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STUDIES ON ECOLOGICAL ADAPTATIONS OF BIRDS OF THE VISTULA RIVER*

Several years' observations of birds on Vistula River in the vicinity of Wyszogród and studies on their food enabled the analysis of: daytime activity cycles of Vistula birds, value of particular Vistula habitats for waterfowl, interrelations between different species, food relations of birds. These studies permitted also to demonstrate the morphoecological types of these birds.

The problem of structural pattern of a biotic community in spite of numerous studies, remains still open. In the present paper an attempt has been made to analyse the biocenotic relations among aquatic birds' species as well as between them and the invertebrate and fish fauna forming their food. Such analysis has to be based on the knowledge of: 1) the differentiation of the territory, 2) specific composition of the studied group of animals, 3) abundance of the species in question, 4) their ecological adaptations (habitat requirements, diel periodicity, food etc.).

The about 2 km long section of the Vistula River near Wyszogród was chosen for my studies. This area is highly differentiated. The presence of islands, old river beds and shallows, rich plant vegetation and varying water level allowed to expect that abundant and varied bird life would be found there.

The study area is typical for the middle course of the Vistula River which forms everywhere lateral beds ("oxbows") and islands, has shores similarly

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shaped and overgrown, similar invertebrate fauna (Mikulski and Tarwid 1951, Szczepański 1953, Kajak 1959, Cabejszek et all. 1962), and, finally, similar fish fauna (Backiel 1958). This implies that the results obtained in the present study are true for the whole middle course of Vistula, as it should be supposed that the bird fauna is also similar in composition. This presumption confirms the ornithological classification of Vistula given by Domaniewski (1918). This writer, basing on the uniform species composition of bird fauna, divided the Vistula River into three sections: mountains, great plains and lake regions. The "middle course of the Vistula River" is generally corresponding to the great plains section.

The planned regulation of the Vistula River by means of river deams must greatly influence the character of the river. No doubt, all the fauna would change, the bird fauna included. So it seemed worth while to learn the state of the bird fauna before the intended regulation. This would provide means for estimating the subsequent changes.

One more reason for choosing this particular area for study purposes was that simultaneously investigations were carried on the benthic fauna of the old river bed Konfederatka by the Institute of Ecology, Polish Academy of Sciences[1] and on the fry by the Institute of the Inlandwater Fisheries. This permitted direct comparison of fauna composition and birds' food.

A comparatively large number of bird species exploiting different habitats and different food occurred throughout the studied area. This, together with the above mentioned biological studies of this area, enables to attempt analysis of biocenotical relations among birds as well as between birds and other components of the Vistula biotic community.

Thus the following results are expected:

1. data on the biology of different species of birds occurring on the Vistula,
2. data illustrating the values of certain Vistula habitats for birds,
3. data concerning the mutual relations between various species of birds,
4. data as to mutual influencing of birds and the remaining components of Vistula biocenose.

The results obtained should permit to show the ornithological characteristic of central Vistula and, on the other hand, to analyse the biocenotical relations within the group of birds.

STUDY AREA, MATERIAL, METHODS

The area on which the investigations were performed consisted of an about 2 km long section of the Vistula River near the town of Wyszogród (853–855 km of the river course) together with the adjacent flood plain ponds

[1] Sampling material for this study was started in the Institute of Ecology, Polish Academy of Sciences.

– Konfederatka and Zgięty Rękaw. Konfederatka is an old river branch about 1700 m long with a very slack flow and completely cut off at low water (Backiel 1958, Kajak 1958). Zgięty Rękaw is a narrow, open river branch about 1000 m long and divided with a fascine dam at about a half of its length. Occasional observations were also made on the large open river branch of Czerwińsk and on the sandy part of the island (Grube Piaski) located between two branches of Vistula current (Fig. 1).

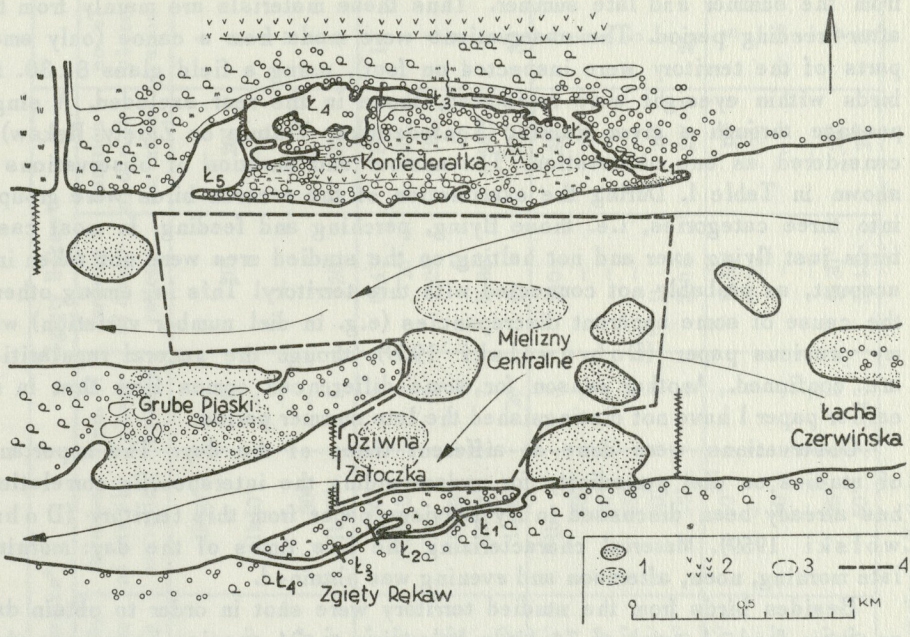

Fig. 1. The old branch of the river – Konfederatka

1 – shoals 1952, 1955, *2* – cultivated ground, *3* - limits of periodical reservoirs, *4* – route of observations on Vistula

The shores of the river and its old beds are overgrown by low swamp willow and leafy trees (mostly willow, poplar and alder). The current of the river because of the artificial dikes is meandering and producing shallows. Konfederatka is highly differentiated and divided by fascine matters sils into five sections. Its area (Backiel 1958) when there is no water flow amounts to about 8.5 ha. Section IV is intensively overgrown with submerged and floating weeds. There are also belts of emerged plants. This section is of about 5 ha area and of the nature of a pond (Backiel 1958). Similar in character are the small ponds seperated from the Konfederatka as well as a part of section II. Section I and parts od section II and III are shallow with more or less sandy shores. Section V is the deepest one (up to 4 m),

with high-pitched shores. Zgięty Rękaw is more uniformly shaped. Sections I and IV have the shores sandy, II and III – overgrown with willow brakes down to the water level and grassy. The branch of the section II is of a pond nature. It is shallow, with slimy bottom and is overgrown by submerged plants.

The observations were carried on from July 9, 1952 to September 31, 1956. Four periods were distinguished – spring (May, June), summer (July and August till the 25th), late summer (from August 25 to September 5), autumn (from September 5 to the half of November). The majority of my material comes from the summer and late summer. Thus these materials are mainly from the after-breeding period. The observations were made from a canoe (only small parts of the territory were inspected on foot), using a field glass 8×30. All birds within eyesight were registered, those in the rear excluded. A single passage through a given habitat (Konfederatka, Vistula or Zgięty Rękaw) is considered as one observation. The number and duration of observations is shown in Table I. During the examination of the records birds were grouped into three categories, i.e. those flying, perching and feeding. In most cases birds just flying over and not halting on the studied area were not taken into account, as probably not connected with this territory. This is, among others, the cause of some apparent discrepancies (e.g. in diel number variation) with my previous paper (Dobrowolski 1959), though the general regularities are confirmed. Another reason for some differences comes from that in my earlier paper I have not distinguished the late summer period.

Observations were done at aifferent times of the day. The importance of studies on diel periodicity for understanding the interspecific correlations has already been discussed in my previous paper from this territory (Dobrowolski 1959). Material characterizing the five times of the day: morning, late morning, noon, afternoon and evening was obtained.

Besides birds from the studied territory were shot in order to obtain data on their food. A total of 74 birds belonging to 34 species have been shot. The stomach contents was preserved in 75% alcohol possibly not later than half an hour after the bird has been killed. Then the stomach contents and in some cases the crop contents were segregated under a stereoscopic microscope and the found animal remains were indentified with greatest possible accuracy. The fish fragments have been identified by mgr. H. Jakubowski, the *Mollusca* fragments by mgr. T. Uminski, those of the *Trichoptera* by mgr. W. Riedel and insects, except the larvae of *Tendipedidae* by doc. dr. P. Trojan. The rest of fragments were identified by myself. I wish to express my most sincere thanks to all persons who helped me in this task.

As a result of these studies 127 species of birds were recorded on the described area. All these species on account of their mode of life, food, habitat etc. can be classified in three ecological groups: 1) terrestrial species, 2) aquatic species and 3) transitional group. The most questionable group is of course the third one. It seems, however, that these species which at

Number and duration of observations

Tab. I

Season	Time of the day	Hour	Konfederatka*			Zgięty Rękaw*			Vistula		
			no. of observations	duration of observations	duration of one observation	no. of observations	duration of observations	duration of one observation	no. of observation	duration of observations	duration of one observation
Spring	M	4– 7	2	3h	1h30'	–	–	–	1	40'	40'
	LM	7–11	–	–	–	1	20'	20'	2	3h50'	1h55'
	N	11–15	1	1h50'	1h50'	–	–	–	1	20'	20'
	A	15–17	–	–	–	–	–	–	–	–	–
	E	17–20	1	30'	30'	–	–	–	–	–	–
	Σ		4	5h20'	1h20'	1	20'	20'	4	4h50'	1h10'
Summer	M	4– 7	10	14h47'	1h30'	8	1h45'	15'	11	24h05'	2h10'
	LM	7–11	4	5h05'	1h15'	2	20'	10'	3	4h10'	1h25'
	N	11–15	2	2h	1h	2	20'	10'	6	9h	1h50'
	A	15–17	3	4h30'	1h30'	1	5'	5'	2	3h50'	1h55'
	E	17–20	8	9h	1h10'	7	1h30'	15'	8	10h25'	1h20'
	Σ		27	35h22'	1h20'	20	4h	10'	30	51h30'	1h45
Late summer	M	4– 7	4	3h50'	1h	3	1h05'	20'	5	4h37'	55'
	LM	7–11	6	5h	50'	–	–	–	4	1h	15'
	N	11–15	6	4h50'	50'	–	–	–	7	1h40'	15'
	A	15–17	4	3h35'	55'	–	–	–	5	1h20'	15'
	E	17–20	4	3h30'	50'	2	1h	30'	5	3h05'	35'
	Σ		24	20h45'	55'	5	2h05'	25'	26	11h42'	27'
Autumn	M	4– 7	4	3h10'	50'	7	1h50'	15'	5	8h52'	1h45'
	LM	7–11	–	–	–	1	25'	25'	–	–	–
	N	11–15	1	50'	50'	–	–	–	–	–	–
	A	15–17	–	–	–	–	–	–	–	–	–
	E	17–20	3	2h50'	55'	5	1h30'	20'	3	3h48'	1h15'
	Σ		8	6h50'	50'	13	3h45'	20'	8	12h40'	1h35'

* Konfederatka, Zgięty Rękaw – names of two branches of Vistula.
M – morning, LM – late morning, N – noon, A – afternoon, E – evening.

least at certain periods of life (or under certain conditions) exploit the aquatic food, should be included into the transitional group. In the tally of aquatic birds all the noted diurnal rapacious birds were included also, on the assumption that they represented a separate but still essential superior unit which could not be ignored in any study of a biotic community.

