ANNAL. BIOL. TIHANY | 28 | 211–216 | HUNGARIA 1961

# THE OXYGEN CONSUMPTION OF THE *DREISSENA POLYMORPHA* (LAMELLIBRANCHIATA) AT DIFFERENT TEMPERATURES

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Received 14th March, 1961

Only a few data are to be found in the literature on oxygen consumption of water animals, and among them, of the Molluscs. These data, furthermore, were established by various methods and were worked up from different points of view (K. BERG, 1952; K. BERG—K. W. OCKELMAN, 1959; E. VALEN, 1958). Most of the measurements do not extend to the complete temperature range in which the animals live. Consequently it is difficult to compare the data to be found in the literature and to establish any sort of generalizing laws among them. The purpose of collecting data extending over the different classes of animals should be that they are suitable for establishing laws, that we can get to possess data for comparison. Measurement of the oxygen concumption of *Dreissena polymorpha* belongs in such a scheme.

*Dreissena polymorpha* settled in the Balaton after 1932 and rapidly spread. It is quantitatively one of the prominent forms in the animal association of the rocks on the shores. From the standpoint of natural biology it takes a significant part as an organism feeding and recuperating on organic detritus and bacteria (ENTZ—SEBESTYÉN, 1940) in the life associations of the littoral of the lake (WOYNÁROVICH 1954, 1956). The animal itself also comes into consideration as a fish-food feeding organism.

It often is a nuisance as well; by settling in the pipes which take water from Lake Balaton it stops them up and obstructs the water service.

## Material and methods

The *Dreissena*'s were collected in the autumn of 1959 and 1960 (September, October) from the stony shore of the lake in front of the Institute. For the measurements the two most frequently occurring size groups were selected from the fully developed specimens. The length of shell of the smaller ones was 13 to 14 mm; that of the larger was 16 to 18 mm. The oxygen consumption of the animals was measured in a total of six series. Besides these still other measurements were made to complete our data.

The animals were collected two or three days before the experiment and were fasted for 24 hours. After the 24-hour fasting there was an adaptation to the different temperatures, which lasted 12 hours. The temperature adaptation was carried out in two steps. At first, for 8 to 10 hours the animals were kept at a temperature approximately 2 to 3°C near the experimental

temperature. Then for 2 to 4 hours just before the tests they were kept at the experimental temperature. The adaptation as thus carried out proved successful.

In the second phase of adaptation and during incubation time the animals were adjusted in ultrathermostats to the correct temperatures. The measurements took place simultaneously at the different degrees of temperature. For the measurements at the 7 different degrees of temperature 6 ultrathermostats and an ice bath (0,5° C) were employed.

The oxygen consumption of the animals is significantly affected by their general condition, duration of fasting, their fat content, etc. For that reason great emphasis was laid on using animals deriving from one place, collected at the same time and treated uniformly up to their adaptation.

Determination of oxygen consumption was made titrimetrically with vessels and methods invented by the author (WOYNÁROVICH 1959). For the test measurements of oxygen content a microburette and norm/200 $Na_2S_2O_3$ were used.

The oxygen consumption was determined for each measurement in parallels of three, at 7 different degrees of temperature (28, 25, 20, 15, 10, 5, 0,5°C). In 3 series the measurements were made not at 28°C but at 30°C. These data also appear in the tables.

An effort was made to see that the animals were not in water with less than 50% oxygen content during incubation. Those results were not taken into consideration, where the oxygen consumption was more than 50% of the initial oxygen content.

One to four molluscs were put into each determinating vessel; at low temperatures more were used, and at higher temperatures only 1 to 2 animals were put into the vessel.

Duration of incubation time was 70 to 120 minutes at the higher temperatures and 120 to 240 minutes at low temperature ranges.

It may be supposed that the oxygen consumption of *Dreissena* also changes at different seasons of the year. In this work we consider only that of animals collected in the autumn. Previous tests had shown that the oxygen consumption of the dry substance of the body without shell is the least in the autumn. At that time the animals contain the most reserve nutriment which largely counts as inactive from the standpoint of oxygen consumption. This hypothesis, however, still awaits further proof.

