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The structure of groups and the numbers of fish populations in the River Nysa Kłodzka upper catchment basin

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Abstract — An ichthyological investigation was carried out using a current generator at 90 stations in 24 rivers and streams of the River Nysa Kłodzka upper catchment basin (southwestern Poland). The occurrence of 22 fish species with a predominance of the brook trout was found. Cenological methods were used in determining ichthyofauna communities. These results, associated with certain elements of hydrography, permitted the classification of the water courses of the investigated basin into two fish regions (zones), that of the trout and that of the grayling. The numbers of the ichthyofauna per 1 ha of water surface were estimated.

Key words: fish, structure of groups, numbers.

1. Introduction

In most rivers and streams of the River Nysa Kłodzka upper catchment basin the waters have so far corresponded to the highest criteria of quality. However, in recent years the rapid development of towns (including the development of health resorts and tourist facilities) and industry have contributed to a constant deterioration of the purity of surface waters (Mańczak et al. 1976). These changes cannot be unimportant with regard to the species composition and numbers of fish populations.

On the basis of ichthyological investigations carried out in the Nysa Kłodzka region for several years, the species composition of the ichthyofauna, the distribution of the different species of fish and lampreys in the

rivers, and some aspects of their biology were elaborated. In spite, however, a number of papers having appeared (Kozikowska 1961 1965, Krajewski 1983, Lohnisky 1961, 1968, 1977, Witkowski 1972, 1975, 1979), no documented data on the structure of the occurring ichthyofauna communities have so far been obtained. Therefore, the aim of the present work was to define similar habitats in the investigated basin, on the basis of the fish occurring there, and to examine the groups of species on the basis of their joint or separate presence. Besides, an attempt was made to estimate the number of fishes per unit of the river surface, this making it possible to evaluate the stocking rates in the form of the hatch or fry of the brook trout, as corresponding to the operating norms.

2. Material and method

The material was collected at 90 stations in the River Nysa Kłodzka and its primary and secondary affluents in the years 1970—1977. The hydrographical description of the stations was given in an earlier work (Witkowski 1979). A total of 14 007 fishes and lampreys were caught in the period of the investigation. The catches were conducted using a current generator of 220 V and 3—5 A, according to methods described by Penczak (1967, 1967a, 1969). In small shallow rivulets fish were caught by workers wading upstream, while in large and deep rivers the catches were made from a boat. The catching sectors were 300 m in length. The numbers of fish of the given sector were evaluated using the Seber and Le Cren method (1967). For this purpose at about 1 hr intervals methodical electrofishing was carried out at a few selected stations in rivers of different breadth, depth, and gradient. According to the authors mentioned above, the formula which makes it possible to estimate the numbers of the ichthyofauna, by using the method of two successive electric catches, has the following form: $N = c_1^2 / c_1 - c_2$, where c_1 = the number of fishes in the first electrofishing, and c_2 = the number of fishes in the second electrofishing. The application of this method also permitted the computation of the effectivity indices of the catches ($p = c_1 - c_2/c_1$) for different types of river. On the basis of the indices, the numbers of fishes at the remaining stations, where only one electrofishing was made, were estimated. The number of fish obtained in a sector of 300 m was converted to the area of 1 ha of river surface.

On the basis of the definition of similarity proposed by Marczewski and Steinhaus (1959), the different stations were compared, the composition and number of the occurring species of fish and lampreys being taken into consideration. The same methods were used for computing the cenological similarity of species. For the grouping of both stations

and species the method of "Wrocław taxonomy" (F l o r e k et al. 1951) was applied in plotting the dendrites and the Czekanowski diagrams. On the basis of these data the final grouping was worked out, a synthetic diagram being plotted according to R o m a n i s z y n's method (1970). This made it possible to group the similar stations and species or fish communities occurring there, and, moreover, to determine the dependence of species or communities upon the different ecological factors of the River Nysa Kłodzka upper catchment basin.

3. Characteristics of the investigated area

The River Nysa Kłodzka upper catchment basin, which covers 1731 km², lies in the area determined by the name "Ziemia Kłodzka" — the Kłodzko region. This most southerly part of the Province of Wał-

Fig. 1. Stations of catches in the River Nysa Kłodzka upper basin

brzych is surrounded by the state border with Czechoslovakia from three directions, east, west, and south. The investigated area is drained by the rivers of three different catchment basins, those of the rivers Oder, Elbe, and Danube. The largest part of the Kłodzko region belongs to the Nysa Kłodzka catchment area in the River Oder basin (fig. 1).

The River Nysa Kłodzka flows out from the western slopes of Mount Trójmorski Wierch (975 m above sea level) in the Śnieżnik Massif. The river is 195 km in length, the investigated sector being its first 77 kilometres. The afforestation of the upper basin is 39%. The largest affluents are the rivers Ścinawka (61.4 km), Biała Lądecka (52.7 km), and Bystrzyca Dusznicka (35 km), the remaining (20) tributaries varying in length from a few to several kilometres. The River Nysa Kłodzka and all its affluents within the Kłodzko region are montane or sub-montane water courses. The springs of the affluents lie at 1090—420 m above sea level. This altitude contributes to the high gradient, reaching even 90% in some sectors of short rivulets (Punzet 1963, Wojtowicz et al. 1974). Almost all the rivers are characterized by the highest criteria of water purity, being classified to the first or second (only rarely to the third) purity class according to the Polish norms (Szpindor 1976, Mańczak et al. 1976). The high quality of the water is also shown by a number of physico-chemical factors. According to the results obtained by Krajewski (1983) and to data of the Institute of Environmental Engineering in Wrocław, the waters of the investigated catchment area have the following parameters: the content of Ca^{++} varies from 10.0—68.5 mg/l, O_2 — 9.2—12.3 mg/l, N_{NO3} — 0.75—3.30 mg/l, pH — 6.1—7.6, conductivity — 64—355 μS; water hardness — 1.3—7.6 mval, oxygen saturation — 84—100%, and BOD_5 — 1.1—2.9 mg/l.

