Oceanological and Hydrobiological Studies
International Journal of Oceanography and Hydrobiology
Vol. XXXIX, No.4

Institute of Oceanography (83-98) University of Gdańsk
ISSN 1730-413X 2010 eISSN 1897-3191

DOI 10.2478/v10009-010-0052-2
Original research paper

Received: November 20, 2009
Accepted: December 02, 2010

Habitat variability and fish species structure in the Kończak stream

Janusz Golski[1], Antoni Przybył, Jan Mazurkiewicz, Wojciech Andrzejewski, Jakub Trawiński

University of Life Sciences in Poznań, Institute of Zoology
Division of Inland Fisheries and Aquaculture
ul. Wojska Polskiego 71 C, 60-625 Poznań, Poland

Key words: Kończak stream, habitat, ichthyofauna, species structure

Abstract

In the year 2008, studies on ichthyofauna were carried out in the Kończak stream. The stream was divided into four sections representing the variability of the water course. In each section, a research segment (100–150 meters long) was defined. In the ichthyofauna structure analysis, the indices of quantitative biocenotic domination and biomass were used. Furthermore, on the basis of the obtained data, the Shannon-Wiener indices of species diversity (H), as well as the abundance and the biomass (ABC index) were calculated. Altogether, in all research localities, 667 fish specimens were collected, with a total weight of 8,760 g and classified into 19 species. The caught fish were classified into 8 reproductive groups. Significant differences in the species composition and the number of fish were recorded between the particular sections. The number of species occurring in the studied sections oscillated between 2 and 17. The richest ichthyocenoses were recorded in the transitional and forest sections characterized by a comparatively small transformation of the habitats and good environmental conditions. In the remaining two sections, located in the middle and in the upper stream course, there was a distinct impoverishment of ichthyocenoses caused by the decreased attractiveness of the habitats.

[1] Corresponding author: *golski@up.poznan.pl*

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

INTRODUCTION

In the analyses related to the occurrence of ichthyofauna in rivers and streams, the attention should be focused on a number of essential factors influencing the groups of fish occurring in flowing waters. Water quality together with the hydromorphic characteristic features of habitats may exert a significant influence, both on the species structure of nekton as well as on the quantitative relations within a given group (Humpl, Pivnicka 2006; Bylak et al. 2007; Wyżga et al. 2008). The most important abiotic features of river habitats include: water flows, sinuosity of the river bed, bottom substratum, bottom deformation, shape of river banks (Allan 1998). From the above mentioned abiotic factors, also some biotic factors result, such as the species composition, food quality, degree of river banks overgrown with vegetation, the presence of hydromacrophytes.

Already since the beginning of the 20th century, due to the development of industry, the increasing development of urban agglomerations and the intensification of agriculture, one could observe the intensification of negative anthropogenic interference in the environment. Anthropopressure on the ecosystem of flowing waters is manifested in three different forms: regulation of the water beds, melioration of the river basin and the overfishing (Przybylski 1994, Wiśniewolski 2002). Although the water quality has been improving, slowly but continually, and the excessive exploitation can be relatively easily prevented, the transformations in the habitat structure caused by the reconstructions of water beds and the ecotonic zone, as well as the interference into the hydrogenic relations of the whole water basin, are very difficult to change in a short time .

Tributaries of the middle and lower Warta have become the object of interest of researchers already at the turn of the 19th century. At that time, Grotrian (1896, 1900) and Seligo (1902) were working on inventorying the ichthyocenotic relations in the Warta river basin. Kulmatycki (1929) was the first scientist who specifically drew attention to the negative effect of transformations in the river ecosystems and postulated the need for immediate reaction to the situation. After the 2nd World War, the studies on ichthyofauna of the Warta River and its tributaries were continued by Kaj (1958, 1959, 1966), Jaskowski (1962), Iwaszkiewicz (1964, 1966), Włoszczyński (1963, 1964), Mastyński (1971) and Przybył (1976). Since the end of the 1970s, as a result of drastic water pollution, ichthyological studies on the Warta tributaries, including the Kończak stream, were discontinued.

After more than 30 years, it was again decided to take inventory of ichthyofauna in the Kończak stream, against the background of environmental conditions and to compare the obtained results with the data obtained by

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

Iwaszkiewicz (1964a, 1964b). At that time, the total lower water course, according to the fishery typology, belonged to the brown trout (*Salmo trutta* m. *fario*) area, as indicated both by the habitat character and by the population of the leading species.

The main objective of this work was to determine the relationship between the ichthyocenoses structure and the quality of the habitats, as well as to find an answer to the question whether the Kończak stream was still providing the adequate conditions for the existence of the stream brown trout. The studies presented in this paper and their results have a pilot character for a broader action aiming at reintroducing salmonid species into the water courses of the Warta river basin.

MATERIAL AND METHODS

Study area

The Kończak stream is a right-bank tributary of Warta. It flows in the area of the districts of Oborniki and Czarnków – Trzcianka in the Wielkopolska province. The mouth of the Kończak stream into the Warta River is located at its 188th kilometer and 17 km to the West of the town of Oborniki,in the village of Stobnica.