The above described method of observations illustrates relatively accurate the qualitative composition, but does not enable detailed quantitative alalysis of the terrestrial species. The transitional group could not be precisely elaborated either. The aquatic species and some of those belonging to the transitional group were analysed in detail.

Due to the relatively small number of observations made on each particular year it has been decided to combine the data for the same seasons. In order to state whether such a combination would not obliterate the real interspecific relations on the studied area, i.e. if there were no essential differences between the successive years, the number and frequency of birds observed during summer 1952 and 1956 were compared, as it was for these seasons and these years that the largest material has benn obtained. As the different time of observations performed in different habitats makes the direct comparison of the numerical data impossible, the average number of birds per 10 minutes' observation throughout the whole day has been estimated (Tab. II). Moreover, the index of the specific composition similarity (*QS*) and the index of the dominance similarity (*Re*) were calculated[2]. While calculating the second index for Zgięty Rękaw the occasional occurrence of *Corvus frugilegus* L. was not taken into account.

The values of both indices are shown in the following table:

	Konfederatka	Zgięty Rękaw	Vistula
QS	78%	43%	81%
Re	56.0	34.7	52.52

This comparison implies that on the Vistula in the years 1952 and 1956 dominated the same species. Similar is the case with Konfederatka. Some divergences on the Zgięty Rękaw can be explained by the fact that in 1956 the observations were done on the whole old river branch, while in 1952 only on its initial part, the rest being cut off by a large shallow. A relatively great number of rooks on the Zgięty Rękaw in 1956 was caused by the occurrence of one big flock during one single observation.

Of course one can not expect the interspecific relations to be identical on every year. The changes in the habitat itself do influence these relations. On the area studied and during the time of observations changed the course

[2] The method of calculating the indices *QS* and *Re* is given by Balogh (1958) and Łuczak (1953).

Average number of birds met throughout the day per one 10 minutes observation

Tab. II

Species	Konfederatka		Zgięty Rękaw		Vistula	
	1952	1956	1952	1956	1952	1956
Nyroca fuligula (L.)	–	–	–	–	0.01	–
N. nyroca (Güld.)	0.05	–	–	–	0.05	0.03
Anas crecca L.	–	0.02	–	–	–	–
A. querquedula L.	0.28	0.29	–	0.07	0.03	0.06
A. platyrhynchos L.	1.04	0.51	0.63	2.51	5.24	1.68
Larus canus L.	–	–	–	0.37	0.96	1.05
L. minutus Pall.	–	–	–	–	–	0.05
L. ridibundus L.	0.06	–	–	–	0.66	0.03
Sterna albifrons Pall.	0.07	–	0.27	–	1.24	2.71
S. hirundo L.	0.64	0.29	0.54	1.63	5.11	8.84
Hydroprognae tschegrava (Lepech.)	–	–	–	–	–	0.03
Chlidonias nigra (L.)	–	–	–	–	0.09	1.00
Calidris alpina (L.)	–	–	–	–	–	0.01
Actitis hypoleucos (L.)	0.21	0.55	1.54	1.40	1.08	1.18
Tringa nebularia (Gunn.)	0.49	0.61	0.36	–	0.64	0.98
T. glareola L.	0.39	0.02	0.63	–	3.45	0.17
T. ochropus L.	–	0.12	–	–	0.01	–
T. totanus L.	0.03	0.02	–	–	0.32	0.02
Numenius arquata (L.)	–	–	–	–	–	0.15
Limosa limosa (L.)	–	–	–	–	0.02	0.02
Capella gallinago (L.)	0.02	–	0.09	–	0.12	–
Charadrius dubius Scop.	–	–	–	–	0.05	0.04
Vanellus vanellus (L.)	0.04	–	0.09	–	2.39	0.07
Burhinus oedicnemus (L.)	–	–	–	–	0.03	–
Gallinula chloropus (L.)	0.05	0.06	0.18	–	–	–
Ixobrychus minutus (L.)	0.09	0.02	–	1.26	0.02	0.01
Ardea cinerea L.	0.71	0.06	0.09	–	0.61	0.35
Ciconia ciconia (L.)	–	–	–	–	–	0.01
Circus aeruginosus (L.)	0.06	0.04	–	0.07	0.31	0.28
C. cyaneus (L.)	–	–	–	0.07	0.08	0.08
Pandion haliaëtos (L.)	–	–	–	–	0.01	0.01
Alcedo atthis L.	0.13	–	0.09	0.15	0.01	–
Riparia riparia (L.)	1.06	2.78	–	2.67	1.46	0.67
Delichion urbica (L.)	0.02	1.01	–	–	–	–
Hirundo rustica (L.)	1.36	3.73	–	7.33	0.03	0.18
Motacilla flava (L.)	0.03	–	–	0.40	0.01	0.17
M. alba L.	0.08	0.08	0.36	0.56	0.13	0.62
Corvus frugilegus L.	–	–	–	22.20	0.77	8.65
C. cornix L.	0.08	0.08	0.19	0.29	0.80	1.74
Podiceps cristatus L.	–	–	–	–	0.02	–
Milvus migrans Bodd.	–	–	–	–	0.04	–

of the Vistula, the water level (Backiel 1958, Kajak 1958, 1960), the dislocation of shallows, the degree of overgrowth of the shores by low swamp

Average number and per cent of frequent birds from the aquatic and transitional groups

Tab. III

Species	Environment	Spring		Summer		Late summer		Autumn	
		average for 10 min.	per cent	average for 10 min.	per cent	average for 10 min.	per cent	average for 10 min.	per cent
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Anas querquedula L.	Vistula	–	–	0.06	0.2	0.03	0.09	0.12	0.26
	Konfederatka	0.2	6.5	0.3	3.46	–	–	0.76	4.7
	Zgięty Rękaw	–	–	0.05	0.32	–	–	–	–
A. platyrhynchos L.	Vistula	0.07	0.32	4.7	16.7	26.6	61.8	11.3	25.5
	Konfederatka	0.52	18.1	1.1	12.2	0.34	2.38	9.42	58.8
	Zgięty Rękaw	–	–	1.9	6.1	1.5	10.7	1.05	17.4
Larus canus L.	Vistula	0.9	4.1	0.9	3.02	0.6	1.4	0.15	0.34
	Konfederatka	–	–	0.04	0.43	–	–	–	–
	Zgięty Rękaw	–	–	0.35	0.99	–	–	–	–
L. ridibundus L.	Vistula	0.54	2.5	0.54	1.9	1.9	4.4	1.2	2.5
	Konfederatka	–	–	0.01	0.1	–	–	–	–
	Zgięty Rękaw	–	–	–	–	0.8	0.6	–	–
Sterna albifrons Pall.	Vistula	0.7	3.25	1.7	6.1	0.2	0.46	–	–
	Konfederatka	0.1	3.4	0.11	1.3	–	–	–	–
	Zgięty Rękaw	–	–	0.15	0.65	–	–	–	–
S. hirundo L.	Vistula	3.5	15.9	6.4	22.9	1.6	3.8	–	–
	Konfederatka	0.22	7.8	0.7	8.2	–	–	–	–
	Zgięty Rękaw	1.5	30.0	1.45	4.85	0.08	0.6	0.6	0.83
Chlidonias nigra (L.)	Vistula	–	–	0.4	1.4	–	–	0.04	0.09
	Konfederatka	–	–	–	–	–	–	–	–
	Zgięty Rękaw	–	–	–	–	–	–	–	–
Actitis hypoleucos (L.)	Vistula	–	–	1.1	4.2	0.44	1.02	0.2	0.45
	Konfederatka	0.06	2.1	0.26	3.03	0.63	4.4	0.06	0.37
	Zgięty Rękaw	0.5	10.0	1.75	5.8	1.4	9.83	0.45	7.1
Tringa nebularia (Gunn.)	Vistula	–	–	2.1	7.5	1.8	4.2	0.47	1.08
	Konfederatka	–	–	0.6	6.88	0.14	1.0	–	–
	Zgięty Rękaw	–	–	0.25	0.99	1.5	10.7	0.65	10.8
T. glareola L.	Vistula	–	–	1.2	4.3	0.2	0.46	0.1	0.24
	Konfederatka	0.04	1.3	0.22	2.6	0.3	2.0	–	–
	Zgięty Rękaw	–	–	0.35	1.3	0.6	4.2	0.2	3.3
T. totanus L.	Vistula	–	–	0.05	0.17	–	–	–	–
	Konfederatka	–	–	0.01	0.14	–	–	–	–
	Zgięty Rękaw	–	–	–	–	–	–	–	–

Tab. III (con.)

1	2	3	4	5	6	7	8	9	10
Capella gallinago (L.)	Vistula	–	–	0.05	0.17	0.02	0.09	0.01	0.02
	Konfederatka	0.04	1.3	0.01	0.14	0.05	0.3	–	–
	Zgięty Rękaw	–	–	0.05	0.32	0.12	0.84	0.2	3.3
Charadrius dubius Scop.	Vistula	0.04	0.2	0.05	0.17	–	–	0.03	0.07
	Konfederatka	0.06	2.1	–	–	–	–	–	–
	Zgięty Rękaw	–	–	–	–	–	–	–	–
Vanellus vanellus (L.)	Vistula	0.04	0.2	1.7	6.18	0.02	0.03	0.2	0.45
	Konfederatka	0.15	5.2	0.06	0.72	–	–	–	–
	Zgięty Rękaw	–	–	0.05	0.32	–	–	–	–
Gallinula chloropus (L.)	Vistula	–	–	–	–	–	–	–	–
	Konfederatka	–	–	0.05	0.5	0.09	0.63	0.12	0.75
	Zgięty Rękaw	–	–	0.1	0.32	–	–	0.08	1.6
Ixobrychus minutus (L.)	Vistula	–	–	0.03	0.1	0.02	0.09	–	–
	Konfederatka	0.04	1.3	0.1	1.3	0.09	0.63	–	–
	Zgięty Rękaw	1.0	20.0	0.85	2.9	–	–	0.08	1.7
Ardea cinerea L.	Vistula	0.04	0.2	0.31	1.12	0.84	2.0	0.53	1.22
	Konfederatka	0.2	6.5	0.15	1.7	0.22	1.5	0.22	1.4
	Zgięty Rękaw	–	–	0.05	0.32	0.2	1.4	0.04	0.83
Circus aeruginosus (L.)	Vistula	0.11	0.52	0.31	1.12	–	–	–	–
	Konfederatka	0.04	1.3	0.08	0.86	–	–	–	–
	Zgięty Rękaw	–	–	–	–	–	–	–	–
C. cyaneus (L.)	Vistula	0.14	0.65	0.07	0.24	–	–	–	–
	Konfederatka	–	–	–	–	–	–	–	–
	Zgięty Rękaw	–	–	0.1	0.32	–	–	–	–
Alcedo atthis L.	Vistula	–	–	0.01	0.03	–	–	0.06	0.14
	Konfederatka	–	–	0.09	1.01	0.5	3.4	0.22	1.4
	Zgięty Rękaw	–	–	0.15	0.65	0.32	2.2	0.5	2.5
Riparia riparia (L.)	Vistula	0.6	2.79	1.5	5.3	0.16	0.37	9.04	20.6
	Konfederatka	0.04	1.3	1.4	15.8	0.04	0.25	2.12	13.2
	Zgięty Rękaw	–	–	9.3	30.09	4.8	33.7	0.75	12.4
Delichion urbica (L.)	Vistula	–	–	0.01	0.03	–	–	–	–
	Konfederatka	–	–	0.3	3.1	–	–	–	–
	Zgięty Rękaw	–	–	2.5	8.1	–	–	–	–
Hirundo rustica (L.)	Vistula	–	–	0.09	0.3	1.28	3.0	6.27	14.3
	Konfederatka	0.8	26.8	1.9	21.7	12.0	81.3	1.52	10.7
	Zgięty Rękaw	–	–	9.6	31.0	3.04	21.3	2.0	33.06
Motacilla alba L.	Vistula	–	–	0.42	1.5	0.03	0.09	1.53	3.5
	Konfederatka	0.1	3.4	0.11	1.3	0.04	0.25	0.26	1.6
	Zgięty Rękaw	1.5	30.0	0.45	1.6	0.08	0.6	0.2	3.3
M. flava (L.)	Vistula	0.07	0.32	0.08	0.27	0.03	0.09	0.21	0.48
	Konfederatka	0.04	1.3	0.04	0.43	0.02	0.12	–	–
	Zgięty Rękaw	0.5	10.0	0.3	0.99	0.08	0.6	–	–

Tab. III (con.)

