KOMITET EKOLOGICZNY - POLSKA AKADEMIA NAUK

EKOLOGIA POLSKA - SERIA A

Tom XI Warszawa 1963 Nr 19

Ewa PIECZYŃSKA, Eligiusz PIECZYŃSKI,
Tadeusz PRUS and Kazimierz TARWID

THE BIOMASS OF THE BOTTOM FAUNA OF 42 LAKES IN THE WĘGORZEWO DISTRICT*

An analysis was made of certain regularities found in the formation of the biomass of the bottom fauna in a group of Masurian lakes. The biomass of the lakes examined varies within limits of 0.2 to 37.0 g/1 m², not exceeding 6 g/1 m² in the majority of the lakes. It was found that lakes of the pond type possess a greater biomass than eutrophic lakes. The positive correlation of the biomass with primary productivity[1], and the negative correlation with the mean size and depth of the lakes were shown. In some cases, however, certain deviations were observed from the above mentioned regularities.

Investigations of the bottom fauna of lakes in the Węgorzewo district were carried out within the framework of group research on the fish farming of the lakes in this area, initiated and directed by the Institute of Inland Fishery, owing to which these lakes are relatively well known from the limnological and fishery aspect. *Inter alia* data have been published on the morphology and morphometry of the lakes (Kondracki and Szostak 1960), vegetation (Bernatowicz 1960), growth of fish (Zawisza 1961) and many of the abiotic elements of the environment (Patalas 1960a, 1960b, 1960c, 1960d).

The field part of the work on the bottom fauna of the Węgorzewo district lakes was carried out from 1953–1955. In order to determine the biological productivity of the bottom zone in the middle of the lake, series consisting of 10 samples were taken by means of the Szczepański type tubular sampler

*From Institute of Ecology, Polish Academy of Sciences and from University of Warsaw, Chair of Evolutionism and Animal Ecology, Warszawa.

[1]Acc. Patalas (cf. Fig. 3).

Basic data on the lakes analysed in the Węgorzewo district

Tab. I

No.	Name of lake	Limno-logical type	Area in ha	Mean depth in m	Biomass g/1 m²		Participation in biomass (in %)		
					range	mean	*Tendipedidae*	*Oligochaeta*	Other groups
1	Arklickie	*P*	62.2	1.3	6.9–9.3	8.1	33	1	66
2	Babka	*E*	33.1	2.9	2.3–5.0	3.7	40	5	55
3	Bartelnik	*P*	10.0	1.4	–	37.0	99	1	–
4	Białe	*P*	7.4	1.2	3.1–14.9	6.9	62	20	18
5	Biała Kuta	*P*	21.3	1.7	0.0–0.9	0.6	100	–	–
6	Bimbinek	*E*	6.6	3.6	0.8–12.2	2.5	24	19	57
7	Brzozówka	*E*	58.5	3.8	4.0–5.5	4.8	49	50	1
8	Ciche	*E*	16.6	3.5	–	0.5	–	20	80
9	Czarna Kuta	*P*	25.2	1.3	0.0–0.7	0.2	100	–	–
10	Czarna Woda	*P*	1.4	2.2	1.4–18.9	11.3	96	2	2
11	Głęboka Kuta	*E*	17.9	7.6	0.1–0.3	0.2	79	21	–
12	Gołdopiwo	*b-M*	860.4	12.6	2.1–65.2	13.8	78	5	17
13	Jagoczany	*P*(?)	4.2	2.2	3.1–15.0	7.1	66	26	8
14	Kirsajty	–	206.8	2.5	3.9–6.7	5.3	35	2	63
15	Krzywa Kuta	*E*	122.9	4.0	0.0–24.0	3.7	63	14	23
16	Lemięt	*E*	70.5	5.5	–	0.7	10	90	–
17	Łękuk Wielki	*E*	23.9	4.6	–	2.0	61	15	24
18	Mszar	*S*(?)	2.0	0.3	–	0.2	18	82	–
19	Oświn	*P*	637.9	1.1	25.4–30.8	28.1	64	11	25
20	Piecek	*S*	23.3	3.4	0.8–1.1	1.1	–	49	51
21	Piłaki Wielkie	*P*	8.7	1.5	–	5.9	27	41	32
22	Pniewskie	–	45.2	1.5	6.4–9.9	8.2	17	1	82
23	Pozezdrze	*P*	124.3	2.2	3.7–7.5	5.6	52	46	2
24	Przerwanki	*P*	6.5	0.5	–	4.2	88	5	7
25	Przylesne	*P*	25.9	1.0	15.2–25.5	20.4	50	7	43
26	Purwin	*P*	3.2	1.3	–	0.3	–	100	–
27	Rominty	*P*	25.3	0.9	8.6–29.7	15.6	7	44	49
28	Rydzówka	*E*	511.9	7.5	1.2–6.4	3.8	82	1	17
29	Siewki	*E*	21.3	3.6	0.2–9.4	3.4	1	6	93
30	Silec	*E*	109.0	5.3	0.8–5.0	2.6	73	27	–
31	Siniec	*E*	38.6	6.6	0.3–16.2	5.2	17	2	81
32	Smolak	*S*	5.3	2.4	–	27.5	11	5	84
33	Sołtmany	*E*	181.0	4.7	–	3.4	–	15	85
34	Stręgiel	*E*	411.6	3.7	–	4.8	77	12	11
35	Stręgielek	*E*	39.4	3.5	4.4–6.9	5.6	43	53	4
36	Święcajty	*b-M*	813.8	10.5	0.5–7.8	2.8	75	16	9
37	Upinek	*E*	10.0	2.0	0.6–2.1	1.4	59	36	5
38	Węgielsztyńskie	*P*	77.8	1.4	–	0.7	100	–	–
39	Wilkus	*E*	94.4	1.7	0.8–3.2	1.7	80	4	16
40	Żabin	–	32.2	1.4	–	18.1	80	18	2
41	Żabinki	*E*	40.6	10.6	0.0–6.4	2.6	48	45	7
42	Żywy	*E*	115.0	4.7	0.0–3.2	1.1	35	14	51