According to the physico-geographical division of Poland (Kondracki 1998), the river basin of the Kończak stream is included in the subprovince of the South Baltic Lakeland in the macroregion of the Toruń-Eberswald proglacial stream valley and in the mesoregion of the Gorzów Valley.

The total length of the studied stream is 36 km, its length in the straight line is 16 km. The percentage of the development of the stream is estimated at 44.4%. The river basin of the stream includes an area of 227.8 km^2 (Hydrographical division of Poland 1983), the slope of the stream calculated on the basis of altitude points (on a map at a scale of 1:100 000) for the whole stream is 1.46 % (Iwaszkiewicz 1964).

The Połajewski Canal is regarded as the source segment, whereas the source area of the Kończak stream is the peatland in the surroundings of the villages of Orłowo and Ludomicko (Kostecki 2003). Over 50% of the whole river basin consists of forests, while the middle segment of the stream runs only through the forest areas of the Noteć Primeval Forest. In the remaining part of the river basin, which is mostly agriculturally used, there is also a rather vast wetland.

Only areas situated around the middle course of the stream retained their natural character. Drainage works have been carried out over ca. 50% of the agricultural area,. Usually the maximum values of water levels and water flow occur in March, while the minimum values - at the turn of August and

September. The water flow during the lowest water levels amounts to 0.6 m^3 s^{-1} (Kostecki 2003). About one kilometer above the stream mouth, there is a dam used for fish ponds and for flooding situations.

Methods

Studies on the ichthyofauna of the Kończak stream were carried out at the beginning of September 2008. The stream was divided into four sections presenting different characteristics of the water course. In each section, a research segment was delimited (100 – 150 m long). Inventory works consisted of two stages, during which the characteristic environmental conditions of the water course were determined (morphometric parameters of the water bed, water flows, bottom substratum, surroundings, aquatic vegetation, the most important physicochemical indices) and research fish catches were performed with the use of impulse catching apparatus of IUP 12 type. The fish catches were carried out using the surviving method, after their identification, counting and weighing, the fish were returned to the stream in the place where they had been caught.

The total number of the caught fish was 667 individuals with a total weight of 8760 g. The fish species were arranged according to their affiliation to the reproductive groups, according to the division proposed by Balon (1990). Fish density and fish biomass were expressed in pieces and grams per 1000 m^2 of the stream bottom. In the analysis of the ichthyofauna structure, the indices of the quantitative biocenotic domination and biomass were applied. Furthermore, on the basis of the obtained data, the indices of species diversity were calculated according to Shannon-Wiener (H) (Krebs 2001), as well as the abundance of fish and their biomass (ABC index) (Meire, Dereu 1990). These indices define the degree of the balance in biocenoses and they inform about the occurrence of possible factors disturbing this balance.

All calculations were carried out with the use of the spreadsheet Excel of Microsoft Office.

RESULTS

Environmental conditions

The first section (KI) is located in the closest distance from the mouth of the stream into the Warta River. Characteristics of the studied habitats are presented in Table 1. The water in the stream flows in a narrow bed, its maximum width does not exceed 2.9 meter. The depth of this research section is not much differentiated and it does not exceed one meter (when water levels are low), which causes that the stream bed is not much differentiated – over a fragment of

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

Table 1

Habitat characteristics of four sections in Kończak stream.

	KI	KII	KIII	KIV
Distance from stream mouth [km]	0.2	5	9	15
Depth max./mean [m]	1/0.6	1.5/0,4	1.6/0.8	1.5/0.4
Width range/mean [m]	1-2.9/2.1	2.7-7.6/3.5	1.9-6.2/2.7	2.3-6.7/3.9
Water level/flow [cm s^{-1}]	low/high (63.7)	low/average (39.4)	low/small (19.1)	low/absent (-)
Deepened/shallowed/meanders [per 100 m]	4/4/2	9/9/4	6/6/5	2/2/absent
Banks	PA	N	N	PA
Shelters	H,G	TR,H,UB,S	TR,H,UB,S	H,IM
Bottom substrate [% covers]	ST(5),G(5), SN(90)	ST(10),G(40), SN (40), SL(10)	G(10),SN(60), SL (30)	SN(50),SL(50)
Water vegetation	EC	BE, VB,CV	MK, LM, NL	MK,RD,NL,CD,AC
Brushes (at 50 m distance)	absent	both banks	both banks	both banks
Trees (at 20 m distance)	absent	>50	>50	10-50
Shading [%]	2	3	3	2
Basin use	agric.,forest, built up	forest	forest	meadows, built up
Temperature [°C]	12.9	10.1	10.8	11.6
Oxygen content [mg l^{-1}]	8.36	7.06	5.04	4.8
Conductivity [µS cm^{-1}]	336	334	332	349
Reaction	8.1	8.0	7.88	7.93

Banks* N – natural, PA – partially artificial, CS – completely strengthened; **Shelters**** TR – tree roots, H – hollowings, UB – underwashed banks, S – stones, G – grasses, IM – immersed macrophytes; **Bottom substrate***** ST – stones, G – gravel, SN – sand, SL – slime; **Water vegetation** ****** EC – *Elodea canadiensis*, BE – *Berula erecta*, VB – *Veronica becabunga*, CV – *Callitriche verna*, LM – *Lemna minor*, NL – *Nuphar lutea*, CD – *Ceratophyllum demersum*, AC – *Acorus calamus*; **Shading** ******* 1 – 0%, 2<25%, 3<50%, 4 up to 100%;

