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FISH ASSEMBLAGES IN THE SŁUPIA RIVER SYSTEM (NORTHERN POLAND)

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ABSTRACT. Electrofishing was carried out at 66 sites in the Słupia River system. Twenty-five fish species were noted. The most frequent were trout (*Salmo trutta*), three-spined stickleback (*Gasterosteus aculeatus*) and bullhead (*Cottus gobio*). Three groups of sampling sites were distinguished based on fish densities and species composition. These fish assemblages inhabited places that did not differ widely with regard to the 13 environmental parameters assessed. Although there were also no clear sequences of assemblages, the distinct influence of lakes and impoundments was evident.

Key words: RIVER, ICHTHYOFAUNA, FISH DISTRIBUTION

INTRODUCTION

In older publications regarding river ichthyofauna rivers are divided into sequences of fish zones whose names are taken from the leading fish species. This system is based on the findings of Huet (1949, 1954) and was applied to the rivers of Podkarpacie and Małopolska by Starmach (1956). It has also been applied in some more recent papers concerning the ichthyofauna of these regions (e.g., Kołder et al. 1974, Skóra and Włodek 1991, Augustyn et al. 1996). However, this system often does not work: leading species are not present; sequential changes in river character are disturbed by, for example, the presence of lakes and anthropogenic pressure. The classic fish zonation system in central and northern Poland is usually inadequate and does not reflect the actual distribution of fish in rivers (Backiel 1964, Penczak 1969, 1972, Witkowski 1985, Witkowski and Błachuta 1988, Dębowski 1990, 1999). Backiel (1964) proposed distinguishing fish zones based on the actual distribution and dominance of species. According to Penczak (1969), fish sites should be grouped using cenological methods, while the role of hydrographic factors should be of secondary importance. This approach was used by Dębowski (1999) in the analysis of fish

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assemblages in the Parsęta River drainage basin. Five groups of sites were distinguished based on differences in ichthyofauna characteristics. Differences in habitat characters were noted as well.

Pomeranian rivers are very interesting from an ichthyological point of view. As they are situated in glacial terrain, they have steep slopes and firm bottoms, both of which are appropriate for salmonid fish. The Baltic Sea, into which these rivers drain, restricts migration for some species but facilitates it for others. Dębowski et al. (2001, 2002a, b) have recently supplemented the knowledge of the ichthyofauna of Pomerania.

Ichthyological studies of the rivers of the Słupia River drainage basin were carried out in 1998 and 1999. Detailed characteristics of the fishing sites, the fish distribution, and relative fish densities were reported by Dębowski et al. (2000). The current work presents the general characteristics of the ichthyofauna and its habitat. An attempt was made to distinguish fish assemblages and to determine whether the sites where they occur differ with respect to environmental conditions.