4. Results

4.1. Groups of stations

The stations, described in an earlier work (Witkowski 1979), were grouped using the dendrite method which made possible their shortest and objective arrangement. The obtained dendrite of stations (fig. 2) was distinctly divided into four groups (letters A—D), 12 smaller single stations with no connection appearing between them. A short hydrographical description of the differentiated groups is given in Table I.

The largest group (A) included 45 stations chiefly lying in the upper parts of rivers and streams. Three smaller sub-groups marked, A1, A2, and A3, appear very distinctly within the A group. The elaborated specification showed that in the sub-group of A2 habitats the headwater

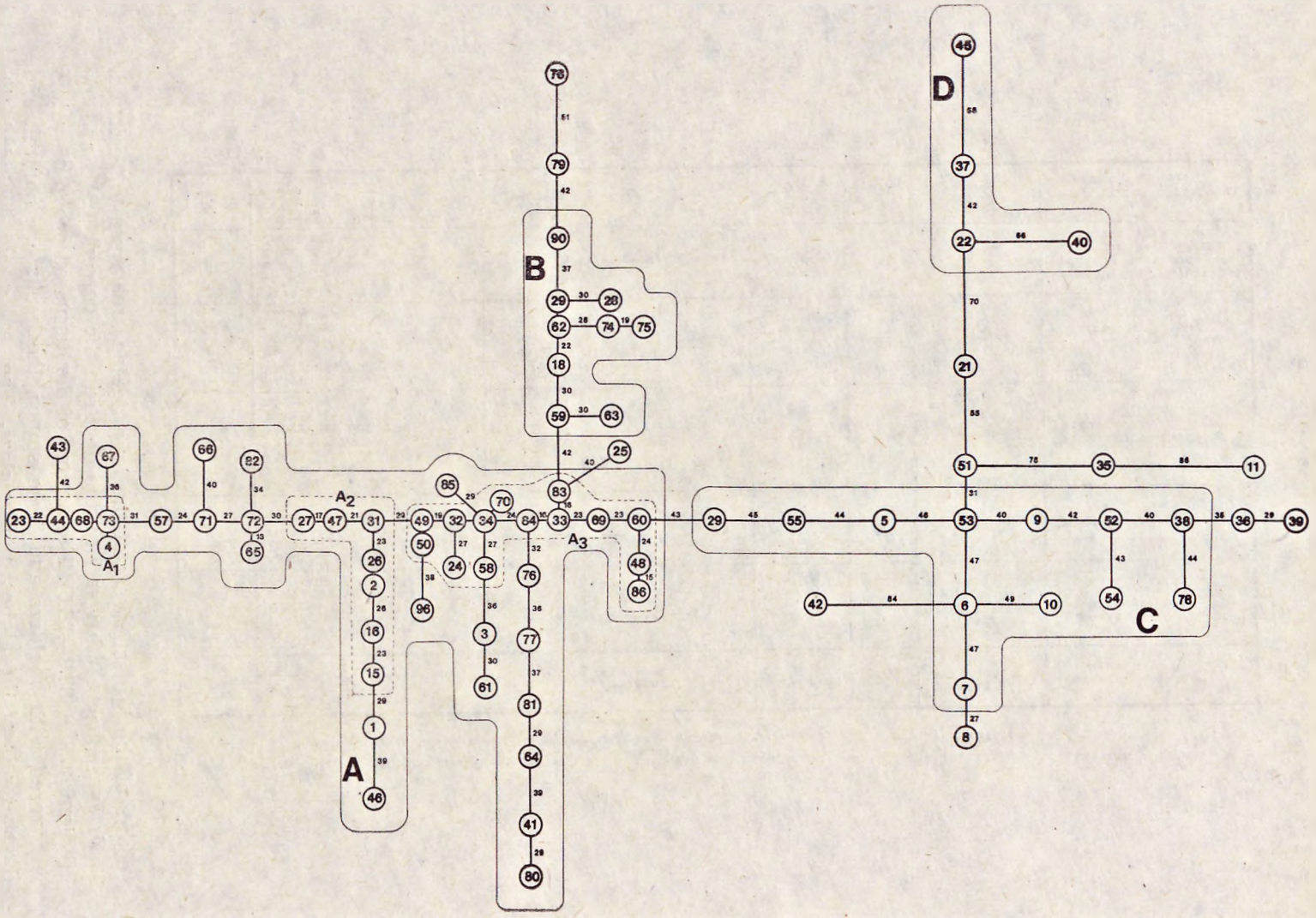


Fig. 2. Dendrite of stations against the background of the ichthyofauna of the River Nysa Kłodzka upper catchment basin

Table I. Short hydrographical characteristics of rivers and streams in the differentiated groups of stations