1	2	3	4	5	6	7	8	9	10
Corvus frugilegus (L.)	Vistula	14.6	66.2	2.88	10.26	3.64	8.5	10.04	22.88
	Konfederatka	—	—	0.9	10.2	—	—	1.0	6.2
	Zgięty Rękaw	—	—	0.2	0.65	0.08	0.6	—	—
C. cornix L.	Vistula	0.2	0.97	1.0	3.4	3.12	7.2	0.64	1.4
	Konfederatka	0.25	8.61	0.16	2.0	0.07	0.5	0.02	0.12
	Zgięty Rękaw	—	—	0.4	1.3	0.28	1.9	0.1	1.6

Absolute numbers of rare birds from the studied groups

Tab. IV

Species	Konfederatka				Vistula				Notes
	spring	summer	late summer	autumn	spring	summer	late summer	autumn	
Colymbus sp.				1					
Podiceps cristatus (L.)				1		1	2	4	
Phalacrocorax carbo (L.)				1					
Mergus merganser (L.)					1				
Bucephala clangula (L.)			1						
Nyroca fuligula (L.)				1		1		1	
N. nyroca (Güld.)	1	1		1	3	1			
N. ferina (L.)					7				
Anas domestica L.		7		12					
A. crecca L.		5					2		
A. strepera L.						10		58	
Tadorna tadorna (L.)								2	
Stercorarius parasiticus (L.)								2	
Larus minutus Pall.						3			
Hydroprognae tschegrava (Lepech.)						4			
Limicola falcinellus (Pont.)								38	
Calidris alpina (L.)						6		15	
C. minuta (Leisl.)									
Tringa ochropus L.		7				1			
T. erythropus (Pall.)							10		
Numenius arquata (L.)						9			
Limosa limosa (L.)						12			
Burchinus oedicnemus (L.)						8	1		
Fulica atra (L.)							1		
Porzana parva (L.)				1					
Ciconia ciconia (L.)		1				3			
C. nigra (L.)						5			

Tab. IV (con.)

Species	Konfederatka				Vistula				Notes
	spring	summer	late summer	autumn	spring	summer	late summer	autumn	
Accipiter nisus (L.)		2			2				1 spring ZG
A. gentilis (L.)						2	2	1	1 late summer ZG
Falco tinnunculus L.	2	1	(2 nests)			4	2	1	3 summer ZG a.CŁ
F. subbuteo L.			6				6	2	4 late summer CŁ
Buteo buteo (L.)						1	1		
Milvus migrans Bodd.						3			
M. milvus (L.)							1		
Pandion haliaëtos (L.)			1			3	3	2	

ZG – Zgięty Rękaw, CŁ – Czerwińska Łacha.

willow (because of its exploitation). Thus it was not surprising that (as it is shown on Tab. II) on the studied area in 1952 more numerous was *Vanellus vanellus* (L.) and *Tringa glareola* L. and in 1956 – *T. nebularia* (Gunn.), *Chlidonias nigra* (L.) and *C. frugilegus* L.

Despite these reservations it was assumed that the general system of dominants was permanent year in year out, so that it was possible to characterize the studied area by mean values from several years. Such method was used in the further characterizing of the territory. The average numbers of more frequently occurring birds are given in Table III. Less abundant species and accidentals are included in Table IV, giving absolute numbers of birds recorded during the observations. For the remaining species, not mentioned in Tables II and III it was in most cases impossible to give any quantitative data. These species are listed below.

Crex crex (L.)
Perdrix perdrix (L.)
Phasianus colchicus (L.)
Streptopelia turtur (L.)
Columba oenas L.
C. palumbus (L.)
C. domestica L.
Asio otus L.
Jynx torquilla L.
Dryobates major (L.)
Picus viridis L.
Certhia brachydactyla Br.
Cuculus canorus L.
Upupa epops L.
Micropus apus (L.)
Muscicapa striata (Pall.)
Lanius collurio L.
Phoenicurus ochruros (Gm.)
Erithacus rubecula (L.)
Luscinia svecica (L.)
L. luscinia (L.)
Saxicola rubetra (L.)

Turdus merula L.
T. pilaris L.
T. viscivorus L.
Troglodytes troglodytes (L.)
Parus palustris L.
P. coeruleus L.
P. major L.
Aegithalos caudatus (L.)
Remiz pendulinus (L.)
Phylloscopus sybilatrix (Bechst.)
P. trochilus L.
P. collybita Vieill.
Locustella luscinoides (Savi.)
L. naevia (Bodd.)
Acrocephalus paludicola Vieill.
A. schoenobaenus (L.)
A. palustris (Bechst.)
A. scirpaceus (Herm.)
A. arundinaceus (L.)
Hippolais icterina Vieill.
Sylvia curruca (L.)
S. communis Lath.
S. atricapilla (L.)
S. borin (Bodd.)
Anthus trivialis (L.)
Galerida cristata (L.)
Alauda arvensis (L.)
Emberiza schoeniclus L.
E. hortulana L.
E. citrinella L.
Passer montanus (L.)
P. domesticus (L.)
Fringilla coelebs L.
Carduelis carduelis (L.)
C. cannabina (L.)
Chloris chloris (L.)
Carpodacus erythrinus (Pall.)
Oriolus oriolus (L.)
Sturnus vulgaris L.
Pica pica (L.)
Coleus monedula (L.)
Corvus corax L.

RELATIONS BETWEEN AQUATIC FAUNA COMPOSITION AND BIRDS' FOOD

In spite of numerous data from the literature on the food composition of many birds and therefore of a rather satisfactory knowledge of their feeding habits, any biocenotic studies need, as to my opinion, a detailed account of the food actually taken. This is indispensable because of great food plasticity of most birds. General knowledge of this problem enables to conclude that the composition of birds food undergoes large changes in various seasons and various habitats.

Beside the knowledge of food composition, informations on the ways of feeding of various species are needed, too. Thus, for example, it is significant that *Ch. nigra* (L.) does not dive while feeding but only dips its beak into water (Kistjakovskij 1957). This way of catching prey makes it essentially different from *Sterna albifrons* Pall. and *S. hirundo* L. It is also important to know that *Anas platyrhynchos* L. feeds most intensively at evenings and nights often searching food in fields (Niethammer 1938, Dunajewski 1943 and others) and that it peels the gastropodes bigger than 8–10 mm before eating them (Žarin and Taščilin 1953); that *Corvus cornix* L. is able to pick fishes out of water either wading (according to author's own observations) or flying over the surface like the *Larinae* (Gusev and Čueva 1951). The fact that *Riparia riparia* (L.) is able to pick in flight the insect larvae from under the water surface (*Culex* sp., *Ephemeroptera*) (Naumann 1901) is sufficient to include it also as regards the feeding habits into the group of aquatic birds. On the other hand, many species of birds fly to the

water only to drink and not to feed there. These are e.g. *Numenius arquata* (L.) (Kistjakovskij 1957), *Burchinus oedicnemus* (L.) (Naumann 1902), *Carduelis cannabina* (L.), *Columba palumbus* (L.), *C. oenas* L. or *Streptopelia turtur* (L.) (according to author's own observations).

The knowledge of food composition and of methods of getting it enables first to connect closely the bird with its environment and, next, to analyse the interspecific contacts. Taking this into account I presume that in the habitats located near water-side the following species may be connected with the aquatic habitat: *Muscicapa striata* (Pall.), *Luscinia svecica* (L.), *Turdus pilaris* L., *Acrocephalus palustris* (Bechst.), *Phylloscopus trochilus* L. Namely, the aquatic insects have been found in the stomachs of these species (Tab. VI). Moreover, (despite the lack of writer's own studies) it seemed that the following species could also be suspected of food relations to the aquatic habitat: *Micropus apus* (L.), *Erithacus rubecula* (L.), *Luscinia luscinia (L.), Remiz pendulinus* (L.), *Locustella luscinoides* (Savi.), *L. naevia* (Bodd.), *Acrocephalus paludicola* (Vieill.), *A. schoenobaenus* (L.), *Emberiza schoeniclus* L., *Corvus corax* L., and may be also *Sylvia* sp.

The relations of birds to the aquatic organisms can be highly varied, starting with the parasite transferal and ending with feeding on fish, invertebrates or aquatic plants (Dunajewski 1943, Sakowicz 1952, Žarin and Taščilin 1953, Wolny 1955, Dobrowolski 1957, Bocheński 1960). The opinions of many writers as concerns the problem of birds' influence upon the aquatic fauna are divergent. Žarin and Taščilin (1953) find for example that a flock of ducks above 150–200 individuals per one ha.can limit the benthic fauna. Wolny (1955) comes to a quite different conclusion. During his studies he noted that a flock of ducks caused the destruction of flora which consequently resulted in the increase of benthic invertebrates' number. Anyway, the influence of birds upon the invertebrates is unquestionable.

As the invertebrate fauna of Konfederatka has been already studied, a comparison was possible between the frequencies of occurrence of common animals in the environment and in the birds' stomachs. Kajak (1960) wrote that on the Konfederatka 34 species of *Tendipedidae* were found of which the most frequent were *Tendipes pulmosus* L. and *Pelopia kraatzi* Kieff. and next *Polypedilum nubeculosum* Mg., *Procladius* Skuze, *Pelopia punctipennis* Mg., *Cryptochironomus defectus* Kieff., *Glypotendipes gripecoveni* Kieff., and *Endochironomus tendens* F. According to Stańczykowska (1960) 12 species of gastropodes and 7 of bivalvies (the *Pisidium* species excluded) occurred on the Konfederatka. *Valvata naticina* Menke, *V. piscinalis* Müll., *Viviparus fasciatus* Müll. and *Bithynia tentaculata* L. dominated in number. From among the bivalves the species of *Pisidium* were found in large numbers. The majority of molluscs occurred at depths from 0 to 50 cm.

The comparison of food found in the stomachs of birds is given in Table V. The list of *Tendipedidae*, *Mollusca* and *Pisces* which were found in birds' stomachs are shown in Table VI. The species considered by Backiel (1958), Kajak (1960) and Stańczykowska (1960) as dominants are underlined.