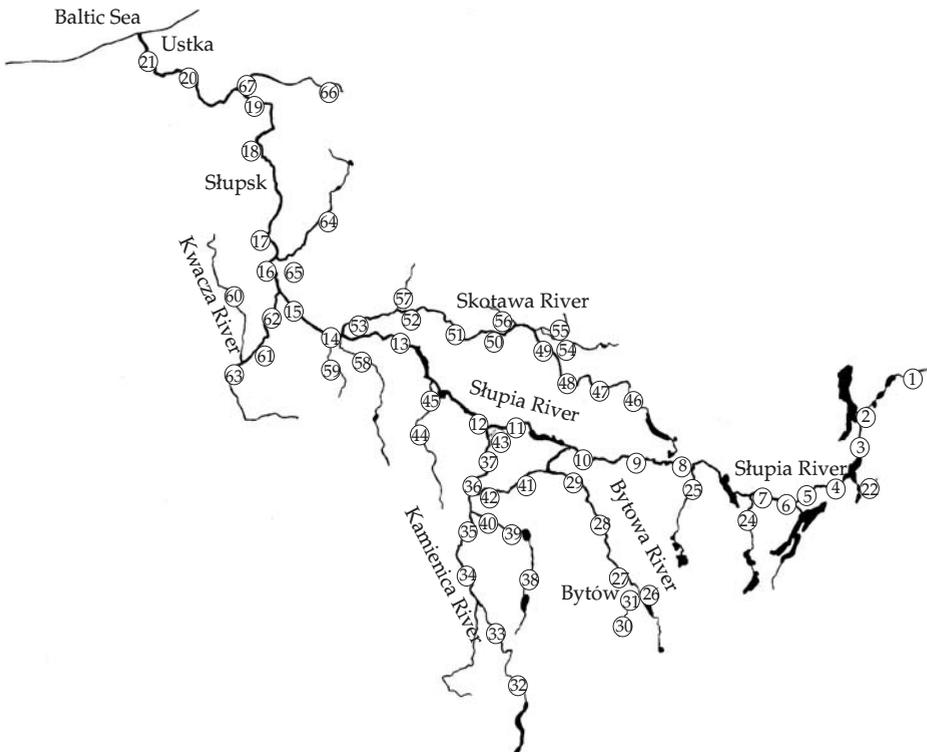


Fig. 1. Sampling sites in the Słupia River system.

MATERIALS AND METHODS

The source of the Słupia River is located near Sierakowice in moraine hills at an altitude of 175 m above sea level. It is 126 km long with a drainage area of 1623 km² and an average slope of 1.39‰. The river discharges into the sea at the town of Ustka.

Sixty-six sampling sites (Fig. 1) were described using 13 environmental parameters (Table 1). The locations of the sites in the drainage basin were described using five parameters (Table 2). The fish were caught by electrofishing, and various techniques were used depending on river size. In small streams, the researchers walked 150 m upstream, while in large rivers they sailed downstream along one river bank for 500 m (Dębowski et al. 2000). The fish species were segregated into ecological groups according to Penczak (1969), and the stability of their occurrence was computed (Table 3). Due to difficulties in identifying the juveniles of various forms of *Salmo trutta*, the species were divided into three categories as follows: *S.t. juv.* (fish under 20 cm caudal length); *S.t. fario* (over 20 cm, identified as brown trout); *S.t. trutta* (over 20 cm, identified as sea trout). The ichthyofauna of each site was described by eight parameters (Table 4).

TABLE 1

List of environmental parameters that characterize the sampling sites

Parameter	Symbol	Range	Description
Width (m)	W	0.8 - 20.0	Mean
Depth (m)	De	0.2 - 1.8	Mean
Slope (0/00)	Sl	0.3 - 15.0	Calculated from maps 1:50000
Riffles (%)	Ri	0 - 90	Percentage of site area with riffles assessed on the basis of turbulent water surface in shallow places
Substrate	Su	1 - 2.5	Mean estimated with the Bain method (Bain et al. 1985) for bottom areas covered by four substrate categories: sand (particles of diameter < 2 mm); gravel (2-20 mm); pebbles (20-100 mm); stones (> 100 mm)
Substrate diversity	SDSu	0 - 0.98	Standard Deviation of Su
Submerged plants (%)	Pl	0 - 90	Percentage of bottom with vegetation
Cover	Cr	1 - 3	Every undercut bank, tree and shrub roots in water, overhanging bank vegetation, damaged fascine constructions, fallen trees or branches were considered as available cover and three ranks were assigned from (1) – lack of such places to (3) – many such places at a site
Course	Ce	1 - 3	Three-rank scale of river course from (1) straight channel to (3) meandering channel
Shadow	Sh	1 - 3	Since shading of a stream surface depends on the canopy formed by riparian vegetation, a three-rank scale was applied from (1) banks without any trees or shrubs to (3) more than 50% overgrown
Regulation	Re	0 - 1	Regulated (1) or not (0)

TABLE 2

List of parameters that characterize the location of sampling sites in the river system

Parameter	Symbol	Range	Description
Distance from sources (km)	D1	2 - 122	Calculated from maps 1:50000
Distance from the sea (km)	D2	4 - 123	Calculated from maps 1:50000
Order	O	1 - 4	Strahler method
Link magnitude	L	1 - 48	Scheidegger method; the number of first order segments upstream of a given point of a channel (Osborne and Wiley 1992)
Downstream link	DI	2 - 49	Magnitude of the link of the channel below the next downstream confluence (Osborne and Wiley 1992)

TABLE 3

List of fish species – reproductive groups: lithophils (L), indifferents (I), phytophils (Ph), psammophils (Ps), ostracophils (O), partial pelagophils (Pp), special group (S)

