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MIKHAEVICH TATIANA VASILIEVNA

ECOLOGICAL AND ENERGETICAL CHARACTERISTICS OF THE BRYOZOAN PLUMATELLA FUNGOSA FROM THE REFRIGERATED WATER RESERVOIR OF THE BEREZOWSKAYA POWER STATION (BELARUS).

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THESIS

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Scientific Supervisor: N.N.Khmeleva, Professor

Official opponents: V.I.Popchenko, Professor
V.P.Semenchenko, Doctor of Biol.

The Head Institution: The Institute of Hydrobiology, Ac. Sci., Ukrainian SSR.

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G.A.Semeniuk, Doctor of Biological Sciences

General Description

Importance of the work. Complex and rational management of natural resources has been an extremely important problem regarding constantly increasing number of power plants and volume of warm waters. Due to the long-term thermal impact, the drastic changes of the hydrochemical and hydrobiological regimes occur in the cooling reservoirs. The most significant consequences of thermal press are rising temperature and heavy eutrophication. These two interrelated factors cause the supplanting of aboriginal moderate-water complexes by warm-water ones. As a rule, the eutrophication of reservoirs is followed by "flowering" with blue-green algae which are hardly consumed and are often toxic. Thus, it's very important to reveal potential consumers which can facilitate transformation of blue-green algae organic matter into detrital food chains. It's very important to study theoretically and practically all aspects of energy conversion in hydrobionts of warm-water reservoirs for their efficient use.

It appears nowadays that Bryozoa which almost have been neglected not long ago, are the important elements of organic substance turnover in warm-water ecosystems. In the Uchinsk, Chizhovsk, Ivankovsk water reservoirs and in the cooling reservoirs of Chernobyl Atomic Power Plant, Bereza, Zmievsk, Krivorozhsk and Tripol Power Plants, Bryozoa biomass can constitute on different substrate from 1 to 20 kg/m². Bryozoa form large biomass aggregations and consume suspension, thus, acting as biological filter which improves ecology of warm waters.

Nontraditional use of bryozoan biota and its ability to sedimentation of man-made reefs open good prospects for the wide-scale use of this biological filter capable of removing suspension and cleaning water reservoirs. Moreover, it forms new biotope for the introduction of commercially valuable benthic organisms, increases their abundance and biomass, and can serve as additional food for fish.

The study of productivity of freshwater bryozoans in the warm-water reservoirs has never been fulfilled before. So this pilot investigation of their ecology and their energetics makes a contribution to our knowledge of productive processes in thermal ecosystems and helps in solving some problems of ecological monitoring and controlled management of warm-water ecosystems.

Aim of the study. To make quantitative estimation of energy transformation by Bryozoa population in terms of the growth, defecation, respiration, reproduction, populational structure and to evaluate the functional role of bryozoans in the cooling reservoir.

The main tasks of the study:

1. To make quantitative account of the defecation and oxygen consumption rates in relation to temperature of the cooling reservoir.
2. To estimate quantitatively Bryozoa growth in relation to temperature and trophic conditions of the environment.
3. To determine somatic-to-generative growth rate ratio in bryozoan colonies.
4. To estimate the energy flow in bryozoan population and to make a comparative analysis of the efficiency of energy transformation relative to other mass benthic populations of the cooling reservoir.

The scientific novelty. The specific analysis of Bryozoa zooid and colony growth, defecation and oxygen consumption rates in the large gradient of temperature and trophic conditions of the cooling reservoir have been made for the first time. The time of the development of freshwater Bryozoa vegetative reproductive organs (floatoblasts and sessoblasts) and the ratio of somatic-to-generative growth rate in the colony were evaluated.

The revealed specifics of growth at the initial stages predetermines three-dimentional distribution of a modular Bryozoa organism. It's shown that the growth efficiency of assimilated food in bryozoans from the cooling reservoir reaches maximal index ever reported for other poikilothermal animals. In the gradient of trophic and temperature conditions of the cooling reservoir, the optimal growth has been observed within viability scale at high temperatures and low food concentration (8.8 – 17.5 mg of dry seston/litre) or at low temperatures and high (70 mg) food concentration.

It is found that in contrast to unitary organisms, the feeding and respiration of modular bryozoans at the initial growth stages in favourable conditions is not limited allometrically in relation to mass growth. That's why the relationship between the defecation and respiration rates and colonial mass are described by linear function.

Using the evaluated quantitative ratio for defecation, the functional role of bryozoans as biofilters in the process of utilizing organic matter of blue-green algae has been described. On the basis of the data obtained for all principal biological functions, the flow of energy through bryozoan population has been evaluated for different seasons of the year.

Applied aspect. Basing on the thorough research of the functional role of Bryozoa in the cooling reservoir, we received the data which can be used for ecological monitoring and management of warm-water ecosystems. The results of the study were used as a background for the estimation of tolerable thermal press and possible impact of discharged warm waters on biological processes in the cooling reservoirs of hydro-electric and atomic power plants for the Atomenergoproject Institute and the Fishery Management Department of Lithuania.

The author's results of study and the latest literature data on Bryozoa are used in the educational course "Invertebrates" at the biological faculty of the Belorussian State University.

Approval of the study. The results of the study were reported at the 1st and 4th Conference of Young Scientists, Zool.Inst., Ac. Sci. BSSR (Minsk,1982;1986); the 5th Conference of Young Scientists of the Institute of Hydrobiology, Ac. Sci. USSR (Kiev,1985); the 8th Conference of Young Scientists, Ac. Sci. USSR (Borok, 1987); the 7th All-Union Colloquium on Fossil and Resent Bryozoa (Moscow, 1986); the XXII All-Union Conference on Baltic Inner Reservois Study (Klaipeda, 1987); the 1st All-Union Conference of Young Limnologists (Leningrad, 1988); the 3d All-Union Symposium "Trophic Links and Productivity of Water Communities" (Chita,1988); a special Meeting of Scientific Consulting Council of Ichthyological Commission of Fish Management of Heated Waters, All-Union Hydrobiological Society Belorussian Department and Institute of Zoology, BSSR Ac. Sci. (Beloozersk, 1990).