Stangenberg's limnological types (acc. Patalas 1960d): *E* – eutrophic lakes, *P* – pond type lakes, *b-M* – b-mesotrophic lakes, *S* – „suchar's" acido-dystrophic lakes).
Data on area and mean depth of lakes acc. Kondracki and Szostak (1960).
Other groups (in order of frequency of occurrence): *Heleidae*, *Ephemeroptera*, *Asellus aquaticus* Racov., *Hirudinea*, *Trichoptera*, *Sialis lutaria* L., *Coleoptera*, *Odonata*.

which has a surface of 10 cm^2, and in the first year of study the Ekman dredger which has a surface of 225 cm^2, was also used. Samples were taken in a sequence usually arranged along the longest axis of the lake. In the case of lakes of a more complicated shape samples were taken in two or three such sequences. In the majority of cases samples were taken during the summer stagnation period, from once to several times during three years of study. A total of 1421 samples was taken with the Szczepański type tubular sampler, and 156 samples with the Ekman dredger. The greater part, that is, 60% of the samples from 38 lakes, were taken during August and September, which made it possible to compare results from lakes less intensively explored.

The present work gives the data referring to the biomass of bottom fauna of the middle of 42 lakes in the Węgorzewo district, attention being drawn to certain regularities in its formation. *Mollusca* and *Chaoborus crystallinus* Deg. were omitted from the analysis of the biomass. In calculating the biomass of benthos organisms use was made of the data contained in the papers by Berg (1948), Konstantinov (1958), Morduchaj-Boltovskoj (1954) and Kajak (material not published).

Basic data on the lakes examined, the biomass of bottom fauna and the percentage in the biomass of *Tendipedidae*, *Oligochaeta* and other groups are given in Table I.

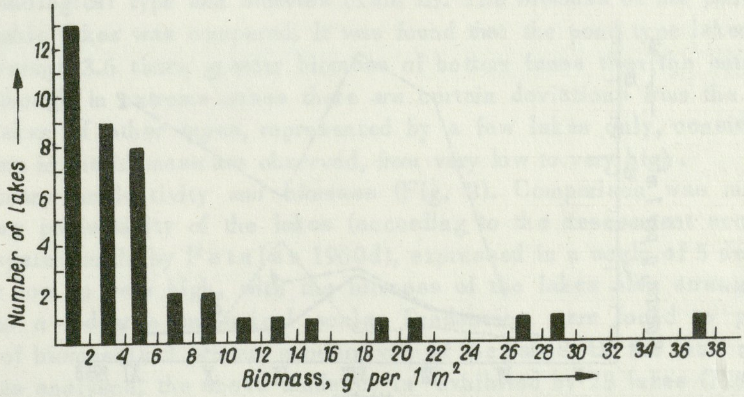

Fig. 1. Distribution of the biomass of bottom fauna in the Węgorzewo district lakes

