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On the rate of filtration and feeding in some bivalved molluscs of the North Caspian Sea

L.V. Sanina

Many bivalved molluscs of the Caspian Sea are a main source of food for food-fish (7, 15, 17). In the meantime, there is very little information on the feeding of the molluscs themselves in scientific articles. On the whole, all literature on this subject deals with the qualitative composition of their food. It is known that a large number of bivalved molluscs of the Caspian Sea belong to the group of filter-feeding organisms (4, 14, 16). Along with detritus, planktonic water plants are often found as part of their food (1, 4, 5, 18). In general, there is no data on the quantitative aspect of the feeding habits of molluscs of the Caspian Sea.

In order to determine the rate of water filtration by molluscs, two methods are employed: one direct and the other indirect. The first method consists in the direct measurement of the volume of water running out of the exhalent siphon of the mollusc. The groundwork for the

direct method of investigation in sea molluscs was laid in experiments by Nelson (28, 29), who used the so-called water-jet method. Other researchers (19-21, 23, 26, 27, 30) used this method with some modification in their work. The indirect method, that is, the determination of the rate of filtration by means of changes in the concentration of various suspensions, was first employed by Fox (22). It is still being used at present, with some modifications. In a monograph by Jørgensen (25), there is a summary of almost all foreign experimentation in the determination of the rate of the passage of water in filter-feeding organisms and, in particular, by bivalved molluscs. Jørgensen came to the conclusion that the rate of filtration in these species depends on the size of the mollusc and not on the alimentary properties of the consumable particles. High concentrations of food lowered the rate of the passage of water, whereas low concentrations had no influence. /p.23

Research by Soviet scientists in this field began in the 1940's using mussels of the White Sea (6) and the Black Sea (10). Research continues until the present day. Investigating the influence of food concentration on the rate of filtration, Mironov and Kudinova-Pasternak (9, 10) concluded that the rate of filtration in the mussel does not depend upon the concentration of suspension in the water. Later, using other species of bivalved molluscs, it was shown that the rate of filtration changes

with a change in the concentration of the suspension--the smaller the concentration, the higher the rate of filtration (2, 8, 11-13). All the authors mentioned above came to the conclusion that the absolute value of the rate of filtration increases with an increase in the size (weight) of the mollusc, whereas the relative value decreases (3).

We studied these very questions using filter-feeding molluscs of the Caspian Sea. Research was carried out in 1967-1968 at a temporary experimental station (the Kulaly Islands). Material for the experiments was collected in the North Caspian Sea and in the northern part of the Central Caspian Sea using expeditionary ships of the Caspian Scientific Research Institute of Fisheries, equipped with a bottom grab of the "Okean" variety and with a drag net. In all, about a thousand molluscs of various sizes and genera were collected. Five species of molluscs that were most common to the Caspian benthos were selected for the experiments: Cerastoderma lamarcki (Reeve) (Cardium edule), Didacna trigonoides (Pall.), Didacna longipes (Grimm), Hypanis (Monodacna) angusticostata (Borcea), Mytilaster lineatus (Gmel.).

The molluscs were kept in glass crystallizing dishes or in shallow enamelled baths with simulated sea bottoms characteristic for their habitat. The Cardium (cockles) and Monodacna were imbedded in sand containing silt and the Didacna in broken mussel shells. The druses* of the

* Meaning of this word not clear in this context. Translator

Mytilaster generally lay on the bottom or attached themselves to the walls of the vessel. Twice a day the water was changed completely. Since the salinity of sea water was somewhat high (11-12%) for Monodacna, it was diluted with fresh water to a salt content of 9.5%. The molluscs were fed cultures of various unicellular water plants. On different days during the course of the experiment the temperature varied between 16-24° C. In order to adapt the molluscs to the conditions of the experiment, generally, two to three size groups of molluscs of one species were selected daily (24 hours) and moved to containers without simulated sea bottoms. During the experiments they were placed in cylindrical beakers or in crystallizing dishes with a volume of 25-300 $cm.^3$ depending on the size of the molluscs. In a majority of cases only one mollusc was placed in each experimental vessel. Only in the case of smaller varieties of Cardium and Mytilaster were 2-4-5 specimens placed in one vessel. /p.24