Publications. Nine scientific articles have been published on problems of the dissertation research.

The size of the dissertation. The dissertation consists of 173 typed pages, including Introduction, 5 Parts and Conclusion, 45 Figures and 23 Tables, list of 85 native and 130 foreign references.

Part I. MATERIAL AND METHODS

The field and laboratory studies of freshwater Bryozoa *Plumatella fungosa (Pallas,* 1768) as a dominating species of zooperifiton have been performed on the basis of cooling reservoir of the Bereza Power Plant (Brest Region, Belarus) in 1983-1988. Species definition was confirmed by the Japanese specialist on phylactolemas Hideo Mukai (1988) from the Gunma University. Experimental study was fulfilled in the Laboratory of Comparative Hydrobiology of the Institute of Zoology, BSSR Ac. Sci., using the methods of Bryozoa cultivation developed by the present author.

Our research interests involve various aspects of Bryozoa viability at zooid and colony levels, in particular, lenght and weigth characteristics of zooids and statoblasts; energy content of zooids, statoblasts, consumed food and feces; defecation rate; oxygen consumption rate; linear growth of zooids and growth of colony abundance; time of generative product formation and the ratio of somatic-to-generative growth rate in Bryozoa colony; seasonal dynamics of the populational structure.

The material obtained was analyzed according to the traditional hydrobiological methods (Methods of evaluating the productivity in aquatic animals, 1968).

The studies of defecation and oxygen consumption rates were made simultaneously under similar temperature and trophic conditions (35g of dry matter/liter). For the estimation of bryozoan defecation and respiration in the gradient of naturally existing temperatures 15-20-25-30-33-35°C we used colonies from the cooling reservoir; for high temperature gradient – from thermal channel (33°C), for low temperatures from the cooling reservoir Beloie Lake (25°C). Before the experiment Bryozoa colonies were kept for acclimation at experimental temperatures for 6 hours. The longer period of acclimation is unreasonable because bryozoans can die.

Bryozoan colonies inhabit an extremely abundant biota, so to avoid mistakes in respiration they were cleared from accompanying organisms.

Because of great value variations as compared to other physiological parameters, the growth of Bryozoa from statoblasts at the initial stages of colony growth was studied in relation to two dominating factors of the cooling reservoir – the temperature gradient of 20, 25, 30, 33°C and seston concentration of 8.8, 17.5, 35 and 70mg of dry matter per liter. This corresponded to 4 times and 2 times lower concentration than in natural seston in summer (35mg) and its 2 times concentration. Some temperature corrections were obtained during the study of relationships between process rates (defecation, growth, respiration) and temperature. The principal biological processes in Bryozoa colonies were investigated under natural conditions of feeding by seston inhabiting the cooling reservoir. The time of statoblast development and the somatic-to-generative growth rate relations were studied in the colony fed on Chlorella at 25°C. The daily growth diagram was drawn.

The structure of the Bryozoa population was studied in the sites of mass colony development on the pontons with stews fixed in the warm-water channel of the cooling system. Zooid and statoblast number and biomass of colony were estimated.

The energy flow in the Bryozoa population was estimated using the equation: $A = Ps + Pg + T$. Calculation of energy balance was made in terms of such data on populational structure as growth and respiration rates and time of generative product formation through the year round. Daily somatic production (Ps) was estimated by multiplying colony growth rate into average biomass. Generative production (Pg) was calculated basing on generative growth of bryozoan population.

The ratio of assimilated food efficiency for somatic growth ($K2 = \frac{Ps}{Ps+T}$) was calculated using integral values of its consumption for metabolism and growth. All components of the balance equation were calculated on the basis of relationship revealed during present research.

The material obtained was analyzed statistically using special program and DVK-3 computer.

Part II. SHORT DESCRIPTION OF THE FRESHWATER BRYOZOA BIOLOGY AND LIVING CONDITIONS

The freshwater bryozoans constitute an important component of the greater part of natural ecosystems. However, their biology and relations with ecological environmental factors have been hardly ever studied.

There were no reports on the bryozoan fauna of Belarus before 1986. Even at present there's no list of bryozoan species of Belarus but we assume that it is very similar to that of the Ukraine and Poland. For Ukrainian fauna 7 freshwater bryozoan species were reported – *Plumatella fungosa, P.repens, P. emarginata, P. fruticosa, Fredericella sultana, Cristatella mucedo, Lophopus crystallinus* (Braiko, 1983). For Poland the list is the same, but instead of the latter is *Paludicella articulata* (Konopacka, Szymalkowska, 1980).

Due to the increasing anthropogenic impact on water reservoirs, mass development of Bryozoa has been observed. This necessitated their ecological and energetic study in addition to traditional faunistic approach aimed at defining the functional role of the freshwater bryozoans in new ecosystems.

Mass development of bryozoans is related to clonal development and high rate of replication. Together with the hydroids, sponges, corals, colonial ascidiforms and many other protozoa, fungi and plants, bryozoans constitute among 19 types a group of abundant modular organisms. In contrast to unitary organisms, the modular ones consist of number of monomorphic constructive modules which vary greatly in number and are highly environment-dependent in their development. If in plants the main constructive module is a leaf, then in Bryozoa it is zooid. If in unitary organisms the notion "specimen" is clearly defined, then in modular organisms it is not. For bryozoans different authors define as a "specimen" both the whole colony and zooids. It is known that all zooids are interrelated in a bryozoan colony, still we shouldn't exclude the fact that zooid is a functional unit of an integral colonial organism which performs principal biological functions – feeding, respiration, growth and reproduction. In this respect the term "ganet" introduced by Kays, Harper (1974) seems to be more preferable which means that "genetic individual", or in other terms, colony of bryozoans is a pattern developed from one zygod , or statoblast, in case of vegetative reproduction. However, in natural conditions it is very difficult to distinguish an individual bryozoan "ganet", because it is impossible to find the number of statoblasts in the given colony, especially under rapid growth of bryozoans in warm waters. In this connection, the study of ecology and biology of modules is more preferable. Thus, the modular organisms should be studies at two interrelated levels: the level of module (zooid) and the level of colony. This is what we did during our work.

