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DOBROWOLSKI K.A. (1973)
Waterfowl and their role in lake ecosystems
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Translated by G.Jaworski.

We know very little about the role of birds in different ecosystems, despite numerous interesting works of researchers and amateur ornithologists scattered throughout the world. Less attention is paid to freshwater ecosystems because of the difficulties encountered in the experimental methods as well as a lack of interest on behalf of hydrobiologists, for the activities of birds in these ecosystems. As a result research has been limited mainly to faunistic lists, the distribution of fish parasites through waterfowl, or opinions on the destructiveness of fish feeding birds. Meanwhile there is a great need for ecological data in order to understand fully the structure and function of a lake ecosystem.

Palmgrena (1936) was first to associate birds with limnology, he established three types of lakes according to the occurrence of birds. He named the first "Colymbus", which referred to oligotrophic lakes where the bird population is small, up to 0.5 pairs/ha and characterised by divers. His second type "Podiceps" consisted of eutrophic lakes with a bird population between 0.5-1 pairs/ha. The third type "Nyroca" was made up of ponds where the bird population was more than 1 pair/ha. This classification considering local Finnish conditions and climate is not universal. It would be difficult to include our oligotrophic lakes under "Colymbus" type because in practice this species does not nest. However the idea to show a connection between birds and types of lake is reasonable. In this respect tests were carried out later by Ekman (1943), Dunajewski (1943) and Dobrowolski (1961) among others. Although it would be very difficult to make a proper classification for large regions (the main obstacle being a variation in species dominating the different localities) their works however threw sufficient light on the existence of a correlation between types of lakes and the numbers and composition of bird species found. Moreover the experiments confirm the understanding that the most numerous and heterogeneous populations are on shallow, strongly overgrown, pond-type lakes or the outflow (inflow) parts of a lake. It can be proved that the stronger the advancement of a lake towards eutrophication the more diverse will be the representation of bird group and the more substantial will be the influence of biocenosis on the ecosystem. Another type of experiment, which connected birds with the lake ecosystems, investigated the occurrence of avifauna in the various regions of a lake. An analogue of the first type of experiments links woodland birds with the types of wood, and in a second type of experiments there is similarity to the above data about the territorial distribution. From the rich history of woodland investigations we know more or less which birds occupy definite territories but the research of waterfowl still does not give a clear answer. Several authors were occupied with the problems of regional distribution of birds on lakes, amongst others Dunajewski (1943), Horvath (1958), Lewandowski (1964), Dobrowolski (1969) and Jablonski (1969). Results show that the bird distribution on a lake is random but specific regions of a lake are occupied by definite species. Of course, this distribution is not permanent. It differs with the time of year and may even depend on the weather conditions (Szijj 1965). Simple statistical methods show agreement conforming to the morphology and biology of the species. In effect these are dependent on the total body of birds found on our lakes (on an eutrophic lake almost 60 species) being subdivided into groups occupying definite regions of the lake. These species can be arranged into the following types and morphoecological forms (Dobrowolski 1969), underlining the dominant forms.

Type 1 - swimming birds

Form 1 - filtering benthophages

<u>Anas platyrhynchos</u>, <u>Anas strepera</u>, <u>Aythya ferina</u>, <u>Ay. nyroca</u>, <u>Ay. fuligula</u>, Asas querquedula, A. crecca, A. acuta, A. clypeata, Bucephala clangula, Cygnus olor, Fulica atra, Gallinula chloropus.

Form 2 Aquatic phytophages

<u>Cygnus olor</u>, <u>Fulica atra</u>, <u>Anser sp</u>.

Gallinula chloropus, Anas platyrhynchos, A. querquedula, A. crecca, A. clypeata, A. acuta, Aythya ferina, Ay. fuligula, Ay. nyroca

Form 3 - aquatic ichthyophages
Podiceps cristatus, Phalacrocorax carbo, Mergus merganser M. serrator, Podiceps griseigena, P. ruficollis, Colymbus sp., Bucephala clangula, Aythya sp.

Type II Semi aquatic wading birds.
Form 1. Beach entomophages
Motacilla alba, M. flava, Charadrius sp., Tringa sp., Calidris sp., Actitis hypoleucos, Sturnus vulgaris, Corvus corone, C. frugilegus
Form 2. Shore benthophages
Tringa sp., Charadrius sp., Calidris sp.,Actitis hypoleucos Corvus corone Anas sp.
Form 3. Shore ichthiophages
Ardea cinerea, Botaurus stellaris
Ixobrychus minutus, Alcedo atthis, Tringa nebularia, Corvus corone, Ciconia nigra
Form 4. Shore entomophages
Ixobrychus minutus, Botaurus stellaris, Alcedo atthis, Gallinula chloropus, Ardea cinerea, Cinonia cinonia.
Type III Birds feeding in flight
Form 1. Air entomophages
Riparia riparia, Hirundo rustica, Apus apus, Chlidonias nigra, Larus ridibundus,Delichon urbica, Larus minutus
Form 2. Air ichthyophages
Larus ridibundus, Sterna hirundo, S. albifrons, Chlidonias nigra Larus minutus, L. canus, L. fuscus, Pandion haliaetus, Haliaetus albicilla, Milvus milvies, M. migrams, Corvus corone
Form 3. Shore predators
Circus aeruginosas, C. pygargus, Milvus milvus, M. migrans Accipiter gentilis, A. nisus, Falco subbuteo, Haliaetus albicilla Buteo sp.
Type IV Birds on trees (shrubs?) and reeds.
Form 1. Reed entomophages
Acrocephalus arundinaceus, A. scirpaceus, A. schoenobaenus, A. palustris, Locustella sp., Luscinia svecica,

Remiz pendulinus, Parus sp., Emberiza schoeniclus, Sturnus vulgaris

Form 2 Reed phytophages

Emberiza schoeniclus, Carpodacus erythrinus.