100 meters, four minor hollows and 4 shoals were found. The average water flow velocity was 63.7 cm s^{-1} and it was the highest velocity among the studied sections. The banks of the stream are partially strengthened, not offering too many hiding places, only in some places, one can notice partially immersed grasses. The bottom substratum is dominated by sand whose contribution in the total bottom surface is about 90%. Among the immersed vegetation, only *Elodea canadensis* was identified. Sedges dominate on the banks, and there are no shrubs or trees. In the described section, the water temperature reached the highest value of 12.9°C and at the same time, the best oxygen conditions were at the level of 8.4 mg dm^{-3} O_2. Water conductivity and water reaction (pH) were similar in all sections and they oscillated around 335 µS cm^{-1} and 8, respectively.

The second section (KII), with a comparatively natural character, was demarcated in the forest segment, about 5 kilometers from the stream mouth into the Warta river. The strongly winding bed of the water course frequently

bifurcates and it is definitely wider (the maximum width reaches up to 7.6 m).The water flow velocity was lower as compared to section KI and it reached 39.4 cm s^{-1}. The depth of this section is variable and it reaches 1.5 meter with the average value of 0.4 m. The shape of the water-course bottom is also characterized by a high variability – along a 100-meter section, as many as 9 hollows and 9 shoals were found, which create many hiding places in the form of tree roots and undermined banks. Furthermore, the number of refuges is increased by big stones and the aforementioned hollows. The bottom substratum in this segment is also very differentiated. Gravel (40%) and sand (40%) dominate, but one can also find some stony parts (10%) and organic parts (10%) covered with slime of a rather small thickness. Among aquatic vegetation, the following plants were identified: *Berula erecta, Veronica anagalis* and *Cellitriche verna*. Both banks are rather densely covered with shrubs and trees, which causes a significant shading of the stream bed. In the described segment, the lowest recorded temperature was 10.1°C at 7.06 mg l^{-1} O_2.

The third section (KIII) was also demarcated within the forest segment with a comparatively natural character, about 9 kilometers upstream from its mouth. In the studied section, numerous beaver dams were found with fresh traces of their presence. The winding stream bed was slightly narrower than in the previous segment. The maximum width reached 6.2 meters. Water flow speed was distinctly lower amounting to 19.1 cm s^{-1}. The average depth was about 0.8 m, with the maximum bottom shape variability of 1.6 m , which was slightly lower as compared to the previous section. Six hollows and shoals were found, and the hollows were deeper than in the KII section. Stream banks were completely natural providing natural hiding sites, similarly as in section KII. In the bottom structure, sand (60%) and slime (30%) definitely dominated, reaching the medium thickness The contribution of gravel over the total surface was not high (10%), however, slightly below, under the layer of sand and slime, greater amounts of both stones and gravel occurred. Aquatic vegetation was represented by *Elodea canadensis, Calliriche verna* and small numbers of *Lemna minor* and *Nuphar lutea*. Both banks of the stream are characterized by significant afforestation and numerous shrubs causing some shading. The water temperature in the described segment was 10.8°C, and the oxygen content was on the level of 5.04 mg 1^{-1} O_2.

The fourth section (KIV) includes the stream course flowing through agricultural areas devoid of forests and with a rather high contribution of wetlands. The stream basin in this segment is significantly transformed, mainly by land improvement activities. The width of the described segment reaches 6.7 m, with the average value oscillating around 3.8 m. The bed of the stream is completely straightened up and strengthened, and it is characterized by rather limited diversity, both regarding the depth of the bottom and the number of

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

hiding sites. It was also found that the water flow is almost unperceivable and its velocity was not possible to be measured because of the vegetation occurring over the entire width of the stream, represented by: *Elodea canadensis, Ceratophyllum demersum, Sparganium, Nuphar lutea, Lemna minor, Acorus calamus*. The water temperature was slightly higher than in the two other localities and it amounted to 11.6°C, while the oxygenation reached a lower value of 4.8 mg l^{-1} O_2.

Ichthyofauna

In all the studied localities, 19 fish species were identified, they represented 8 reproductive groups (Table 2). The greatest number of species belonged to the phytolithophilous group, which was definitely the dominating one, mainly regarding their count. Among the lithophilous species, the stream brown trout was distinguished; regarding its biomass it was found to be a co-dominant. In the stream, also the presence of protected species was found, including spined loach, stone loach and bullhead. As many as 14 taxa were encountered in one locality, and only two taxa occurred in all four studied research segments.