These lakes differ greatly, particularly as regards size, the group including both small lakes of only one or a few hectares in area (Czarna Woda, Mszar, Purwin, Jagoczany, Smolak and others), and large lakes, with an area of several hundred hectares (Gołdopiwo, Święcajty, Oświn, Rydzówka, Stręgiel). The mean depth of the lakes examined was calculated from figures ranging from 0.3 m (Mszar) to 12.6 m (Gołdopiwo), the shallow lakes the mean depth of which does not exceed 3.0 m being more numerous. As regards the limnological type, the types represented in the greatest number are eutrophic and pond type lakes, and sporadically dystrophic lakes (3 lakes) and b-mesotrophic lakes (2 lakes). The biomass of bottom fauna varies within wide limits from 0.2 to 37.0 g/1 m². Detailed distribution of the biomass is shown in Fig. 1.

Although the range of variation of the biomass is considerable, the great majority, that is, 30 out of the 42 lakes examined (71%) have biomass not exceeding 6 g/1 m². The distribution of the biomass is characterised by one distinct peak with the lowest values (below 2 g/1 m²). Deevey (1941), who analysed his own material from the Connecticut lakes and compared them with the data of other authors from lakes in different geographical regions (Northern Germany, the Alps, the Soviet Union, Sweden, Norway and Finland), draws attention to the very great differentiation of the biomass of bottom fauna within lakes belonging to one group. As a result of an analysis of this kind, the author (Deevey 1955) reaches the conclusion that differences within a uniform region may exceed differences between different regions. This probably arises from the fact that the specific composition and abundance of the fauna are more connected with the size and shape of the lake than with the productivity of the region. The Connecticut lakes, which possess a similar level of biomass to that of the Węgorzewo district lakes, differ as to its distribution, which is characterised by two peaks of the number of lakes – with values 2–4 and 6–8 g 1 m² (Deevey 1941).

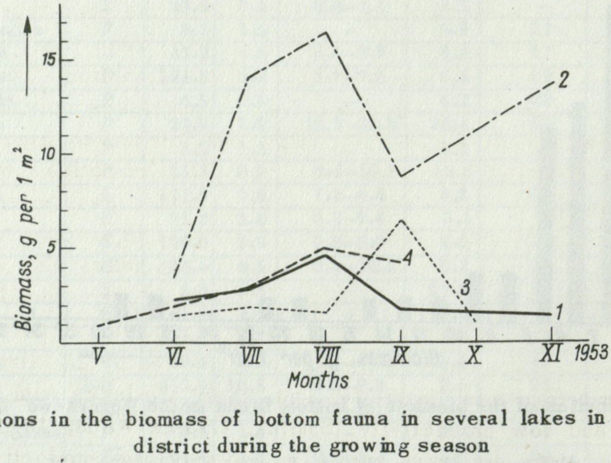

Fig. 2. Variations in the biomass of bottom fauna in several lakes in the Węgorzewo district during the growing season

1 – Święcajty, *2* – Gołdopiwo, *3* – Bimbinek, *4* – Krzywa Kuta

Taking four lakes which were examined in detail, and in which the wealth of bottom fauna, differed, as an example, the variations in the biomass over the growing season were traced (Fig. 2).

The following may be stated: beginning with the spring and beginning of summer the biomass distinctly increases, attaining a maximum in August (Święcajty, Gołdopiwo and Krzywa Kuta) or in September (Bimbinek). A decrease in the biomass as a rule takes place during the further part of the growing season. It was only in lake Gołdopiwo that a second increase in biomass was observed (in November) to a level approximately equal to the maximum. The occurrence of maximum biomass at the end of the summer is probably characteristic of the whole group of lakes in this area. In other areas the situation may of course be different. For instance, Deevey (1941), whose investigations of the Connecticut lakes were continued over an entire year, found the maximum of abundance and biomass of the bottom fauna in the winter, and the minimum in the spring or early summer.

Connection between limnological type and biomass of bottom fauna of lakes in the Węgorzewo district

Tab. II

Limnological type	No. of lakes	Biomass in g/1 m²	
		range	mean
Eutrophic lakes	19	0.2–5.6	2.8
Pond type lakes	15	0.2–37.0	10.1

Certain regularities in the formation of the biomass in the whole group of lake was next analysed. We shall discuss them in turn.

1. Limnological type and biomass (Tab. II). The biomass of the pond type and eutrophic lakes was compared. It was found that the pond type lakes have on the average 3.6 times greater biomass of bottom fauna than the eutrophic lakes, although in extreme cases there are certain deviations from the above rule. In lakes of other types, represented by a few lakes only, considerable fluctuations in the biomass are observed, from very low to very high.