Family	Species	Reproductive groups	Occurrence stability	Maximum number at site
Petromyzontidae	<i>Lampetra planeri</i> (Bloch)	L	21	1
Salmonidae	<i>Salmo trutta</i> juv. ¹	L	65	274
	<i>Salmo trutta morpha fario</i> L. ²	L	59	58
	<i>Salmo trutta morpha trutta</i> L. ³	L	18	14
	<i>Salmo salar</i> L.	L	3	7
	<i>Salvelinus fontinalis</i> (Mitchill)	L	2	1
	<i>Oncorhynchus mykiss</i> (Walb.)	L	15	53
Thymallidae	<i>Thymallus thymallus</i> (L.)	L	18	16
Esocidae	<i>Esox lucius</i> L.	Ph	32	5
Anguillidae	<i>Anguilla anguilla</i> (L.)	S	6	1
Cyprinidae	<i>Rutilus rutilus</i> (L.)	Ph	27	15
	<i>Carassius auratus gibelio</i> (Bloch)	Ph	8	27
	<i>Gobio gobio</i> (L.)	Ps	47	668
	<i>Leucaspius delineatus</i> (Heckel)	Ph	6	5
	<i>Leuciscus leuciscus</i> (L.)	I	9	4
	<i>Leuciscus cephalus</i> (L.)	L	8	25
	<i>Alburnus alburnus</i> (L.)	Ph	15	29
	<i>Phoxinus phoxinus</i> (L.)	L	26	399
	<i>Rhodeus sericeus amarus</i> (Bloch)	O	6	170
	<i>Tinca tinca</i> (L.)	Ph	12	3
Cobitidae	<i>Cobitis taenia</i> L.	Ph	6	25
Gadidae	<i>Lota lota</i> (L.)	Pp	9	4
Gasterosteidae	<i>Gasterosteus aculeatus</i> L.	Ph	53	112
	<i>Pungitius pungitius</i> (L.)	Ph	26	126
Percidae	<i>Perca fluviatilis</i> L.	I	33	54
	<i>Gymnocephalus cernuus</i> (L.)	I	3	5
Cottidae	<i>Cottus gobio</i> L.	L	50	145

¹All *S. trutta* below 20 cm caudal length²*S. trutta* above 20 cm identified as brown trout³*S. trutta* above 20 cm identified as sea trout

TABLE 4

List of ichthyological parameters that characterize the sampling sites

Parameter	Symbol	Range
Number of fish	T	3 - 745
Number of species	Sp	1 - 14
Index of species diversity (Shannon index)	H'	0 - 0.95
Litophils (%)	Li	0 - 100
Indifferents (%)	In	0 - 82
Phytophils (%)	Ph	0 - 100
Psammophils (%)	Ps	0 - 93
Others (%) (ostracophils+partial pelagophils+ special group)	Ot	0 - 82

Cluster analysis of sampling sites was performed on the basis of standardized quantities of fish species: $x_s = (x_i - x_m) \times SD^{-1}$ (where, x_i – number of fish of a particular species at a site; x_m – mean number of fish of a particular species at all sites; SD – standard deviation). The data was analyzed using the STATISTICA package (StatSoft™). The intervals between elements were measured using the Euclid distance, while the Ward method was used to form groups. This permitted constructing a hierarchical tree. Group division was based on the following criterion: $D = 50$, where $D = 100 \times \text{linkage distance} \times \text{maximum distance}^{-1}$. Then, using the Kruskal-Wallis test ($\alpha = 0.05$), the average values of all the listed parameters for separated groups were compared.

RESULTS

Twenty-five species were noted in the rivers of the Słupia River drainage basin. The most frequent were trout (*S. trutta*), three-spined stickleback (*Gasterosteus aculeatus*) and bullhead (*Cottus gobio*), which were present at at least 50% of the sites (Table 3). Gudgeon (*Gobio gobio*), minnow (*Phoxinus phoxinus*) and trout (*S. trutta*) attained the highest densities at more than 200 individuals per site (Table 3). The highest number of fish at one site was 745 (Table 4).

Based on cluster analysis, the sites were divided into three groups; one site, no. 2, was excluded (Fig. 2). Five parameters that describe the ichthyofauna (Table 5) and four of the remaining factors (Table 6) differed significantly between the groups.