In the first section (I), 17 species were identified including seven rheophile species, among which chub and asp belong to the lithophilous reproductive group (Table 3). Among all species found in the stream, only brown trout and sunbleak did not occur in the described section. Also protected species, such as bitterling, spined loach, stone loach and bullhead are worthy of mentioning. The density and the biomass of the fish were definitely the highest among all the studied sections and they amounted to 1902 and 21933 g per 1000 m^2 of the stream bottom, respectively. Roach was the definite dominant, whose contribution in the total number was 59% and 36.5% in the biomass (Table 3, Fig.1). Regarding the biomass, the subdominants included three rheophile species: chub, dace and ide. Their contribution in the total number oscillated around 12% (Fig. 2). Asp and blue bream occurred in very small numbers. Species diversity expressed by the Shannon-Wiener coefficient (H) reached the highest value of 0.68 for the whole stream with a comparatively low coefficient of uniformity (Table 3).The ABC index had a negative value (-4.36).

The second section (KII), regarding the structure of fish composition and the quantitative relations differs completely from the first section. The ichthyocenosis of this segment was strongly dominated by brown trout and bullhead (rheophile species). Their contribution in the number and the biomass was 30% and 93.4% respectively in the case of brown trout, and 63% and 5.8% in the case of bullhead (Table 3, Fig. 1,2). The presence of the remaining species, i.e. gudgeon and three-spined stickleback, can be regarded insignificant. The ABC diversity index was quite different than in the first

Table 2

Ecological reproductive guilds, number of obtained individuals (N), their biomass (B,g), share in the number (D,%), share in the biomass (W,%) and occurrence frequency (C) of fishes of Kończak stream (totally for all sections).

Reproductive guilds	Species		N	D	B	W	C
Non-guarding, open substratum eggs scattering (A.1)							
Lithophils (A.1.3)	Brown trout	*Salmo trutta m. fario*	13	1.95	1494	17.05	0.25
	Chub	*Leuciscus cephalus* (L.)	15	2.25	943	10.76	0.25
	Asp	*Aspius aspius* (L.)	2	0.30	4	0.05	0.25
Phytho-lithophils (A.1.4)	Dace	*Leuciscus leuciscus* (L.)	15	2.25	720	8.22	0.25
	Ide	*Leuciscus idus* (L.)	17	2.55	861	9.83	0.25
	Roach	*Rutilus rutilus* (L.)	353	52.92	2519	28.76	0.25
	Bleak	*Alburnus alburnus* (L.)	67	10.04	286	3.26	0.25
	Blue bream	*Abramis ballerus* (L.)	1	0.15	4	0.05	0.25
	Silver bream	*Blicca bjoerkna* (L.)	60	9.00	456	5.21	0.25
	Perch	*Perca fluviatilis* (L.)	10	1.50	467	5.33	0.25
Phythophils (A.1.5)	Pike	*Esox lucius* (L.)	7	1.05	440	5.02	0.50
	Rudd	*Scardinius erythrophthalmus* (L.)	1	0.15	35	0.40	0.25
	Spined loach	*Cobitis taenia* (L.)	1	0.15	10	0.11	0.25
Psammophils (A.1.6)	Stone loach	*Barbatula barbatula* (L.)	10	1.50	92	1.05	0.50
	Gudgeon	*Gobio gobio* (L.)	39	5.85	271	3.09	100
Non-guarding, brood hiding (A.2)							
Ostracophils (A.2.3)	Bitterling	*Rhodeus sericeus amarus* (Bloch)	15	2.25	19	0.22	0.25
Guarding, clutch tending (B.1)							
Phytophils (B.1.4)	Sunbleak	*Leucaspius delineatus* (Heckel)	1	0.15	1	0.01	0.25
Guarding, nesting (B.2)							
Ariadnophils (B.2.4)	Three-spined stickleback	*Gasterosteus aculeatus* (L.)	9	1.35	22	0.25	100
Speleophils (B.2.7)	Bullhead	*Cottus gobio* (L.)	31	4.65	116	1.32	0.50
Total			667	100	8760	100	-

Table 3

Number (L, pcs 1000 m^{-2}), biomass (B,g 1000 m^{-2}), species diversity (H – ShannonWiener, E – evenness), ABC index in Kończak stream in the particular research sections.

Species	KI		KII		KIII		KIV	
	L	B	L	B	L	B	L	B
Brown trout	0	0	25	2846	0	0	0	0
Chub	48	2994	0	0	0	0	0	0
Asp	6	13	0	0	0	0	0	0
Dace	48	2286	0	0	0	0	0	0
Ide	54	2733	0	0	0	0	0	0
Roach	1121	7997	0	0	0	0	0	0
Bleak	213	908	0	0	0	0	0	0
Blue bream	3	13	0	0	0	0	0	0
Silv er bream	190	1448	0	0	0	0	0	0
Perch	32	1483	0	0	0	0	0	0
Pike	16	1000	0	0	4.9	309	0	0
Rudd	3	111	0	0	0	0	0	0
Spined loach	3	32	0	0	0	0	0	0
Stoned loach	29	197	0	0	2.5	74	0	0
Gudgeon	70	581	4	19	29.6	151	7.7	44
Bitterling	48	60	0	0	0	0	0	0
Sunbleak	0	0	0	0	2.5	2	0	0
Three-spin. stickleback	6	6	2	4	4.9	15	10.3	15
Bullhead	13	73	51	177	0	0	0	0
Total	**1902**	**21933**	**82**	**3046**	**44**	**551**	**18**	**59**
Species number	**17**		**4**		**5**		**2**	
H/E	**0.68/0.55**		**0.38/0.63**		**0.47/0.54**		**0.3/0.997**	
ABC	**-4.36**		**9.86**		**1.73**		**8.7**	

section. In this case, the H coefficient had low values with a higher value of uniformity, while the ABC index was at the level of 9.86.