Comparison of number of birds' stomachs containing particular sorts of food

Tab. V

Species	Konfederatka				Vistula				Zgięty Rękaw a. Grube Piaski			
	no. of birds	no. of stomachs containing			no. of birds	no. of stomachs containing			no. of birds	no. of stomachs containing		
		T	*M*	*P*		*T*	*M*	*P*		*T*	*M*	*P*
Mergus merganser (L.)	0				1	x	x	1	0			
Bucephala clangula (L.)	1	x	1	x	0				0			
Anas domestica L.	1	1	x	x	0				0			
A. crecca L.	0				0				1	1	x	x
A. querquedula L.	2	1	2	x	0				0			
A. platyrhynchos L.	2	2	1	1	0				0			
Larus ridibundus L.	0				1	1	x	1	0			
Sterna hirundo L.	0				2	x	x	1	0			
Hydroprognae tschegrava (Lepech.)	0				2	x	x	2	0			
Limicola falcinellus (Pont.)	0				2	2	x	x	0			
Calidris minuta (Leisl.)	0				1	1	x	x	0			
Actitis hypoleucos (L.)	3	1	1	x	3	1	x	x	0			
Tringa nebularia (Gunn.)	3	2	2	2	4	x	1	3	3	x	x	2
T. glareola L.	3	3	2	x	0				0			
Charadrius dubius Scop.	0				1	1	x	x	0			
Gallinula chloropus (L.)	2	1	2	x	0				0			
Ixobrychus minutus (L.)	1	1	1	1	0				1	1	x	1
Muscicapa striata (Pall.)	1	1	x	x	0				0			
Total	19	13	12	4	17	6	1	8	5	2	x	3

T = *Tendipedidae*, *M* = *Mollusca*, *P* = *Pisces*. 0 – no birds shot, x – stomach did not contain this particular food.

Numbers of *Tendipedidae*, *Mollusca* and *Pisces* found in the stomachs of birds (explanations in text)

Tab. VI

Species	Konfederatka		Vistula		Zgięty Rękaw		Grube Piaski	
	no. of birds	no. of individuals	no. of birds	no. of individuals	no. of birds	no. of individuals	no. of birds	no. of individuals
Cryptochironumus defectus Kieff.			1	1				
Glypotendipes gripecoveni Kieff.	3	45	1	30	1	46		
Tendipes plumosus L. + + *T. thummi* Kieff.	6	28	2	34			1	3
Polypedilum nubeculosum Mg.							1	1
Polypedilum sp.	2	2						
Endochironomus dispar Mg.	1	1						
E. tendens F.	4	9	1	1				
Tendipedini macrophtalama Tshernovskij	2	6						
Microtendipes chloris Mg.	1	1						
Cricotopus biformis Edw.	1	1						
Pelopia punctipennis Mg.	1	1						
Procladius Skuze							1	1
Allochironomus Kieff.	1	1						
Trichocladius sp.			1	1				
Tendipedidae sp. (larvae)	1	4						
Tendipedidae sp. (pupae)	2	14						
Tendipedidae sp. (imagines)	5	6						
Tendipedidae Σ	30	119	6	67	1	46	3	5
Planorbidae	2	2						
Lymneidae	1	1						
Radix limosa L.	1	4						
Radix sp.	4	18						
Bithynia tentaculata L.	2	9						
B. leachi Shepp.	1	1						
Bithynia sp.	1	2						
Lytoglyphus naticoides L. Pfr.	1	1						
Valvata piscinalis Müll.	2	197						
V. naticina Menke	1	1						
Gastropoda gen. sp.	5	5	1	1				
Pisidium henslovanum Shepp.	1	1						
Pisidium sp.	1	1						
Sphaerium sp.	2	4						
Unio sp.	1	1						
Bivalvia gen. sp	5	17						
Mollusca Σ	31	265	1	1				
Leuciscus leuciscus (L.)	2	4	6	41				
Leucaspius delineatus (Heck.)	2	2					1	1
Alburnus alburnus (L.)			1	2			1	7
Rutilus rutilus (L.)	1	1	1	1				
Cyprinidae			1	1				
Cobitis taenia L.			1	1				
Lota lota (L.)			1	1				
Pisces Σ	5	7	11	47			2	8

The species found most frequently in the stomachs of birds are printed in bold type. This comparison shows that in the case of *Tendipedidae* the most abundant forms are most frequently eaten (similar conclusions were expressed by Borodulina 1951, 1960, Žarin and Taščilin 1953). In birds' stomachs there is only one dominant described by Kajak (1960) that is lacking viz. *Pelopia kraatzi* Kieff.

While comparing the *Tendipedidae* species found in the stomachs of birds with the occurrence of various species in various Vistula environments (Mikulski and Tarwid 1951, Szczepański 1953, Kajak 1959, Cabejszek et all. 1962) the conclusion can be drawn that birds rarely exploit semilentic[3] habitats, more frequently, instead, the mixed sand and muddy, muddy and those overgrown by vegetation. Birds exhibit greater selectivity as concerns the molluscs. *Viviparus fasciatus* Müll. which occurred in masses was never found in birds' stomachs. while *Radix* sp. was found there in numbers, though it was not a dominant in the studied area. The size of gastropodes found in the stomachs did not exceed 8 mm. So this were all young or small forms. The lack of *V. fasciatus* Müll. in food can be explained by the fact that at the time when birds were shot, young gastropodes from this species occur mostly in depths inaccessible to birds (Stańczykowska 1960). (On the other hand the error of the method might have been involved – as it was stated by Žarin et Taščilin (1953) the gastropodes larger than 8–10 mm were eaten by ducks after peeling them of their shells). It seems that birds in the studied area feed above all on young and small molluscs. *Tendipedidae*, instead, are eaten both as larvae and as imagines.

Some Vistula fishes exploit food similar to that of certain species of birds (aquatic insects – mainly the *Tendipedidae*, molluscs). Because *Blicca björkna* (L.) and *Abramis brama* (L.) feed in the same habitats as do some groups (mud in lentic part of the river, depositif mud in lotic part of the river and coastal bays, Pliszka 1951, Pliszka et all. 1951) it can be presumed that fishes and birds may be food competitors and moreover that they do represent the same trophic level in the ecological pyramid of the biotic community. Thus the community of food animals (insects and others) is under pressure of a large community of benthophagous animals (fish and birds) which does exploit it in various ways. It seems under these circumstances that the conclusion of Kajak (1960) that eating away does not influence the abundance dynamics of *Tendepedidae* must be given further checking, the more so that *Tendipedidae* are eaten not only in various habitats but also at different growth stages – as larvae and pupae (fish and birds) and as imagines (birds).

Backiel (1958) stated that particular proportions were found among the fry occurring in the Konfederatka. The dominants are *Rhodeus sericeus amarus* (Bloch), *Rutilus rutilus* (L.), *Gobio gobio* (L.), *Leuciscus leuciscus* (L.)

[3] Temporarily being under the influence of the river current.

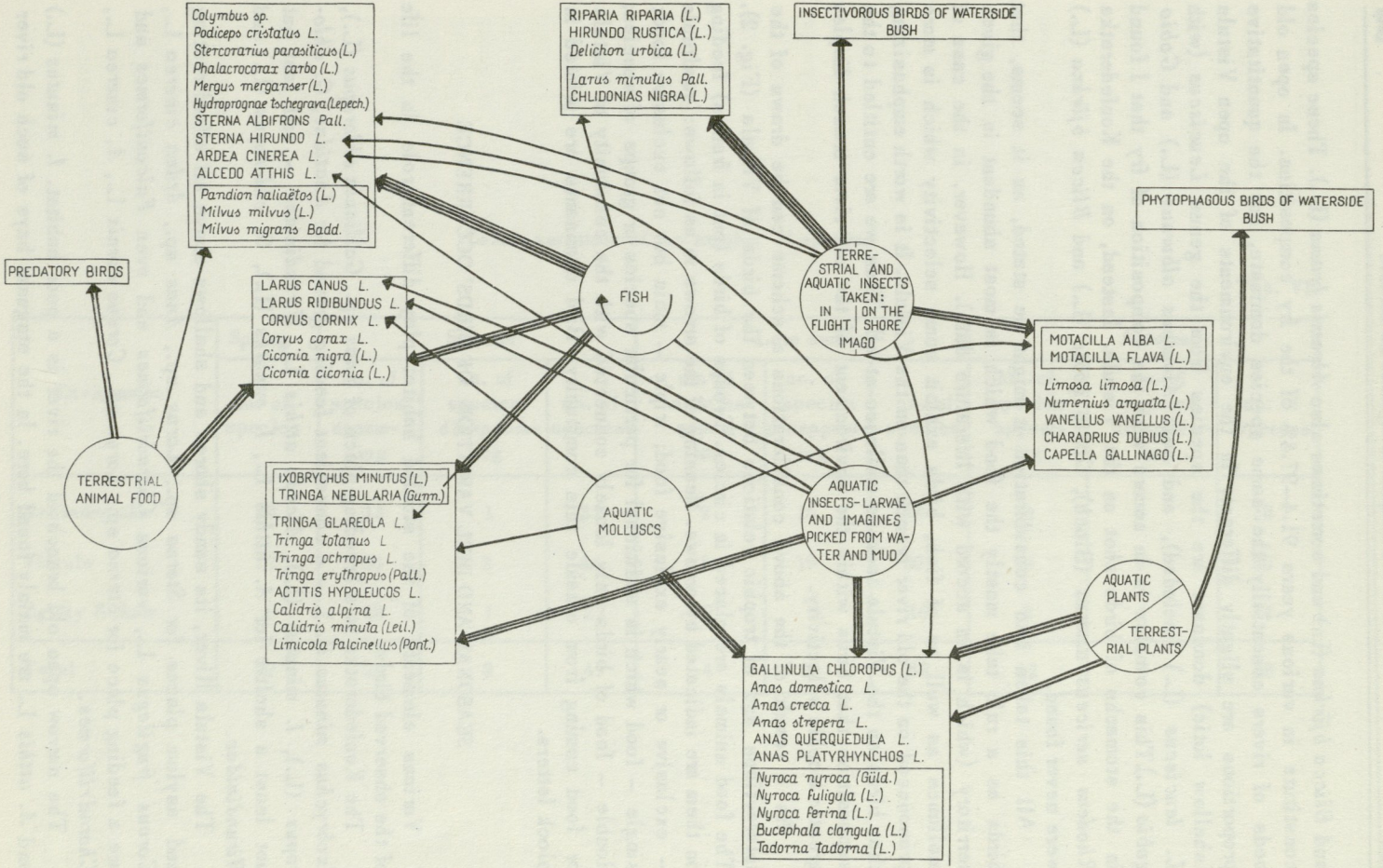

Fig. 2. Food relations of birds of Vistula (for details see text)

and *Blicca björkna* (L.) and sometimes also *Abramis brama* (L.). These species constitute in various years 91.4–97.4% of the fry composition. In open old beds of rivers essentially the same species dominate, but the quantitative proportions are slightly different. In the environments of the open Vistula (shallow lotic) dominant are the species from the genus *Leuciscus* (with *L. leuciscus* (L.) included), and next *Alburnus alburnus* (L.) and *Gobio gobio* (L.). This complex is in accord with the composition of fry that I found in the stomachs of birds shot on the Vistula. Instead, on the Konfederatka *Rhodeus sericeus amarus* (Bloch), *Gobio gobio* (L.) and *Blicca björkna* (L.) were never found.

All this taken into consideration it might be stated, as it seems, that birds as a rule take mostly the food which is most abundant in the given territory (which is in accord with literature data). However, in the case of molluscs as well as of fish, birds exhibit some selectivity which is more pronounced on the old river branch than on the Vistula. It is worth emphasizing that birds on the Vistula took no molluscs at all. Thus we are entitled to the supposition that birds within the environment of the old river branch display greater trophic selectivity.

As a result of the above considerations a scheme can be drawn of the interactions and of trophic relations between the birds of Vistula (Fig. 2). The food animals are placed in circles. Groups of birds (put in frames) feeding on them are indicated by arrows. Meaning of the arrows is as follows: quadruple – exclusive or nearly exclusive food; triple – main but not exclusive food; single – food which is additional for particular species or groups of species; double – food of birds only loosely connected with the community of Vistula or food coming from outside this community. Bird dominants are printed in block letters.