The live weight of the animals used in the experiment was measured as well as the weight of their shells and the weight of the dry substance of the entire body. The live weight is possibly inaccurate, as the water in the parts under the shell could not be removed with any certainty. The weight of the shell was determined by dissolving the soft parts in 10% NaOH solution, then washing in distilled water, and measuring after drying. From the above measurement results are calculated the live weight, without shell, and the dry weight.

The number of animals investigated we see was 254. Average live weight was 0,389 g. Average weight of shell: 0,152 g. The shell was 39,08% of the live weight. Average weight of the soft parts was 0,237 g and the average weight of the dry substance of the soft parts was 0,0136 g, which calculating without shell comes to 5,73% dry substance content and 94,27% water content. A 28,603-rd part of the living body is dry substance without shell, and 17,43-rd of the living body without shell.

*Table 1*

Result of measurements

The following table contains data on the animals used for the determinations:

| Serial number of measurements Mérési sorozat száma | The animals used for the measurements A mérésben részt vett állatok | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | number száma | av. live wt. (g) átlagsúlya (g) | shell av. wt. (g) héj átlag-súlya (g) | soft parts av. wt. (g) lágyrészek átlag-súlya (g) | soft parts' dry substance av. wt. (g) lágyrészek száraz-anyagának átlagsúlya (g) | wt. of shell % héjsúly % | dry substance % szárazanyag % |
| I. | 42 | 0,292 | 0,121 | 0,171 | 0,0078 | 41,55 | 4,55 |
| II. | 42 | 0,300 | 0,121 | 0,179 | 0,0099 | 40,17 | 5,55 |
| III. | 69 | 0,439 | 0,167 | 0,272 | 0,0155 | 38,07 | 5,71 |
| IV. | 53 | 0,494 | 0,190 | 0,304 | 0,0185 | 38,49 | 6,10 |
| V. | 9 | 0,483 | 0,191 | 0,292 | 0,0167 | 39,54 | 5,73 |
| VI. | 39 | 0,331 | 0,131 | 0,200 | 0,0127 | 39,58 | 6,33 |
| Total: Össz.: 6 | 254 | | | | | | |
| Total of averages: Az egész átlaga: | | 0,389 | 0,152 | 0,237 | 0,0136 | 39,08 | 5,73 |

The oxygen consumption at different temperatures is calculated to 1 g dry weight without shell, to 1 g body weight without shell (to the weight of the soft parts and to 1 g live weight. The two last data are more changeable in the different determinative series than the oxygen consumption in relation to 1 g dry substance.

The oxygen consumption in relation to 1 g body dry substance, without shell, is given in the following table.

*Table 2*

| Temperature °C Hőmérséklet C° | 0, 5 | 5 | 10 | 15 | 20 | 25 | 28 | 30 |
|---|---|---|---|---|---|---|---|---|
| N° of measurements Mérések száma | 15 | 14 | 15 | 14 | 14 | 11 | 11 | 9 |
| Average results X/mg/hr. Eredmények átlaga X/mg/h | 0,14 | 0,35 | 0,57 | 0,92 | 1,32 | 1,86 | 2,39 | 1,83 |
| Standard deviation Standard deviatio (s) | ±0,05 | ±0,05 | ±0,07 | ±0,11 | ±0,19 | ±0,15 | ±0,37 | ±0,49 |

From the table it appearsthat the oxygen consumption of *Dreissena* rises almost evenly from 0,5 to 28°C; and between 28 and 30°C, as this temperature is disadvantageous, the oxygen consumption drops. The animals were often found to die at this temperature.

In the measurements carried out in 1959 the vessels containing the animals in the thermostat were kept moving. The experimental vessels in 1960 were not kept in motion moving. Results of the measurements made by the two different methods were the same. Hence movement of the animals does not particularly change their oxygen consumption.

The change in oxygen consumption in the temperature range investigated is fairly clearly shown by the Q values. The $Q_3$ value show this specially well. (For calculating the $Q_3$ value the oxygen consumption must be established at every 3 degrees, partly from the measurements and partly from the curve built up from them.)