Form 3 Entomophages and phytophages on shoreline vegetation

Parus sp., Acrocephalus palustris, Remiz pendulinus, Luscinius sp., Chloris chloris, Emberiza citrinella, Fringilla coelebs, Carpodacus erythrinus, Carduelis carduelis, C. spinus, Hippolais icterina, Phylloscopus sp.

Species belonging to one morphoecological form occupy a definite zone of the lake and live more or less on the same food. Differences exist resulting either from a food specialization or the means of collecting food. Szijj (1965) from research of Lake Bodenski, showed an interesting comparison of feeding methods influencing the differentiation of a group of <u>lamellirostres</u>

Table I

Frequency of a given type of feeding in different species of *Anseriformes* (percentage)

Gatunek—Species	Typ odżywiania się-Type of feeding					
	nurkowanie-diving	nurkowanie częściowe-partial diving	zanurzanie głowy i szyi-immersion of head and neck	zbieranie pokarmu-food intake		polowanie na upatrzoną zdobycz-feeding upon prey actually sighted
				z wody-from water	z lądu-from land	
Anas crecca	—	12	36	16	36	—
Anas querquedula	—	29	37	22	—	12
Anas penelope	—	—	20	26	54	—
Anas strepera	—	13	71	1	15	—
Anas clypeata	3	14	46	37	—	—
Anas platyrhynchos	1,5	42	44	7	1,5	4
Dafila acuta	—	63	37	—	—	—
Cygnus olor	—	40	60	—	—	—
Netta rufina	34	40	13	13	—	—
Aythya ferina	79	18	3	—	—	—
Aythya fuligula	90	10	—	—	—	—
Bucephala clangula	100	—	—	—	—	—

Such a difference within a group assures maximum utilisation of environmental stores, often one species will make available previously inaccessible food for another species. (Hobbs 1957 observed the feeding of coots, waterhens and grebes). At the same time a study of such a difference (although the region of occurrence is variable in particular seasons of the year and not only dependent on food) informs about the load to a given zone of a lake by a definite morphoecological type, shows the course of energy flow, suggesting also that a characteristic lake for a group of birds does not refer to the limnological type but to littoral and shore areas. The movement of birds is an important feature influencing their place in the lake ecosystem, as well as the fact that many birds nest on the lakeside and feed on the lake. Such birds include herons, cormorants, some ducks, storks, birds of prey and numerous perching birds. There also exists those birds which collect food from around the lake - on the land; ducks, geese, coots, (exceptional here), black-headed gulls, terns, birds of prey and numerous perching birds. An arrangement of this type causes the removal of organic matter from the lake shore by birds and at the same time provides mineral nutrients in the form of excrement. These are factors opening a chain in the circulation of organic matter in a lake.

As a result, in order to estimate the trophic role of birds, we need to understand the following factors:

1) The species composition of a group as well as its structure and therefore the morphoecological types. In this case we now have an initial distinction. However we need to know the number of separate types and morphoecological forms, of which we know relatively little.
2) The annual dynamics of particular morphoecological forms or at least dominant species (there is inadequate information on this).
3) Type of food of particular morphoecological forms or dominant species and its seasonal variation. Data from the literature is sufficiently enlightening only for a few species. Moreover it is mainly qualitative data about the type of food with a lack of quantitative data concerning daily food requirements or simply the amount of food consumed. In phytophagous forms or those living on a mixed plant and animal diet as a rule (according to the literature) there seems

to be a greater consumption of animals in the spring-summer months (April-August) than the rest of the year. In order to confirm what birds gather from a lake we need to know the type as well as the amount of food.

4) Quantity and quality of experiments, along with an indication of how many are carried out on the lake. Data about this is practically non-existent.

Conclusions to enlighten these points are not consoling, as we are still a long way from establishing the role of birds in the lake ecosystem. We should try on a basis of incomplete data (mainly literature) to present this problem at least in part. Comparatively the easiest to settle is the duration of particular periods throughout the seasons of the year, when the numbers of birds as well as their regional distribution and type of food, will be changing. This has great importance in evaluating the role of birds. Of course the duration of these periods will be changeable, as it is not possible to determine exactly to the day and it can be somewhat variable for different species. With these reservations it is possible from literature and certain data to make the following division.

1. Period before nesting (usually spring) - lasting from mid April or the April/May turning point, more or less 30 days.
2. Nesting period - May-June lasting about 30 days.
3. Period after nesting - June-July lasting nearly 75 days.
4. Autumn period - mid-September until the freezing of the lakes (usually mid January), about 120 days.