SEASONAL AND DIEL VARIATION OF BIRDS' OCCURRENCE

Various elements of the studied habitat play different role in the life of the observed birds.

The Konfederatka is a breeding place of *Anas* sp., *Gallinula chloropus* (L.), *Ixobrychus minutus* (L.), – a convenient feeding ground for *Anatidae*, *G. chloropus* (L.), *I. minutus* (L.), *Alcedo atthis* L., *Hirundinidae* – and last but not least a shelter for *A. atthis* L., *I. minutus* (L.), *G. chloropus* (L.) and *Hirundinidae*.

The Vistula River, its sandy shores and shallows above all afford resting and asylum places for *Sterna* sp., *Larus* sp., *Anas* sp., *Ardea cinerea* L., *Corvus frugilegus* L., various *Charadriiformes* and even *Falconiformes* and are a feeding place for *Sterna* sp., *Larus* sp., *Corvus cornix* L., *A. cinerea* L., *Charadriiformes*.

The narrow open old branch of the river is a poor habitat. *I. minutus* (L.) and *A. atthis* L. are mainly found here. In the stagnant bays of such old river

Yearly variation of the number of species

Tab. VII

Environment	Spring	Summer			Late summer			Autumn		
	no. of species	no. of species appear-ing	no. of species disappear-ing	no. of species	no. of species appear-ing	no. of species disappear-ing	no. of species	no. of species appear-ing	no. of species disappear-ing	no. of species
Konfederatka	20	13	1	32	2	16	18	8	8	18
Vistula	17	30	3	44	5	19	30	9	9	30
Zgięty Rękaw	6	18	1	23	2	9	16	2	4	14
Total	27	24	2	49	4	20	33	12	7	38

beds *A. platyrhynchos* L., are breeding. *Charadriiformes* stay near the Vistula or on the water dam.

The role of particular habitats is variable throughout the year. It may be caused by habitat – e.g. in autumn Konfederatka becomes an open branch of the river with a strong current. At this time large flocks of *Anas platyrhynchos* L. and assembling there and species appear which should be expected rather on the Vistula (*Bucephala clangula* (L.), *Podiceps cristatus* (L.) and others).

The specific composition of birds undergoes marked changes during the course of a year. At different seasons different numbers of bird species occur in particular habitats (Tab. VII). Generally speaking, the number of species increases in summer, then it decreases greatly in late summer and keeps about the same level in autumn. Attention should be paid to the fact that in autumn many species leave and they are replaced by new ones. Thus it seems that late summer is a season of quick changes in the specific composition. The summer stabilization becomes disturbed and the autumn system emerges.

This varying number of species causes that certain species play a different role in different seasons of the year. This significance for a given season and habitat is indicated by their abundance (in per cent of all birds). It appears that the system of dominants thus obtained is changing throughout the year. This is suggested by the data of Table III out of which only the more important (in bold type) will be discussed here[4]. In spring on the Konfederatka occur *Hirundo rustica* (L.), *A. platyrhynchos* L., *C. cornix* L., *S. hirundo* L., *A. querquedula* L. On the Vistula in this season there are found above all *C. frugilegus* L., *Sterna* sp. and *Larus* sp. Few birds visit the Zgięty Rękaw – only six species were seen there. In summer the number of *H. rustica* (L.) decreased and that of *Riparia riparia* (L.) increased. The role of *S. hirundo* L. and *Charadriiformes* slightly increases, and there appears *A. atthis* L. The number of *Anatidae* and *A. cinerea* L. increases. At this time on the Vistula dominate *Sterna* sp., the role of *C. frugilegus* L. strongly decreases, while that of *A. platyrhynchos* L. and *Charadriiformes* increases. On Zgięty Rękaw, similarly as on Konfederatka, dominate *Hirundinidae* and besides rather numerous is *A. platyrhynchos* L., *I. minutus* (L.), *Actitis hypoleucos* (L.) and *S. hirundo* L. The large number of species occurring on summer consists of the majority of breeding birds still staying there and of already appearing migrant ones. The departure of local species starts in late summer. The number of species decreases and the structure of dominance changes also. At this time on the Konfederatka dominate *H. rustica* (L.), the role of *A. atthis* L., *A. hypoleucos* (L.) increases, the remaining *Charadriiformes*, *R. riparia* (L.) and *A. platyrhynchos* L. become less important. *S. hirundo* L. disappears completely. At the same time on Vistula increases rapidly the role of *A. platyrhynchos* L., while

[4] *Corvus frugilegus* L. is not discussed here in spite of high numbers recorded. These were birds crossing only the Konfederatka on their way to the nesting colony or back.

Number of species and mean abundance of all birds on different sections of Konfederatka

Tab. VIII

Sections of Konfederatka	Spring			Summer			Late summer			Autumn		
	no. of species	mean abundance of birds	mean abundance of birds except *Hirundo rustica* (L.)	no. of species	mean abundance of birds	mean abundance of birds except *Hirundo rustica* (L.)	no. of species	mean abundance of birds	mean abundance of birds except *Hirundo rustica* (L.)	no. of species	mean abundance of birds	mean abundance of birds except *Hirundo rustica* (L.)
I	9	7.8	3.5	15	4.6	4.4	9	10.7	1.7	5	3.0	2.9
II	6	7.3	4.8	17	8.5	4.5	9	13.3	3.4	5	5.3	5.0
III	6	3.3	2.5	19	20.9	12.9	12	27.2	2.2	5	9.9	9.1
IV	10	6.3	5.0	23	21.7	19.2	12	17.8	4.3	13	53.6	52.2
V	3	2.3	1.8	13	3.6	3.5	3	4.7	0.1	5	1.5	1.5

that of *Larus ridibundus* L., *C. cornix* (L.), and *H. rustica* (L.) slightly decreases. *C. frugilegus*(L.), *R. riparia* (L.), *Sterna* sp. and *Charadriiformes* except *Tringa nebularia* (Gunn.) become less frequent. On Zgięty Rękaw still dominate *Hirundinidae* and *Charadriiformes*. *Sterna* sp. becomes less abundant and *I. minutus* (L.) is not found any more. In autumn the number of species undergoes only slight changes, but these are other species than those occurring in other seasons. On Konfederatka dominate *A. platyrhynchos* L. and *R. riparia* (L.). *H. rustica* (L.) and *Charadriiformes* disappear almost completely. On Vistula dominate *R. riparia* (L.), *H. rustica* (L.) and *C. frugilegus* L. *Sterna* sp. is not noted, the role of *Charadriiformes* grows small. On Zgięty Rękaw dominate *Hirundinidae* and *A. platyrhynchos* L. and the considerable role of *Charadriiformes* is still kept. Everywhere except Zgięty Rękaw appear species which did not occur there in other seasons.

In accord with the Thienemanns rule the most differentiated habitat, i.e. the Vistula, harbours the greatest number of species, Konfederatka being the next, and the most uniform one – Zgięty Rękaw (Tab. VII) taking the third place.

The complex of birds occurring on Konfederatka is influenced by the strongly stagnating section IV (Tab. VIII). This is where the greatest number of species as well as that of individuals occur. It becomes particularly explicit when the average values of *H. rustica* (L.) are subtracted, because this species is dispersed rather evenly along all the Konfederatka. Birds occurring mostly on old river beds are: *Gallinula chloropus* (L.), *Ixobrychus minutus* (L.), *H. rustica* (L.), *Alcedo atthis* L. These birds were never or very rarely noted on Vistula. *Larinae* and *Sterninae* are found on Vistula much more often than on flood-plain ponds. Some of them (e.g. *Chlidonias nigra* (L.)) do not occur on old river beds. Zgięty Rękaw shows higher similarity of the specific composition to Vistula than it is the case with Konfederatka, but it is in general poorly inhabited (Tab. IX). This situation is illustrated in a simplified way on Figure 22. The indices of the specific composition similarity (*QS*) for these three habitats are resembling each other very much:

	Spring	Summer	Late summer	Autumn	Whole year
Konfederatka and Vistula	59,4%	68,4%	66,7%	50,0%	71,6%
Zgięty Rękaw and Vistula	26,1%	65,7%	65,2%	50,0%	60,9%
Konfederatka and Zgięty Rękaw	38,5%	80,0%	70,6%	56,2%	70,8%

However, because the number of species occurring on a given habitat influences to some extent the value of this index, the per cent has been calculated of birds common for Vistula and for the given habitat.

Number of species of birds occuring in the three environments studied

Tab. IX

Environment	Spring		Summer		Late summer		Autumn		Whole year	
	no. of species	no. of endemic species	no. of species	no. of endemic species	no. of species	no. of endemic species	no. of species	no. of endemic species	no. of species	no. of endemic species
Vistula	17	6	44	16	30	11	30	14	56	19
Konfederatka	20	6	32	4	18	2	18	5	39	4
Zgięty Rękaw	6	–	23	–	16	–	14	1	26	–
Vistula a. Konfederatka	11	9	27	6	16	4	12	4	34	10
Vistula a. Zgięty Rękaw	3	1	22	1	15	4	11	3	25	2
Konfederatka a. Zgięty Rękaw	5	3	22	1	12	1	9	1	23	1

	Spring	Summer	Late summer	Autumn	Whole year
Konfederatka	55,0%	84,4%	88,8%	66,6%	87,2%
Zgięty Rękaw	50,0%	95,7%	93,7%	78,6%	96,2%

This method accentuates better than the index *QS* the similarity of the specific composition between birds from Zgięty Rękaw and those from Vistula. The analogous calculation for Zgięty Rękaw against Konfederatka indicates that the similarity of these two habitats decreases in late summer and in autumn. In spring on Zgięty Rękaw occur 83,3% of species common with Konfederatka, in summer – 95,6%, in late summer 75,0%, in autumn 64,3%, and throughout the whole year 88,5%.

Differences in diel periodicity also imply that various parts of the studied territory have different values for birds. This has already been discussed in my previous paper (Dobrowolski 1959), basing on analysis of 10 species. The present studies enable a more precise analysis of this problem. Out of the 22 species observed (Fig. 3–21) 5 do not occur at all on Konfederatka or come there only exceptionally (*Larus canus* L., *L. ridibundus* L., *Chlidonias*

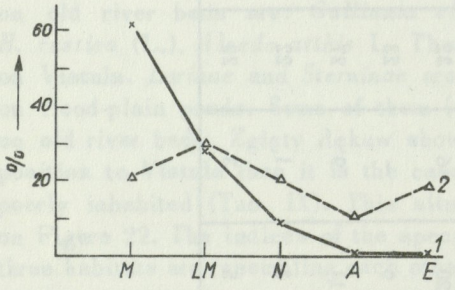

Fig. 3. Diel periodicity of *Anas querquedula* L. in per cent
1 – Vistula, summer (17 individuals), *2* – Konfederatka, summer (66 ind.). *M* – morning, *LM* – late morning, *N* – noon, *A* – afternoon, *E* – evening

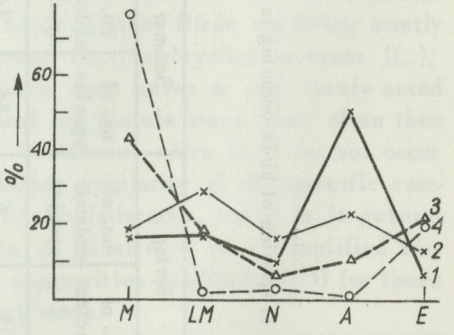

Fig. 4. Diel periodicity of *Anas platyrhynchos* L. in per cent
1 – Vistula, summer (1475 ind.), *2* – Vistula, late summer (1727 ind.), *3* – Konfederatka, summer (230 ind.), *4* – Konfederatka, late summer (46 ind.). Other abbreviations as in Fig. 3

nigra (L.), *Circus cyaneus* (L.), *Corvus frugilegus* L.), 1 bears similar relation to Vistula (*Alcedo atthis* L.). Out of the remaining 16 species – 9 do display different activity on Vistula and on Konfederatka. These are: *Anas querquedula* L., *A. platyrhynchos* L., *Sterna albifrons* Pall., *S. hirundo* L., *Actitis*