Bryozoan distribution depends on many factors. It is very important what is the type of substrate, especially during sedimentation of larvae and statoblasts. Freshwater bryozoans prefer slow waterflow, they are rather indifferent to light intensity and oxygen content of water. Most of bryozoans are euritherms but some are stenotherms, as for example, arctic bryozoans living at 1-2°C.

In the cooling reservoir of the Bereza Power Plant Bryozoa *P. fungosa* lives in a wide gradient of temperatures through the year – from 7- 8°C to 38°C. In summer the most typical temperature is 30-33°C which inhibits bryozoan growth. The extreme temperature for spring and autumn populations is 38°C, for winter – 36°C.

The oxygen content of water decreases sharply with rising temperature. Actually during the whole year round in the system of the cooling reservoir, the mass development of planktonic blue-green algae (*Anabaenopsis raciborskii, Aphanisomenon flos-aquae, Oscillatoria limnetica*) is observed. The distribution of the bryozoan population is limited by availability of substrate. As macrophytes occupy only 3% of the lake square, and bryozoans grow only on the lower 5-10 cm part of their stems, their biomass in the lake is rather small. Bryozoa live on iron pontons, stews, stone channel sides. At the initial growth stages zooids formed sphere-shaped colonies. Growing into each other, bryozoan colonies gradually formed a thick "carpet" which was maximal on stews. Due to the fact that growing bryozoans have been constantly removed from stews by fishery farm workers in order to maintain good conditions of fish nursery, the samples of bryozoans were taken on iron pontons where living conditions were more stable and biomass – rather significant.

Basing on the data obtained, the principal weight and energy characteristics for zooids and statoblasts have been evaluated. The coefficients of equation relating dry and wet mass to the number of zooids, floatoblasts and statoblasts were calculated.

Table 1

Weight and Energy Characteristics of Bryozoa *P. fungosa*

Indices	zoid	floatoblast	sessoblast
Average wet mass, mg	0.394	0.0167	0.0639
Dry mass, mg	0.0404	0.0059	0.0211
Dry matter content, %	9.77	39.85	35.17
Average caloric content,			
Cal/mg of dry matter	3.67	3.84	3.69
Energy equivalent, cal/spm	0.15	0.023	0.078

Part III. THE IMPACT OF ECOLOGICAL FACTORS ON DEFECATION, GROWTH AND RESPIRATION

The study of the principal vital processes of bryozoans is quite necessary for elucidating their functional role in the ecosystem of the cooling reservoir.

Defecation. In the cooling reservoir the main food for bryozoans is seston, with blue-green algae dominance. As they produce distinct fecal packets consisting by 95% of blue-green algae *A. raciborskii,* we estimated their ability to settle out suspended organic matter, or to act as biofilters in terms of fecal packets production rate per time unit in the gradient of temperatures 15-35°C, typical for cooling reservoir.

If in unitary organism the relation between body mass and consumed food amount is described by power function, then in bryozoans as modular organisms with no program of aging, the colony mass-to-fecal mass relations are described by linear function. Basing on the correlation obtained, the temperature dependent rate of bryozoan defecation at the stage of zooid was described in the temperature gradient of 15-30°C by the following exponential function:

$$Vf = 0.29\, e^{0.045\, t^{\circ}C} \qquad (Sy = 0.13,\ c.v. = 32.8,\ r = 0.99) \qquad (1)$$

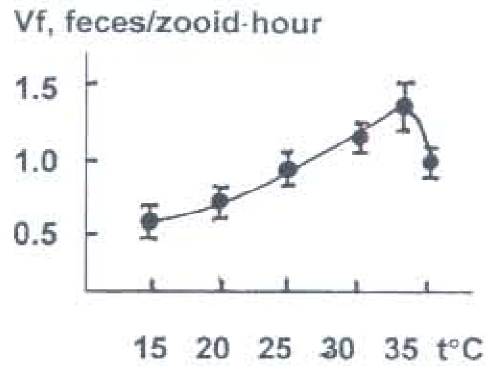


Fig.1. The relation between temperature and defecation rate in Bryozoa P.fungosa.

As we see from Fig. 1, with growing temperature the defecation process goes 1.2 times faster at 20°C, 1.4 – at 25°C, 1.9 – at 30°C and 2.2 – at 33°C. The maximal fecal production is observed at 33°C. The temperature of 35°C inhibits sedimentational activity of bryozoans.

Growth. The growth and plasticity of modular organisms is much greater that of unitary ones. It is modular pattern that provides this plasticity, since all principal vital functions of bryozoans are realized both at the modular (zooid) level and at the integral organism level (colony).

Three patterns of modular organisms can be distinguished: horizontal (bryozoan growth at the initial stages), vertical and combined (wide-distributed colonies of corals and bryozoans).

Bryozoan colony growth is a replication of monomorphic modules (zooids) which have low variability. Three-dimensional distribution of the colony at definite developmental stages is a result of appearance of zooids, or "growth leaders", of bigger size and with more tentacles which consequently, better respiratory and feeding conditions.

The linear growth of small and big zooids is descibed in Fig.2 by power function $y = ax^b$.