Usually the lakes are frozen for 4 months, till the April/May turning point. During this time very few birds inhabit the lakes, but while there is still a little free water the autumn migration will be delayed. By March a few swans, ducks and herons appear while lakes are still frozen.

The number of individual species changes distinctly during successive periods. Characterising this process generally, it is possible to confirm that birds are most numerous in the third period, after nesting, when on our lakes there are still birds nesting, chicks growing and roving birds appearing from the north east.

At this period the greatest variety in species of birds occurs.

The autumn period begins sufficiently rich but quickly loses large numbers of birds foreby a variety of species. Blackheaded gulls, mallard and coots remain longest. Unexpected flocks of species of ducks and grebes appear at this time but after a short stay on the lakes they disappear as suddenly as they have appeared. The period before nesting is characterized by the number of few established birds as well as little stabilisation of the groups, this stabilisation will occur in the nesting period.

The presentation of analysis of waterfowl numbers is really difficult, in the literature we come across several methods.
There are authors who give simple arbitrary numbers and some who will count the number of birds over 1, 10 or 100 ha of the water surface, those who compare the amount with a length of shoreline, a length of line or observation time. Few authors count the number of birds over an area of water plants. In each of these methods the number of birds in relation to the area they occupy can be positive and negative. Of course an arbitrary count is of fundamental importance in analysing the occurrence of birds and dynamics of their numbers on a part of a lake. However when comparing lakes, one needs to collect arbitrary data of numbers in relation either to the surface area or a length of shore.

Such counts have an acute fault - the assumption that birds fully occupy all parts of a lake; of course this is not true. As stated previously, different morphoecological types of birds will occupy and utilise different regions of a lake. Counting over the whole area of a lake it would be possible with a little toil to make a correct estimation for species like grebes, cormorants, terns, gulls and some ducks. For other species (coots and some ducks) it would not be a true reflection since these birds rarely venture into open water, they frequent solely the regions of reeds and belt of submerged plants. Remembering these restrictions we need to confirm that the best method at present is a count of the number of birds over one hektare of the lake. A count over 1 km^2 seems reasonable to me for obtaining analysis and comparisons of larger regions, however if we want to know the amount on a definite lake we must count this over 1 hektare or more so 10 hektares,

Finally I give here a warning that there is one more difficulty in estimating bird numbers. Many authors, giving the amount of birds in the nesting habitats, will give the numbers of pairs or nests and not the number of birds. One should be particularly cautious in the case of ducks, where it is generally known that the female will undertake all the trouble of incubation and rearing of chicks, while the male often stays in completely different habitats. A certain number of birds do not breed, as a rule these seem to be male reserves still moulting in the breeding season and generally do not leave the rushes for open water. Effectively they disappear from view.

After these warnings and methodical reservations we should try to make a thorough analysis on the number of waterfowl in our country (alas there is little information). I include here data from other parts of Europe and Asia for a comparison, stipulating that my material is gathered only from random tests and is not a complete indication of the waterfowl numbers. I present also, only relative data concerning a few of the most numerous species occurring here. Data which I have used in tables of composition and comparisons were taken from lakes and ponds shown in figure 1. The number of birds settling on different lakes has an influence on very many factors. Not trying at present to analyse this particular problem, I want to give a warning on the observed fact by Wobus (1964) that the relative number of birds (particularly in nesting habitats) is relsted to the size of the lake. He showed grebes to be more numerous on ponds up to 10 ha. - in a count over 1 ha. the number was not exact. This relationship (corroborated by Hanzak 1952) is shown in tab. II.

I have made a similar count for lakes from material gathered from a nesting habitat. Tab. III.

Table II

Relation between numbers of *Podiceps cristatus* and size of pond (after Wobus 1964) based on analysis of 34 ponds

Powierzchnia stawów w ha — Area of ponds in ha	>10	10—50	50—100	100-1000
Ilość par na ha — Number of pairs per ha	0,213	0,096	0,065	0,034

Table III

Relation between numbers of several species of waterfowl and size of lakes.

Gatunek — Species	Powierzchnia jeziora w ha — Area of lake in ha					liczba jezior — number of lakes
	<10	10—50	50—100	100—1000	>1000	
Podiceps cristatus	0,0	1,02—1,13	0,42	0,19	0,05	19
Fulica atra	1,1	0,68	0,33	0,25—0,41	0,33	21
Anas platyrrhynchos	0,23	0,31	0,80	0,12	0,15	12
Aythya ferina	8,22—11,66	?	?	0,044	0,19	7
Aythya fuligula	?	?	?	0,05	0,06	5
Cygnus olor	2,0	0,5	0,03	0,09	0,05	25

Data relating to pochard and tufted duck are merely indicators and do not justify conclusions about the small number of lakes analysed. From data for Czechoslovakia and the GDR (Bezzel 1969) it is possible to try to establish a similar relationship for pochard on ponds (tab. IV). This distribution is similar to that acquired for lakes. Perhaps a more detailed analysis of this type would be able to establish for certain fields whether there exist ecological optima for particular species. Every time, material is presented to show the occurrence of different bird species on lakes of different size, no matter how it is arranged the majority of species prefer smaller lakes and their numbers fall with an increase in area. Quoted tables suggest still more eg. mallard have a preference for lakes from 50 to 100 hektares, and pochard very small or large lakes but not average size lakes. Regarding the few lakes analysed this is the only suggested characteristic. However this may have a definite consequence on the composition of bird groups on a particular lake as well as the energy flow through biocenosis.

