Determination of the weight of some crustaceans from body size

by S. P. Belousova

Original title: Определение веся некоротых planktonnykh rakoobraznykh по размерам tela


Translated by the Translation Bureau (WDP)
Foreign Languages Division
Department of the Secretary of State of Canada

Department of the Environment
Fisheries Research Board of Canada

Marine Ecology Laboratory, Dartmouth, N. S.
Arctic Biological Station, Ste. Anne de Bellevue, P. Q.
1973

13 pages typescript
**TRANSLATED FROM** - **TRAJICTION DE**

Russian

**INTO - EN**

English

**AUTHOR - AUTEUR**

S. P. Belousova

**TITLE IN ENGLISH - TITRE ANGLAIS**

Determination of the weight of some crustaceans from body sizes

**TITLE IN FOREIGN LANGUAGE (TRANSLITERATE FOREIGN CHARACTERS)**

Opredelenie vesa nekorotykh planktonnykh rakoobraznykh po razmeram tela

**REFERENCE IN FOREIGN LANGUAGE (NAME OF BOOK OR PUBLICATION) IN FULL, TRANSLITERATE FOREIGN CHARACTERS.**

Izvestiya Tikhookeanskogo nauchno-issledovatel'skogo instituta rybnoogo khozainstva i okeanografii (TINRO)

**REFERENCES IN ENGLISH - RÉFÉRENCE EN ANGLAIS**

Journal of the Pacific Scientific Research Institute of Marine Fisheries and Oceanography

**PUBLISHER - ÉDITEUR**

Dal'nevostotchnoe knizhnoe izdatel'stvo (Far East Book Publishing House)

**PLACE OF PUBLICATION**

Petropavlovsk-Kamchatskii, USSR

**DATE OF PUBLICATION**

1970

**NUMBER OF TYPED PAGES**

13

**REQUESTING DEPARTMENT - MINISTÈRE-CLIENT**

Environment

**TRANSLATION BUREAU NO.**

143641

**BRANCH OR DIVISION**

Fisheries Service, Office of the Editor

**TRANSALATOR (INITIALS)**

WDP

**PERSON REQUESTING - DEMANDÉ PAR**

John Camp, Administrator, Scientific Documentation

**UNEDITED TRANSLATION**

For information only

**DATE OF REQUEST - DATE DE LA DEMANDE**

22 November 1972

JAN 18 1973
Determination of the Weight of Some Planktonic Crustaceans from Body Sizes

By S.P. Belousova

The difficult problems of the nutrient content of a body of water and of food rations for juvenile fish cannot be solved without knowing the weight of the food organisms and their biomass in the water body.

Samples of comparatively large benthic animals can be weighed directly fairly easily, but it is difficult to weigh small planktonic organisms, and it is often impossible to determine the weight of a sample owing to the excessively small mass of the organisms.

* Numbers in the right-hand margin indicate the corresponding pages in original.
A number of researchers have derived average weights of planktonic organisms either by direct weighing or geometrically (Sushkina, 1940; Amelina, 1941; Zinov'ev, 1947; Kharin, 1948; Ulomskii, 1951; Meshkova, 1953; Mordukhai-Boltovskoi, 1954; Zimbalevskaya, 1966). These data have been utilized to compile composite tables of the weights of different planktonic organisms. These tables can be used to determine the weight of various species to the first approximation without resorting to weighing (Kiselev, 1956; Borutskii, 1960).

The derivation of an equation linking size and weight, has represented a further development of the methods of determining the weight of zooplankters.

M.M. Kamshilov (1951), when he studied the biology of Calanus finmarchicus Gunner, established that even in the same body of water the size, and consequently the weight, of the organisms of a single species at the same stage of development vary considerably according to the seasons of the year. The biomass of crustaceans, calculated from the above tables, may therefore differ considerably from the true value. Since, however, the shape of crustacean bodies varies little, their weight can be calculated from their size.

