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Morphological differences between lake and river populations of roach – *Rutilus rutilus* (L.)

Morfologiczne zróżnicowanie populacji jeziorowych i rzecznych płoci – *Rutilus rutilus* (L.)

Summary. Four populations (two from rivers and two from lakes) of roach *Rutilus rutilus* (L.) were tested for a variation of morphological features depending on the given habitat. 23 biometric and 11 meristic variables were analysed. The compared fish populations showed little variability as regards the meristic features. Lake roaches were characterised by higher values of biometric characteristics than the river populations. The habitat affected the selected biometric variables. The following features: eye diameter, length of the caudal peduncle and head depth were the least changeable. The greatest differences between the fish populations were identified in the case of head and body width. River roaches had higher fins and a greater predorsal length. The lake roach populations were showed greater pectoral – pelvic fin distances. Moreover, the fish from lakes were characterized by lower variability of countable traits as compared with the river fish.

Key words: fish morphology, fish biometry, lake populations, river populations, roach, *Rutilus rutilus* (L.)

INTRODUCTION

Morphological variability is a natural phenomenon encountered in all living organisms. Phenotypic variability and varying body proportion are the result of the fact that particular species inhabit different parts of the world or continents. However, such changes are also found on a much smaller scale. A number of studies compare the variability of biometric and meristic characteristics of fish populations occurring in different habitats. Fish morphology is significantly influenced by environmental conditions, such as velocity of water flow, physical and chemical parameters which are differentiated in the rivers and lakes [Szczyglińska 1980 a, b, McLaughlin and Grant 1994, Brinsmead and Fox 2002, Neat *et al.* 2003].

A number of authors working on fish morphology attempted to find the possible influence on the body ratio and morphological features in individuals of fish from different habitats. Some of the work concerned the differences in morphology between wild and hatchery populations of the same species [Taylor 1986, Swain *et al*. 1991, Von Cramon-Taubadel *et al*. 2005] while others focused on the phenotypic variability of fish occurring in different zones of the lake or from different lakes [Dynes *et al*. 1999, Sacotte and Magnan 2006]. In addition, a few studies concentrated on the impact of changes in the velocity of water flow to changes in phenotypic and morphological characteristics of *Salmonidae* fish [Claytor 1991, McLaughlin and Grant 1994, Pakkasmaa and Piironen 2001, Imre *et al*. 2002].

Roach *Rutilus rutilus* (L.) is a successful generalist fish species in central European freshwater habitats [Schiemer and Wieser 1992]. As a species, it is present all over Europe with the exception of the Iberian Peninsula, the Adriatic and Greek reception basin and in Northern Scandinavia. It is also encountered in the depths of Asia. Due to its popularity the roach is the fundamental species in numerous types of inland waters [Zalewski and Suszycka 1980, Horppila and Kairesalo 1990, Horpilla *et al*. 1996, Peltonen *et al*. 1999, Psuty *et al*. 2007]. It often considerably influences ecosystem functioning by food pressure and preferences [Brabrand 1985] and large numbers of roaches can affect water reservoir trophism [Tarvainen *et al*. 2002].

Few of the papers were concerned with the profiles of the biometric and meristic features of roach. Additionally, such research was only conducted in order to compare morphological variability of roach populations living in natural and artificial reservoirs with different degrees of pollution and diverse thermal conditions [Szczyglińska 1980 a, b].

Ecosystems of lakes and rivers differ significantly in hydrology, physical and chemical water parameters as well as in habitat conditions; it seems that the morphological characteristics of fish from populations from different ecosystems should be varied. Although the roach species is widespread, there are no studies on the variability of its morphological characteristics, especially those caused by their occurrence in different habitats, such as lakes and rivers. Hence, the aim of this paper is to identify which of the morphological characteristics of roach *Rutilus rutilus* (L.) vary depending on the different habitats and those are mostly plastic and shaped under the influence of the conditions in lakes and rivers.

STUDY AREA

The roach populations from two shallow lakes (Głębokie and Syczyńskie) and from two rivers (Kosarzewka and Gałęzówka) were studied. Lake Głębokie is located in Łęczna – Włodawa Lakeland. It is a shallow eutrophic lake with the average depth of 3.4 m and maximum depth of 7.1 m. Oxygen sag is quite often observed in its profundal zone [Kornijów *et al*. 2002 a]. The catchment basin of the lake is 173.82 ha (Tab. 1).

Lake Syczyńskie is small, polymictic and shallow lake (max. depth 4 m). The catchment area of the lake is 458.17 ha. With regard to its trophism, Lake Syczyńskie was classified by Harasimiuk *et al*. [1998] as eutrophic, while Kornijów *et al*. [2002 b] defined it as extremely hypertrophic (Tab. 1).