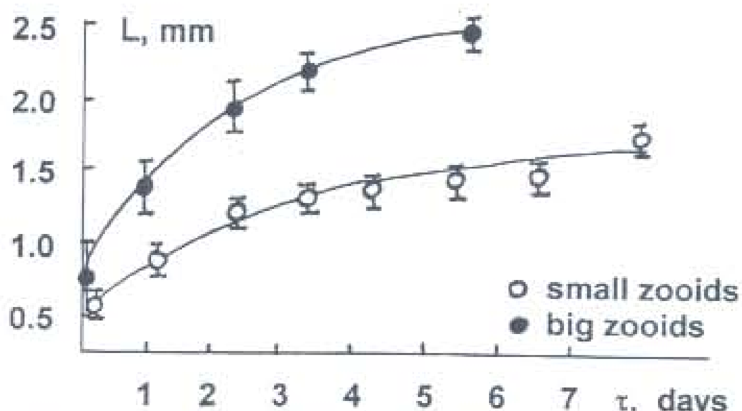


Fig.2. The linear growth of Bryozoa *P.fungosa*

The specific rate of linear growth in big zooids is higher than in small ones at the initial stages of colony growth and makes up for the period of 1.34 days from germination 0.54 and 0.34 $days^{-1}$, respectively. Thus, the leaders' growth rate was 1.5 times higher than that of small zooids; this enables the colony to occupy new spaces while growing and to replicate in three dimensions.

Table 2

Parameters and Statistic Indices to the Equation of Linear Growth For Small (N 2) and Big (N3) zooids

N of Equation	a	b	σy	Sy	c.v.	r	Number of counts
2	0.98	0.30	0.34	0.12	27.4	0.99	270
3	3.13	0.18	0.68	0.30	39.5	0.96	37

At the initial stages of germination from statoblast, growth of the colony as the most variable physiological parameter was studied under the influence of two dominating factors: gradient of temperatures 15 – 33°C and seston concentration 8.8, 17.5, 35 and 70 mg of dry matter per liter. As we see from Fig.3, the maximal specific growth rate of the colony dry mass at low seston concentration of 8.8 and 17.5 mg is observed at high temperatures (30 – 33°C). Maximal value of specific growth rate at high seston concentration of 70 mg was registered at low temperatures (25 – 27°C).

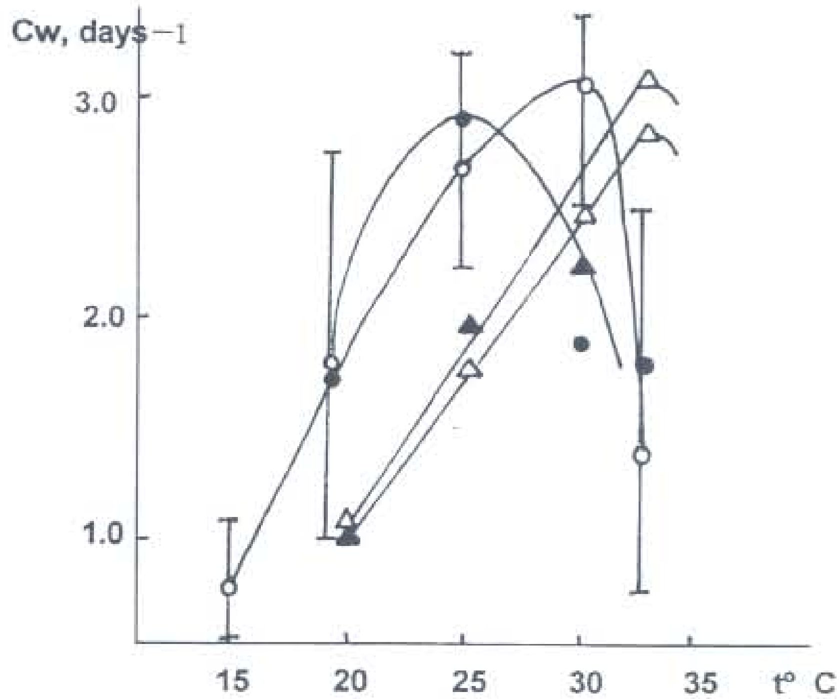


Fig.3. Temperature dependence of specific growth rate of bryozoan colony dry mass at different seston concentrations in the cooling reservoir.

● 70   o 35   Δ 17.5   ▲ 8.8   mg of dry matter/l

The optimal bryozoan growth at the average dry matter content of 35 mg was observed at 25 – 30°C during summer experiments. For the temperatures of 15 – 33° the linear temperature dependence of specific growth rate of the bryozoan colony dry mass was calculated :

$$Cw = 0.017 \cdot t^{\circ} C - 0.17 \qquad (\sigma y=9.11,\ Sy=0.005,\ c.v.=52.6,\ r=0.99) \quad (4)$$

which shows that at 20°C rises 1.5 times, at 25°C – 3.8, at 30° C – 4.6 times.

Respiration. It is known that the relation between oxygen consumption rate and body mass in unitary organisms is described by power function. Besides, the growth of animal mass is related allometrically to respiration. On the contrary, respiration of modular bryozoans which consist mostly of monomorphic interrelated zooids is not limited allometrically by the growth of colony mass . The limits can be imposed by environmental factors – unavailability of substrate, oxygen deficiency and others. In this respect the ratio of oxygen consumption rate to colony raw mass in the temperature gradient of 10 – 35° C is described by linear function. The dependence of the average respiration rate of zooid (R, mcl/zooid·hour) and intensity of colony respiration (R/W, mcl/mg·hour) on temperature is described by exponential function at 10 – 33 °C:

$$R = 0.015\ e^{0.089t\,^{\circ}C} \qquad (\sigma y=0.12,\ Sy=0.05,\ c.v.=85,\ r=0.97)\ (5)$$

$$R/W = 0.038\ e^{0.089t\,^{\circ}C} \qquad (\sigma y=0.30,\ Sy=0.12,\ c.v.=85,\ r=0.97)\ (6)$$