I have achieved a comparison of the average numbers of waterfowl in Poland with the remainder of Europe and Asia, counting the number of individuals / ha during the nesting period. There is comparatively little difference.

In the after nesting period a population increase follows due to the hatching of chicks. This growth is not very large thanks to a strong reduction in the number of chicks during the early stages of their lives.

Although the birds discussed generally do not lay less than 4 eggs, ducks laying considerably more (in the region of 10 or more), the number of young falling to one pair is much less. Sokolowski (1967) gave the average young/pair for grebes as 2.05 on different lakes in the locality of Poznan, Wobus (1964) gave a mere 1.15.

Table IV

Relation between numbers of *Aythya ferina* and size of lake acc. to Bezzel data (1969)

Powierzchnia stawów w ha Area of ponds in ha	do -to- 10	10 - 50	50—100	100—1000
Ilość par na ha — Number of pairs per ha	8,25—14,15	0,369—0,67	0,21	1,87—3,21

Material collected from the Mazurian lakes (Sobczyk unpublished) gives anaverage of 2.39 young/pair. Wobus writes that the average young/pair for coots lies between 2.85 and 4.15. The following data is given for swans: Zajac (1963) for western lakes 4.3 young/pair; Kazmierski (1969) 1.57 young/pair in the Zninski district; and Szijj (1963) 2.55 young/pair on Lake Bodenski. I think that the average for mallard, pochard and tufted duck lies between 3 and 5 young/pair. Therefore in the after nesting period the natural population has an increase of 2-4 times. At this same time migrating birds arrive on our lakes while the young individuals are beginning to disperse. This gives little stability but as a rule typifies a rise in numbers compared to the previous period.

Autumn is a poor time, both quantitatively and qualitatively. The amount and type of food consumed by birds will vary with the seasons of the year. Unfortunately few data are available to us related to food requirements of waterfowl, most work on this theme discusses Passeriformes or birds of prey. In spite of this it is possible to make a comparison on the food requirement of waterfowl during the course of a day. It is stated that small birds will eat relatively more than large birds. From the data of Schildmacher (1929), Dementev (1949), Szuman (1951), Dunajewski (1943) and Sokolowski (1967) a list has been compiled. (Table V.) From this list it is noticeable that consumption of food depends not only on the size of the bird but on other factors like the type of food. Quoting authors, a Bombycilla garrulus weighing about 57 gms consumes 170 gms of grain daily, Accipiter gentilis (weighing 1500 gms) - a duck weighing 800-1000 gms and Pandion haliaetus (weighing 1600 gms) - consume up to

2 kgs of fish daily.

According to Lack (1954) small continental birds about 10-90 gms weight daily consume 10-30% of their weight, while birds weighing between 100 and 1000 gms consume 5-9% of their weight. Kendeigh (1934) says that adult seed eaters consume 10% of their weight daily, insectivores 40%. The amount of food consumed can be dependent on the sex of the species, age or external temperature.

Table V

Amount of food eaten by different species of birds

Gatunek—Species	Ciężar—Weight (g)	Dzienna ilość pokarmu — Daily portion of food	
		(g)	(% ciężaru ciała) (% of body weight)
Regulus regulus	5,6—6,5	1,4—1,6	25
Regulus regulus	6,8	1,74	28
Parus coeruleus	11	3,30	30
Erithacus rubecula	16	2,35	14,7
Sturnus vulgaris	76,5	9,16	11,9
Turdus ericetorum	89	8,72	9,8
Zenaidura macroura	100	11,2	11,2
Turdus merula	118	8,6	7,3
Colinus virginianus	170	14,96	8,8
Athene noctua	150—170	20	11,77—13,33
Falco tinnunculus	200	15,40	7,7
Buteo buteo	855—900	38,48—40,50	4,5
Podiceps cristatus	~1000	200	~20
Ardea cinerea	~1300	250	19,2
Accipiter gentilis	1500	150	10
Mergus merganser	~1600	300	~18,8
Gallus gallus	1800	61,20	3,4
Gallus gallus	2000	110	5,5
Kaczka domowa—Domestic duck	3000	329—384	10,97—12,8
Indyk — Turkey	4000	180	4,5
Indyk—Turkey	6000	230	3,83
Indyk—Turkey	8000	270	3,38
Gęś domowa—Domestic goose	5000	443	8,86
Gęś domowa—Domestic goose	5500	529	9,6

Jordan (1953) stated that <u>Anas platyrhynchos</u> consumes 132 gms of grain daily during early autumn, in winter 150 gms when drakes eat 15% more than ducks, but in spring ducks will consume 16.5% more food than drakes. Young ducklings, 8-9 weeks old, grow rapidly consuming about 44% more than adults. Schildmacher (1929) stated that a 40 gm Ploceus cucullatus consumes 20% of its weight daily at 18°C, 25% at 9°C and 28% at 7°C.

Quoted data show difficulties in operating synthetic indicators for food requirements and reveal comparatively little knowledge yet in this field. Therefore further counts done by me should be treated very carefully, merely as first approximations.