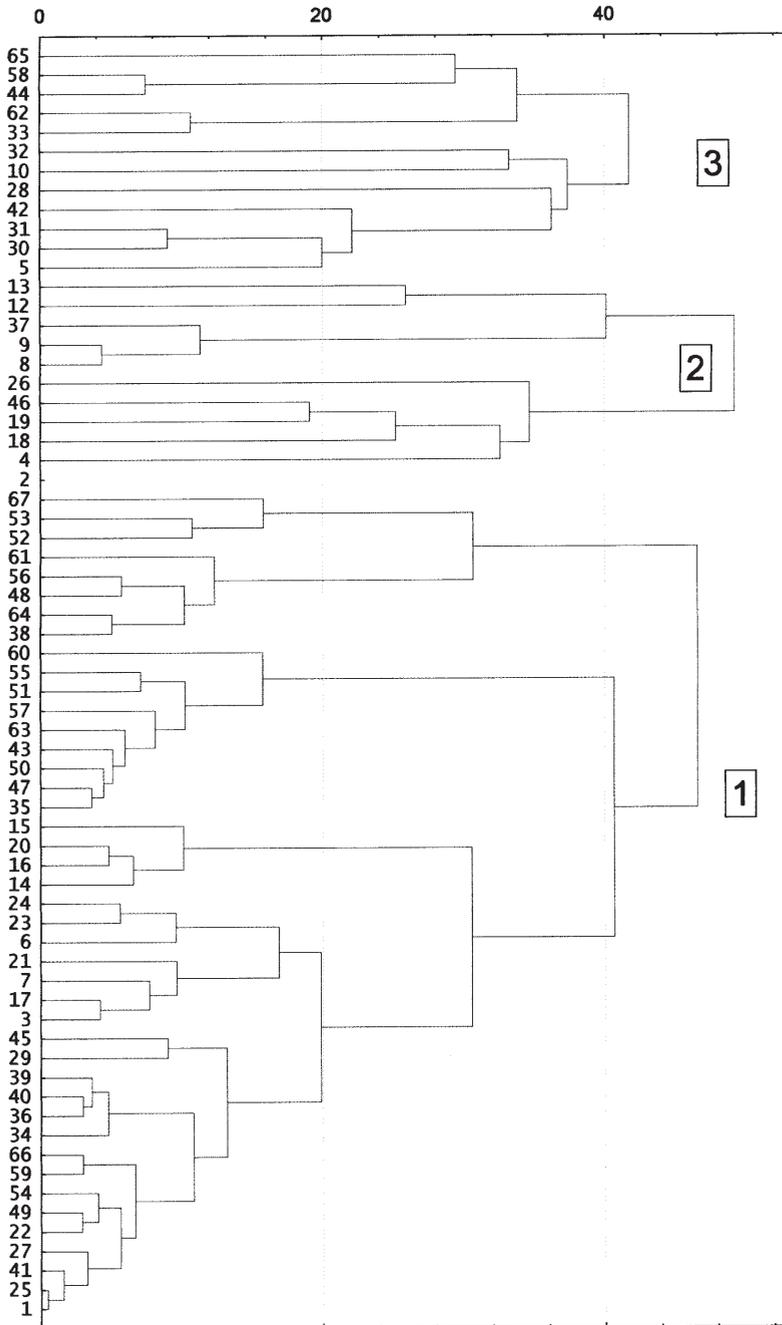


Fig. 2. Hierarchical tree and division of sites into three groups. Y axis – site numbers; X axis – distance expressed as $100 \times \text{linkage distance} \times \text{maximum distance}^{-1}$ (1, 2, 3 – groups of sites).

TABLE 5

Average values of ichthyological parameters in groups of sites (n = numbers of sites).

*Parameter differs significantly among groups ($\alpha=0.05$, Kruskal-Wallis test)

Parameter	Groups of sites		
	1 n = 45	2 n = 9	3 n = 11
Number of fish (T)*	66	102	205
Number of species (Sp)*	4.4	8.7	5.3
Index of species diversity (H')*	0.36	0.68	0.31
Litophils (%) (Li)	54	40	74
Indifferents (%) (I)*	5	19	1
Phytophils (%) (Ph)	32	21	16
Psammophilis (%) (Ps)*	8	18	2
Others (%) (Ot)	0	2	7

The first group was the biggest and included 45 sites. These sites were characterized by low numbers of fish species and low species diversity. Fish were not abundant; litophils dominated, but phytophils were also relatively numerous (Table 5). Juveniles of trout, three-spined stickleback and bullhead were dominant, while juveniles of trout, older brown trout and three-spined stickleback were the most frequent (Table 7). The sites were situated in various parts of the drainage basin – both in the uppermost and lowest areas (Fig. 3).