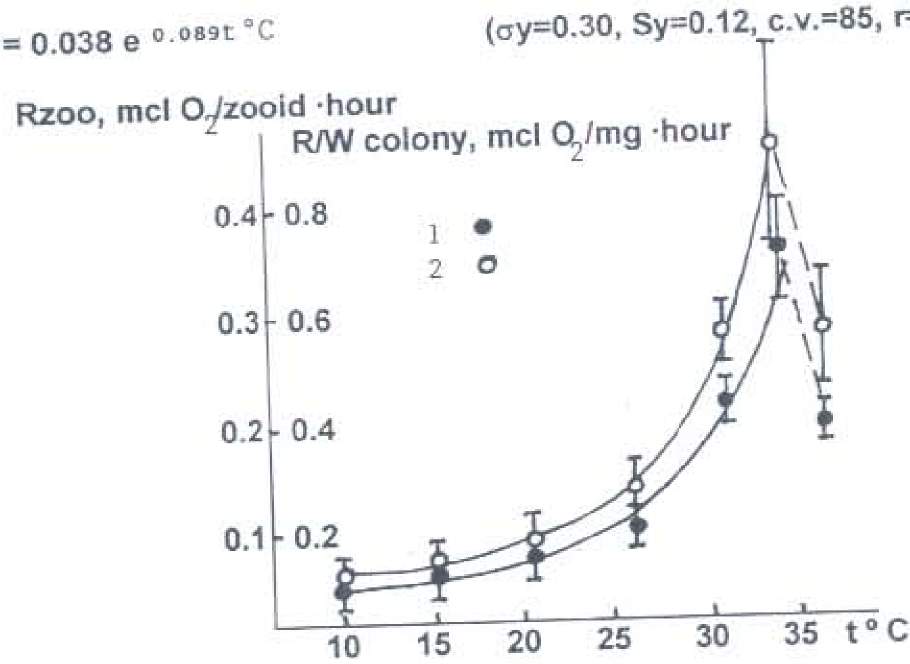


Fig. 4. Temperature dependence of the oxygen consumption rater (1) (Rzoo, mcl O_2/zooid hour) in bryozoan zooid and of the respiration intensity in the colony (2) (R/Wcolony, mcl O_2/mg hour).

As it is shown in Fig. 4 , the maximal respiration rate of zooid and intensity of colony metabolism are observed at 33°C, while at 35°C these physiological parameters go sharply down.

The comparison of Q10 value for the process studied showed that the defecation process is more temperature-dependent as Q10 varies within narrow range. Though rising temperature significantly intensifies metabolism, the maximal values of respiration and defecation rate have been observed at the same temperature range – 25 – 33°C. The high Q10 values for growth and respiration rates can be explained by the fact that bryozoans exist on the upper limit of species viability scale. For bryozoans of the cooling reservoir, the optimal range is 20 – 30° C.

Table 2

The Q10 values for temperature-intensified defecation, respiration and specific growth rate in Bryozoa *P. fungosa*

Parameter	temperature, t°C							
	10-15	15-20	20-25	25-29	25-30	29-33	33-33	30-35
Defecation Rate	1.54	1.37	1.48		1.72		1.79	1.24
Respiration Rate		1.87	1.75	6.76		3.33	1.15	
Specific growth Rate		5.11	2.82		1.43			

In this way through various responses of processes to temperature, the effect of high plasticity is achieved by modular organisms of bryozoans which live in the conditions of wide temperature range and suffer from temperature press in the cooling reservoir.

Part 4. REPRODUCTION OF FRESHWATER BRYOZOA

Reproduction is the principal function of the organism which is responsible for its preservation in time and space.

If during somatic colony growth the main constructive module is zooid, then during vegetative reproduction of bryozoans from the cooling reservoir it is statoblast. Two types of statoblasts are distinguished: drifting small and abundant floatoblasts and attached big and scanty sessoblasts.

Statoblasts of freshwater bryozoans are species-specific reproductive cryptobiotic structures formed during the process of adaptiogenesis to extreme environmental conditions. They possess physiological endogenous mechanism of dormacy and resistance to wide range of environmental factors similar to protozoa cysts, spores of ferns, moss, galls, eggs and larvae of some worms and arthropoda, gemmules of freshwater sponges, hybernaculars of seawater Bryozoa. As a result of such adaption and resistance, the principal function of freshwater Bryozoa which is responsible for their preservation in time and space, namely reproduction, is realized.

Bryozoan colony consisting approximately of 61 zooids produced 61 floatoblasts and 14.7 sessoblasts in the ratio 4:1.

According to empirical data presented in Fig. 5, the exponential relation of number of floatoblasts (7), sessoblasts (8) and zooids (9) to colony growth time have been calculated. The indices of generative – somatic growth estimated in terms of floatoblast and sessoblast energy have 1:1 ration.

Table 3
Parameters and statistic indices of the equations N 7 – 9 for generative-somatic colony growth in Bryozoa.

N of equation	a	b	σy	Sy	c.v.	r	n
7	1.84	0.085	20.0	20.3	98.5	0.82	47
8	1.57	0.061	3.9	8.3	46.8	0.92	22
9	7.38	0.055	19.3	29.6	65.4	0.82	54