*Table 2*

The $Q_3$ values are as follows:

$$28 - 25 = 1{,}28$$
$$25 - 22 = 1{,}21$$
$$22 - 19 = 1{,}23$$
$$19 - 16 = 1{,}25$$
$$16 - 13 = 1{,}26$$
$$13 - 10 = 1{,}36$$
$$10 - 7 = 1{,}33$$
$$7 - 4 = 1{,}43$$
$$4 - 1 = 1{,}76$$

Oxygen consumption rises rapidly from 1°C to 4°C, fairly rapidly from 4°C to 7 C. Between 7 and 13°C the rise may be said to be regular. Between 13 and 25°C it is almost completed regular. It increases to a scarcely appreciable degree between 25 and 28°C.

From the changes in $Q_3$ values it may be concluded that in the temperature ranges between 13 and 25°C there is no physiological effect on the *Dreissena* that could change the regular rise in oxygen consumption.

The $Q_3$ values show up well the measurements of rise in oxygen consumption. This, as calculated from the oxygen consumption measured between 5 and 25°C, is 5,31.

The oxygen consumption of 1 g body weight without shell may also be calculated in two ways.

In one series of results the oxygen consumption of the different animals used for the experiment was calculated. But good results were also obtained by the other method of calculating. It may be seen from *Table 1* that the average dry weight of all the soft parts of the molluscs is 0,0136, that of the soft parts without shell being 0,237. The dry substance is hence the 17,43-rd part of the living body. Dividing the oxygen consumption value relating to 1 g dry substance of the body without shell *(Table 2)*; 17,43 comes relatively near to the oxygen consumption of 1 g living body without shell.

The second column of *Table 3* contains the values thus calculated.

*Table 3*

| Temperature °C<br>Hőmérséklet C° | 0,5 | 5 | 10 | 15 | 20 | 25 | 28 | 30 |
|---|---|---|---|---|---|---|---|---|
| 1 g live wt. without shell<br>1 g héjnélküli élőállat<br>$O_2$ consumption calculated values | 0,008 | 0,021 | 0,030 | 0,054 | 0,076 | 0,120 | 0,130 | 0,110 |
| Oxigénfogyasztás (kapott érték) | 0,008 | 0,020 | 0,033 | 0,053 | 0,076 | 0,107 | 0,137 | 0,105 |

The calculated values diverge to a relatively small degree from the averages of the values given by the different measurements. Hence by calculation too it is possible to reach the truth on nearly approximative values.

In *Table 4* the data on oxygen consumption of 1 g of the living molluscs are presented. In this *Table* too, two columns of data are given. The one is calculated from the measurements; the other from the data on the dry weight, live weight and their comparison — of all the animals used in the experiments as described heretofore, and the data in *Table 2*.

The dry weight without shell is the 28,603-rd part of the live weight. Dividing by this the data in *Table 2* we obtain the second column of data in *Table 4*. From comparison of the two columns it appears that there is no significant difference between the calculated results and those obtained by direct measurement.

*Table 4*

| Temperature °C<br>Hőmérséklet C° | 0,5 | 5 | 10 | 15 | 20 | 25 | 28 | 30 |
|---|---|---|---|---|---|---|---|---|
| $O_2$ consumption of 1 g live animal mg/hr (received value)<br>1 g élőállat $O_2$-fogyasztása mg/h (kapott érték) | 0,004 | 0,013 | 0,022 | 0,031 | 0,044 | 0,060 | 0,075 | 0,062 |
| $O_2$ consumption of 1 g live animal mg/hr (calculated value)<br>1 g élőállat $O_2$-fogyasztása mg/h (számított érték) | 0,005 | 0,012 | 0,020 | 0,032 | 0,046 | 0,065 | 0,084 | 0,064 |

## Discussion

A uniform rise in oxygen consumption with changes in temperature is a characteristic of the oxygen consumption of *Dreissena polymorpha*. More significant change existe only at the low and the high temperatures. This general picture of its oxygen consumption differs from the oxygen consumption of *Carinogammarus* (Lukacsovics 1955). From the data the eurythermic nature of the animal is also apparent.