The third section (KIII) was also characterized by the specific ichthyocenosis (on the scale of the Kończak stream) (Table 3, Fig. 2). In the discussed segment, brown trout retreated and its place was taken by another predator – pike, whose contribution in the count and the biomass was 11% and 56%, respectively. The definite dominant regarding the count was gudgeon (67%). The remaining identified species included: stoned loach, sunbleak and three-spined stickleback .With the presence of 5 species, the quantitative domination of gudgeon, the H coefficient and uniformity coefficient (E) showed low values (0.47 and 0.54, respectively). The biomass index was insignificantly positive and it amounted to 1.73.

The fourth section (KIV) has shown to be very poor in species. It included only gudgeon and three-spined stickleback. Regarding the count, the three-spined stickleback dominated (57%), while regarding the biomass, gudgeon had a higher contribution (74.7%). The presence of only two species caused a low

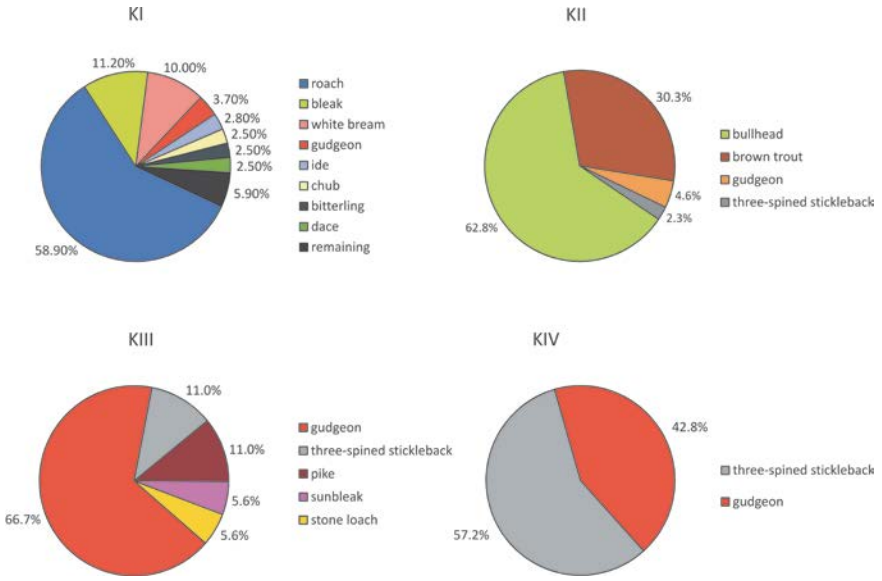


Fig. 1. Share in the number (D) of particular ichthyofauna species of Kończak stream.

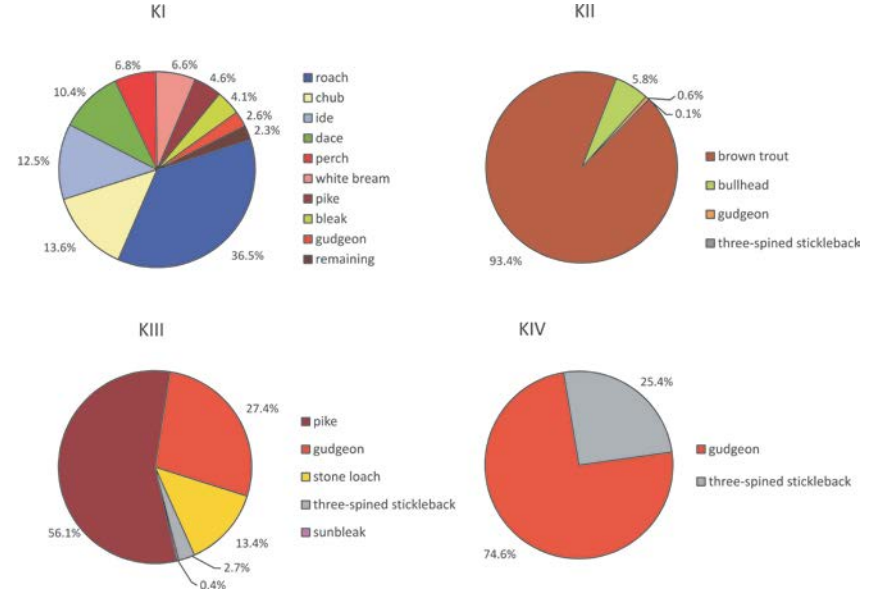


Fig. 2. Share in the biomass (W) of particular ichthyofauna species of Kończak stream.

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

species diversity (0.3), with a very high uniformity coefficient (0.997). The ABC index reached a very high value of 8.7.