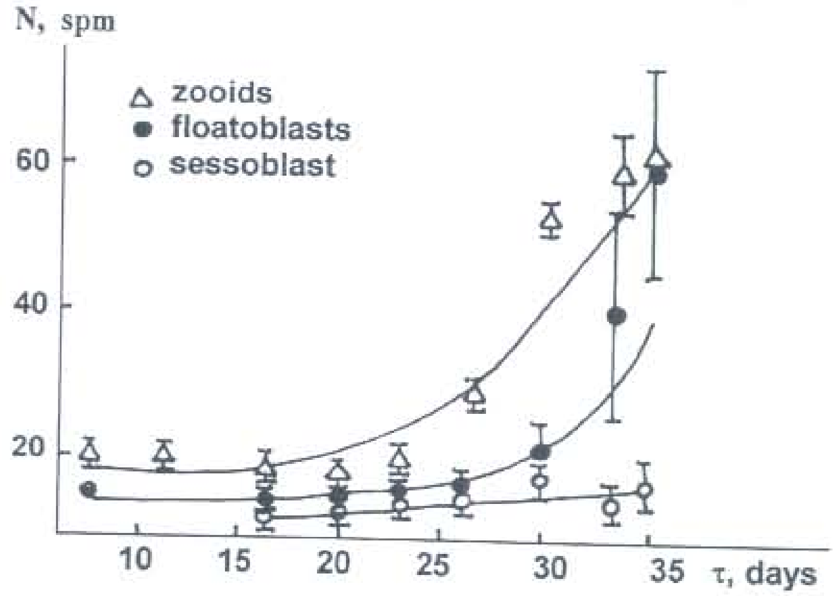


Fig. 5. Growth of number of zooids, floatoblasts and sessoblasts in the Bryozoa P.fungosa colony.

Thus, though the number of floatoblasts is 4 times higher, their contribution to generative colony growth is equivalent to that made by sessoblasts which have 3.6 times higher mass. The development time for 2 types of statoblasts also differs and makes up 5.3 and 3.8 days for floatoblasts and sessoblasts, respectively.

Relative fertility or the index of generative-somatic colony growth in terms of energy of both type statoblasts made up 37%, so it is consistent with the same data known for other invertebrate groups. The index of reproductive effort calculated in terms of total generative growth for statoblasts of both types, made up 0.27.

It should be noted that formation and quantity of different vegetative product and its energy content is related in bryozoan colony to different functional role of statoblasts of 2 types. Role of statoblasts is to occupy by species as wide area as possible, so they are produced in small mass and great number. The role of floatoblasts is to provide constant colony development at one and the same site. As sessoblasts have more stable animals lies within 0.2 – 0.4 range (Winberg, 1985). According to our data the bryozoan population has a high efficiency of somatic growth reaching maximal values reported for poikilothermal animals (Zaika, 1983). Specific production is also very high and it corresponds to that known for such water animals as hydra, ascidiforms, siphonophores and jellyfish.

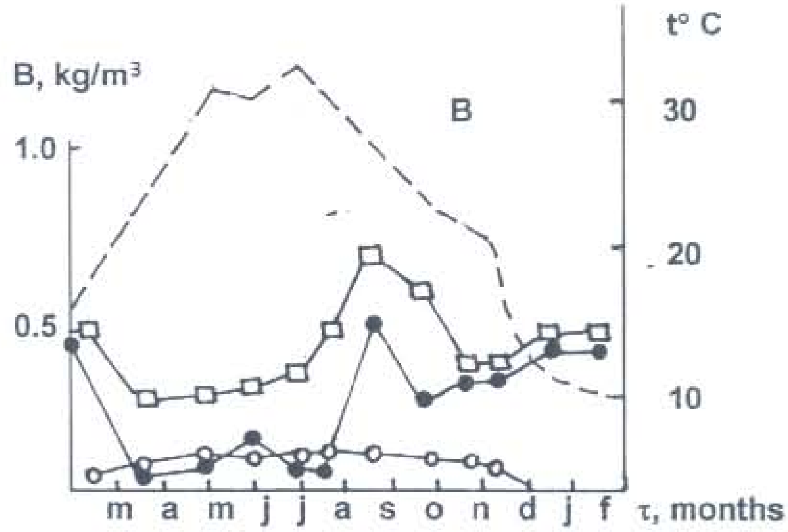


Fig. 6. Average annual dynamics of zooid and statoblast number (A) and bryozoan overgrowth (B) in the cooling reservoir.

□ overgrowth   o zooids   • statoblasts

While estimating the role of bryozoans in the transformation of blue-green algae, the main supplier of organic matter in the cooling reservoir, it was found that in summer bryozoan colony covering 1 m² of substrate settles the matter in a quantity equal to that of primary product of phytoplankton produced in the volume of 74 m³ of thermal channel.

The comparison of energy flow going through bryozoan population acting as sedimentator, and through microphages, widely spread in its biota ostracoda and dominating in benthos mollusc phisella, revealed the highest absolute values of energy flow in bryozoans. Energy flow through microphage populations of ostracoda and phisella made up 7.3 % of the net phytoplankton product. If the microphage ration totally consists of 60%-assimilated pellets settled out by bryozoans, it is obvious that they are able to consume only 0.2 % of bryozoan pellet energy.

It can be stated that actually all energy-containing suspended matter settled by bryozoans out of water flow is being used in the ration of sapro-and-detritophages. Because of extremely low assimilation of the consumed by bryozoans suspension (6.2%) and low coefficient of ecological efficiency (K1= 1.6%) , we can state that their principal role in the cooling reservoir is to settle suspension without proper utilizing it as a food and to supply bottom biocenoses with highly active seston matter for its conversion into detrital chains. The abundant feces produced by Bryozoa populations during vegetative season gives the evidence of significant role of bryozoans in self-cleaning of the cooling reservoir.

living conditions, they are greater in size but smaller in number as compared to drifting floatoblasts which die a lot , if not attached to substrate.