The oxygen consumption calculated to 1 g dry substance is to a great degree influenced by the proportion of the actively breathing parts of the body of the organism investigated to those not taking part at all in respiration or at any rate less actively (Smardina 1954). Hence the oxygen consumption calculated to 1 g dry substance must be made up to the oxygen consumption of 1 g dry substance of an actively respirating part of the body. In the case of many animals it would be difficult to distinguish between the actively breathing and the inactive parts but the separation of the shell of the molluscs and the chitin covering of the Arthropods, the yolky substance of fish larvae do not cause any particular difficulty.

In the *Dreissena polymorpha* the dry substance of the body without shell practically approximates the dry substance content of the active breathing body.

One characteristic of the oxygen consumption of the animals may be the total value of oxygen consumption measured to 1 g dry substance at 7 different degrees of temperature. Adding up the quantities of oxygen con-

sumption at the different degrees of temperature we get a relatively low number in the case of *Dreissena polymorpha :* 7,55 (see *Table 2* Average results). In fish spawn this is much larger, in immature pike perch *(Lucioperca lucioperca)* it is 24,08, in carp *(Cyprinus carpio)* spawn 22,52, in pike *(Esox lucius)* spawn 21,66; and in sheatfish *(Silurus glanis)* spawn 17,89.

According to this *Dreissena polymorpha* may be placed among the organisms with small oxygen requirements.

The data on oxygen consumption of *Dreissena polymorpha* can be used for practical purposes, if it is desirable to kill off the animals in the water supply system. This is the simplest method, does not injure the pipes, and the lack of oxygen suffocates the molluscs.

The author wishes to express his appreciation to Mrs. Brigitta Szabó for her expert assistance during these experiments.

**Summary**

The oxygen consumption of *Dreissena polymorpha* of medium size specimens between 12 and 18 mm length, collected in September and October, was determined at 8 different degrees of temperature between 30 and 0,5°C. The data are given for 1 g dry substance, 1 g live weight without shell and 1 g live weight, summarized in Tables. It appears from the data that *Dreissena polymorpha* is an organism of small oxygen requirement. However, by bringing about a lack of oxygen in water supply pipes masses of the molluscs which have settled in them may be effectively destroyed.

## A *DREISSENA POLYMORPHA* (LAMELLIBRANCHIATA) OXIGÉNFOGYASZTÁSA KÜLÖNBÖZŐ HŐMÉRSÉKLETEN

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Összefoglalás

A szerző 30—0,5 C° között, nyolc hőmérsékleti ponton határozta meg a *Dreissena polymorpha* szeptember—októberben gyűjtött, közepes 12—18 mm-es nagyságú példányainak oxigénfogyasztását. Az adatokat 1 g szárazanyagra, 1 g héj nélküli élősúlyra és 1 g élősúlyra adta meg, melyeket táblázatban foglalt össze. Az adatokból kitűnik, hogy a *Dreissena polymorpha* kis oxigénigényű szervezet. Vízszolgáltató csövekben megtelepedett tömegeit azonban oxigénhiány előidézésével hatásosan lehetne irtani.

## ПОТРЕБЛЕНИЕ КИСЛОРОДА DREISSENA POLYMORPHA (LAMELLIBRANCHIATA) ПРИ РАЗВНЫХ ТЕМПЕРАТУРАХ

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Реюзме

Потребление кислорода собранных в месяцах сентябрь-октябрь экземпляров Dreissena polymorpha среднего (12—18 мм) размера определилось при восьми разных точках температуры от 30 до 0,5°Ц. На таблице приведены данные в переводе на 1 г сухого вещества, на 1 г живого веса без наружной коры и на 1 г живого веса. Из полученных данных явствует, что Dreissena polymorpha требует мало кислорода. Тем не менее, искусственно созданный недостаток кислорода позволило бы успешно уничтожить поселившиеся в водоподводящих трубах массы Dreissena polymorpha.