ to 12+ found on the surface of stones in the area of Abram Mys and on the metal surface in Retinskaya Bay. No pronounced features of distribution of molluscs infested with embryonic stages have been established.

2. As shown in Figures 2-4 for the area of Abram Mys and Retinskaya Bay, infection rate with mature trematode parthenitae of molluscs *L. saxatilis* found on the surface of stones is lower (taking into account the number of dissected molluscs) than in Mishukovo. Infection rate is typical for molluscs of different ages in studied areas: from 1+ to 11+ for *L. saxatilis* and from 2+ to 13+ for *L. obtusata*. Infested molluscs *L. littorea* are found with the age of 7+ and 9+.

3. In general, coming from Figures 4-6 the highest rates of infection with mature trematode parthenitae (taking into account the number of dissected molluscs) are observed for the younger and older age groups of *L. saxatilis* on the algae and metal construction surfaces in Retinskaya Bay. Periwinkles *L. obtusata* and *L. littorea* are found on the surface of algae in Retinskaya Bay. The first of them are characterized by a high infection rate of age 7+ and 8+, 85% and 83% respectively for the second EI, taking into account that the number of dissected molluscs is low.

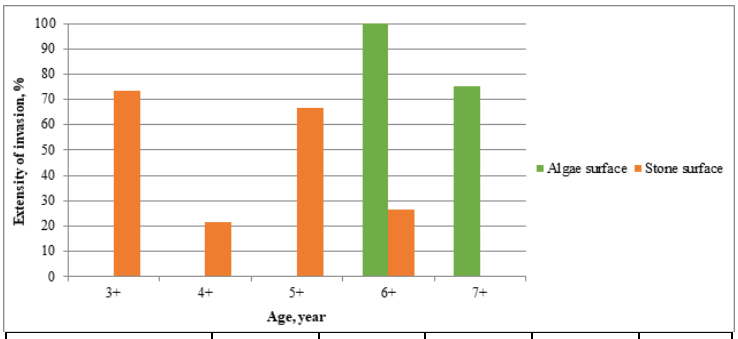
Molluscs which are found in a single specimen per age group on a certain substrate and being infested in a single specimen are not presented as graphic data and are not reflected in Figures 2-6.

Most likely the peak of infection rate with trematode parthenitae occurs during the spring-summer period as mentioned earlier and as a result the level of infection rate with *Microphallus sp.* of embryonal stages is low and infection rate with mature parthenitae is typical for both younger and older age groups of molluscs.



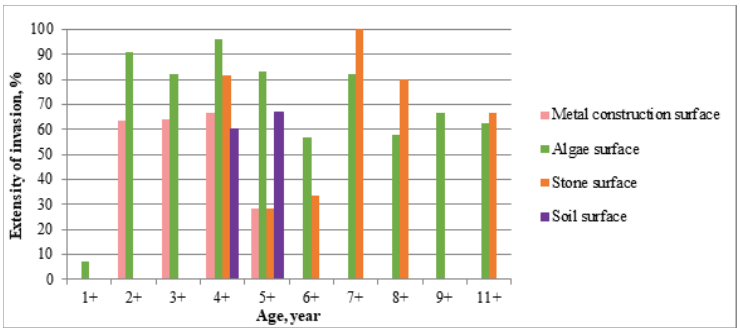
Age, year	2+	4+	5+	6+	7+	9+	10+
Stone surface	41	34	38	47	36	18	7

Figure 2: Age structure of molluscs *L. saxatilis* infested with mature trematode parthenitae *Microphallus pygmaeus* and *Microphallus piriformes* on various substrates in Abram Mys Settlement.
Note: This figure and the subsequent table show the number of dissected molluscs (in specimen) with corresponding age and on corresponding substrate.