The study of the rate of filtration and the quantitative aspect of feeding was based on the determination of changes in the concentration of the prescribed food before and after the experiment. Cultures of Chlamydomonas and Scenedesmus were used as food in concentrations of 16 to 134 thousand cells per 1ml. In order to obtain the initial concentration, the number of cells in the culture being used was determined first. Then, the appropriate dilution was made. The experiment was set up for an hour

during a three day period (three series). On the first day the concentration of food was the greatest--about 100 thousand cells per 1 ml. On the second day the concentration was approximately half as great, and on the third day, one quarter as great. Two to three size groups of molluscs participated in each series of experiments. The experiment was carried out in a parallel way on 6-12 specimens within each group. All three series of experiments were set up using the same molluscs. Preliminary observations showed that the sedimentation of the water plants in the vessels during the hour of the experiment was insignificant. For this reason, it was not taken into consideration. Faeces from the experimental molluscs was observed very rarely. Pseudofaeces in small quantities were observed occasionally when the food concentration was great and among the larger species.

As a control, vessels with the same volume and the same concentration of water plants as in the vessels used for the experiments were set up in a similar way. In order to calculate the concentration of cells in the water plants, 50 ml. of the suspension were taken from each experimental vessel.

The cells in the water plants were counted in a Nazhott* chamber. In order to determine the concentration more accurately, each sample was usually counted twice. The rate of filtration was determined according to Gauld's

* Transliteration. Translator

formula (24): /p.25

$$F = \frac{L_g C_o - L_g C_t}{t\ L_{ge}} V$$

where

F - the rate of filtration of one specimen per hour;

V - the volume of water required for a specimen in ml.;

C_o and C_t - the first and the final concentration of cells of water plants in the culture (C_o was defined as the average in the initial concentration of water plants and in the two or three controlled vessels);

t - the duration of the experiment, one hour;

e - the basis of natural logarithms.

The number of consumed cells was calculated according to the difference in the concentration of cells of the water plants multiplied by the volume of the suspension required for one specimen.

The preliminary results of our experiments verified the direct dependence between the rate of filtration and the size of the molluscs (see table). The average value of the rate of filtration in the D. longipes which measured between 14.0 and 36.9 mm. increased from 52 to 283 ml./hr. and the number of consumed cells from 1.6 to 8.2 million/hr. In the D. trigonoides which measured between 8.4 and 39.2 mm., these values changed from 16 to 305 ml./hr. respectively and from 0.9 to 12.6 million/hr. In the C. lamarcki, measuring between 5.9 and 19.2 mm., the values changed from 9 to 196 ml./hr. and from 0.3 to 4.9 million/hr.

In the investigation of the relationship between the rate of filtration and the quantity of consumed cells and the food concentration for different species, various results were obtained. In two species of the genus Didacna the rate of filtration rose when the food concentration decreased and the number of consumed cells in groups of similar size remained more or less constant (see table). A tendency towards an increase in the rate of filtration where there is a decrease in food concentration was observed both in Mytilaster lineatus and in Hypanis angusticostata, which were not included in the table because of a lack of data. Within the limits of the concentrations studied, the rate of filtration showed almost no change in Cardium, and the number of consumed cells decreased with a reduction in the concentration of water plants.

Apparently, the question of the influence of food /p.27 concentration on the value of the rate of filtration cannot be solved identically for all species of molluscs. The limits of fluctuation of the concentration to which various species of molluscs react are different. It is interesting to note that Cardium belongs to organisms that are capable not only of filtering particles found in benthonic water, but also of actively blowing them up from the surface of the ocean floor (14, 16). It is entirely possible that in this species accustomed to living in very muddy water, the rate of filtration will change in the presence of higher

Скорость фильтрации и количество потребленных клеток водорослей в зависимости от концентрации корма у каспийских моллюсков разных размеров