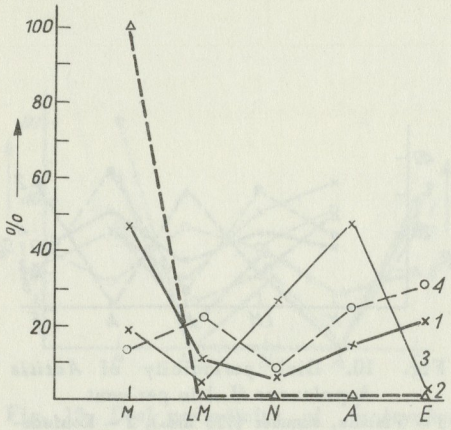

Fig. 5. Diel periodicity of two *Larus* species in per cent

Larus canus L. *1* — Vistula, summer (295 ind.), *2* — Vistula, late summer (39 ind.), *Larus ridibundus* L. *3* — Vistula, summer (172 individ.), *4* — Vistula, late summer (122 ind.). Other abbreviations as in Fig. 3

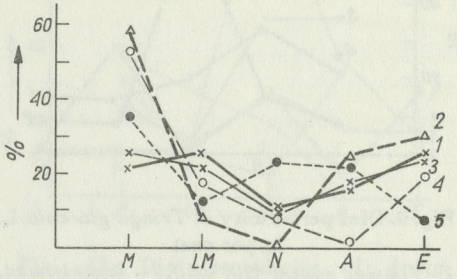

Fig. 6. Diel periodicity of two *Sterna* species in per cent

Sterna albifrons Pall. *1* — Vistula, summer (536 ind.), *2* — Konfederatka, summer (26 ind.), *Sterna hirundo* L. *3* — Vistula, summer (2028 ind.), *4* — Konfederatka, summer (155 ind.), *5* — Vistula, late summer (107 ind.). Other abbreviations as in Fig. 3

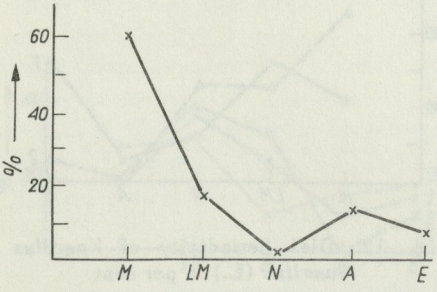

Fig. 7. Diel periodicity of *Chlidonias nigra* (L.) in summer on Vistula in per cent (120 ind.)

Other abbreviations as in Fig. 3

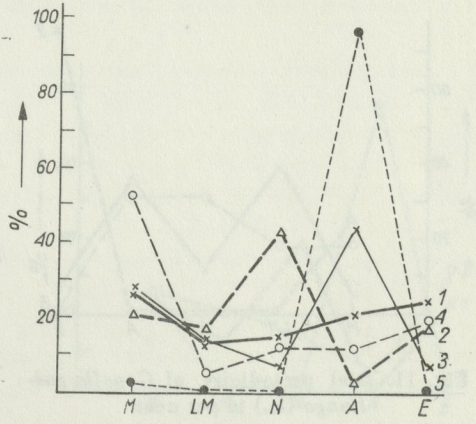

Fig. 8. Diel periodicity of *Tringa nebularia* (Gunn.) in per cent

1 — Vistula, summer (666 ind.), *2* — Konfederatka, summer (127 ind.), *3* — Vistula, late summer (116 ind.), *4* — Konfederatka, late summer (18 ind.), *5* — Zgięty Rękaw, summer (5 ind.). Other abbreviations as in Fig. 3

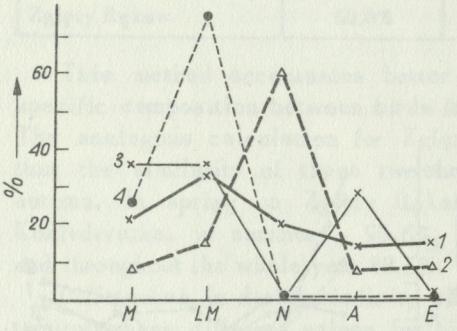

Fig. 9. Diel periodicity of *Tringa glareola* L. in per cent

1 – Vistula, summer (380 ind.), *2* – Konfederatka, summer (48 ind.), *3* – Vistula, late summer (13 ind.), *4* – Zgięty Rękaw, summer (7 ind.). Other abbreviations as in Fig. 3

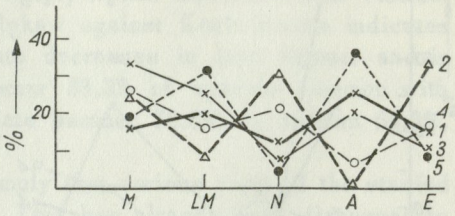

Fig. 10. Diel periodicity of *Actitis hypoleucos* (L.) in per cent

1 – Vistula, summer (373 ind.), *2* – Konfederatka, summer (57 ind.), *3* – Vistula, late summer (29 ind.), *4* – Konfederatka, late summer (84 ind.), *5* – Zgięty Rękaw, summer (36 ind.). Other abbreviations as in Fig. 3

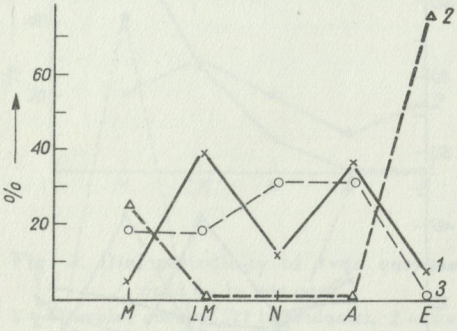

Fig. 11. Diel periodicity of *Capella gallinago* (L.) in per cent

1 – Vistula, summer (15 ind.), *2* – Konfederatka, summer (3 ind.), *3* – Konfederatka, late summer (8 ind.). Other abbreviations as in Fig. 3

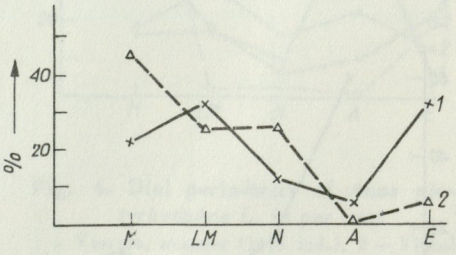

Fig. 12. Diel periodicity of *Vanellus vanellus* (L.) in per cent

1 – Vistula, summer (547 ind.), *2* – Konfederatka, summer (13 ind.). Other abbreviations as in Fig. 3

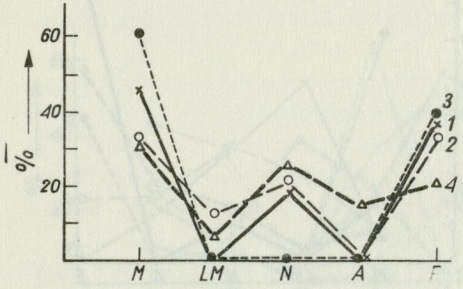

Fig. 13. Diel periodicity of *Ixobrychus minutus* (L.) in per cent

1 – Vistula, summer (10 ind.), *2* – Konfederatka, summer (23 ind.), *3* – Zgięty Rękaw, summer (17 ind.), *4* – Konfederatka, late summer (11 ind.). Other abbreviations as in Fig. 3

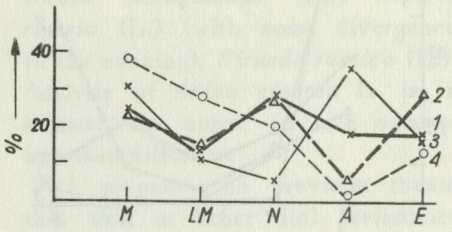

Fig. 14. Diel periodicity of *Ardea cinerea* L. in per cent

1 – Vistula, summer (165 ind.), *2* – Konfederatka, summer (33 ind.), *3* – Vistula, late summer (55 ind.), *4* – Konfederatka, late summer (23 ind.). Other abbreviations as in Fig. 3

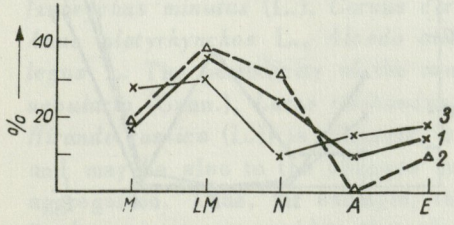

Fig. 15. Diel periodicity of two *Circus* species in per cent

Circus aeruginosus (L.) *1* – Vistula, summer (100 ind.), *2* – Konfederatka, summer (15 ind.), *Circus cyaneus* (L.) *3* – Vistula summer (21 ind.). Other abbreviations as in Fig. 3

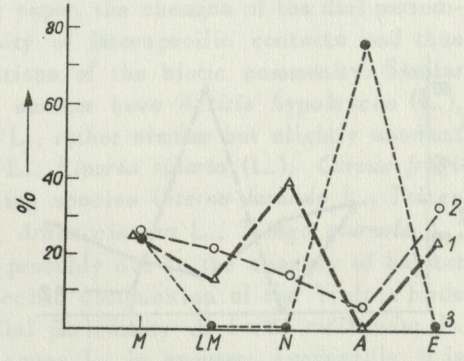

Fig. 16. Diel periodicity of *Alcedo atthis* L. in per cent

1 – Konfederatka, summer (21 ind.), *2* – Konfederatka, late summer (65 ind.), *3* – Zgięty Rękaw, summer (3 ind.). Other abbreviations as in Fig. 3

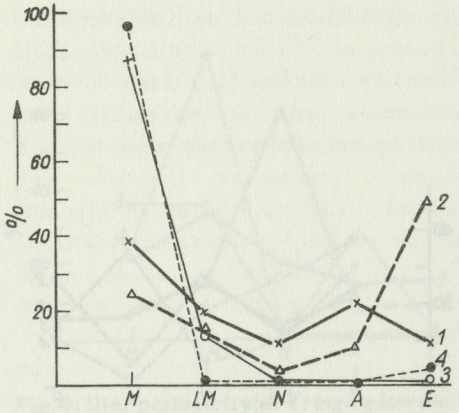

Fig. 17. Diel periodicity of *Riparia riparia* (L.) in per cent

1 — Vistula, summer (473 ind.), *2* — Konfederatka, summer (298 ind.), *3* — Vistula, late summer (11 ind.), *4* — Zgięty Rękaw, late summer (186 ind.). Other abbreviations as in Fig. 3

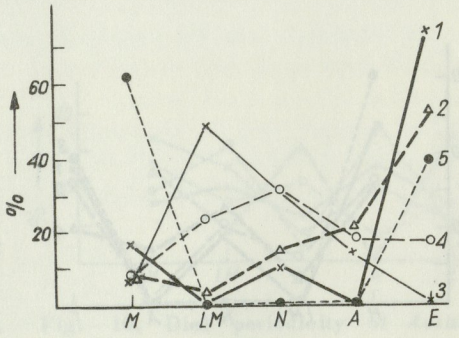

Fig. 18. Diel periodicity of *Hirundo rustica* (L.) in per cent

1 — Vistula, summer (26 ind.), *2* — Konfederatka, summer (405 ind.), *3* — Vistula, late summer (84 ind.), *4* — Konfederatka, late summer (1582 ind.), *5* — Zgięty Rękaw, summer (192 ind.). Other abbreviations as in Fig. 3