TABLE 6

Average values of parameters that differed significantly among the groups of sites

($\alpha=0.05$, Kruskal-Wallis test)

Parameter	Groups of sites		
	1	2	3
Width (W)	6	12	4
Distance from sources (D1)	25	52	15
Order (O)	2.1	3.2	1.9
Link magnitude (L)	8	19	3

The second group included nine sites and was characterized by not very numerous, but highly diversified, ichthyofauna represented by an average of nearly nine species at each site. The share of indifferents and psammophilis was relatively high (Table 5). The dominant species were gudgeon, perch (*Perca fluviatilis*), and trout juveniles. Gudgeon, also the most frequent species, occurred with grayling (*Thymallus thymallus*) and roach (*Rutilus rutilus*) at 78% of the sites in the group (Table 7). The sites were usually in the main river, in sections with an order higher than three, a wide riverbed, and located far from sources or below lakes (Table 6, Fig. 3).

TABLE 7

Dominant species (mean numbers in parentheses), (A) and the most frequent species (percentage of occurrence stability in parentheses), (B) in groups of sites

	Groups of sites		
	1 n=45	2 n=9	3 n=11
A	<i>S.t. juv</i> (14)	<i>G. gobio</i> (18)	<i>P. phoxinus</i> (66)
	<i>G. aculeatus</i> (14)	<i>P. fluviatilis</i> (18)	<i>S.t. juv</i> (66)
	<i>C. gobio</i> (11)	<i>S.t. juv</i> (12)	<i>C. gobio</i> (20)
B	<i>S.t. juv</i> (64)	<i>G. gobio</i> (78)	<i>S.t. juv</i> (73)
	<i>S.t. fario</i> (62)	<i>T. thymallus</i> (78)	<i>S.t. fario</i> (64)
	<i>G. aculeatus</i> (58)	<i>R. rutilus</i> (78)	<i>C. gobio</i> (64)

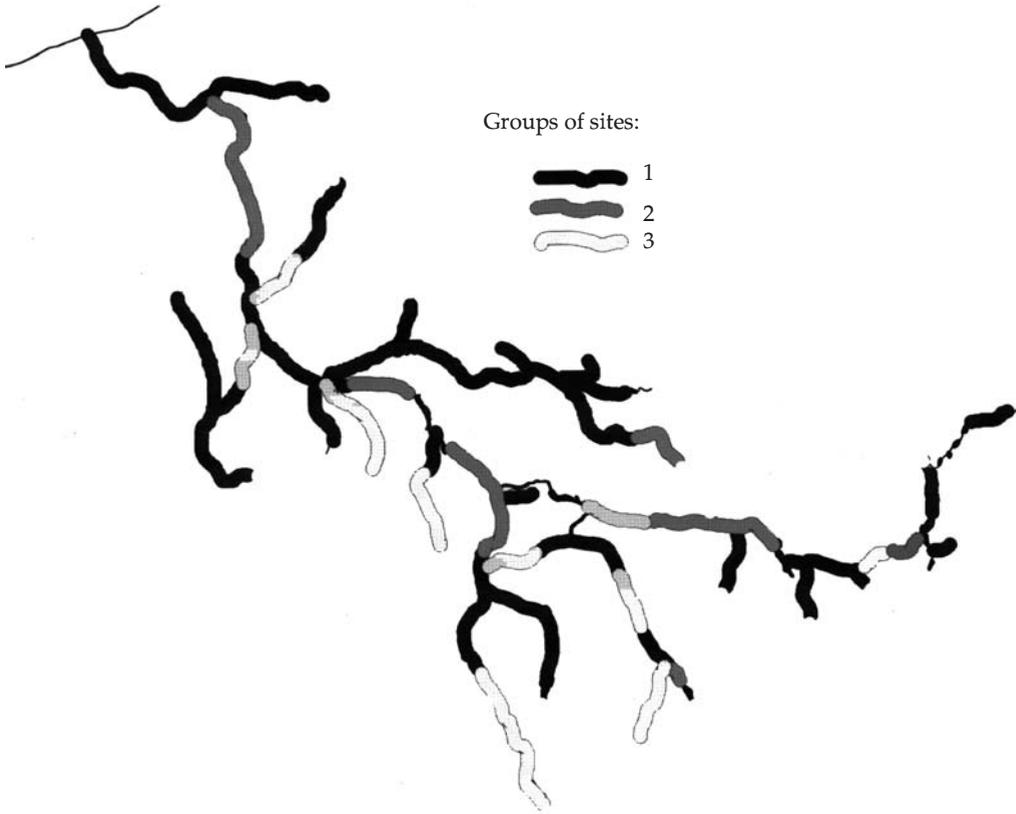


Fig. 3. Location in the river system of sites that belong to groups.