Age, year	3+	4+	5+	6+	7+
Algae surface	-	-	-	2	4
Stone surface	34	23	24	30	-

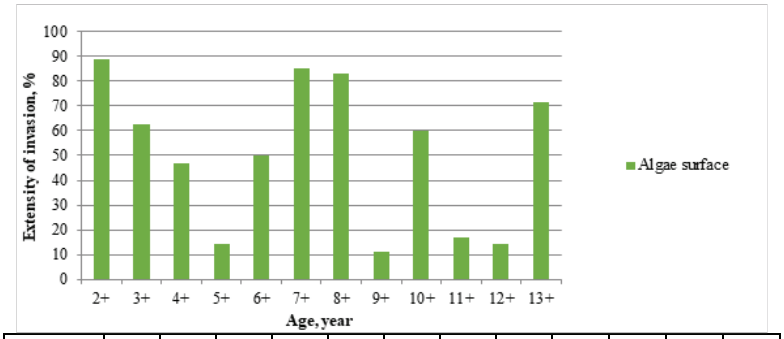
Figure 3: Age structure of molluscs *L. saxatilis* infested with mature trematode parthenitae *Microphallus pygmaeus* and *Microphallus piriformes* on various substrates in Mishukovo Settlement.



Metal construction surface => Suraface of metal structures

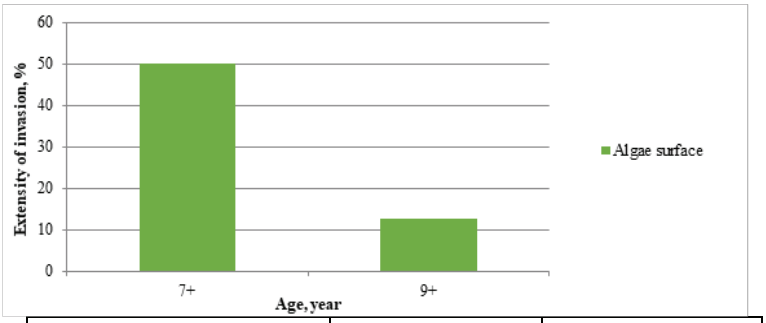
Age, year	1+	2+	3+	4+	5+	6+	7+	8+	9+	11+
Metal construction surface	-	11	25	21	7	-	-	-	-	-
Algae surface	43	33	73	24	6	23	17	19	9	8
Stone surface	-	-	-	11	7	3	3	5	-	6
Soil surface	-	-	-	5	3	-	-	-	-	-

Figure 4: Age structure of molluscs *L. saxatilis* infested with mature trematode parthenitae *Microphallus pygmaeus* and *Microphallus piriformes* on various substrates in Retinskaya Bay.



Age, year	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+
Algae surface	9	8	17	7	10	20	35	9	5	6	7	7

Figure 5: Age structure of molluscs *L. obtusata* infested with mature trematode parthenitae *Microphallus pygmaeus* and *Microphallus piriformes* on various substrates in Retinskaya Bay.



Age, year	7+	9+
Algae surface	2	8

Figure 6: Age structure of molluscs *L. littorea* infested with mature trematode parthenitae *Microphallus pygmaeus* and *Microphallus piriformes* on various substrates in Retinskaya Bay.

4. Conclusion

Our data about the distribution of molluscs of the genus Littorina infested with mature trematode parthenitae on various substrates in the littoral zone represent an analysis of the consequence of behavioural disturbances. Indeed, present study shows that those infested *L. saxatilis* (the number of which was higher than other periwinkles) with mature parthenitae *Microphallus spp.* prefer being on algae, metal constructions and stone surfaces instead of hiding under the stones, in the thickness of algae and in other possible shelters at low tide. The former behavioural patterns, therefore, can show the presence of violations associated with motor ability and activity.

Conflict of Interest

The authors have no conflict of interest to declare.

References

[1] Fredensborg, B. L., Poulin, R. (2005). Larval helminths in intermediate hosts: Does competition early in life determine the fitness of adult parasites? *International Journal for Parasitology*, vol. 35 (10), pp. 1061-1070.