DISCUSSION

The presented data indicate that the Kończak stream is characterized by a significant diversity of environmental conditions, since in a relatively short water course, one can find habitats with a high degree of transformation, providing different conditions of existence for hydrobionts including fishes. This is reflected by the species composition and by the structure of ichthyofauna.

The location of the first section, between a weir damming up the water and the mouth into the Warta River, certainly exerts an influence on this section. Differences in the water level and its flow might be responsible for the small number of hiding places, and the domination of sand in the bottom substratum. During our studies, we recorded the highest flow velocity within the entire water course. The occurrence of water thyme (*Elodea canadensis*) as the only representative of immersed vegetation informs us about the environmental conditions prevailing over a longer time interval. Filipiak et al. (1995) reported that the occurrence of this species, depending on its intensity, is an evidence of water eutrophication. In the described segment, also the water temperature reached the highest values, but at the same time, the oxygenation was the most favorable. The water stagnating above the damming up place has a higher temperature and it may be more susceptible to algae blooming, which, in turn, exerts an influence on the oxygen content. High original production in the basin caused a higher inflow of organic matter and biogens into the water course (Allan 1998, Penczak et al. 1993). A negative effect of the damming up weirs was recorded by Penczak and Kruk (2000).

Mastyński (1971), who investigated a spawning ground for migratory trout in the lower segment of the Kończak stream, found slightly different conditions. Along the whole segment, the highest contribution in the bottom surface was covered by stone and gravel fractions with only a small admixture of sand. According to the aforementioned author, such a bottom structure, is characteristic of migratory trout spawning grounds in the river basins of Drawa and Gwda.

During the studies carried out in the 1970^{s}, the water flow velocity, with the lowest water levels, oscillated between 37 and 62 cm per sec.$^{-1}$ and the water temperature did not exceed 14°C. Mastyński did not identify the water thyme (*Elodea canadensis*), however he recorded, among others, the occurrence of *Berula erecta*, which was quoted by Filipiak et al (1995) as an indicatory species for good quality waters.

In section KI, our attention was called by a high number of identified species of typically rheophile type, including bullhead. Unfortunately, for this section, there are no literature data for making any comparisons. The occurrence of river fish, such as: asp, chub, dace, blue bream is probably connected with the neighborhood of a big water course, i.e. the Warta River. Younger individuals of these species find good conditions in the mouth section of the studied stream. In the described section, as many as four protected species were identified, among which bitterling was characterized by a high contribution in the count. Certainly, the lower reaches of the Kończak stream can be included among localities with a strong population of this taxon. Unquestionable domination of roaches was the phenomenon, which gives an unfavorable evidence about the ecological status of the stream. The roach is a typical eurytopic species (Zalewski and Penczak 1973), which, due to its high elasticity regarding habitat utilization and food selection, attains the highest developmental success in the waters of Central Europe (Penczak et al. 1990, Horppila and Peltonen 1994). Because of the proven relationship between the extent of environmental degradation and the number of roaches, a proposal was made to recognize the roach as an indicator species of water courses with low ecological status (Oberstdorff and Hughes 1992). In the case of KI section, the juvenile stages of roaches, similarly as rheophile fishes, find better conditions in a smaller water course and they get here from the Warta River.

In KI section, the highest value of the H index and the lowest value of the ABC index were recorded, which is connected with the large number of species, however, with a significant contribution of individuals with small body dimensions.

The forest sections (KII and KIII) significantly differed from each other regarding the habitat, which was reflected in the ichthyocenotic relations. Section KIII differs from section KII primarily in a lower flow velocity, the bottom substratum with a higher contribution of sand and slime, plant species characteristic of waters with higher fertility. It was also found that the temperature was insignificantly higher, but oxygenation conditions were definitely worse. In forest sections, similarly as in the two other sections, the water reaction oscillated around 8. This value is within the optimal range for fish, as reported by Starmach et al. (1976) and Dojlido (1998).

During the research of Iwaszkiewicz (1964), the experimental segment was placed in the central course of the forest part of the stream, therefore, one can assume that he characterized the water course between our sections KII and KIII. The aforementioned author, based on the classification of Berg (1948), characterized the water flow at low levels as a strong one (49-86 cm s^{-1}). He also described the stream bottom as a diversified, sandy, stony, gravelly bottom, in some places covered with a layer of slime not exceeding 2 cm. Among the

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

aquatic vegetation, he mentioned *Potamogeton pectinatus, Batrachium fluitans, Acorus calamus, Nuphar lutea* and *Berula erecta*. The maximum water temperature in the summer season did not exceed 13,5°C, and the oxygenation did not drop below 9 mg 1^{-1} O_2.

When we compare our own results with literature data, we find that section KII preserved its former character, however, in section KIII, unfavorable changes of habitat conditions took place. According to the authors of the present work, the described changes are connected with the excessive density of European beaver (*Castor fiber* L.) which constructs numerous weirs damming up the water (even as high as 50 m) and causes a slower water flow with all its negative effects, such as water warming, oxygen decrease, development of aquatic vegetation, additionally decreasing the water flow and sliming the bottom. Studies by Hőgglund and Sjőberg (1999) could constitute a confirmation of this hypothesis. The authors studied forest brown-trout streams in Sweden. They also found the negative effects of beavers on the environmental conditions and the population of dummy salmonid fishes.

