FBA Transl. (New Series) No. 4.
[Translated by J.E.M. Horne]

On the nutrition of Polyphemus pediculus (L.)

by

L.G. Butorina and Yu.I. Sorokin.

Trudy Inst.Biol.vnutr.Vod. 12(15), 170-174.

Many sides of the biology of Polyphemus pediculus are adequately studied at the present time. Most complicated is the question of its feeding. Dissection does not give an idea of the composition of the food, since Polyphemus strongly grinds its food with its mandibles. In the works of Fischer (1851), Ischreyt (1933) and Eriksson (1934), they chance only on fragmentary information regarding the food objects of P. pediculus. This is mainly in the form of infusoria, rotifers, algae (mainly protococcal), detritus, and some small Entomostraca (Bosmina, Lynceus, Cypris). There are indications of cannibalism of the crustaceans (Ischreyt, 1933). Observations on the nutrition of Polyphemus are complicated, as it moves in jerks and the intake of food does not happen continuously (Eriksson, 1934). L.G. Butorina (1965) added observations on the mode of feeding of P. pediculus and defined the structure of its mouth parts, establishing that the crustacean is an active predator. The eye and the limbs, well adapted for catching prey, allow polyphemus actively to hunt and seize a mobile victim. The food, thanks to the movements of the gnathobases, is actively pushed into the food chamber, the dimensions of which determine to some degree the choice of the feeding of polyphemus. The captured prey is ground by the numerous teeth of the mandibles and is sucked in by the pulsating oesophagus.

For clarification of the composition of the food of Polyphemus pediculus, we carried out in July and August 1962 a series of experiments with the application of radio-carbon methods, described earlier in the work of A.V. Monakov and Yu.I Sorokin (1961). In the present experiments we judged the degree of utilization of one or other foods by the quantity of C^{14}, accumulated in the body of the crustacean after feeding. Particular attention in these experiments

was given to the question of the possibility of the utilization by polyphemus of plant food - bacteria, algae and detritus. From a comparison of quantitative data of assimilated and accumulated C^{14} (see table), we formed an idea about the general composition of the food of Polyphemus, about the intensity of feeding on one or another kind of food and about choice with respect to various foods.

C^{14} marked plant food was prepared by means of preparing cultures of single-celled algae (green, blue-green and diatoms), filamentous algae (Vaucheria) and a higher plant (Elodea) in the presence of radioactive bicarbonate. The single-celled algae were washed clean from marked bicarbonate on filters and introduced into the experimental vessels in the form of a suspension. The C^{14} marked filamentous algae and elodea were ground with sand and a small quantity of water to produce a suspension of fine detritus. Bacteria containing C^{14}, we obtained by means of their preparation in a medium with glucose, with marked C^{14}.

Animals were marked with C^{14} by means of feeding with marked algae or bacteria.

The experiments with crustaceans were carried out in flasks with a capacity of 100ml, in which were poured out $50cm^3$ of ultra-filtered water.

With each kind of food the experiment consisted of three replications: one vessel was the control. Into the experimental flasks were placed in 40's the living crustaceans, collected from the reservoir. Into the control flask were introduced as many crustaceans, killed with formalin. Then to the flasks were added equal quantities of food marked with C^{14}. Food was given in plenty. Algae and detritus were

introduced at the rate of concentration in the experimental vessel of 4-6 mg/l.; concentrations of animal food comprised from 2 to 120 g/m^3. The experiments were carried out in the hours of daylight (the beginning of the experiment at 10-12 o'clock) at a temperature of 18.2-21.0°C and with equal lighting (the flasks were placed on a window-sill). The experiments lasted for 4, 6, and 24 hours, after which the crustaceans were washed clean, with a stream of distilled water, from the marked food and placed for 1 hour in a vessel with unmarked food to free the guts from undigested residues of marked food. Then the crustaceans were again washed clean of food, fixed in formalin, placed in 20's on object-glasses in a drop of 0·1% solution of agar and dried. The glasses with the crustaceans were placed in a standard position under a meter for observation of the radioactivity of the bodies of the crustaceans (r). Calculation of the quantity of the substance of marked food assimilated by the crustaceans during the time of the experiment, was deduced by the formula