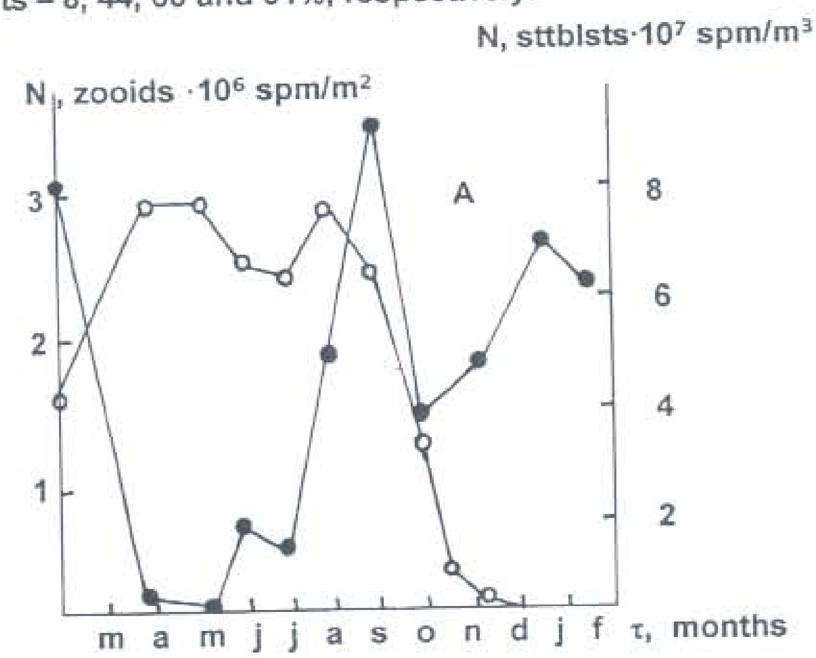
The mechanism regulating production process in statoblasts of 2 types is unknown as well as unknown is the mechanism of choice of either sexual or vegetative reproduction strategy and factors inducing it. It's quite possible that in warm waters bryozoans choose a simpler vegetative type of reproduction with advantageous number of offspring by producing statoblasts.

Part 5. EVALUATION OF BRYOZOA SIGNIFICANCE IN THE COOLING RESERVOIR

The data on abundance and biomass dynamics in combination with the obtained parameters on growth, respiration and reproduction may be used for estimation of energy flow in Bryozoa population of the cooling reservoir.

The specific structure of the bryozoan population predetermines the share of the contribution of somatic (zooids) and generative product (statoblasts) into total production of the population.

Bryozoan overgrowth is a three-component formation of up to 3 cm tall. It has upper self-replicating live layer (zooids) producing generative product of statoblasts which are accumulated in dead tubes of zooids (lower non-live layers). The share of zooids in the total overgrowth makes up 28% in spring, 30% - in summer, 10% - in autumn and 0.95 – in winter; of statoblasts – 8, 44, 60 and 91%, respectively.



In the energy flow going through bryozoan population in spring-summer season, the main share belongs to somatic, in spring-winter – to generative production, the latter being more significant. Generative production begins in summer, reaches maximum in autumn. Dead overgrowth accumulates generative product which we called "generative depot" in winter. Loss of energy for metabolism in bryozoan population is not very significant and depends on somatic component. According to literature data, the most typical value of K2 for aquatic

Table 4. Energy flow through the population of Bryozoa P.fungosa in the cooling reservoir at different seasons.

Season	Zooid number, Spm/m²	Statoblast number, spm/m³	Zooid biomass kcal/m²	Statoblast biomass, kcal/m³	Overgrowth biomass, kg/m³	kcal/m² · day				K2	%, Ps/A	%, Pg/A	%, T/A	C, day^{-1}	%, A/B	Feces production, kcal/m²·season
						Ps	Pg	T	A							
Spring	$2.7 \cdot 10^6$	$1.4 \cdot 10^7$	400	317	0.39	80	1.5	33.4	115	0.70	70	1.3	29	0.20	16	92520
Summer	$2.9 \cdot 10^6$	$2.9 \cdot 10^7$	430	657	0.39	133	99	74.4	306	0.64	44	32	24	0.31	28	140850
Autumn	$1.4 \cdot 10^6$	$6.0 \cdot 10^7$	208	1360	0.58	42	560	17.3	619	0.70	7	90	3	0.20	40	48276
Winter	$0.09 \cdot 10^6$	$6.6 \cdot 10^7$	13	14950	0.42	0.6		0.5						0.045		2016

