REPRODUCTIVE STRATEGIES OF FRESHWATER BIVALVES IN ARCTIC ECOSYSTEMS

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Freshwater invertebrates are able to develop specific ecological adaptations that enable them to successfully inhabit an extreme environment in high latitudes. We investigated the brooding (embryonic development) of *Pisidium casertanum* Arctic Russia. The studies were conducted in the northern part of Vaygach Island (Fig. 1). The island is located on the border of the Barents and Kara Seas, between South Island of the Novaya Zemlya Archipelago and Ugorskiy Peninsula. The territory belongs to the Arctic tundra zone and is, therefore, characterised by an Arctic climate. The ice-free period duration is ca. 2.5 - 3 months, from early July to late September. The average temperature of the warmest month is +5 °C (August), the coldest is -18.5 °C (February). During the study period in August, average water temperatures in the Talatinskoe Lake were in the range 4.6 - 10.4 °C (Bespalaya Y.V. *unpublished data*). The diurnal amplitudes were in the range 1.0 - 7.0 °C. Average air temperatures were in the range 2.8 - 9.7 °C. (Fig.2)

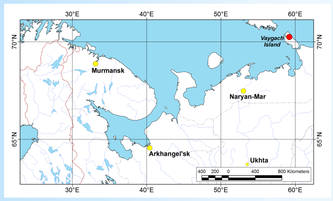

Figure 1. Map of the study area.

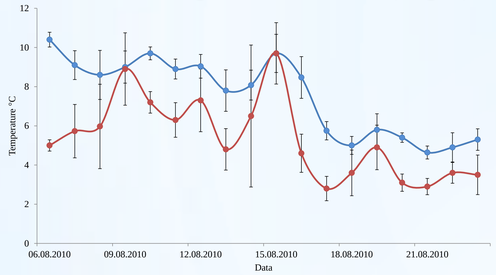

Figure 2. Average air and water temperature dynamic during the study period Error bars for the average values of water and air temperature represent (SD). Red line - airtemperature; blue line - water temperature.

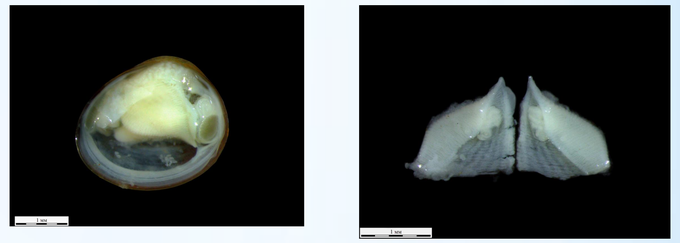

Figure 3. (a) The internal morphology dissected individuals of *Pisidium casertanum* (Talatinskoe Lake, Vaigach Island), (b) left and right brood sac

We examined a total of 795 specimens of *Pisidium casertanum* in the laboratory using a stereomicroscope (Leica M165C). All specimens were measured (maximum shell length) and dissected to discover the ratio of gravid animals in each length class and for presence of brood sacs and embryos (Fig. 3).
Size frequency structure of *Pisidium casertanum* population is presented in Fig. 4. According to our data, the brood sac with embryos in the examined, population are formed when the shell length of molluscs was, at least, 2.2 mm.
The proportion of juvenile individuals was 49% and mature bivalves was 51%, and among them the percentage of gravid molluscs was 17.5%.

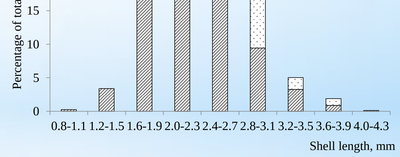

Fig. 4. Size frequency structure of the *Pisidium casertanum* sample with proportion of gravid and non-gravid individuals (*N* = 795).

Fig. 5. The left and right brood sac dissected individuals of *Pisidium casertanum*

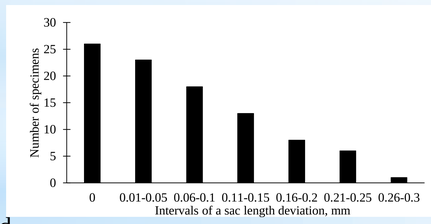

Fig. 6. Frequency histogram of sac length deviation of *Pisidium casertanum*.

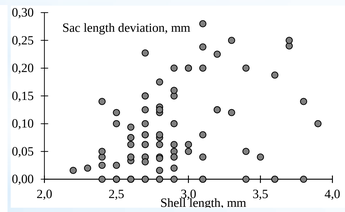

Fig. 7. Sac length deviation versus freshwater bivalve shell length

Table 1. Mean number of embryos by size classes versus shell length class.

Length class of shell, mm	Size classis of embryos															
	Class 1				Class 2				Class 3				Class 4			
	Mean number of embryo	min-max	SD	*N*	Mean number of embryo	min-max	SD	N	Mean number of embryo	min-max	SD	*N*	Mean number of embryo	min-max	SD	*N*
2.4-2.7	3.9	1-8	2.2	14	5.1	1-10	2.5	16	1	1-3.	1	3	2,8	2-4	1.09	5
2.8-3.1	3.6	1-10	2.6	16	6.2	3-11	2.6	17	1	n/a	n/a	1	3,1	1-8	2.3	9
3.2-3.5	10.7	6-17	5.7	3	6.8	1-24	8.5	6	4,7	2-7	2.5	3	3.2	2-5	1.6	5
3.6-3.9	4	3-5	1.4	2	12.5	9-16	4.9	2	7	n/a	n/a	1	5	n/a	n/a	1

In some cases, the development of the brood sacs at one of the gills presented a few lags, which could present at either of the right or the left gills (Fig. 5). The frequency histogram of sac length deviation of *Pisidium casertanum* shows that a total 69 specimens (72.6% of sample) have asymmetric development of sacs with mean D±SD = 0.104±0.07 mm, min-max = 0.02 - 0.28 mm (Fig. 6 and 7). The number of lay embryos depends on parent length, i.e. the longer the length of shell of the parent individuals, the higher the number of embryos. The number of extramarsupial embryos is much lower than the number of initial embryos (Table 1, Fig. 8). Variations in embryo size within a individuals were also observed. Thus, it was found that in one individual, embryos can develop, the length of which is different on several occasions (Fig. 9).

We, thus, detected that *Pisidium casertanum* has a specific process of brooding, comprising of asynchronous development and release embryos per one individual, providing a first evidence for coin-flipping in molluscs species.
Our results suggest that, in extreme climatic conditions at high latitudes the freshwater bivalves are able to develop reproductive strategies, aimed at increasing the population breeding success in the Arctic region.

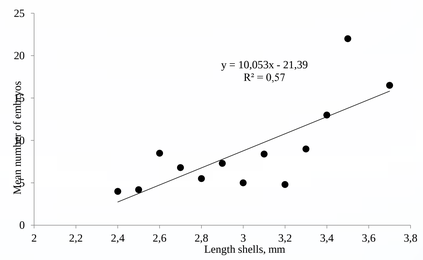

Fig. 8. Mean number of embryos versus shell length of *Pisidium casertanum*.

Fig. 9. Variations in embryo size within an individuals of Pisidium casertanum