Proceeding from the fact that among organisms with isometric growth, weight is approximately proportional to the cube of length, Kamshilov derived the following regression equation for copepods

\[
y = 0.043x - 0.038,
\]

where \( y \) is the cubic root of the weight in mg;

\( x \) is the length of the body in mm.
Kamshilov believes that this equation can be used to calculate the weight of any marine copepod with sufficient accuracy if its length is known.

A like simple relationship between size and weight has been established by A. P. Shcherbakov (1952 and 1956) for small freshwater crustaceans. Shcherbakov prepared a regression equation for freshwater Copepoda (the symbols are the same as in Kamshilov's equation):

\[ y = 0.54x - 0.03 \]

and for some Cladocera (from actual data supplied by S. N. Ulomskii):

<table>
<thead>
<tr>
<th>Species</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daphnia (gen. Daphnia) (3 species)</td>
<td>( y = 0.056x + 0.01 )</td>
</tr>
<tr>
<td>Daphnia hyalina</td>
<td>( y = 0.32x + 0.08 )</td>
</tr>
<tr>
<td>Daphnia cucullata kahlbergensis</td>
<td>( y = 0.21x + 0.12 )</td>
</tr>
</tbody>
</table>

V. V. Dukina (1957), on the basis of direct weighings of different species of Cyclops, expressed the size-weight ratio among freshwater Cyclops in the form of a curve. The author believes that this curve permits calculation of the weight of any crustacean without direct weighing if its length is known.

The application of generalized formulas to a definite species of crustacean from a given body of water, however, encounters a certain amount of difficulty, since the size, weight and even proportions of plankter bodies vary depending on the type of water body, the season and a number of other factors. Thus G.F. Mazenova (1963) has demonstrated that the actual weights of third-stage copepodites* and of mature Cyclops kolensis exceed the weights calculated from Shcherbakov’s formula by 2.7 and 1.27 times respectively. Such a degree of accuracy is in a number of cases insufficient when quantitative research is being carried out on the biological processes in a body of water.

---

* Translator's note. A direct rendition of the Russian kopepodit.
When we studied the food supply and feeding pattern of juvenile sockeye salmon in Lake Azabach'e, one of the largest lakes in Kamchatka, we attempted to determine the biomass of the plankton as accurately as possible. The purpose of this paper is to describe the size-weight ratios of the most important zooplankton representatives of Lake Azabach'e and to supply formulas for determining their weight from their length in order to avoid continual recourse to mass weighings.

Methods and Results

The average weights of organisms are usually established from material that has been fixed in Formalin, i.e., it is the wet Formalin weight which is determined, and not the weight of the living organisms. Borutskii (1934) found that fixing alters the weights of organisms, the amount of deviation from live weight depending on the concentration of the fixative, the volume of the fixing liquid, the temperature at the time of fixing, the size and age of the animal, and the season of the year.

The problem of the weight ratios of live organisms and those fixed with Formalin has hitherto remained completely unsolved. The material that we used for weighing had been preserved for about two years in a 4% concentration of Formalin. The following were selected for weighing: *Cyclops* (copepodites in the third to fifth stages of maturity separately, males and females) and *Daphnia* of the following size groups (in mm): 0.4 to 0.6; 0.6 to 0.8; 0.8 to 1.0; 1.0 to 1.2. The crustaceans were measured before being weighed.

The weighing was carried out in accordance with a slight variation of Ulomskii’s method (1951) – not in a closed weighing bottle, but rather on a small piece of gauze on torsion scales (scale division 0.2 mg).
The weight of the Cyclops eggs and nauplii was established geometrically from their volume: the weight of the eggs was calculated from the formula for a sphere; the nauplii were divided into three size groups and not by their stages of metamorphosis, and their weight was determined from the formula for an ellipsoid (Table 1).