r - rocks; s - stones; g - gravel; sa - sand; n - natural; pr - partly regulated

Groups of stations	Names of rivers and the symbols of stations	Depth in m	Breadth in m	Character of the bottom	Gradient in ‰	Banks	Rate of water current in m/sec	Predominating fish species
A2	Nysa Kłodzka 1, 2 Bystrzyca Dusznicka 15, 16 Bystrzyca 26, 27 Wilczka 31 Biała Lądecka 46, 47	$\frac{0.30}{0.20-0.40}$	$\frac{7}{2.5-10}$	r,s	$\frac{40.8}{83.3-26.6}$	n	$\frac{1.0}{0.7-1.6}$	Salmo trutta m. fario Cottus poecilopus
A1	Nysa Kłodzka 4 Kamienny Potok 23 Pośna 44 Kamieńczyk 68 Różana 73	$\frac{0.25}{0.20-0.30}$	$\frac{5}{1.2-7}$	s,s-g	$\frac{19.0}{28.2-9.5}$	n,pr	$\frac{0.7}{0.3-1.2}$	Salmo trutta m. fario Cottus poecilopus
A3	Kamienny Potok 24 Pławna 32, 34 Biała Lądecka 48-50 Skrzyneczana 58 Piotrówka 60 Różana 69 Cicha 83, 84, 86	$\frac{0.30}{0.20-0.70}$	$\frac{5}{1.8-14}$	s,s-g g,sa	$\frac{9.7}{13.3-5.0}$	n,pr	$\frac{0.5}{0.3-0.8}$	Salmo trutta m. fario Cottus gobio
B	Wilczka 28-30 Piotrówka 59 Równica 62, 63 Łomnica 75 Jaszkówka 90 Różana 72	$\frac{0.30}{0.20-0.40}$	$\frac{4}{1.0-7}$	g,g-s	$\frac{7.8}{11.1-4.5}$	n,pr	$\frac{0.6}{0.4-1.2}$	Salmo trutta m. fario Phoxinus phoxinus
C	Nysa Kłodzka 5-7, 9, 10 Ścinawka 38 Biała Lądecka 52-55 Duna Górna 78 Jaszkówka 89	$\frac{0.40}{0.20-0.60}$	$\frac{12}{1.8-14}$	g-s,g	$\frac{6.3}{10.0-2.5}$	pr	$\frac{0.7}{0.4-0.8}$	Noemacheilus barbatulus Phoxinus phoxinus Salmo trutta m. fario Thymallus thymallus
D	Bystrzyca Dusznicka 22 Ścinawka 37, 40 Pośna 45	$\frac{0.60}{0.20-1.20}$	$\frac{7.5}{1.3-12}$	sa-g	$\frac{4.8}{8.0-2.4}$	n	$\frac{0.5}{0.3-0.8}$	Noemacheilus barbatulus Phoxinus phoxinus

sectors of the largest rivers of the investigated area were to be found. Their average breadth was 7 m, the depth in the current 0.3 m and the gradient 40.8‰ (83.3—26.6). The bottom of the discussed group of waters is covered with boulders and large stones, the banks are natural, and the water is of the highest purity class. The A1 group included the

stations in rivers with a mean gradient of 19‰ (28.2—9.5), depth of 0.25 m, and breadth of 5 m. In this group of stations the bottom is most frequently stony or gravelly-stony. As in the previously discussed group, the water can be categorized in the highest purity class. In the A3 group 7 rivers are contained with a predominance of the mouth sectors of smaller affluents of the rivers Nysa Kłodzka and Bystrzyca Dusznicka and the middle course of one of the largest affluents, the Biała Lądecka. In this group of stations the mean gradient is 9.7‰ (13.3—5.0), the depth 0.3 m, and the breadth 5 m. Here the bottom shows a varied structure with alternating zones of stony, gravelly-stony, and even sandy bottom. The banks are natural or only partly regulated. The water is of the highest purity class.

The B group includes 9 stations lying in six direct affluents of the River Nysa Kłodzka. Within this unit the mean gradient is 7.8‰ (11.1—4.5), the depth 0.3 m, and the breadth 4 m. As in the first discussed group (A), the water of this group corresponds to the highest criteria of quality. The bottom is gravelly or, more rarely, stony-gravelly; the banks are natural or, only exceptionally, partly regulated.

Twelve stations lying in the lower river course of the Nysa Kłodzka and in the mouth sector of its largest tributaries are included in the third group (C). The stations of this group have the greatest mean width, reaching 12 m, and a mean depth of 0.4 m. The bottom is stony-gravelly or gravelly, the gradient being 6.3‰ (10.0—2.5). The waters are only slightly polluted with municipal wastes.

The last group (D) comprises 4 stations (3 rivers), at which fish were still present, decidedly differing from those described above. The rivers of this group (Bystrzyca Dusznicka and Ścinawka) showed the highest level of pollution in the investigated area, with both industrial and municipal wastes (Mańczak et al. 1976).

4.2. Grouping of ichthyofauna

Besides the chief aim of putting all the stations in order, the problem of the joint or separate appearance of 22 species of fish and lampreys noted in the River Nysa Kłodzka upper basin also seemed interesting.

The dendrite and the Czekanowski diagram (figs 3 and 4) reveal that the ichthyofauna of this area is composed of 9 parts: 4 groups of species (marked a—d) and 5 species which do not show any cenological affinity with each other or with the differentiated groups.

The figures in the work show a particularly strong association between the species which were included in groups a and b. These two groups are chiefly composed of limnophilous and phytophilous species, such as the crucian carp, the rudd, the tench and pike, and the perch and bleak, thus non-typical elements of the biocenosis of montane rivers