The third group consisted of 11 sites. Their ichthyofauna was numerous, but not diversified, with the distinct domination of litophils (Table 5) represented by minnow, trout juveniles and bullhead (Table 6). Trout juveniles and bullhead, along with older trout, were also the most frequent fish in this group. The sites were situated in low order runs, not far from sources, mainly in small tributaries (Table 6, Fig. 3).

The ichthyofauna of the excluded site consisted of very high numbers of gudgeon and seven other fish species.

DISCUSSION

The abundance of fish species in the Słupia River and its tributaries (25 species) was similar to that in adjacent river systems: Łeba (21 species; Dębowski et al. 2002a), Wieprza (24; Dębowski et al. 2002b), Parsęta (22; Dębowski 1999). Most of the fish caught belonged to litophilic species (57%), which is typical for other Pomeranian rivers as well as for submontane rivers (e.g., Skóra et al. 1994, Augustyn et al. 1996). The ichthyofauna of rivers in other Polish regions is usually dominated by phytophilic and psammophilic species (e.g., Penczak 1969, Witkowski et al. 1991, Przybylski 1993).

The fish assemblages differ mainly with regard to fish density, diversity, and the share of rare reproductive groups. They inhabit places that cannot be separated by the environmental parameters used, but only by the location in the river system. However, no clear sequences of assemblages or any kind of "zones" were detected. Rather, they generate a mosaic in the system that is distinctly influenced by lakes and impoundments. The number of groups distinguished was lower than in the Parsęta River system; however, the drainage area of Słupia River is almost two times smaller.

The most frequent species assemblage was trout with bullhead or three-spined stickleback, which is similar to that in the Parsęta River system (Dębowski 1999) and some small Pomeranian streams (Radtke and Dębowski 1996).

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STRESZCZENIE

ZESPOŁY RYB W DORZECZU RZEKI SŁUPI (PŁN. POLSKA)

W 1998 i 1999 roku przeprowadzono połowy elektryczne na 66 stanowiskach na rzece Słupi i jej dopływach (rys. 1). Złowiono przedstawicieli 25 gatunków ryb (tab. 3). Najczęściej występującymi gatunkami były pstrąg potokowy i/lub troć (*Salmo trutta*), ciernik (*Gasterosteus aculeatus*) i głowacz białopłetwy (*Cottus gobio*). Największe zagęszczenia osiągały: kiełb (*Gobio gobio*), strzebla potokowa (*Phoxinus phoxinus*) i troć/pstrąg. Stanowiska połowu opisano za pomocą 13 parametrów środowiskowych (tab. 1), a ich usytuowanie w dorzeczu – dalszych 5 parametrów (tab. 2). Ichtyofaunę stwierdzoną na każdym ze stanowisk

scharakteryzowano przy użyciu 8 parametrów (tab. 4). Przeprowadzono analizę skupień stanowisk w oparciu o standaryzowane liczebności ryb poszczególnych gatunków. Pozwoliło to na podzielenie stanowisk na 3 grupy (rys. 2, tab. 5):

1. Stanowiska z nielicznymi rybami, małym zróżnicowaniem gatunkowym i z dominacją *Salmo trutta*, ciernika i głowacza (najwięcej stanowisk);

2. Stanowiska z nielicznymi rybami, ale zróżnicowanymi gatunkowo, z dominacją kielbia, okonia (*Perca fluviatilis*) i *Salmo trutta* znajdujące się z reguły w głównej rzece;

3. Stanowiska z licznymi rybami, prawie wyłącznie litofilami, z dominacją strzebli, *Salmo trutta* i głowacza, znajdujące się najczęściej w dopływach.

Grupy te nie różniły się wyraźnie warunkami środowiskowymi. Większe różnice były między nimi w usytuowaniu w dorzeczu (tab. 6), ale mimo to nie stwierdzono wyraźnej sekwencji, czy też strefowości, typów stanowisk, czyli poszczególnych zespołów ryb (rys. 3). Zdecydowany wpływ na to rozmieszczenie ryb w dorzeczu Słupi miała obecność jezior i licznych spiętrzeń.