$$Ca = \frac{1{\cdot}56r \cdot Cr{\cdot}24}{t} \text{ mgC/example}$$

where Ca is the quantity of organic carbon of the marked food, assimilated by the crustaceans calculated for 24 hours; r = mean radioactivity of a single crustacean in the control, in imp./min; C is the quantity of organic carbon of the food, related to 1 imp. of its activity in mg/imp; 1·56 is the coefficient of self-absorption of radiation in the body of the crustacean. The radioactivity of the food for calculation of Cr was determined in standard conditions of calculation; the content in it of organic carbon was analysed by means of "wet burning" with 0.1N solution of bichromate in concentrated H_2SO_4 at 100° for two hours. The residue of bichromate was titrated iodometrically. The method of determining the coefficient of self-absorption is described in the work of one of the authors (Sorokin, 1960). The results of the experiments are given in the table, where they are presented in the form of quantity of Ca. related to the mean content of carbon in the body of Polyphemus. The lowest values

[are] near to the relative daily increase of matter of the body of the crustacean owing to assimilation of marked carbon.

Absolute values of the index of assimilation P and Ca, shown in the table, evidently are somewhat over-estimated on account of this, that they were obtained by (?)extrapolating the results of short-time experiments to 24-hours. In the short-time experiment the animals can feed more intensively than on average over 24 hours. This is obvious from a comparison of the data of 24-hour and short-time experiments, which is shown in the table. The values of P, obtained in short-time experiments, reflect, evidently, the maximum possible quantities of intensive feeding of the crustaceans.

Comparison of the intensity of feeding of the crustaceans on different kinds of plant and animal food shows that they prefer animal food to plant (see the table). If the percentage of daily increase of matter of the body of Polyphemus — P — owing to living animal food, oscillates from 0·77 to 26·3%, then P owing to living plant food is only from 0·3 to 0·73%

Polyphemus pediculus eats up living animal food better than killed animals (P=0.1 - 1.9%) or decomposed (ones) (0%). (With this) it prefers soft non-loricate rotifers (Conochilus P= 26·3%) and infusoria (Paramecium). The bigger the animals and the harder their outer cover, the less willingly does Polyphemus eat them. Thus, if Daphnia longispina is offered to polyphemus, the daily increase of its body is nil (i.e. the crustacean was not feeding); with feeding the crustaceans on adult Bosmina longirostris, it is 0·74% Polyphemus eats up more willingly young Bosmina longirostris. The value of P with this is 15·5% Loricate rotifers (Brachionus diversicornis) it eats up less willingly than young Cladocera. Polyphemus sucks out these rotifers, casting away the lorica, then like young Cladocera it eats (them) entire. The large non-loricate rotifers Asplanchna are

eaten poorly, probably due to their large size.

Plant food, as can be seen from the low value of index of assimilation, cannot serve as (?)adequate food for Polyphemus, and, apparently, at the best serves only as a supplementary source of nutrition.

Among the various kinds of plant food, P. pediculus prefers algae, gently sinking to the bottom of the flask -, such as Scenedesmus, Nitzschia, Asterionella, Anabaena, Chlamydomonas. Algae which maintain themselves well in the suspended state - Chlorella, Coelosphaerium, Aphanizomenon, Microcystis - are consumed more poorly. Better than all is the consumption of protococcal algae, then diatoms, worst of all are assimilated bluegreen algae. P. pediculus to a slight degree is capable of feeding on decomposed algae. Thus, decomposed blue-green algae it assimilates relatively better (P=0·4%) than living diatoms, and so much the more (than) living blue-green algae (P=0·03-0·2%). Polyphemus fairly willingly eats up fragments of detritus, both fresh and decomposed. The values of the index of assimilation P with feeding on detritus of vaucheria reaches 1·9%, which is significantly higher than any value for P for feeding on algae. Consequently, detritus is for polyphemus a more adequate food than algae.

Experiments on the clarification of the ability of P. pediculus to feed on bacteria dispersedly distributed in the water showed that the value of 24-hour assimilation of matter of the body of the crustacean with the given kind of food is very insignificant - 0·2% This tells (us) that Polyphemus is not capable of adequately feeding on bacteria. Evidently, this is connected with the lack of adaptation of its mouth apparatus to catching separate cells of algae and bacteria.

Thus, animal food is the best food for P. pediculus under natural

conditions.