[2] Blakeslee, A. M., Keogh, C. L., Fowler, A. E., et al (2015). Assessing the Effects of Trematode Infection on Invasive Green Crabs in Eastern North America. *Plos One*, vol. 10 (6), pp. 1-20.

[3] Matthews, P. M., Montgomery, W. I., Hanna, R. E. B. (1985). Infestation of littorinids by larval digenea around a small fishing port. *Parasitology*, vol. 90, pp. 277-287.

[4] Galaktionov, K. V., Nikolaev, K. E., Aristov, D. A., et al. (2018). Parasites on the edge: patterns of trematode transmission in the Arctic intertidal at the Pechora Sea (South-Eastern Barents Sea). *Polar Biology*, vol. 42 (9), pp. 1719--1737.

[5] Galaktionov, K. V., Bustnes, J. O. (1995). Species composition and prevalence of seabird trematode larvae in periwinkles at two littoral zone sites in North-Norway. *Sarsia*, vol. 80, pp. 187-191.

[6] Buchmann, K. (2019). *Metazoan endoparasites as biological indicators of Baltic cod biology.* In Baltic Sea in the 21st century - contemporary hazards and challenges. London: InTechOpen.

[7] Grabovoi, V., Granovitch, A., Mikhailova, N. (2011). Zonal patterns of five Littorina species distribution in habitats with different salinity (the Barents Sea, Russia), in *Proceedings of 10 Int.Symp. on Littorinid Biol. and Evol.* St.Petersburg: Polytechnical University Publishing House.

[8] Heller, J. (2015). *Sea Snails - A Natural History*. Switzerland: Springer International Publishing.

[9] Reid, D. G. (1996). Systematics and evolution of Littorina. L.: The Ray Society.

[10] Ayala-Diaz, M. (2014). Trematode infection effects on survival and behaviour of *Littorina sitkana*. Master's thesis, University of Victoria.

[11] Seaman, B., Briffa, M. (2015). Parasites and personality in periwinkles (Littorina littorea): Infection status is associated with mean-level boldness but not repeatability. *Behavioural processes*, vol. 115, pp. 132-134.

[12] Galaktionov, K. V. (1992). Seasonal dynamics of the age composition of hemipopulations of daughter sporocysts of pygmaeus microphallids (trematoda: microphallidae) in intertidal molluscs *Littorina saxatilis* from the Barents sea. *Parasitology*, vol. 26 (6), pp. 462-469.

[13] Granovitch, A. I., Maximovich, A. N. (2013). Long-term population dynamics of *Littorina obtusata* -- the spatial structure and impact of trematodes. *Hydrobiologia*, vol. 706 (1), pp. 91-101.

[14] Granovitch, A. I., Sergievsky, S. O., Sokolova, I. M. (2000). Spatial and temporal variation of trematode infection in co-existing populations of intertidal gastropods *Littorina saxatilis* and *L. obtusata* in the White Sea. *Diseases of Aquatic Organisms*, vol. 41, pp. 53--64.

[15] Galaktionov, K. V., Dobrovolskij, A. A. (2003). The Biology and Evolution of Trematodes. An Essay on the Biology, Morphology, Life Cycles, Transmission, and Evolution of Digenetic Trematodes. Boston, Dordrecht, London: Kluwer Academic Publishers.

[16] Galaktionov, K.V., Bustnes, J.O. (1999). Distribution patterns of marine bird digenean larvae in periwinkles along the southern Barents Sea coast. *Diseases of Aquatic Organisms*, vol. 37, pp. 221--230.

[17] Mikhailova, N.A., Granovich, A.I., Sergievsky, S.O. (1988). Effect of trematodes on the microbiotopical distribution of molluscs *Littorina obtusata* and *L. saxatilis*. *Parasitology*, vol. 22 (5), pp. 398-407.