The summarized lists of results show the general dynamics of changes in a number of birds (tab. VI).

The column "sum" is an average of all analysed lakes; in the column "number of lakes" the first figure refers to all lakes, the second to Polish lakes. I obtained theoretical values by multiplying the condition of nesting time by the highest given rise in the numbers of young, these values are not always concordant with observations. It is possible to explain these divergences with insufficient material as well as certain incomplete rates which served the counts. Having rates, dynamics and numbers, and knowing the amount and type of food requirement it is possible to calculate the amount of food consumed by birds from a lake. On basis of the data given above, I have accepted that the daily food requirement for a grebe is 200 gms, a coot 100 gms, mallard, pochard and tufted duck 150 gms, and a swan 500gms. In principle the food of a grebe consists 100% of animals for simplification it is possible to assume that this is fish; the food of coots and swans is 90% plants and 10% invertebrates; the food of mallard is 80% plants and 20% invertebrates and that of pochard and tufted duck is 60% animals and 40% plants.

From adequate counts and assuming that young individuals by 30 days are consuming 40% more food than adults, we get the following data (tab VII) explaining the consumption of food over one hektare during the vegetative season by the birds discussed here.

The top row in table VII shows the theoretical rise in consumption between the period of nesting and after nesting; the bottom row is results from observation.

I estimate that the species described by me are the main consumers of plants in our lakes, and the value of consumption does not reach 80-90% of that eaten by all freshwater birds (investigations are still in progress with some ducks, geese and water hens). Further I think that the amount of fish consumed by grebes may be 40-50% of that eaten by all our avifauna (terns, gulls, some lamellirostes, herons, cormorants and birds of prey).

As in the case of fish I would make a similar estimation for the consumption of invertebrates.

There is still comparatively less data about the amount and composition of bird wastes than about food. It is known that the rate of digestion is very great and that many species fill their stomachs 2 - 5 times daily. Szuman (1951) gives data which unfortunately concerns domestic birds but nevertheless give some indication. The yearly production of excrement in hens is 5-10 kgs/individual, ducks 8-9 kgs/individual, (Dunajewski 1943 accepts that for a mallard weighing 0.5 kg the excrement during a vegetative season lasting 200 days will be 3.98 kgs), geese 11-13 kgs/individual and pigeons 2-3 kgs/individual. Obviously the composition of excrement will vary with the bird species, with respect to different food and digestion. For example the digestion of hens is 28%, geese 22%, and pigeons 35% (Szuman 1951).

Table VI

Quantitative variations in some species of waterfowl

Gatunek—Species		Okres—Period				
		przedlęgowy-prenesting	lęgowy -nesting	polęgowy-postnesting wartość-value teoretyczna -estimated	polęgowy-postnesting wartość-value uzyskana -obtained	jesienny -autumn
1		2	3	4	5	6
Podiceps cristatus	Suma—Sum total	0,08	0,50	1,1	0,24	0,32
G. crested grebe	Polska—Poland	0,08	0,56	1,23	0,23	0,35
	liczba jezior number of lakes	7;7	22;19		12;11	10;9
Fulica atra	suma—sum total	2,04	0,60	1,65	1,57	1,94
	Polska—Poland	2,04	0,41	1,13	1,25	2,27
	liczba jezior number of lakes	2;2	26;13		13;10	12;9
Anas platyrhynchos	suma—sum total	0,36	0,43	1,40	0,39	0,99
	Polska—Poland	0,45	0,35	1,14	0,51	0,46
	liczba jezior number of lakes	4;3	21;6		11;5	5;3
Aythya ferina	suma—sum total	0,07	1,45	3,21	0,43	0,55
	Polska—Poland	0,12	0,04	0,13	0,58	0,37
	liczba jezior number of lakes	2;1	10;2		0;5	4;2

1		2	3	4	5	6
Aythya fuligula Tufted Duck	suma—sum total	0,36	0,58	1,68	0,24	0,26
	Polska—Poland	0,34	0,04	0,13	0,28	0,26
	liczba jezior number of lakes	3;2	17;3		5;4	3;3
Cygnus olor	suma—sum total	0,59	0,15	0,41	0,39	0,005
	Polska—Poland	0,32	0,10	0,28	0,46	0,01
	liczba jezior number of lakes	4;3	36;16		16:13	3:1

Table VII

Amount of food consumed per 1 ha by some species of waterfowl

Gatunek —Species	Okres—Period						
	przedlęgowy -pre-nesting	lęgowy -nesting	polęgowy -post-nesting	jesienny -autumn	razem -total	pokarm zwierzęcy -animal food	pokarm roślinny -plant food
Podiceps cristatus	0,36 0,36	3,6 3,6	19,66 3,55	0,72 0,72	24,34 8,23	24,34 8,23	0,0 0,0
Fulica atra	6,12 6,12	1,23 1,22	9,14 11,72	15,00 15,00	31,49 34,07	3,15 3,41	28,34 30,66
Anas platyrhynchos	2,03 2,03	1,58 1,58	13,43 7,16	8,28 8,28	25,32 19,04	5,06 3,81	20,25 15,23
Aythya ferina	0,54 0,54	0,18 0,18	1,64 8,16	6,66 6,66	9,02 15,54	5,41 9,32	3,61 6,21
Aythya fuligula	1,53 1,53	0,18 0,18	1,64 3,84	4,68 4,68	8,03 10,23	4,09 6,13	3,21 4,82
Cygnus olor	4,80 4,80	1,50 1,50	11,55 21,56	0,60 0,60	18,45 33,86	1,56 1,85	30,48 33,86

The composition of fresh bird droppings is shown in table VIII (Szuman 1951).