2. Primary productivity and biomass (Fig. 3). Comparison was made of the primary productivity of the lakes (according to the assessment according to point system made by Patalas 1960d), expressed in a scale of 5 degrees, from very low to very high, with the biomass of the lakes also arranged according to a 5-degree analogical scale. Tendencies were found to parallel increase of biomass and primary productivity of the lakes. Of the total number of 39 lakes analysed, the above tendency is exhibited by 28 lakes (72%). Certain lakes deviate from this distinctly. Thus there are lakes with high or very high biomass, and low productivity (Smolak, Czarna Woda, Jagoczany), and on the other hand there are lakes with high and very high productivity and low biomass (Węgielsztyńskie, Czarna Kuta).

The above relation between primary productivity and the biomass is in principle in agreement with the observations made by Northcote and Larkin (1956) in the lake district of British Columbia. They found that with an increase in the concentration of the mineral salts dissolved in the water, abundance and biomass of plankton, bottom fauna and fish increase.

3. The size of the lakes and the biomass (Tab. III). The Węgorzewo dis-

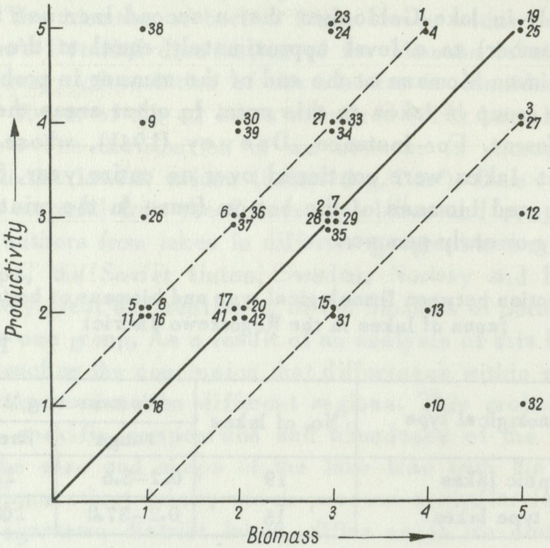

Fig. 3. Connection between primary productivity and the biomass of bottom fauna in lakes in the Węgorzewo district. Numbers indicate each lake acc. to numeration contained in Tab. I.

Productivity (acc. Patalas 1960d): *1* — very low, *2* — low, *3* — medium, *4* — high, *5* — very high; biomass: *1* — very low (< 1.0 g per 1 m²), *2* — low (1.0–3.0 g per 1 m²), *3* — medium (3.1–5.0 g per 1 m²), *4* — high (6.1–12.0 g per 1 m²), *5* — very high (> 12.0 g per 1 m²)

Connection between size of the lakes and biomass of the bottom fauna of lakes in the Węgorzewo district

Tab. III

Class of size of lakes in ha	No. of lakes	Biomass in g/1 m² range	Biomass in g/1 m² mean
1–10	11	0.2–37.0	9.5
11–50	15	0.2–20.4	5.8
51–100	5	0.7–8.1	3.2
>100	11	1.1–28.1	6.8

trict lakes investigated were arranged in 4 classes, from the smallest to the largest. It was found that together with an increase in the size of the lakes the biomass regularly decreases. This negative correlation between the area of the lakes and the benthos biomass applies, however, only to lakes not exceeding 100 hectares in size. In the class of lakes over 100 ha in size a higher biomass is observed that in the class of smaller lakes.

Connection between mean depth of lakes and biomass of bottom fauna of lakes in the Węgorzewo district

Tab. IV

Mean depth in m	No. of lakes	Biomass in g/1 m²	
		range	mean
0–3.0	23	0.2–37.0	9.5
> 3.0	19	0.2–13.8	3.4

4. Mean depth of the lakes and the biomass (Tab. IV). The lakes were divided into two groups: with mean depth below and over 3.0 m. It was found that the shallower lakes have 2.8 times higher biomass than the deeper lakes. The above regularity in the decrease of benthos biomass with increasing depth of the lake is in principle in agreement with the observations made by Rawson (1955) in the Canadian lakes area. Northcote and Larkin (1956), referred to above, also reached similar conclusions in the lake district of British Columbia. They found that the amount of fauna in lakes with considerable mean depth was never as great as in lakes with a low mean depth.