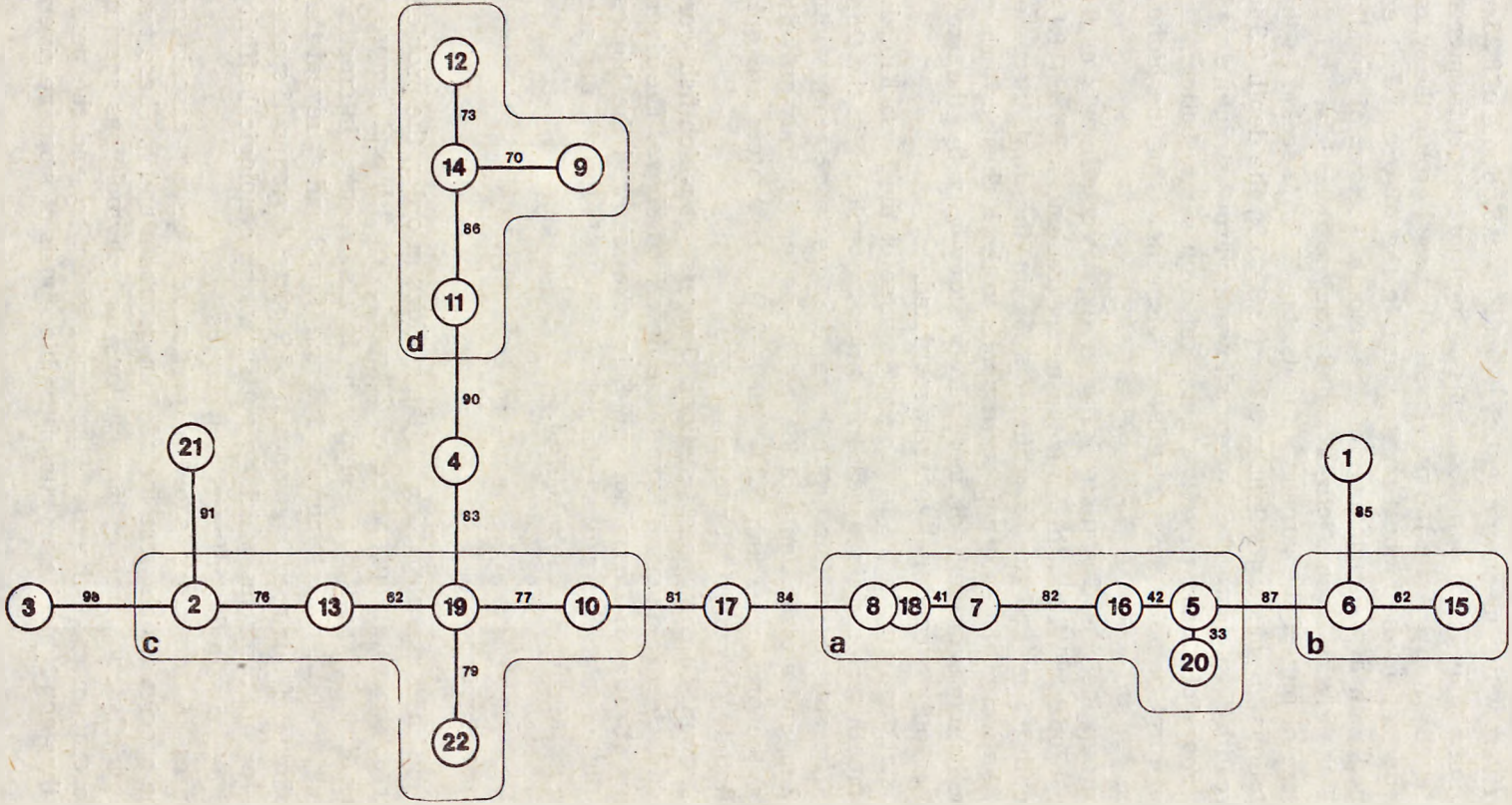


Fig. 3. The ichthyofauna dendrite against the background of stations in rivers and streams of the River Nysa Kłodzka upper catchment basin. 1 — *Lampetra planeri*, 2 — *Salmo trutta* m. *fario*, 3 — *Salmo gairdneri*, 4 — *Thymallus thymallus*, 5 — *Esox lucius*, 6 — *Cyprinus carpio*, 7 — *Tinca tinca*, 8 — *Carassius carassius*, 9 — *Barbus barbus*, 10 — *Gobio gobio*, 11 — *Leuciscus cephalus*, 12 — *L. leuciscus*, 13 — *Phoxinus phoxinus*, 14 — *Chondrostoma nasus*, 15 — *Leucaspius delineatus*, 16 — *Alburnus alburnus*, 17 — *Rutilus rutilus*, 18 — *Scardinius erythrophthalmus*, 19 — *Noemacheilus barbatulus*, 20 — *Perca fluviatilis*, 21 — *Cottus poecilopus*, 22 — *C. gobio*

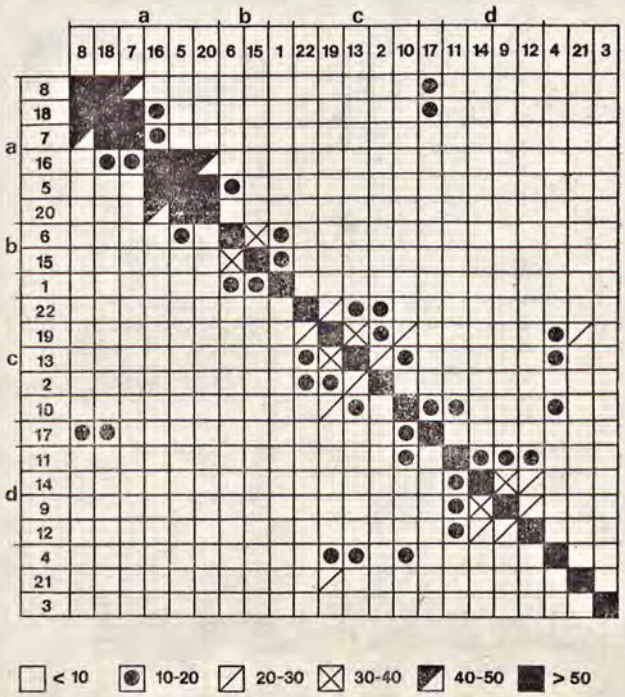


Fig. 4. Similarity of co-occurrence of the ichthyofauna at stations in the rivers and streams of the River Nysa Kłodzka upper catchment basin. Symbols as in fig. 3