Table 1

Average Dimensions and Weights of the Eggs and Nauplii of Cyclops scutifer

<table>
<thead>
<tr>
<th>1. Длина, мм</th>
<th>2. Вес, мг</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.</td>
<td>0.006</td>
</tr>
<tr>
<td>4.</td>
<td>0.12—0.16</td>
</tr>
<tr>
<td></td>
<td>0.16—0.22</td>
</tr>
<tr>
<td></td>
<td>0.24—0.28</td>
</tr>
</tbody>
</table>

Key:
1. Length, in mm;
2. Weight, in mg;
3. Eggs;

The weights of the copepodites and of the mature Cyclops are given in Table 2.
**Table 2**

Actual and Calculated Weights of *Cyclops scutifer*

<table>
<thead>
<tr>
<th>1. Стадия зрелости</th>
<th>2. Количество измеренных организмов</th>
<th>3. Средний размер 1 экз. в мм</th>
<th>4. Средний вес 1 экз. в мг</th>
<th>5. Средний вычисленный вес 1 экз. в мг</th>
<th>6. Вес 1 экз. по Шербакову, в мг</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Исповедники</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
<td>0.437</td>
<td>--</td>
<td>0.005</td>
<td>0.061</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>0.560</td>
<td>--</td>
<td>0.010</td>
<td>0.003</td>
</tr>
<tr>
<td>III</td>
<td>200</td>
<td>0.347</td>
<td>0.010</td>
<td>0.016</td>
<td>0.010</td>
</tr>
<tr>
<td>IV</td>
<td>150</td>
<td>0.725</td>
<td>0.029</td>
<td>0.016</td>
<td>0.010</td>
</tr>
<tr>
<td>V Самцы-семьи</td>
<td>200</td>
<td>0.095</td>
<td>--</td>
<td>0.032</td>
<td>0.027</td>
</tr>
<tr>
<td>V Самки</td>
<td></td>
<td>0.236</td>
<td>--</td>
<td>0.026</td>
<td>0.020</td>
</tr>
<tr>
<td>6. Семьи-семья</td>
<td>1000</td>
<td>0.067</td>
<td>0.032</td>
<td>0.031</td>
<td>0.027</td>
</tr>
<tr>
<td>6. Самки-семья</td>
<td>1000</td>
<td>1.122</td>
<td>0.046</td>
<td>0.046</td>
<td>0.044</td>
</tr>
</tbody>
</table>

**Key:**

1. Stage of maturity;
2. Number of weighed organisms;
3. Average size of one specimen, in mm;
4. Average weight of one specimen during weighing, in mg;
5. Average calculated weight of one specimen, in mg;
6. Weight of one specimen according to Shcherbakov, in mg;
7. Copepodites;
8. Females + males;
9. Males;
10. Females;
11. Sexually mature males;
12. Sexually mature females.
Using weighing data, we derived a regression equation which enabled us to determine with virtually sufficient accuracy the weight of an organism without direct weighing, if its average length were known:

\[ y = 0.271x - 0.034 \]

This equation is fairly close to Shcherbakov's (1952), but differs from it on a graph by the angle of inclination of the straight line (Fig. 1), as a result of which there arises a wide discrepancy among the weights calculated from these formulas for the smallest copepodites, whereas the weights of mature Cyclops, especially females, agree well (Table 2).

Figure 1 - The length-weight ratio of Cyclops scutifer:
1 - actual; 2 - calculated from Shcherbakov's formula.

On the basis of the above equation the weight of Cyclops from Lake Azabach'e can be calculated from the formula

\[ W = \frac{(L - 0.2) + 0.034}{0.271} \]
Using this formula, we calculated the weights of copepodites of the first to the fifth stages of maturity, and of mature Cyclops (see Table 2). The weights of the crustaceans as calculated from our equation, and the results of the weighings, were very close.

The second most significant food organism in Lake Azabach'e is Daphnia cucullata.

The results of the weighings of Daphnia are given in Table 3.