I have accepted that during the vegetative season the production of excrement by grebes and mallard is about 3.5 kgs, tufted duck, pochard and coots 2.8 kgs and swans about 7kgs. From these values and the frequency with which these birds appear on a lake, it is possible to calculate an average loading in kilograms/hektare (tab.IX) Therefore (accepting certain discrete principles) these five species will give us about 10 kgs/ha of excrement in the course of a vegetative season. Finally I should like to underline two points. First, all my enumerations were made from average values taken from summarised data for the whole of Poland. This gives a general picture of the situation. However it does not always explain and sometimes may even obscure the picture which we would get through analysing a definite lake or type of lake.

Table VIII

Composition of fresh birds droppings (after Szuman 1951)

Gatunek — Species	Skład świeżej mierzwy % — Composition of fresh droppings %									
	wody-water	składników organ.-organic components	azot-nitrogen	kwasu fosforowego-phosphoricacid	potasu-potassium	sodu-sodium	wapnia-calcium	magnezu-magnesium	kwasu siarkowego-sulphuric acid	krzemu i piasku-silicon and sand
Gołębie — Pigeons	52	31	1,8	1,8	1,0	0,1	1,6	0,5	0,3	2,0
Kury — Hens	56	26	1,6	1,5	0,9	0,1	2,4	0,7	0,5	3,5
Kaczki — Ducks	57	26	1,0	1,4	0,6	0,1	1,7	0,4	0,4	2,8
Gęsi — Geese	77	13	0,1	0,5	1,0	0,1	0,8	0,2	0,1	1,4

Table IX

Average amount of bird excrement per 1 ha of lake surface (in kg)

Gatunek—Species	Okres—Period						
	przedlęgowy-pre-nesting	lęgowy-nesting	polęgowy post-nesting wartość-value		jesienny-autumn	razem-total wartość-value	
			teoretyczna-theoretical	obserwowana-obtained		teoretyczna-theoretical	obserwowana-obtained
Podiceps cristatus	0,025	0,252	1,281	0,200	0,504	2,062	0,981
Fulica atra	0,673	0,135	0,932	1,031	3,100	4,837	4,937
Anas platyrhynchos	0,189	0,147	1,187	0,536	0,193	1,716	1,065
Aythya ferina	0,040	0,013	0,107	0,479	0,488	0,648	1,020
Aythya fuligula	0,112	0,013	0,107	0,231	0,343	0,576	0,700
Cygnus olor	0,259	0,084	0,588	0,966	0,034	0,954	1,342

I underlined the relation between numbers and settling of birds with the size and character of a lake. The influence on food consumption as well as defects for given conditions will be much greater for a small pond-like lake than a large mezotrophic lake.

The society is not the sole biocenotic function of birds, equally an analysis of the remaining dependent and influencing factors requires more elaboration.

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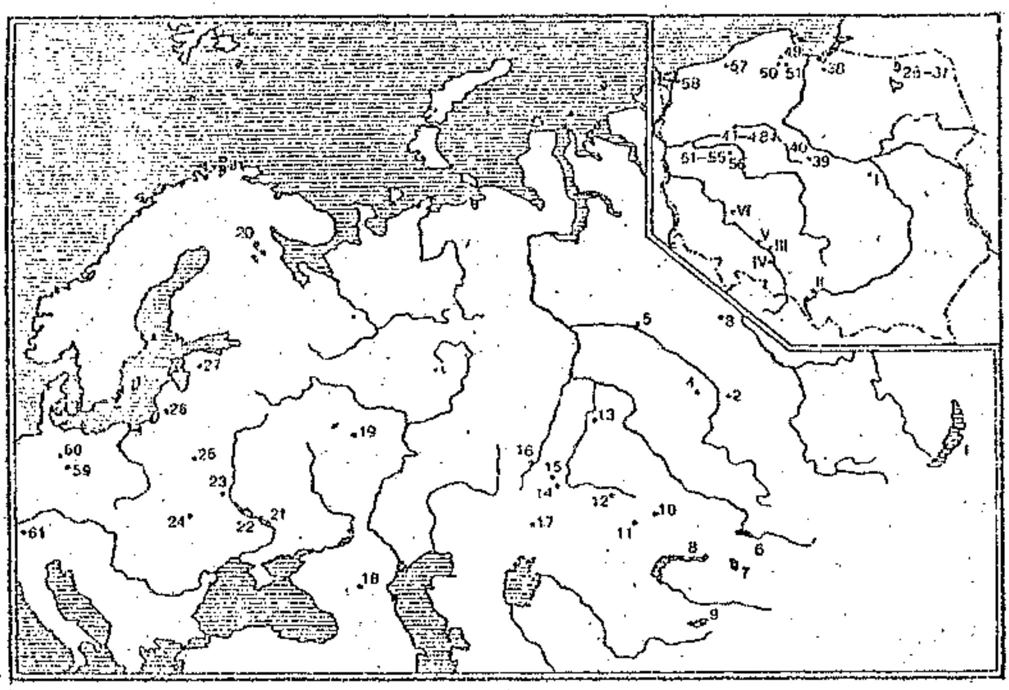