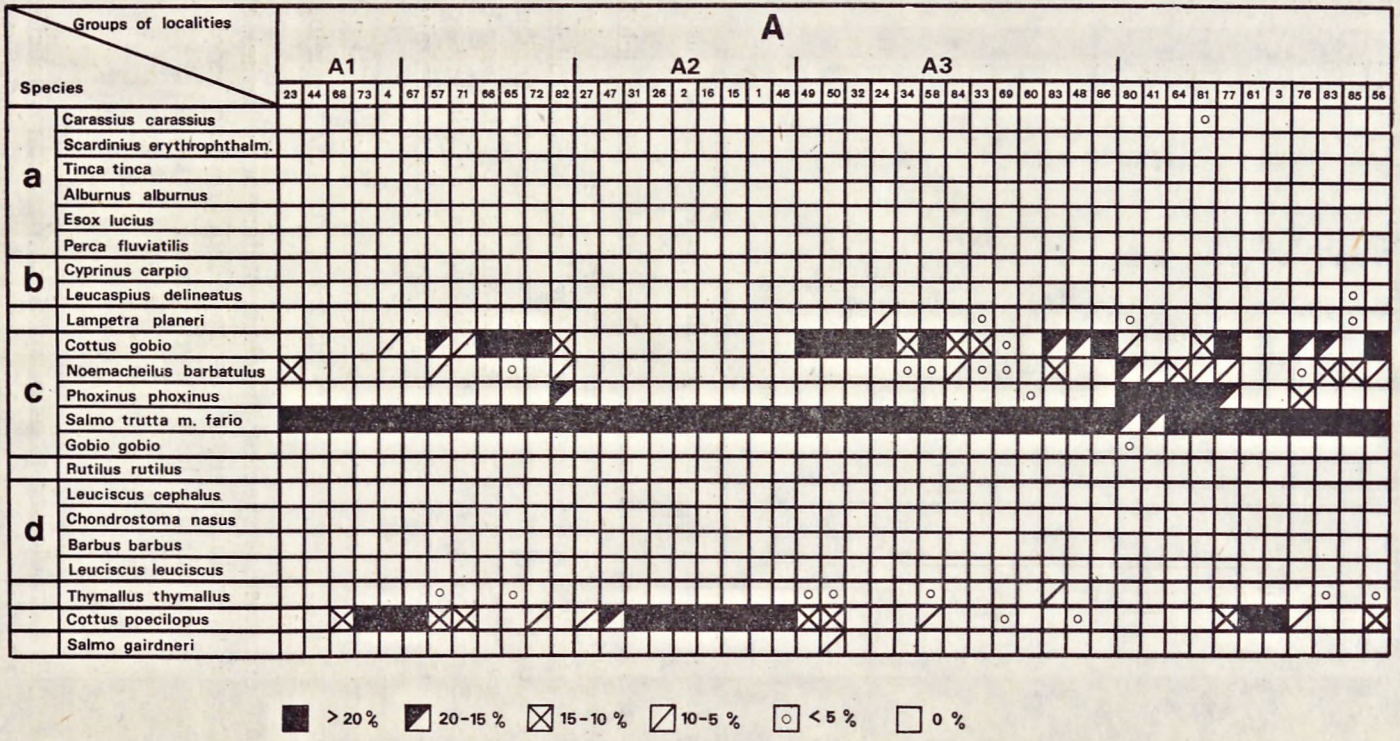
and streams. A close examination of these groups of the ichthyofauna revealed that the species mentioned above were found only at two stations (11 and 25). The former lies in the River Nysa Kłodzka ox-bow lake near Kłodzko and the latter at the mouth of a small tributary, the Kamienny Potok stream, which drains off waters from the near-by breeding ponds. Owing to the fact that the ichthyofauna of these two habitats differs from the remaining stations, any further discussion about them was regarded as irrelevant.

The next very compact group (c) is composed of 5 rheophilous litho- and psammophilous species: the brook trout, minnow, stoneloach, gudgeon and bullhead.

Group d comprises 4 species: the chub, undermouth, barbel, and dace. Such species as the rainbow trout, east bullhead, grayling, brook lamprey, and roach remained outside the last two groups.

4.3. Cenological analysis

The identified conglomerations of species from groups specific for the River Nysa Kłodzka upper catchment basin (except for the a and b groups). However, it is not known with which of the previously iden-