The straight line constructed from this data (Fig. 2) corresponds to the regression equation

$$y = 0.32x + 0.03,$$

in conformity with which the weight of Daphnia is determined from the formula

$$P_{\text{mg}} = (L \cdot 0.33 + 0.03).$$

Fig. 2.- Length-to-weight ratio of Daphnia cucullata (1) and Daphnia cucullata kahlbergensis (2).
Table 3

Actual and Calculated Weights of Daphnia cucullata

<table>
<thead>
<tr>
<th>1. Размерные группы</th>
<th>2. Количество измеренных организмов</th>
<th>3. Средний размер 1 экз., в мм</th>
<th>4. Средний вес 1 экз. при взвешивании, в мг</th>
<th>5. Средний вычисленный вес 1 экз., в мг</th>
<th>6. Вес 1 экз. по Шербакову, в мг</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4—0.6</td>
<td>600</td>
<td>0.5</td>
<td>0.0075</td>
<td>0.007</td>
<td>0.011</td>
</tr>
<tr>
<td>0.6—0.8</td>
<td>600</td>
<td>0.7</td>
<td>0.019</td>
<td>0.018</td>
<td>0.019</td>
</tr>
<tr>
<td>0.8—1.0</td>
<td>1000</td>
<td>0.9</td>
<td>0.031</td>
<td>0.035</td>
<td>0.033</td>
</tr>
<tr>
<td>1.0—1.2</td>
<td>260</td>
<td>1.1</td>
<td>0.063</td>
<td>0.069</td>
<td>0.069</td>
</tr>
</tbody>
</table>

Key:
1. Size groups;
2. Number of weighed organisms;
3. Average size of one specimen, in mm;
4. Average weight of one specimen when weighed, in mg;
5. Average calculated weight of one specimen, in mg;
6. Weight of one specimen according to Shcherbakov, in mg.

The weight of Daphnia calculated from Shcherbakov's formula (1956) does not coincide with that derived by us, since Shcherbakov used the weights of D. cucullata kahlbergensis from Lake Shartash, which differ from the typical form in having a head with a high, pointed helmet* (Bening, 1941).

* Translator's note. "Helmet" is the usual equivalent of the Russian shlem. Another equivalent, perhaps not applicable in this case, is "galea".
Conclusions

1. The dimensions and weights of planktonic crustaceans of Lake Azabach'e have been linked by the following equations:

\[
\begin{align*}
\text{for} \quad & \text{any } C. \text{specie} & y &= 0.271x + 0.031, \\
\text{for} \quad & \text{any } D. \text{specie} & y &= 0.35x + 0.03.
\end{align*}
\]

2. These formulas enable the weight and biomass of planktonic crustaceans of Lake Azabach'e to be determined with sufficient accuracy without recourse to weighing, and irrespective of the season and place of sample removal.
### Bibliography

<table>
<thead>
<tr>
<th></th>
<th>Author</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Amelina, L.G.</td>
<td>The feeding of juvenile carp in flood-plain bodies of water in the Volga Delta. Trudy VNIRO, Vol. XVI, 1941.</td>
</tr>
<tr>
<td>3</td>
<td>Borutskii, E.V.</td>
<td>The technique of the quantitative counting of bottom fauna. The comparison of live and Formalin weight. Trudy of the Kosina Limnological Station, 19, 1934.</td>
</tr>
<tr>
<td>4</td>
<td>Borutskii, E.V.</td>
<td>Key to free-living freshwater copepods of the USSR and adjacent countries from fragments and intestines of fish. Publishing House of the Academy of Sciences of the USSR, 1960.</td>
</tr>
<tr>
<td>5</td>
<td>Dukina, V.V.</td>
<td>Methods of determining the biomass of zooplankton. Trudy of the Scientific Research Institute of Biology and of the Faculty of Biology of Kharkov State University, Vol. XXX, 1957.</td>
</tr>
</tbody>
</table>
15. Kharin, N.N.  
The zooplankton of the Manych water areas.  
Uchenye zapiski (Scientific Journal) of Rostov University, Vol. XII, 1948.

16. Shcherbakov, A.P.  
Size-weight ratios among freshwater planktonic crustaceans.  
DAN (Reports of the Academy of Sciences) of the USSR, 84, 1, 1952.

17. Shcherbakov, A.P.  
The productivity of the zooplankton of Lake Glubokoe.  