Fig. 1. Rozmieszczenie omówionych w opracowaniu jezior i stawów
Location of lakes and ponds discussed

1 — jezioro Bajkał (Skrjabin 1972), 2 — jeziora w rejonie Tomska (Ravkin 1962), 3 — jeziora w rejonie rzeki Tymy (Gjagazov 1968), 4 — jeziora w rejonie rzeki Iksa (Ravkin 1968), 5 — jeziora środkowego biegu Obi (Ravkin 1968), 6 — jezioro Zajsan (Strautman i Stepanov 1968), 7 — jezioro Alakol (Strautman i Stepanov 1968), 8 — jezioro Bałchaš (Strautman i Ştepanov 1968), 9 — jezioro Son-Kul (Ky-

dyralev 1968), *10* — jezioro Kurgaldžin (Kydyralev 1968), *11* — jezioro Čagly (Strautman i Stepanov 1968), *12* — jezioro Teniz (Gavrin 1968), *13* — jeziora Północnego Kazachstanu (Dobrovcev 1972), *14* — jezioro Aksaut (Solomatin 1968), *15* — jezioro Serymuin (Solomatin 1968), *16* — jeziora: Bolšoj Kujaš, Malyj Kujaš, Bainauš, Kabanie, Gribonovskoe (Danilov 1968), *17* — jezioro Turgaj (Strautman i Stepanov 1969), *18* — jeziora: Aktamskoe, Ačikulskie, Batmaklinskie, Prikumskie (Vinogradov 1972), *19* — jeziora: Velikie i Sagava (Novikov 1966), *20* — jeziora Karelii (Ivanter 1972), *21* — zbiorniki zaporowe: Leninskij i Dneprodzierżyńskij (Bułachov 1968), *22* — Kremenčugski zbiornik zaporowy i okoliczne jeziora (Reva 1972), *23* — jeziora w okręgach Kijów, Czernichów, Żytomierz, Równe (Galaka 1968), *24* — jeziora Sackie i Zabolotovskie (Cerkašenko 1972), *25* — jezioro Vygonovskie (Paputov 1968), *26* — jezioro Żumintas (Nadžinskas 1972), *27* — jeziora Estonii (Onno 1970, Renno 1972), *28* — jezioro Gołdopiwo (Nowak 1956), *29* — jezioro Plecek (Sobczyk mat. niepublik.), *30* — jezioro Dgał Mały (Sobczyk mat. niepublik., Jakubczyk mat. niepublik.), *31* — jezioro Warniak (Sobczyk mat. niepublik., Jakubczyk mat. niepublik.), *32* — jezioro Wielkie Mamry (Dobrowolski 1969), *33* — jezioro Tałtowisko (Sobczyk mat. niepublik., Jakubczyk mat. niepublik.), *34* — jezioro Mikołajskie (Sobczyk mat. niepublik., Jakubczyk mat. niepublik.), *35* — jezioro Śniardwy (Sobczyk mat. niepublik., Jakubczyk mat. niepublik.), *36* — jezioro Łukajno (Sobczyk mat. niepublik., Jakubczyk mat. niepublik.), *37* — jezioro Jegocin (Jabłoński 1969), *38* — jezioro Drużno (Nowak 1965), *39* — jezioro Lubieniec (Nitecki 1967), *40* — jezioro Gopło (Czarnecki 1962), *41* — jezioro Małe Żnińskie (Kaźmierski 1962), *42* — jezioro Duże Żnińskie (Kaźmierski 1962), *43* — jezioro Gąsawskie (Kaźmierski 1962), *44* — jezioro Pniewy (Kaźmierski 1962), *45* — jezioro Zioła (Kaźmierski 1962), *46* — jezioro Rogowskie (Kaźmierski 1962), *47* — jezioro Wolskie (Kaźmierski 1962), *48* — torfianki w Jaroszewie (Kaźmierski 1962), *49* — jezioro Karlikowskie (Kozłowski 1967), *50* — jezioro Sytnowskie (Kozłowski 1967), *51* — jezioro Głębokie (Kozłowski 1967), *52* — jezioro Tuczno (Meissnerowski 1966), *53* — jezioro Gorzyckie (Meissnerowski 1966), *54* — jezioro Środkowe (Meissnerowski 1966), *55* — jezioro Górzyńskie (Meissnerowski 1966), *56* — jezioro Bytyńskie (Zubrzycki 1967), *57* — jezioro Lubiatowskie (Górski 1970), *58* — jezioro Ostrowo (Wołk 1968), *59* — Malliner See (Beitz 1966), *60* — Meisinger See (Bezzel 1963), *61* — jezioro Bodeńskie (Szij 1963).