The consumption and assimilation of this or other kinds of food largely depends on the physiological state of the crustacean. Examples, just taken from the reservoir, consume algae significantly more poorly than hungry crustaceans maintained for 24 hours in filtered water. The percentage of 24-hour increase of body matter of hungry Polyphemus with feeding on algae varies from 0.25 to 5.4%, whereas in the crustacean in the normal state, from 0.1 to 0.7%. Hungry Polyphemus best assimilate Nitzschia, then Chlamydomonas and Anabaena, but crustaceans in the normal condition - Scenedesmus.

With hungry crustaceans the consumption of blue-green algae (Anabaena, Coelosphaerium, Aphanizomenon) sharply increases, whereas in the normal state the crustaceans prefer protococcals and diatoms. Somewhat by itself among other kinds of food stands Microcystis. This species of alga P. pediculus does not eat, either in the normal state (P=0.03%) nor in the hungry (0%). Found among cells of Microcystis, the crustacean soon dies (after 3-4 hours).

Thus, the basic food for P. pediculus is rotifers, infusoria, young Cladocera and fragments of detritus. Algae and dispersedly distributed bacteria can to some degree serve it only as a supplementary source of nutrition.

Literature

Butorina, L.G. 1965. Observations on the behaviour of *Polyphemus pediculus* and functions of its extremities in the process of feeding. *Trudy Inst.Biol.vnutr.Vod.* 8(11), 44-53.

Monakov, A.V. & Sorokin, Yu.I. 1961. Quantitative data on the nutrition of Daphnia. *Trudy Inst.Biol.vnutr.Vod.* 4(7).

Sorokin, Yu.I. 1960. Self-assimilation of C_{14} in preparations of invertebrates. *Trudy Inst.Biol.vnutr.Vod.* 3(6).

Eriksson, S. 1934. Studien über die Fangapparate der Branchiopoden. *Zool.Bidr.Uppsala*, 15.

Fischer, S. 1951. Branchiopoden und Entomostraken Ostsibiriens. *Mem.pres.Acad.imp.Sci.St.Petersburg*, 4.

Ischreyt, G. 1933. Uber *Polyphemus pediculus*. *Arch.Hydrobiol.* 26.

Comparative speed of assimilation of different kinds of plant food by Polyphemus.

Kind of food	State of food	Normal Polyphemus		Polyphemus starved for 10–20 hours	
		Assimilation/ 24-hours. 10^{-6} mg C/ex.	P, %	Assimilation/ 24-hours 10^{-6} mg C/ex.	P, %
Chlorella	live	16 (40)	0·1	(37)	(0·25)
Scenedesmus	"	111	0·7	42 (88)	0·3
Nitzschia	"	51 (84)	0·3	804 (288)	5·4
"	decomposed	8	0.05	0	0
Asterionella	live	26	0·2	0	0
"	"	19 (9)	0·1	82 (0)	0·6
Coelosphaerium	decomposed	62	0·4	0	0
Microcystis	live	5 (7)	0·03	0 (11)	0
Aphanizomenon	"	13 (10)	0·1	49 (28)	0·3
Anabaena	"	36 (15)	0·2	(113)	(0·7)
Chlamydomonas	"	37 (52)	0·2	112 (34)	0·8
Elodea, detritus	fresh	0	0	0	0
" "	decomposed	15	0·1	0	0
detritus of Vaucheria	fresh	276	1·9	0	0
bacteria	live	30	0·2	0	0

[2nd table, page 172]

Comparative speed of assimilation of different kinds of animal food by Polyphemus.

Kind of food	State of food	Assimilation in 24-hours. 10^{-6} mg C/ex.	P, %
Eosmina longirostris	live	109	0·74
" "	killed	19	0·1
" "	decomposed	0	0
" " (young)	live	2280 (935)	15·5
Asplanchna priod.	"	580	3·9
Conochilus	"	3860	26·3
Brachionus diversicornis	"	1148	7·8
" "	killed	272	1·9
Paramecium caudatum	live	3370	22·9
Daphnia longispina	"	0	0

Footnote. Figures in brackets signify results of parallel experiments continued over 24 hours.

P = index of assimilation.

Notice

Please note that these translations were produced to assist the scientific staff of the FBA (Freshwater Biological Association) in their research. These translations were done by scientific staff with relevant language skills and not by professional translators.