As mentioned earlier, two forest sections differ significantly regarding the species composition of ichthyofauna. In KII section, the lithophilous fish definitely dominated, i.e. bullhead and brown trout, while in KIII section, gudgeon was the dominant. These differences reflect the environmental conditions prevailing in the two described sections. A high value of the ABC index was connected with the numerous occurrence of relatively big individuals of the brown trout.

Iwaszkiewicz (1964), during his studies, identified brown trout, bullhead, gudgeon, stone loach, roach, pike, three-spined stickleback, sunbleak and crucian carp, whose density and contribution in the count and the biomass are presented in Table 4. The present author has found that the brown trout retreated in the upstream water course, and the domination was taken over by roach. And this can be considered as a characteristic phenomenon. However, in the two upper localities, the brown trout occurred again. The phenomenon of a mosaic occurrence of trout biotopes has been acknowledged as typical of lowland streams, with the same species in the fish fauna.

In the analysis of our own studies, the aforementioned phenomenon of mosaic has not been observed. In KII section, a higher density and contribution of brown trout and bullhead were found as compared with the data of Iwaszkiewicz (1964). In the successive sections, however, these species were not found at all. Gradual impoverishment of ichthyofauna was also recorded by Penczak et al. (2008). The aforementioned authors, who studied fishes in the Gwda River for over thirty years, recorded a sudden decrease in the number of stone loach and bullhead in many water courses, with a simultaneous occurrence of great numbers of roaches.

Table 4

Dominance structure In the number (D,. %), biomass (W, %) and the number of individuals (L, pcs 1000 m^{-2}) and biomass (B, g 1000 m^{-2}) of ichthyofauna, in Kończak stream, in the year 1960 (Iwaszkiewicz 1964).

Species	D	W	L	B
Brown trout	26.4	43.6	20	2619
Bullhead	25.7	2.2	19.4	137
Stoned loach	13.6	1.8	10.3	110
Pike	7.6	21.2	5.7	1304
Roach	20	31.1	15.1	1910
Gudgeon	6.8	1.1	5.1	69
	100	**100**	**75,7**	**6149**

In section IV, the habitat was transformed and degraded to the highest extent. As a result of water damming up, regulation of the stream bed and melioration of the basin, the water flow was almost completely stopped, the water-course bed displayed little differentiation offering a few hiding places for fish, the bottom was slimy with stagnophilous vegetation. The temperature reached the highest value, with the lowest oxygen content among the studied sections. The ichthyofauna structure reflected the environmental conditions. Only two species were identified, which have low environmental requirements, i.e. gudgeon and three-spined stickleback, which occurred in low densities. The diversity index H also reached the lowest value. The ABC index reached a high positive value, however, this fact does not prove that there were no disturbances in the balance of biocenosis. Since there were only two species present, it was not possible to calculate this index properly.

Among the obtained results, the most serious causes for concern were generated by unfavorable changes in section KIII, the most central part of the water course, the impoverishment of the habitat connected with the drastic change in the species composition and in the quantitative relations in the ichthyocenosis. According to the authors of the present paper, it is absolutely necessary to restore the natural character of the water course as quickly as possible. Minimization of the activity of beavers should be the first step in this direction, for example by displacing a certain part of their population to areas, which are less susceptible to their pressure.

REFERENCES

Allan J.D., 1998, *Ecology of water courses* (in Polish). Wydawnictwo Naukowe PWN, Warszawa

Balon E.K., 1990, *Epigenesis of an epigeneticist: the development of some alternative consepts on the early ontogeny and evolution of fishes*. Guelph Ichthyology Reviews. 1, 1-42

Copyright© by Institute of Oceanography, University of Gdańsk, Poland

Berg K., 1948, *Biological Studies on the river Susaa*. Folia Limnol. Skandinavica. No.1, 1-318

Bylak A., Dudek M., Kukuła K., 2007, *Ichthyofauna degradation in the of a small submountainous stream caused by bed regulation* IV Konferencja Naukowo-Techniczna „Błękitny San" (in Polish)

Dojlido J.R., 1994, *Chemistry of surface waters*, Wydawnictwo Ekonomia i Środowisko (in Polish)

Filipiak J., Trzebiatowski R., Sadowski J., 1995, *Fishing. A guide to exercises. 1. Management of open waters* (in Polish) Akademia Rolnicza w Szczecinie

Grotrian, 1896, *Die Fichereiverhaltnisse der Warthe*, Beil. Deutsch. Fischerei Ztg., pp. 194-222

Grotrian, 1900, *Die Fischereiverhaltnisse in der Provinz Posen*, Jb.dtsch. Landw. Berlin, pp 311-321

Hägglund Å., Sjöberg G. 1999.*Effects of beaver dams on the fish fauna of forest streams*. Forest Ecology and Management 115, 259-266

Horppila J., Peltonen H. 1994. *The fate of roach Rutilus rutilus stock under extremely strong fishing pressure and its predicted development after the cessation of mass removal.* Journal of Fish Biology. 45, 777-786