Stawy: *I* — stawy w Pęcicach (Gotzman 1965), *II* — stawy w Gołyszu (Bocheński 1960), *III* — staw Nowokuźnicki (Witkowski 1965), *IV* — staw Nr. 26 pow. Niemodlin (Janowski 1967), *V* — Gospodarstwo Rybackie Krogulno (Janowski 1965), *VI* — stawy w dolinie Baryczy (Mrugasiewicz i Witkowski 1962), oraz 54 stawy w Czechosłowacji (Hanzák 1952), 34 — stawy w Górnych Łużycach (Wobus 1964), 19 stawów w Czechosłowacji i Niemieckiej Republice Demokratycznej (Bezzel 1969)

1 — lake Bajkal (Skrjabin 1972), *2* — lakes in the Tomsk region (Ravkin 1968), *3* — lakes in region of river Tyma (Gjagazov 1960), *4* — lakes in region of river Iksa (Ravkin 1968), *5* — lakes of the middle reaches of the river Obi (Ravkin 1968), *6* — lake Zaisan (Strautman and Stepanov 1968), *7* — lake Alakol (Strautman and Stepanov 1968), *8* — lake Balchaš (Strautman and Stepanov 1968), *9* — lake Son-Kul (Kydyralev 1968), *10* — lake Kurgaldžin (Kydyralev 1969), *11* — lake Čagly (Strautman and Stepanov 1968), *12* — lake Teniz (Gavrin 1968), *13* — lakes in North Kazakstan (Dobrovcev 1972), *14* — lake Aksaut (Solomatin 1968), *15* — lake Serymuin (Solomatin 1968), *16* — lakes: Bolšoj Kujaš, Malyj Kujaš, Bainauš, Kabanie, Gribonovskoe (Danilov 1968), *17* — lake Turgaj (Strautman and Stepanov 1969), *18* — lakes Aktamskoe, Ačikulskie, Batmaklinskie, Prikumskie (Vinogradov 1972), *19* — lakes Velikie and Sagava (Novikov 1966), *20* — Karelian lakes (Ivanter 1972), *21* — dam reservoirs Leninskij and Dneprodzeržynskij (Bulachov 1968), *22* — Kremenčugski dam reservoir and nearby lakes (Reva 1972), *23* — lakes in the Kiev, Czernichów, Żytomierz, Równe regions (Galaka 1968), *24* — lakes Sackie and Zabolotovskie (Cerkašenko 1972), *25* — lake Vygonovskie (Paputov 1968), *26* — lake Żumintas (Nadžinskas 1972), *27* — Estonian lakes (Onno 1970, Renno 1972), *28* — lake Gołdopiwo (Nowak 1959), *29* — lake Plecek (Sobczyk unpubl. mat.), *30* — lake Dgał Mały (Sobczyk unpubl. mat., Jakubczyk unpubl. mat.), *31* — lake Warniak (Sobczyk unpubl. mat., Jakubczyk unpubl. mat.), *32* — lake Wielkie Mamry (Dobrowolski 1969), *33* — lake Tałtowisko (Sobczyk unpubl. mat., Jakubczyk unpubl. mat.), *34* — lake Mikołajskie (Sobczyk unpubl. mat., Jakubczyk unpubl. mat.), *35* — lake Śniardwy (Sobczyk unpubl. mat., Jakubczyk unpubl. mat.), *36* — lake Łukajno (Sobczyk unpubl. mat., Jakubczyk unpubl. mat.), *37* — lake Niegocin (Jabłoński 1969), *38* — lake Drużno (Nowak 1965), *39* — lake Lubieniec (Nitecki 1967), *40* — lake Gopło (Czarnecki 1962), *41* — lake Małe Żnińskie (Kaźmierski 1962), *42* — lake Duże Żnińskie (Kaźmierski 1962), *43* — lake Gąsawskie (Kaźmierski 1962), *44* — lake Pniewy (Kaźmierski 1962), *45* — lake Zioła (Kaźmierski 1962), *46* — lake Rogowskie (Kaźmierski 1962), *47* — lake Wolskie (Kaźmierski 1962), *48* — peat bog in Jaroszewo (Kaźmierski 1962), *49* — lake Karlikowskie (Kozłowski 1967), *50* — lake Sytnowskie (Kozłowski 1967), *51* — lake Głębokie (Kozłowski 1967), *52* — lake Tuczno (Meissnerowski 1966), *53* — lake Gorzyckie (Meissnerowski 1966), *54* — lake Środkowe (Meissnerowski 1966), *55* — lake Górzyńskie (Meissnerowski 1966), *56* — lake Bytyńskie (Zubrzycki 1967), *57* — lake Lubiatowskie (Górski 1970), *58* — lake Ostrowo (Wołk 1968), *59* — Malliner See (Beitz 1966), *60* — Meisinger See (Bezzel 1963), *61* — Bodensee (Szij 1963).

Ponds: *I* — ponds at Pęcice (Gotzman 1965), *II* — ponds at Gołysz (Bocheński 1960), *III* — Nowokuźnice pond (Witkowski 1965), *IV* — pond No. 26 Niemodlin admin. district (Janowski 1967), *V* — fish farm at Krogulno (Janowski 1965), *VI* — ponds in the Barycza Valley (Mrugasiewicz and Witkowski 1962) and 54 ponds in Czechoslovakia (Hanzák 1952), 34 ponds in the Upper Lusation Region (Wobus 1964), 19 ponds in Czechoslovakia and GDR (Bezzel 1969).