Характеристика моллюсков			I серия опытов			II серия опытов			III серия опытов		
	размер, мм	сухой вес, мг	концентрация корма, тыс. кл/мл	скорость фильтрации /экз., мл/час	потребление клеток I экз., млн. кл/час	концентрация корма, тыс. кл/мл	скорость фильтрации /экз., мл/час	потребление клеток I экз., млн. кл/час	концентрация корма, тыс. кл/мл	скорость фильтрации /экз., мл/час	потребление клеток I экз. млн. кл/час
	Didacna longipes										
6	33,1-36,9	101,7-152,6		125,2	9,02		293,1	9,52		430,3	6,21
18	22,8-24,4	26,0- 48,7	90,22	61,8	4,54	53,61	95,7	3,40	33,03	195,6	3,93
18	14,0-15,2	6,4- 15,7		31,7	2,06		43,8	1,49		80,8	1,30
	Didacna trigonoides										
6	33,8-39,2	138,3-212,2		174,5	13,01		436,5	12,01		-	-
6	22,6-26,8	48,3- 98,8	101,14	53,01	4,20	53,18	148,0	4,62	-	-	-
6	8,4-13,9	2,2- 11,9		10,9	0,95		21,3	0,86		-	-
	Cerastoderma lamarcki										
12	16,1-19,2	13,6- 30,5		210,9	9,78		188,2	3,42		187,6	1,46
12	7,8-10,2	2,05- 6,05	117,08	72,4	2,70	42,12	65,8	0,96	17,93	56,1	0,39
12	5,9- 7,8	0,48- 1,30		8,5	0,52		9,1	0,19		9,4	0,08

The rate of filtration and the number of consumed cells of water plants depending on the food concentration in molluscs of the Caspian Sea of different sizes

Characteristics of the molluscs		First series of experiments			Second series of experiments			Third series of experiments		
Size in mm.	Dry weight in mg.	Food concentration in thousands of cells / ml.	Rate of filtration in each specimen in ml./hour	Number of cells consumed by each specimen, in millions of cells/hour	Food concentration in thousands of cells / ml.	Rate of filtration in each specimen in ml./hour	Number of cells consumed by each specimen, in millions of cells/hour	Food concentration in thousands of cells / ml.	Rate of filtration in each specimen in ml./hour	Number of cells consumed by each specimen, in millions of cells/hour

concentrations than in our experiments. If we consider the concentrations in this experiment, it is evident that the Cardium reached its maximum rate of filtration. In Cardium of the Black Sea measuring about 16 mm., the average rate of filtration is 94 ml./hr. (13), that is, almost half as great as in the Caspian Sea variety. Cardium of the Waddenzee Bay (the Netherlands) measuring 30-40 mm. filter 500 ml. of water in one hour (31).

Conclusions

1. The rate of filtration in two varieties of Didacna (Didacna longipes and Didacna trigonoides) and in Cardium is in direct relation to their size (weight).

2. If the concentration of food is increased in Didacna, the rate of filtration decreases and the number of consumed cells of water plants remains approximately on the same level.

3. Within the limits of concentrations studied, the rate of filtration in Cardium does not change noticeably and the number of consumed cells rises with an increase in their concentration.

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Summary

The relationship is shown between the rate of filtration and feeding, the concentration of food, and the size (length and weight) of animals with reference to three species of North Caspian filter-feeding molluscs, Didacna longipes, D.trigonoides and Cerastoderma lamarcki. The rate of filtration of all the molluscs studied rose with an increase in their size. A higher food concentration lowered the rate of filtration in D.trigonoides and D.longipes, whereas in C.lamarcki it remained at about the same level.

In C. lamarcki, the number of filtered plant cells rose markedly both with an increase in the size of the animal, and with a higher density of food, while in D.trigonoides and D.longipes, a higher rate of filtration was observed mainly with an increase in their size.

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On the rate filtration and feeding in some bivalved molluscs of the North Caspian Sea.

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S u m m a r y

The relationship is shown between the rate of filtration and feeding, the concentration of food, and the size (length and weight) of animals with reference to three species of North Caspian filter-feeding molluscs, Didacna longipes, D.trigonoides and Cerastoderma lamarcki. The rate of filtration of all the molluscs studied rose with an increase in their size. A higher food concentration lowered the rate of filtration in D.trigonoides and D.longipes, whereas in C.lamarcki it remained at about the same level.

In C. lamarcki, the number of filtered plant cells rose markedly both with an increase in the size of the animal, and with a higher density of food, while in D.trigonoides and D.longipes, a higher rate of filtration was observed mainly with an increase in their size.