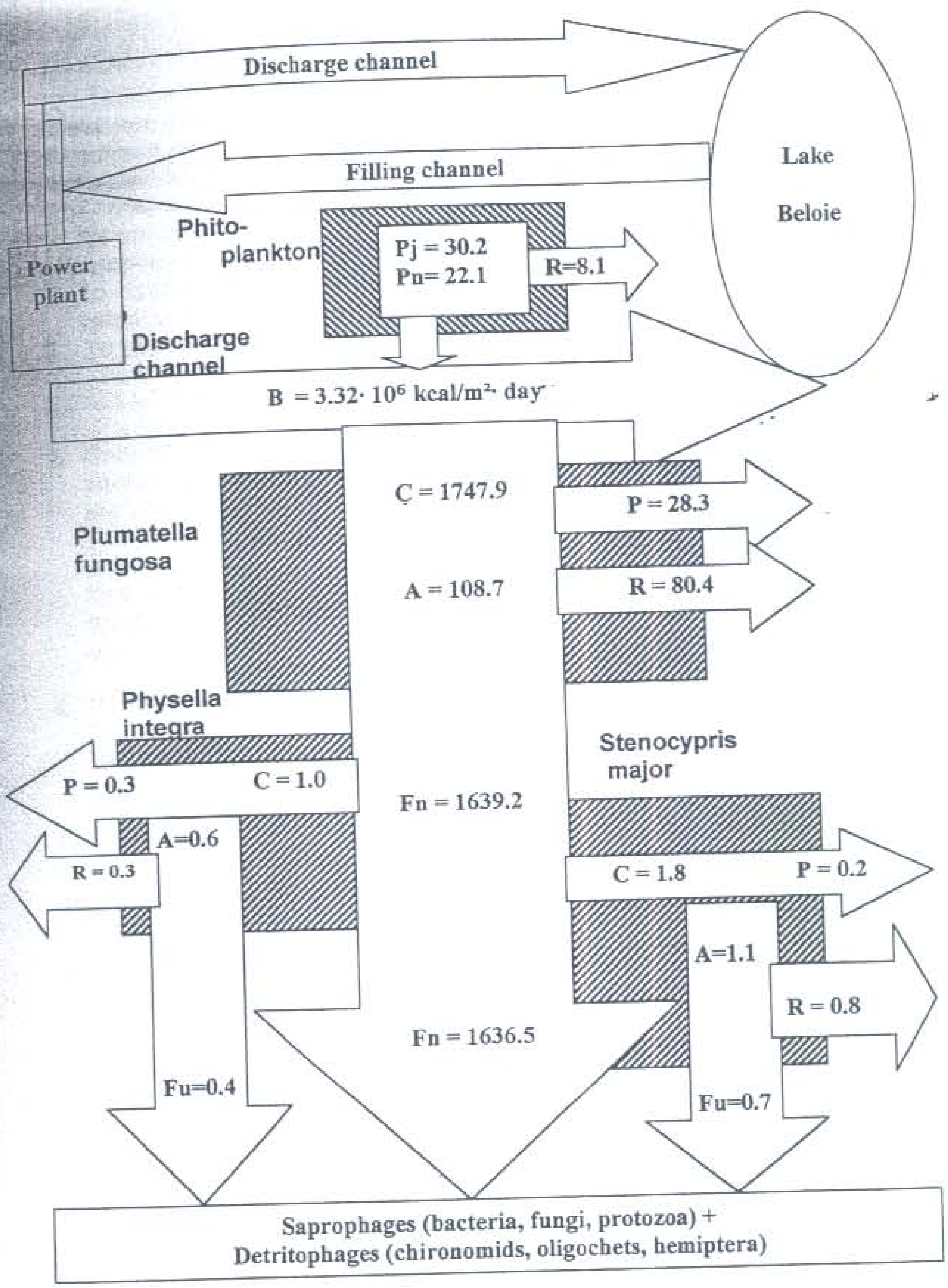


Fig.7 The diagram of organic matter transformation in the block: blue-green algae (kcal/m³·day) – Bryozoa – molluscs – ostracoda (kcal/m²·day).
B – total energy content of seston moving through channel; Pj- gross, Pn- net phytoplankton production; P = Ps + Pg – total production (Ps – somatic, Pg – generative); R – energy loss for respiration; A – assimilated energy; C – ration; Fn – fecal pallets; Fu – nonassimilated food.

We suggest that bryozoan ability to sedimentation activity and to formation of specific biota can be successfully used in the future on man-made reefs installed in the sites which are favourable for bryozoan mass development, in particular, in the cooling reservoirs of atomic and other power plants. Man-made reefs help to solve several tasks:

1. To increase the square of biological filter capable of removing suspension from water and to clean the reservoir.
2. To create a new biotope for the introduction of commercially valuable benthic organisms.
3. To get additional food for fish.

CONCLUSION

1. Quantitative analysis of energy transformation process at the level of zooid, colony and population of freshwater Bryozoa *P.fungosa* from the cooling reservoir of the Bereza Power Plant has been made. It is shown that due to specificity of modular organism , which is characterized by modules' autonomy (zooids), to its replication and interrelation with the whole colony, bryozoan population acquires quality of thermoplasticity and ability to maintain high abundance and biomass under increasing temperatures.

2. It is found out that unlike unitary organisms, modular bryozoans are not allometrically limited in feeding and replication with mass increase, so the ratio of the oxygen consumption and defecation rates to colony mass is described by linear function. The comparative analysis of Q10 values for biological processes showed that the defecation process is not temperature-dependent. The maximal Q10 values for these processes are registered in 20 – 30°C range which is optimal for bryozoan viability in the conditions of the cooling reservoir.

3. It is shown that modularity of bryozoans predetermines high plasticity and three-dimensional distribution. The colony growth is a process of replication of monomorphic modules (zooids) which tend to develop in horizontal (at the initial stages), vertical, or both directions. The colony's three-dimensional structure is provided by growth zooids or "leaders" which tend to occupy new space for the colony.

4. It is found out that in the cooling reservoir under the impact of dominating temperature and trophic conditions, the bryozoan colony growth at the initial stages is quite specific. It is shown that maximal specific growth rate at low seston concentration (8.8 – 17.5) is observed in the high temperature range (30 – 33°C) and at high seston concentration – in the low temperature range (23 – 27°C) of species viability scale in the cooling reservoir.

5. It is shown that in the process of adaptiogenesis to extreme environmental factors, freshwater bryozoans produce special forms of cryptobiotic life, namely statoblasts which have high adaptability to various environmental factors and physiological mechanism of tolerance to these factors at the stage of dormacy. Thus, they

perform three functions: vegetative reproduction, survival in time and distribution in space. It is revealed that in bryozoans of the cooling reservoir replication takes place due to statoblasts of 2 types: drifting small and numerous floatoblasts and attached big and scanty sessoblasts. Though the number of floatoblasts is 4 times higher, the generative growth rate of the colony in energy terms due to floatoblasts and sessoblasts is equal. Regulation of production and quantity of vegetative generative product in the bryozoan colony is related to different functional significance of 2 types of statoblasts: the drifting ones ensures distribution over new areas, the attached-germination at the place of the previous colony.

6. It is revealed that the energy flow going through bryozoan population of the cooling reservoir depends on the populational structure and the share of somatic and generative production. In spring and summer the prevailing growth strategy is somatic, in autumn – generative, the latter dominating. The coefficient of net efficiency of somatic population growth K2 and specific production have maximal value known for poikilothermal animals.

7. It is foud that in the cooling reservoir, the blue-green algae are utilized poorly by Bryozoa. Fecal production prevails over total production in bryozoan population. The main function of bryozoans as biological filters of the cooling reservoir is to settle organic matter of seston for its further conversion into detrital chains.

8. The data obtained on the ecology and energetics of freshwater Bryozoa from the cooling reservoir are quite important for forecasting their development in order to control their overgrowth, to carry out ecological monitoring and management of warm-water ecosystems.

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