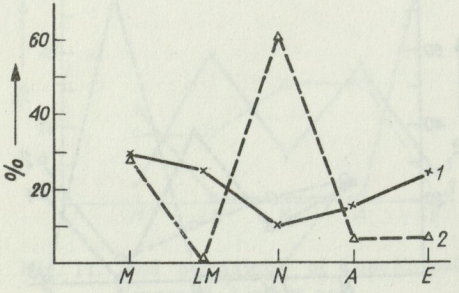

Fig. 19. Diel periodicity of *Motacilla alba* L. in per cent

1 — Vistula, summer (133 ind.), *2* — Konfederatka, summer (23 ind.). Other abbreviations as in Fig. 3

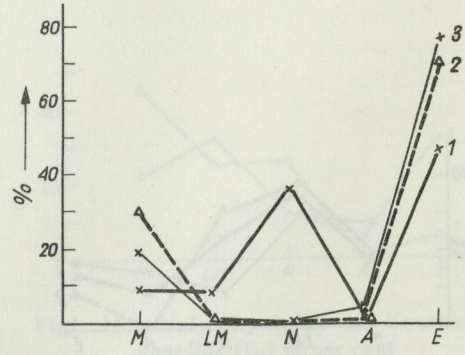

Fig. 20. Diel periodicity of *Corvus frugilegus* L. in per cent

1 — Vistula, summer (905 ind.), *2* — Konfederatka, summer (192 ind., passing ones exclusively), *3* — Vistula, late summer (236 ind.). Other abbreviations as in Fig. 3

hypoleucos (L.), *Tringa nebularia* (Gunn.), *T. glareola* L., *Motacilla alba* L., *Corvus cornix* L., their activity being different in summer and in late summer as well. 6 species show the same activity on Vistula and on Konfederatka. These are: *Capella gallinago* (L.), *Vanellus vanellus* (L.) (both species connected with shores rather than with water), *Ixobrychus minutus* (L.) *Circus aeruginosus* (L.), *Riparia riparia* (L.) (with some divergence in the evening), *Hirundo rustica* (L.). Activity of *Ardea cinerea* L. is in summer the same, in late summer becomes different.

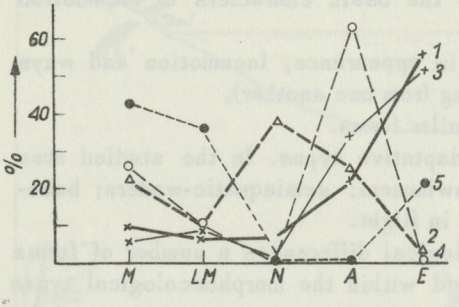

Fig. 21. Diel periodicity of *Corvus cornix* L. in per cent

1 – Vistula, summer (307 ind.), *2* – Konfederatka, summer, (35 ind.), *3* – Vistula, late summer (203 ind.), *4* – Konfederatka, late summer (9 ind.), *5* – Zgięty Rękaw, summer (8 ind.). Other abbreviations as in Fig. 3

I presume the previous thesis that this or other diel periodicity depends upon whether a given species finds in both habitats these or another elements of its ecological niche, to be confirmed by the results presented here. Species with different diel periodicity use Konfederatka first of all as a feeding place, while for rest they assemble on the sandbars of Vistula. Species with concordant rhythms are connected with Konfederatka as well as with Vistula only by food, finding shelter outside these areas or resting at their feeding grounds.

As has been mentioned in my former paper, the changes of the diel periodicity have some bearing on the intensity of interspecific contacts and thus they influence the structures and relations of the biotic community. Similar diel periodicity in summer and in late summer have *Actitis hypoleucos* (L.), *Ixobrychus minutus* (L.), *Corvus cornix* L., rather similar but slightly aberrant *Anas platyrhynchos* L., *Alcedo atthis* L., *Riparia riparia* (L.), *Corvus frugilegus* L. The periodicity of the remaining species (*Sterna hirundo* L., *Tringa nebularia* (Gunn.), *Larus ridibundus* L., *Ardea cinerea* L., *Tringa glareola* L., *Hirundo rustica* (L.)) is different. It is probably due to the changes of habitat and may be also to the changes in specific composition of the Vistula birds aggregation. Thus, for example, the diel periodicity of *Larus ridibundus* L. in late summer resembles that of *L. canus* L. in summer; supposedly it is somehow imposed by the presence of *L. canus* L. In late summer when this species almost completely left the studied area and did no longer modify the activity of *L. ridibundus* L., it attained the form of that of the formerly dominating species.

MORPHOECOLOGICAL TYPES OF BIRDS OF THE VISTULA RIVER

Šulpin (1940) while searching for criterions of distinguishing the ecological groups of birds based on the habitat, the food of birds and their locomotoric capacities. This writer distinguished three "taxa" of minor communities.

1. type – distinguished according to the basic characters of locomotion while feeding,

2. form – comprising species alike in appearance, locomotion and ways of gathering food (i.e. only slightly differing from one another),

3. class – consisting of several similar forms.

This author distinguished 7 main adaptative types. In the studied area occurred birds classified by him as: swimmers; semiaquatic-waders; bush-and-tree-creepers; and, last, those feeding in flight.

Basing on the ecological and morphological differences a number of forms found on Vistula have been distinguished within the morphoecological types given by Šulpin (1940). These are:

I. type – swimmers

1. form – birds filtering silt and grazing on submerged vegetation (*Anas* sp., *Nyroca* sp., *Gallinula chloropus* (L.)),

2. form – fishing birds (*Podiceps cristatus* (L.), *Phalacrocorax carbo* (L.), *Mergus merganser* (L.)),

II. type – semiaquatic-waders

1. form – birds catching insects on beaches (*Charadriiformes*, *Motacilla* sp.),

2. form – birds collecting invertebrates in water and silt (*Charadriiformes*, *Corvus cornix* L.),

3. form – birds fishing from the coast or nearby the coast (*Ardea cinerea* L., *Tringa nebularia* (Gunn.), *Corvus cornix* L., *Ixobrychus minutus* (L.), *Alcedo atthis* L.),

III. type – flight-feeders

1. form – birds catching insects in flight (*Hirundo rustica* (L.), *Riparia riparia* (L.), *Chlidonias nigra* (L.), *Larus minutus* Pall.),

2. form – fishing birds (*Sterna* sp., *Larus* sp., *Pandion haliaetos* (L.)),

IV. type – bush-and-tree-creepers

various forms – mostly *Passeriformes* relatively loosely connected with the biotic community of Vistula.

The distribution of various forms is illustrated by Figure 22. Type I (1) occurs on the old river beds and on Vistula. However, on the old river beds these birds mostly search for food while on Vistula they assemble for rest. Out of the form 1 *Gallinula chloropus* (L.) is lacking on Vistula. Type I (2) occurs in Vistula sporadically (hence these birds were not pictured in Fig. 22), mainly during the autumn and spring passages. Type II (1, 2, 3) is observed mostly on Vistula and on Konfederatka. On Zgięty Rękaw some species are absent (e.g. *Ardea cinerea* L.). On both old river beds occur *Alcedo atthis* L.

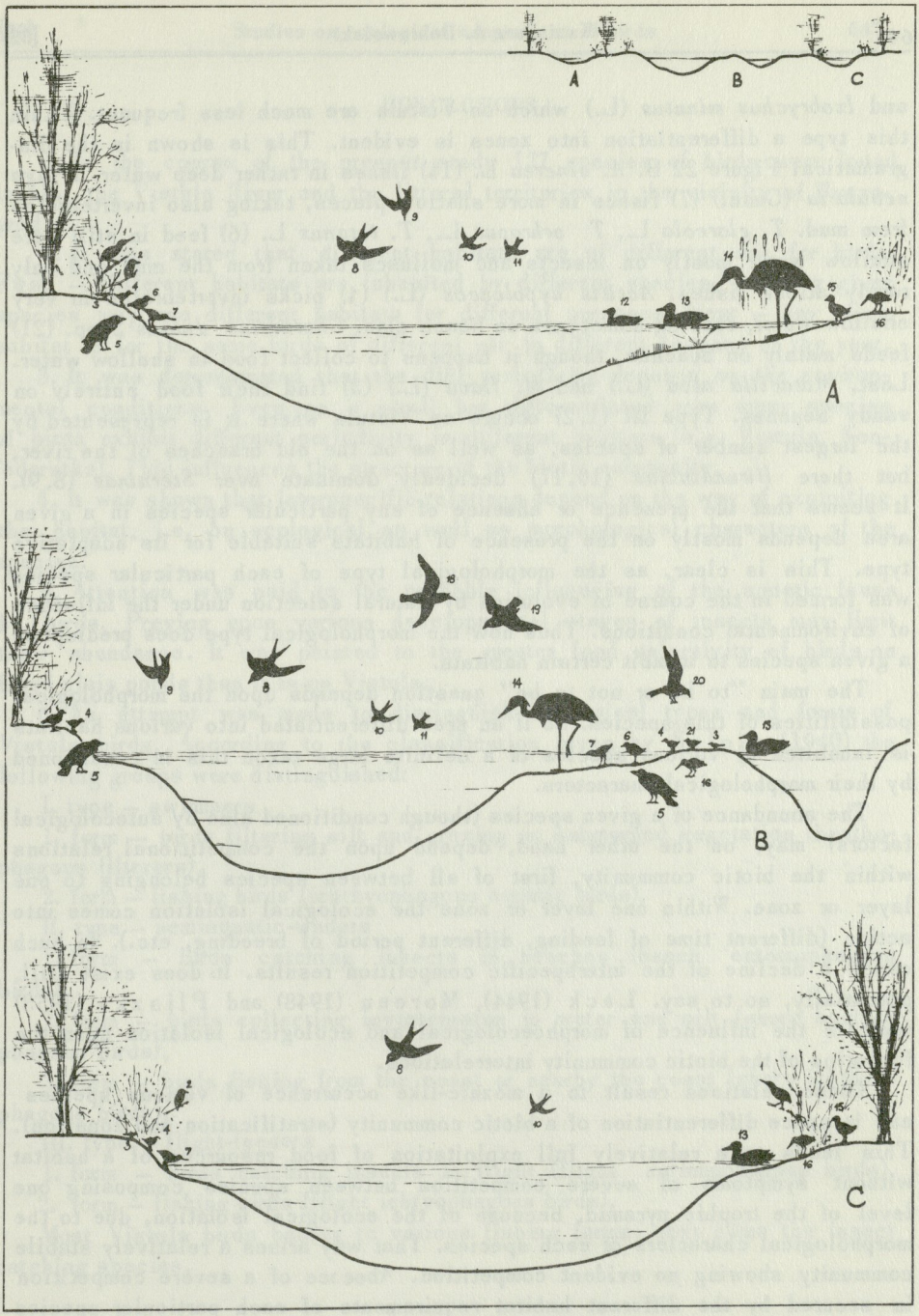

Fig. 22. Distribution of birds on Vistula and on the old river beds

A – Konfederatka, *B* – Vistula, *C* – Zgięty Rękaw, *1* – *Ixobrychus minutus* (L.), *2* – *Alcedo atthis* L., *3* – *Motacilla alba* L., *4* – *Actitis hypoleucos* (L.), *5* – *Corvus cornix* L., *6* – *Tringa glareola* L. (*T. totanus* L., *T. ochropus* L.), *7* – *T. nebularia* (Gunn.), *8* – *Sterna hirundo* L., *9* – *S. albifrons* Pall., *10* – *Hirundo rustica* (L.), *11* – *Riparia riparia* (L.), *12* – *Anas querquedula* L., *13* – *A. platyrhynchos* L., *14* – *Ardea cinerea* L., *15* – *Gallinula chloropus* (L.), *16* – *Capella gallinago* (L.), *17* – *Vanellus vanellus* (L.), *18* – *Larus canus* L., *19* – *L. ridibundus* L., *20* – *Chlidonias nigra* (L.), *21* – *Charadrius dubius* Scop.