Humpl M., Pivnicka K., 2006, *Fish assemblages as influence by environment al factors In streams In protected areas of the Czech Republic*, Ecology of Freshwater Fish, 15, 96-103

Iwaszkiewicz M., 1964a, *Brown trout, Salmo trutta m. fario L. in Warta basin*, Roczniki Wyższej Szkoły Rolniczej w Poznaniu – XXII (in Polish)

Iwaszkiewicz M., 1964b, *Ichthyofauna natural regeneration process in a stream segment experimentally defished by electric current* (in Polish) PTPN. Wydział Nauk Rolniczych i Leśnych. TOM XVIII, zeszyt 1

Iwaszkiewicz M., 1966, *Salmon and trout migratoryt in Lower Warta basin* (in Polish) Gospod. Rybna, Warszawa 8, pp. 8-12

Jaskowski J., 1962, *Materials for the cognition of the ichthyofauna in Warta and its tributaries* Fragmenta Faunistica, Tom IX, Nr 28 Polska Akademia Nauk, Instytut Zoologiczny, Warszawa (in Polish)

Kaj J., 1958, *Network of protected spawning grounds in Warta basin* (in Polish) Ochr. Przyr., 25. Warszawa, 96-110

Kaj J., 1959, *Rare and physiographically interesting fish species of north-eastern Poland* Przyr. Pol. Zach., Poznań, 3, pp. 270-278

Kaj J., 1966, *Actual status of physiographic studies on Wielkolska fishes and important tasks for the future*, Pr. Kom. Mat. Pozn. TPN., Poznań, pp. 99-113 (in Polish)

Kostecki M., 2003, *Commentary to hydrographic map* (in Polish)

Kondracki J., 1998, *Regional geography of Poland* W-wa PWN, (in Polish)

Krebs C.J., 2001, *Ecology.* Wyd. Naukowe PWN, Warszawa

Kulmatycki W., 1929, *Fish water pollution by sewages from Industrial Plants in West Poland provinces* Konferencja Rybacka w Ministerstwie Rolnictwa 8 stycznia 1929. W-wa 1029 (in Polish)

Mastyński J., 1971, *Hydrographical conditions of Salmo trutto m. trutta L spawning ground inWarta tributary near Oborniki* Roczniki Wyższej Szkoły Rolniczej w Poznaniu. LIV, (in Polish)

Meire P. M., Dereu J. 1990. *Use of abundance/biomas comparison method for detecting environmental stress: some considerations based on intertidal macrozoobenthos and bird communities*, J. Appl. Ecol., 27: 210 – 223

Oberdorff T. Hughes R.M. 1992. *Modification of an index of biotic integrity based on fish assemblages to characterize rivers of the Seine Basin, France*, Hydrobiologia, 228: 117-130

Penczak T., O`Hara K., Stankiewicz H. (1990): *Populations of roach, Rutilus rutilus (L.) in the Pilica river drainage area.* Pol. Arch. Hydrobiol. 37, 1-2, 235-242

Penczak T., Galicka W., Grzybkowska M., Koszaliński H., Janiszewska M. et al. 1993, *Effect of Jeziorsko Reservoir on water quality in Warta river, fish populations and their nutrition base*, Rocz. Nauk. PZW 6, 79-114, Warszawa (in Polish)

Penczak T., Kruk A., 2000c, *Threatened obligatory riverine fishes in human-modified Polish rivers*. Ecology of Freshwater fish. 9: 109-107

Penczak T., Kruk A., Marszał L., Zięba G., Galicka W. et al. 2008. *Ichthyofauna monitoring system in Gwda river: third decade of studies*. Rocz. Nauk. PZW, 21, 61-89 (in Polish)

Przybylski M., 1994, *Are the fish communities persistent and stable in the european rivers?* Pol. Arch. Hydrobiol. 41, 3, 365-3375

Przybył A., 1976, *Occurrence and preservation possibilities of two-environmental anadromic fishes in the central basin of Warta* (in Polish). Bad. Fizjogr. nad Pol. Zach., 29 C-Zool.: 7-38

Seligo A., 1902, *Die Fischgewasse der Provinz Westpreussen im Kurzem Darstellung bearb. Danzig*, pp.162-163

Starmach K., Wróbel S., Pasternak K., 1978, *Hydrobiology*. Państwowe Wydawnictwo Naukowe, Warszawa 1978

Wiśniewolski W., 2002, *Favourable and harmful factors for the development and maintenance of fish populations in flowing waters*, Supplementa and Acta Hydrobiologia, Kraków, 3: 1-28 (in Polish)

Wyżga B., Amirowicz A., Radecki-Pawlik A., Zawiejska J., 2008, *Hydromorphological differentiation of mountain river versus the species richness and the number of ichthyofauna*, Infrastruktura, Ekologia Terenów Wiejskich. Nr 2/2008 PAN,oddz. w Krakowie, s. 273-285 (in Polish)

Zalewski M., Penczak T., 1973, *Effect of anthropogenic environmental changes on the rate of roaches Rutilus rutilus* (L.) *growth* (in Polish) Wiadomości ekologiczne Tom XXIV

Copyright© by Institute of Oceanography, University of Gdańsk, Poland