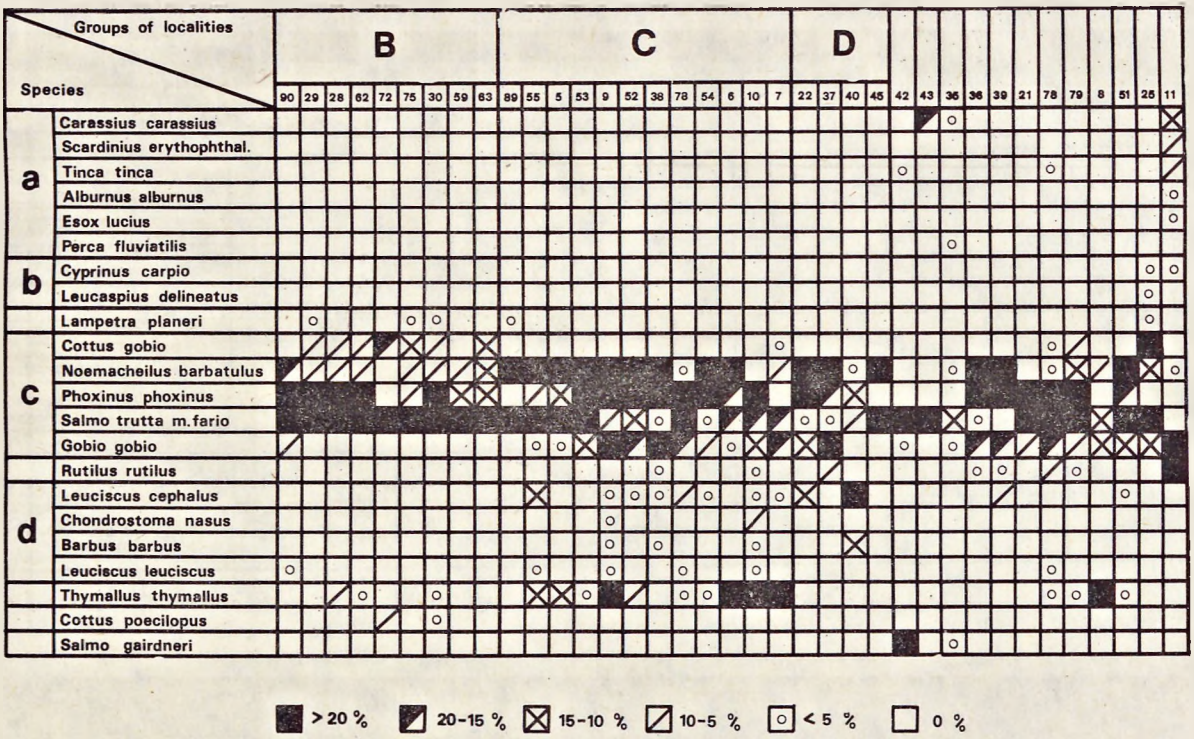


Fig. 5. Similarity of composition and co-occurrence of the ichthyofauna at stations in the rivers and streams of the River Nysa Kłodzka upper catchment basin

Table II. Number of species (in %) in the groups of stations of the River Nysa Kłodzka upper catchment basin

Groups of species \ Groups of stations		A						B		C		D	
		A2		A1		A3							
		Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
	Lampetra planeri					0.0- 6.7	0.5	0.0- 0.5	0.1	0.0- 0.4	0.03		
c	Cottus gobio			0.0- 5.1	1.3	0.0-29.8	10.4	0.0-20.0	6.5	0.0- 4.5	0.4		
c	Noemachailus barbatulus			0.0- 12.9	2.6	0.0-10.6	2.5	0.0-18.0	9.2	0.0-44.2	27.5	0.0-68.0	40.8
c	Phoxinus phoxinus					0.0- 1.3	0.1	0.0-35.5	24.5	0.0-50.2	22.4	0.0-29.6	15.3
c	Salmo trutta m. fario	39.3-90.4	67.4	66.6-100.0	81.8	53.7-98.7	77.1	39.6-79.5	56.9	1.2-60.6	20.3	0.0-32.0	12.2
c	Gobio gobio							0.0- 6.7	0.9	0.0-26.4	11.2	0.0-28.0	13.3
	Rutilus rutilus									0.0- 1.4	0.07	0.0- 8.0	2.0
d	Leuciscus caphalus									0.0-10.6	3.1	0.0-42.8	13.3
d	Chondrostoma nasus									0.0- 5.6	0.5		
d	Barbus barbus									0.0- 1.2	0.5	0.0-14.3	3.0
d	Leuciscus leuciscus							0.0- 1.0	0.1	0.0- 3.1	0.9		
	Thymallus thymallus					0.0- 6.1	1.0	0.0- 5.0	1.5	0.0-52.2	12.9		
	Cottus poecilopus	9.6-60.6	32.6	0.0- 28.2	13.6	0.0-25.1	8.0	0.0- 9.1	0.1				
	Salmo gairdneri					0.0- 7.3	0.4						

tified groups of stations (A—D) they are most associated. The answer to this question can be found in the synthetic diagram (fig. 5) where the dendrite of stations is combined with the Czekanowski dendrite and the diagram of species.

The synthetic diagram shows that in the A group of stations the essential part of the ichthyofauna is formed by species of the c group and the grayling, rainbow trout, east bullhead and brook lamprey. Within this group of stations 3 smaller sub-groups (A1, A2, and A3) were previously identified. They differed fairly distinctly from each other in a number of ecological factors, particularly in the gradient. Thus, in the habitats of the highest gradient (A2) only 2 species of fish occurred, the brook trout and east bullhead. Table II shows the percentage of these species in the discussed group of stations. In the A1 group the ichthyofauna is composed of the two species mentioned above and also of the bullhead and stoneloach, though their numbers are small. The sub-group A3 with the lowest unit gradient within the A group, is characterized by a richer ichthyofauna, i.e. 8 species. Except for the gudgeon, almost all species of the c group appear here. The other members of the sub-group are the east bullhead, grayling, lamprey, and introduced rainbow trout.

At the stations of the B group the qualitative composition is similar to that in the A3 group. The basic part of the ichthyofauna is formed by the c group of species, though their percentages are slightly different. The brook trout quantitatively predominates while the next species in the dominant group is the minnow. In the discussed group of stations the number of grayling and stoneloach increases, while the percentage of the two *Cottus* species decreases, particularly that of the east bullhead. The appearance of such species as the gudgeon and dace was for the first time observed in this group of stations.

The ichthyofauna of the C group is composed of 12 species of the 2 basic groups c and d, and of the grayling, roach, and brook lamprey. The quantitative dominants (over 10%) are the stoneloach, minnow, brook trout, gudgeon, and grayling. The last species had the highest predominance and constancy in this type of environment, reaching 12.9 and 83.3%, respectively.

The last differentiated group of stations (D), composed of sectors of markedly polluted rivers is characterized by the occurrence of only 7 species, appearing in small numbers of specimens. Two species predominate here, the stoneloach and minnow. In spite of the fairly high unit gradient (4.8‰ on the average) in these environments, such stenooxybionts or oligosaprobes as the two *Cottus* species or the grayling are no longer observed. The brook trout, which also belongs to these groups, was only sporadically noted, being represented by mature specimens only, this suggesting that the species does not reproduce here. Its seasonal occurrence can be explained by the carrying away of fishes by

higher water levels and floods from the upper unpolluted sectors of the river or its tributaries.

4.4. The numbers of the ichthyofauna

The numbers of fish calculated per 1 ha of the water course varied distinctly in the differentiated groups of stations (Table III). The list presented in the work shows that in the groups A2 and A1 — thus in those lying in the head water zones of rivers and streams — the density of the ichthyofauna reaches its lowest values, varying from 157—1454 ($\bar{x}$ = 526) specimens · 1 ha^{-1}. According to the results of Krajewski (1983), they were also characterized by the lowest rate of growth. In the groups of these rivers the brook trout, the most valuable species, reached 54—836 ($\bar{x}$ = 371) specimens · h^{-1}.