and *Ixobrychus minutus* (L.) which on Vistula are much less frequent. Within this type a differentiation into zones is evident. This is shown in the diagramatical Figure 22 B. *A. cinerea* L. (14) fishes in rather deep water. *Tringa nebularia* (Gunn.) (7) fishes in more shallow places, taking also invertebrates from mud. *T. glareola* L., *T. ochropus* L., *T. totanus* L. (6) feed in still more shallow water mostly on insects and molluscs taken from the mud and only rarely attack fishes. *Actitis hypoleucos* (L.) (4) picks invertebrates in very shallow water, feeding sometimes on beach also. *Charadrius dubius* Scop. (21) feeds mainly on beaches, though it happens to collect food in shallow water. Last, *Motacilla alba* (L.) and *M. flava* (L.) (3) find their food entirely on sandy beaches. Type III (1,2) occurs on Vistula where it is represented by the largest number of species, as well as on the old branches of the river, but there *Hirundinidae* (10, 11) decidedly dominate over *Sterninae* (8, 9). It seems that the presence or absence of any particular species in a given area depends mostly on the presence of habitats suitable for its adaptative type. This is clear, as the morphological type of each particular species was formed in the course of evolution by natural selection under the influence of environmental conditions. Thus now the morphological type does predispose a given species to inhabit certain habitats.

The main "to be or not to be" question depends upon the morphological possibilities of this species. So if an area differentiated into various habitats is inhabited by various species of a definite large taxon this is conditioned by their morphological characters.

The abundance of a given species (though conditioned also by autecological factors) may, on the other hand, depend upon the competitional relations within the biotic community, first of all between species belonging to one layer or zone. Within one layer or zone the ecological isolation comes into action (different time of feeding, different period of breeding, etc.). In such cases a decline of the interspecific competition results. It does exist still, potentially, so to say. Lack (1944), Moreau (1948) and Pliszka (1953) indicate the influence of morphoecological and ecological isolation upon the formation of the biotic community interrelations.

These relations result in a mozaic-like occurrence of various species and in space differentiation of a biotic community (stratification and zonation). This leads to a relatively full exploitation of food resources of a habitat without symptoms of severe competition between species composing one level of the trophic pyramid, because of the ecological isolation, due to the morphological characters of each species. That way arises a relatively stabile community showing no evident competition. Absence of a severe competition is secured by the different habitat requirements of each particular species which in turn depends upon their different morphological characters.

CONCLUSIONS

1. In the course of the present study 127 species of birds were found inhabit the Vistula River and the littoral territories in the vicinity of Wyszogród.

2. It was stated that different habitats are of different use for birds. First – different habitats are inhabited by different species, and any given species may use different habitats for different purposes. Next – any given habitat is for the same birds of different use in different seasons of the year.

3. It was demonstrated that the diel periodicity depends on the environmental conditions. Even on a small but differentiated area many species of birds exhibit different periodicity in different habitats (e.g. Vistula, Konfederatka). This influences the structure of the biotic community.

4. It was shown that interspecific relations depend on the way of exploiting the habitat, i.e. on ecological as well as morphological characters of the species.

5. Attention was paid to the probable influencing of the aquatic fauna by birds. Preying upon various developmental stages of insects may limit their abundance. It was pointed to the greater food selectivity of birds on flood plain ponds than it is on Vistula.

6. An attempt was made to distinguish ecological types and forms of Vistula birds. According to the classification given by Sulpin (1940) the following groups were distinguished:

I. type – swimmers

1. form – birds filtering silt and grazing on submerged vegetation (benthophagous filterers),

2. form – fishing birds (ichthyophagous aquatic birds),

II. type – semiaquatic-waders

1. form – birds catching insects in beaches (beach entomophagous birds),

2. form – birds collecting invertebrates in water and silt (shore benthophagous birds),

3. form – birds fishing from the coast or nearby the coast (shore ichthyophagous birds),

III. type – flight-feeders

1. form – birds catching insects in flight (flight entomophagous birds),

2. form – fishing birds (flight ichtyophagous birds).

Most Vistula birds belong to various fishing forms, next come the insect catching species.

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BADANIA NAD EKOLOGICZNYMI PRZYSTOSOWANIAMI PTAKÓW WISŁY

Streszczenie

Terenem badań był dwukilometrowy odcinek Wisły pod Wyszogrodem wraz z przylegającymi łachami, otwartą i okresowo zamkniętą (Fig. 1). Teren ten może być uznany za reprezentatywny dla całego odcinka Wisły w Krainie Wielkich Dolin. Badania prowadzono od 9 VII 1952 do 31 IX 1956 r. w czasie wiosny (maj, czerwiec), lata (lipiec i sierpień do 25), późnego lata (od 25 sierpnia do 5 września) i jesieni (od 5 września do połowy listopada). Obserwacji dokonywano przede wszystkim z kajaka przy pomocy lornetki 8 × 30. Ilość i czas trwania prób podaje tabela I. Za jednostkę obserwacji przyjęto przepłynięcie kajakiem przez dane środowisko (Wisłę lub jedną z łach). Notowano sposób zachowania się ptaków. Materiały były zbierane w pięciu okresach dnia (ranek, przedpołudnie, południe, popołudnie, wieczór). Odstrzelono 74 ptaki z 34 gatunków dla dokonania analizy treści ich żołądków.

Ponieważ przy pomocy wskaźnika podobieństwa składu gatunkowego (*QS*), oraz wskaźnika podobieństwa dominacji (*Re*) stwierdzono podobne układy gatunków z roku na rok (tab. II i w tekście), dane z poszczególnych lat połączono i zagadnienia ekologiczne opracowano na materiale łącznym.

W toku badań stwierdzono występowanie 127 gatunków ptaków. Dokładniejszej analizie poddano 27 częściej i liczniej występujących gatunków, odgrywających istotną rolę w budowie biocenozy. (Wykaz ptaków tab. III, IV i spis w tekście).

Analiza roli poszczególnych siedlisk wiślanych dla ptaków w ciągu roku pozwoliła stwierdzić, że dane siedliska grają różną rolę w ich życiu (tab. VII, VIII, IX): z jednej strony różne gatunki występują w rozmaitych siedliskach, a te same gatunki wykorzystują różne siedliska w różny sposób, z drugiej strony te same siedliska w różnych porach roku grają różną rolę dla tych samych gatunków. I tak na przykład na łachy prawie zupełnie nie zalatują mewy, z kolei występowanie bączka i zimorodka jest dużo częstsze na łachach niż na Wiśle. Kurka wodna na Wiśle w ogóle się nie pojawiała. Dla kaczek łachy stanowią latem przede wszystkim miejsce pobierania pokarmu oraz wyprowadzania piskląt. Odpoczywają zaś na mieliznach Wisły, choć jesienią, przy wysokich stanach wody, również i na łachach (fig. 22).

Zauważono, że aktywność dzienna zależy od warunków środowiska. Już nawet

na małym, ale zróżnicowanym terenie wiele gatunków ptaków ma inny rytm aktywności dziennej w różnych siedliskach, na przykład na Wiśle i łasze (fig. 3—21). Może się to wiązać z różnym sposobem wykorzystywania poszczególnych partii terenu przez dany gatunek ptaka, więc z tym, czy dany gatunek znajduje w obu środowiskach te same, czy też inne elementy swej niszy ekologicznej. Dodatkowo ma to wpływ na strukturę biocenozy i na postać oraz stopień manifestowania się konkurencji międzygatunkowej.

Zwrócono uwagę na prawdopodobny wpływ ptaków na faunę wodną. Zjadanie przez ptaki różnorodnych stadiów rozwojowych owadów może być czynnikiem ograniczającym ich liczebność. Wskazano na większą wybiorczość pokarmową ptaków na łasze niż na Wiśle. Wysunięto przypuszczenie, że ptaki i ryby mogą stanowić ten sam poziom troficzny w biocenozie (tab. V i VI). Następnie przeprowadzono analizę zależności pokarmowych między ptakami (Fig. 2).

Dokonano próby wyodrębnienia typów i form ekologicznych ptaków wiślanych w oparciu o zarys klasyfikacji Szulpina (1940) i stwierdzono ogólną przydatność tej klasyfikacji. Rozwijając ją, wyróżniono:

I. typ — pływające

1. forma — ptaki cedzące muł oraz żerujące na łąkach podwodnych (bentofagi cedzące) — np. kaczki, kurka wodna,

2. forma — ptaki łowiące ryby (ichtiofagi wodne) — np. perkoz, tracz, kormoran,

II. typ — brodzące półwodne

1. forma — ptaki łowiące owady na plażach (entomofagi plażowe) — np. sieweczka, pliszka,

2. forma — ptaki łowiące bezkręgowce w wodzie i mule (bentofagi brzegowe) — np. siewkowate, wrona,

3. forma — ptaki łowiące ryby z brzegu (ichtiofagi brzegowe) — np. czapla, kwokacz, wrona, bączek, zimorodek,

III. typ — polujące w locie

1. forma—ptaki łowiące owady w locie (entomofagi powietrzne) — np. dymówka, brzegówka, rybitwa czarna, mewa mała,

2. forma — ptaki łowiące ryby (ichtiofagi powietrzne) — np. rybitwy, mewy, rybołów,

IV. typ — łażące zaroślowo-drzewne (należą tu różne formy, przede wszystkim wróblowate, stosunkowo luźno związane z biocenozą Wisły).

Największe ilości gatunków ptaków wiślanych należą do różnych form łowiących ryby, na drugim miejscu stoją gatunki łowiące owady.

W wyniku tych rozważań można stwierdzić, że nad Wisłą istnieje względnie ustabilizowany, zróżnicowany ekologicznie zespół ptactwa. Ponieważ gatunki tworzące ten zespół wykorzystują różnorodne środowiska (fig. 22) nie ma objawów ostrej walki konkurencyjnej, mimo pobierania w wielu przypadkach tego samego pokarmu. Wytwarza się zróżnicowanie środowiska na strefy wykorzystywane przez niewielką liczbę gatunków. Powstanie tego strefowego zróżnicowania biocenozy osłabia manifestowanie się konkurencji i jednocześnie zapewnia wykorzystanie zasobów pokarmowych środowisk. Warunkowane to jest morfologicznym zróżnicowaniem gatunków. Dopiero w obrębie stref (analogicznych do pięter lub warstw w zespołach leśnych) dochodzi do izolacji ekologicznej. W ten sposób na pierwotne zróżnicowanie zespołu wywołane adaptacjami morfologicznymi nakłada się niejako zróżnicowanie wtórne, oparte na cechach ekologicznych. Tak więc we względnie ustabilizowanej biocenozie konkurencja międzygatunkowa istnieje w formie potencjalnej dzięki zróżnicowaniu na strefy lub warstwy (cechy morfologiczne) i zróżnicowaniu ekologicznemu

w obrębie stref lub warstw. W biocenozach względnie ustabilizowanych konkurencja międzygatunkowa przejawia się w formie izolacji ekologicznej, która jest jednym z czynników warunkujących istnienie struktury biocenozy.

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