Field work was carried out with the support of the Lake Management Department of the Institute of Inland Fishery at Giżycko. We are most grateful to the head of the Department, Docent Dr. S. Bernatowicz for the help he gave us. We should also like to thank Docent Dr. J. Zawisza of the Institute of Inland Fishery for his assistance during field work.

REFERENCES

1. Berg, K. 1948 – Biological studies on the River Sussa – Folia limnolog. scand. 4 pp. 318.
2. Bernatowicz, S. 1960 – Charakterystyka jezior na podstawie roślin naczyniowych – Roczn. Nauk. roln. 77, B : 79–103.
3. Deevey, E. S. Jr. 1941 – Limnological studies in Connecticut. The quantity and composition of the bottom fauna of thirty-six Connecticut and New York Lakes – Ecol. Monogr. 11: 413–455.
4. Deevey, E. S. Jr. 1955 – Limnologic studies in Middle America – Trans. Conn. Acad. Arts. Sci. 39: 213–328.
5. Kondracki, J., Szostak, M. 1960 – Zarys geomorfologiczny i hydrograficzny jezior okolic Węgorzewa – Roczn. Nauk roln. 77, B: 5–59.
6. Konstantinov, A. S. 1958 – Biologija chironomid i ich rozvedenie – Moskva–Leningrad pp. 361.
7. Morduchaj-Boltovskoj, F. D. 1954 – Materiały po srednemu vesu vodnych bespozvonočnych bassejna Dona – Trudy problem. temat. sovešč. II. Probl. gidrob. vnutren. vod 2 : 223–241.
8. Northcote, T. G., Larkin, P. A. 1956 – Indices of productivity in British Columbia Lakes – Journ. Fish. Res. Bd. Canada 13: 515–540.

9. Patalas, K. 1960a – Stosunki termiczne i tlenowe oraz przezroczystość wody w 44 jeziorach okolic Węgorzewa – Roczn. Nauk. roln. 77, B: 105–222.
10. Patalas, K. 1960b – Mieszanie wody jako czynnik określający intensywność krążenia materii w różnych morfologicznie jeziorach okolic Węgorzewa – Roczn. Nauk. roln. 77, B: 223–242.
11. Patalas, K. 1960c – Charakterystyka składu chemicznego wody 48 jezior okolic Węgorzewa – Roczn. Nauk roln. 77, B: 243–297.
12. Patalas, K. 1960d – Punktowa ocena produktywności jezior okolic Węgorzewa – Roczn. Nauk roln. 77, B: 299–326.
13. Rawson, D. S. 1955 – Morphometry as a dominant factor in the productivity of large lakes – Verh. int. Verein. theoret. angew. Limnol. 7: 164–175.
14. Zawisza, J. 1961 – Wzrost ryb w jeziorach okolic Węgorzewa – Roczn. Nauk roln. 77, B: 681–748.

BIOMASA FAUNY DENNEJ 42 JEZIOR OKOLIC WĘGORZEWA

Streszczenie

Analizowano biomasę fauny dennej (bez mięczaków i *Chaoborus crystallinus* Deg.) strefy śródjezierza kompleksu jezior okolic Węgorzewa, zróżnicowanych pod względem typologicznym oraz wielkości i głębokości średniej (tab. I). Biomasa tych jezior waha się w szerokich granicach (fig. 1), jednak większość jezior grupuje się przy niskich wartościach biomasy, nie przekraczających 6 g/1 m². Maksimum biomasy w okresie sezonu wegetacyjnego obserwowano w sierpniu bądź wrześniu (fig. 2). Stwierdzono, że biomasa jezior typu stawowego jest 3,6 razy wyższa niż w jeziorach eutroficznych (tab. II). Dość dobrze wyrażona jest tendencja równoległego wzrostu biomasy i produktywności pierwotnej, jakkolwiek stwierdzono tu szereg odchyleń (fig. 3). Obserwowano też, że ze wzrostem wielkości zbiorników biomasa maleje, przy czym prawidłowość ta dotyczy jezior o powierzchni nie większej niż 100 ha (tab. III). Wreszcie stwierdzono, że jeziora płytkie (o głębokości średniej do 3,0 m) mają 2,8 razy wyższą biomasę od jezior o większej głębokości (tab. IV).

ADRESSES OF THE AUTHORS:
Dr. Ewa Pieczyńska, University of Warsaw, Chair of Evolutionism and Animal Ecology, Warszawa, Nowy Świat 67, Mgr. Eligiusz Pieczyński, Mgr. Tadeusz Prus and Prof. Dr. Kazimierz Tarwid, Institut of Ecology, Warszawa, Nowy Świat 72.