In the A3 group, characterized by a lower gradient, the computation showed the occurrence of 472—8500 ($\bar{x}$ = 2513) specimens per 1 ha. In this number the brook trout reached 286—7863 ($\bar{x}$ = 2106) specimens per 1 ha. Another valuable species, the grayling, appeared in small numbers here (0—145, $\bar{x}$ =19).

At the stations of the B group the greatest numbers of fish were observed (1000—12 791, $\bar{x}$ = 5604). The trout was also represented by the greatest number of specimens, varying from 709—9587, 3585 specimens · · 1 ha^{-1} on the average. However, it should be stressed that this large number of this species was the result of stocking carried out by the Polish Angling Union. Among other streams, the Wilczka, Piotrówka, Łomnica, and Skrzyczana received high stocking rates (from a few to several thousand specimens) in the form of brook trout fry almost every year (Witkowski 1979). In this group of stations the number of grayling was relatively small, varying from 0—192, $\bar{x}$ = 36 specimens · 1 ha^{-1} of the water surface.

The C group of stations, which included the river sectors of the lowest gradient, was characterized by distinctly smaller numbers of fish than the two groups discussed above. The calculations showed that the average number of fish was 1370 (336—5373) specimens per 1 ha of the stream or river surface. The brook trout did not dominate here absolutely (7—1994, $\bar{x}$ = 375), being outnumbered by the minnow. As compared with all other groups, the numbers of grayling reached the highest values here: 105 specimens · 1 ha^{-1} on the average.

In the last group of stations (D), lying in rather polluted rivers, the numbers of the ichthyofauna, and among them of the most valuable species, were markedly small, varying from 95—638 ($\bar{x}$ = 233) specimens · · 1 ha^{-1}.

Table III. Number of fish on 1 ha of water surface in the groups of stations

Species \ Groups of stations	A						B		C		D	
	A2		A1		A3							
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
Lampetra planeri					0- 36	3	0- 24	5	0- 14	1		
Salmo trutta m. fario	54- 836	284	145-727	459	286-7863	2106	709-9587	3585	7-1994	375	4-201	54
Salmo gairdneri					0- 36	3						
Thymallus thymallus					0- 145	19	0- 192	36	0- 285	105		
Rutilus rutilus									0- 4	1	0- 9	1
Leuciscus leuciscus							0- 45	5	0- 39	8		
Leuciscus cephalus									0- 485	57	0- 41	14
Phoxinus phoxinus					0- 73	6	504-2052	1022	0-2707	362	0- 29	15
Chondrostoma nasus									0- 29	4		
Barbus barbus									0- 12	3	0- 13	1
Gobio gobio							0- 309	34	0- 889	145	0- 32	14
Noemacheilus barbatulus			0- 40	8	0- 254	51	0- 947	513	0-1281	304	5-427	134
Cottus poecilopus	21- 618	239	62-169	61	0- 931	139	0- 275	63				
Cottus gobio			0- 11	2	0- 353	172	0-1432	341	0- 20	5		
Total	157-1454	523	218-776	530	472-8500	2513	1000-12791	5604	336-5373	1370	95-628	233

5. Discussion

The observed zonality of occurrence and the percentage of the different components of the ichthyofauna in the River Nysa Kłodzka upper catchment basin is greatly similar to the relations found in most Carpathian rivers. The changing qualitative composition of the ichthyofauna associated with physico-chemical and hydrographical elements of the river structure (chiefly the gradient) which also varied, made it possible to differentiate the zones, communities, or fish regions (Kołder 1966, Kołder et al. 1974, Solewski 1960, 1961, 1962, 1963, 1964, 1965, Rolik 1971, Żarnecki, Kołder 1965) based on earlier concepts of Frič (1872), Borne (1877) and Nowicki (1882, 1889) and further works of Huet (1946, 1949, 1954, 1959) and Starmach (1956), in the longitudinal profile of the water courses.

The groups of stations differentiated by the present author, additionally characterized by the groups of species and by some hydrographical parameters, can be categorized among the classifications proposed by the above-mentioned authors. The stations of the groups A2 and A1 correspond to the upper parts of the trout region. The fish species and their numbers noted there are similar to those in the Upper Vistula, Soła, some tributaries of the Dunajec, and the San. In these rivers, as in the Nysa Kłodzka, the fishstock is composed of 2 or 3 (more rarely of 4) species, with the brook trout as the absolute dominant. As the accompanying forms the minnow and the two *Cottus* species are noted. It should be stressed that in this river zone the east bullhead several times outnumbered the bullhead. Similar observations were made by Rolik (1971) and Starmach (1965, 1972).

With regard to the qualitative composition and numbers of species settling the stations of the A3 group, they correspond to the central regions of the trout zone. In the basin of the River Nysa Kłodzka the ichthyofauna is composed of 8 species. According to Solewski (1960, 1961, 1962, 1963) and Rolik (1971), a similar number of species is noted in the same zone of Carpathian rivers (the Vistula, Soła, Rogoźnik, and San).

The B group of stations can be classified in the lower region of the trout zone, playing the role of a transition to the grayling zone. The ichthyofauna is composed of 9 fish and lamprey species there. In the same zone of Carpathian rivers the qualitative composition is slightly richer, the number of species varying from 10—13. However, it should be mentioned that such species as the Carpathian barbel or riffle minnow, which are fairly numerous in Carpathian affluents of the River Vistula, have never been recorded in the River Oder upper basin. Most authors (among others Kołder 1966, Kołder et al. 1974, Solewski 1964)

postulate that in this zone the salmonid fish predominate, though a considerable admixture of rheophilous cyprinids is observed.

The last group (C) characterized by still unpolluted waters, is composed of water courses which differ considerably from the above-discussed rivers also in the qualitative composition. The ichthyofauna is formed by 12 fish and lamprey species with rheophilous cyprinids predominating. Among them the minnow prevails. Of all discussed groups the grayling appears in the greatest numbers in this type of environment. Similar dependences were observed by Kołder et al. (1974), who assigned these sectors of rivers to the sub-montane zone. According to the criteria of earlier workers, this zone corresponds to a high degree to the grayling zone.

In the differentiated groups of streams and rivers of the Nysa Kłodzka upper basin the number of fish per 1 ha of water surface was almost always greater than in some Carpathian trout rivers (Solewski 1960, 1961, 1962, 1963, 1964). The latter author found that only in the sectors of the rivers Vistula, Rogoźnik, Soła, San and the Białka Tatrzańska stream, of the upper zone of the trout along was the number of all fish species almost double that in the River Nysa. Nevertheless, except for the Vistula upper river course, the number of trout was only slightly smaller than in similar sectors of the rivers investigated by the present author. In the middle sectors of the Carpathian rivers quoted above the population of fish varied from 200 (the River San) to 1700 (the Rogoźnik stream) specimens per ha^{-1}, with 100—840 specimens of the brook trout. In spite of the similarity of conditions found in the Nysa Kłodzka basin with regard to gradient, and the composition and percentage shares of species, these values were distinctly lower (2652 fishes · ha^{-1}, with 2106 trout in this number). However, it should be mentioned here that the large numbers were brought about by the stocking of rivers carried out by the Polish Angling Union. The results of this kind of treatment are also observed in some rivers assigned by the author to the lower region of the trout zone. The total fish population, and in this number also the trout, were from a few to several times more numerous as compared with the data quoted by Solewski (1960, 1961, 1962, 1963, 1964, 1965).

In comparing the numbers of the ichthyofauna in the investigated catchment basin with the results reported by authors from neighbouring areas (Czechoslovakia), a general similarity can be observed (Lusk 1971, 1973, 1976, Libosvárský 1973). However, in a few cases very large numbers of fish were noted there, reaching 10 000—30 000 specimens · ha^{-1} (Lusk 1973, Libosvárský, Lelek 1965, Libosvárský, Wohlgemuth 1973). As in the River Nysa Kłodzka, these great numbers of fish were the result of intense stocking, chiefly with the fry of the brook trout and the rainbow trout.

In the light of the presented results, the question arises as to whether

the applied stocking rates and, in consequence, the density of the fish population in the River Nysa Kłodzka upper basin correspond to the norms determined for this type of water course. In the works of Backiel (1964, 1964a) and Sakowicz (1955) elaborated for Polish rivers, the rate of 0.2 specimens of brook trout or sea trout autumn fry per 1 m^2 of water surface is recommended for small trout rivers. The values computed for the investigated basin of the River Nysa Kłodzka varied from 0.21—0.35 specimens/m^2. Under the existing conditions it seems that the optimum density of trout has been attained, though in the absence of other predators and a fairly large number of calm-feeding fish (particularly the minnow), slightly higher stocking rates (0.3—0.4 brook trouts/1 m^2) might be justified, particularly in the rivers of the middle part of the trout zone.

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6. Polish summary

Struktury zgrupowań i liczebność populacji ryb w górnym dorzeczu Nysy Kłodzkiej

Przeprowadzone badania w 24 rzekach i potokach górnego dorzecza Nysy Kłodzkiej (ryc. 1) pozwoliły na podjęcie próby ich ichtiologicznej klasyfikacji, której podstawą było: a — wyodrębnienie podobnych środowisk na podstawie zasiedlających je gatunków ryb i ich liczebności oraz niektórych parametrów hydrografii; b — poznanie występujących tam zgrupowań gatunków; c — oszacowanie liczebności gatunków ryb przypadających na jednostkę powierzchni.

Największa liczba cieków na badanym terenie odpowiada kryteriom krainy (strefy) pstrąga (tabele I—II, ryc. 1—5), w obrębie której wyróżniono trzy mniejsze jednostki. Górny region tej krainy obejmuje przyźródłowe partie potoków o największych spadkach jednostkowych (83,3—20,0, $\bar{x}$ = 30,0‰). Ichtiofaunę formuje 2 do 4 gatunków ryb, wśród których zdecydowanie dominują pstrąg potokowy i głowacz pręgopłetwy. Środkowy region krainy pstrąga rozciąga się przy spadkach od 13,3 do 5,0, $\bar{x}$ = 9,7‰. W tych partiach cieków ichtiofauna liczy maksymalnie do 8 gatunków ryb i minogów, z dominacją pstrąga potokowego i głowacza białopłetwego. Dolny region tej krainy obejmuje cieki o spadku jednostkowym od 11,1 do 4,5, $\bar{x}$ = 7,8‰. Występuje tu 9 gatunków, wśród których dominują pstrąg potokowy i strzebla potokowa. Kraina (strefa) lipienia w badanym dorzeczu rozciąga się przy spadkach 10,0 do 2,5, $\bar{x}$ = 6,3‰. Ichtiofaunę tworzy 12 gatunków, a ilościowymi dominantami są: śliz, strzelba potokowa, kiełb, pstrąg potokowy oraz lipień.

Liczebność ryb w przeliczeniu na powierzchnię 1 ha w wyodrębnionych strefach różniła się między sobą wyraźnie (tabela III). W górnych regionach krainy pstrąga występowało średnio 526 ryb · ha^{-1} (w tym pstrągów — 371 sztuk). W środkowych partiach tej strefy stwierdzono 2513 ryb · ha^{-1} (pstrągów — 2106), a w dolnym 5604 ryby ·

ha^{-1} (pstrągów — 3585). W ciekach zaliczonych do krainy lipienia stwierdzono na powierzchni 1 ha 1370 ryb, w tym 375 pstrągów potokowych i 105 lipieni.

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