Table 1. Morphological, physical and chemical characteristic of studied lakes (after Kornijów *et al*. 2002a – changed)
Tabela 1. Morfologiczna i fizyczno-chemiczna charakterystyka badanych jezior (dane za Kornijów i in. 2002a – zmienione)

Lake / Jezioro	Głębokie	Syczyńskie
GPS location / Lokalizacja GPS	N 51°28'39 E 22°55'24	N 51°17'13 E 23°14'16
Area (ha) / Powierzchnia (ha)	21.00	6.00
Max. depth (m) / Max. głębokość (m)	7.10	4.00
Mean depth (m) / Średnia głębokość (m)	3.40	0.90
Secchi depth (m) / Widzialność dysku Secchie'go (m)	0.90	0.20
Conductivity (µS cm^{-1}) / Przewodnictwo (µS cm^{-1})	341.00	640.00
Total P (µg dm^{-3}) / Fosfor całkowity (µg dm^{-3})	170.00	338.00
Total N (mg dm^{-3}) / Azot całkowity (mg dm^{-3})	4.73	7.54

Table 2. Morphological, physical and chemical characteristic of studied rivers (values of autumn 2002)
Tabela 2. Morfologiczna i fizyczno-chemiczna charakterystyka badanych rzek (wartości z jesieni 2002)

River / Rzeka	Gałęzówka	Kosarzewka
GPS location / Lokalizacja GPS	N 50°59'37 E 22°31'50	N 51°00'34 E 22°33'41
Length (km) / Długość (km)	5.00	20.30
Width (m) / Szerokość (m)	1.40–2.00	1.50–2.50
Depth (m) / Głębokość (m)	0.20–0.35	0.40–0.70
Average current velocity (m s^{-1}) / Średni przepływ (m s^{-1})	0.20–0.30	0.25–0.37
Temperature (°C) / Temperatura (°C)	12.50	10.70
Oxygen (mg dm^{-3}) / Tlen (mg dm^{-3})	6.70	7.70
Conductivity (µS cm^{-1}) / Przewodnictwo (µS cm^{-1})	530.00	560.00
pH	7.30	7.71
TSS (mg dm^{-3}) / TSS (mg dm^{-3})	11.70	5.20
TOC (mg dm^{-3}) / TOC (mg dm^{-3})	2.70	6.30
N-NO_3 (mg N dm^{-3}) / N-NO_3 (mg N dm^{-3})	9.00	13.90
SUR (mg dm^{-3}) / SUR (mg dm^{-3})	2.90	9.40
COD (mg dm^{-3}) / COD (mg dm^{-3})	4.50	6.80
BOD (mg dm^{-3}) / BOD (mg dm^{-3})	3.40	7.70

The Kosarzewka River flows through the central part of Lublin Upland. The river is a right-bank tributary of the Bystrzyca Lubelska River. The Kosarzewka is a small river only about 20-kilometers long. It has a slope – about 3.3% and the depth ranging from 0.4 to 0.7 m (0.5 m on average). The Gałęzówka River is a small (5 km length) left tributary of the Kosarzewka River. The Gałęzowka River's width oscillated from 1.4 to 2.0 m and the depth ranging from 0.2 to 0.3 m (Tab. 2). The research conducted by the Voivodship Inspectorate of Environmental in 2005 using the CUGW method showed that the analysis results for the physicochemical parameters of the Kosarzewka put it in the third class of water clarity. However, as far as the bacteriological aspect is concerned, the waters do not meet the set standards (NON) [Raport o stanie środowiska 2005]. As there is no available data on the hydrological or hydrochemical parameters of the Gałęzówka River which is the left tributary of the Kosarzewka, the profile mentioned above can also concern the waters of this small water-course. Physical and chemical water parameters were measured by electrometric methods (multiparameter probe, Pastel UV) and water flow were measured using a float (Tab. 2).

MATERIAL AND METHODS

The fish for biometric measurements were collected during the autumn of 2001 and 2002 (50 individuals per lake) and (100 individuals per river). Roaches from lakes were caught using multimesh Norden S-REV gillnet (mesh size: 10, 65, 30, 6.25, 43, 22, 50, 33, 12.5, 25, 8, 38, 75 and 16.5 mm) [Appelberg 2000, PN-EN 14757:2005] and from the rivers using electric gear type IUP-12 (220-250V, 7A) across the whole width of the river bed [Hickley 1990]. The collected roaches were measured using a vernier calliper gauge, exact to 0.1 mm, according to the measurements scheme given by Brylińska [1991]. For fish from each habitat body weight (W) and 23 biometric features were determined (Tab. 3); 7 countable traits were measured in lake fish and 11 in the river fish. The biometric features included: total length (Lt), caudal (fork) length (Lca), body length (Lb), torso length (Lto), head length (Lh), jaw length (Lj), eye diameter (De), postorbital distance (Dpe), head depth (Hh), head width (Wh), max. body depth (MaxH), min. body depth (MinH), predorsal length (Lp), pastdorsal length (Lpast), length of caudal peduncle (Cp), pectoral fin – pelvic fin distance (P-V), pelvic fin – anal fin distance (V-A), dorsal fin base (Dl), dorsal fin height (Dh), anal fin base (Al), anal fin height (Ah), pectoral fin length (Pl), pelvic fin length (Vl) (Tab. 3). All biometric measurements were analyzed and expressed as percent indices of body length (% Lb).

The meristic features included: the number of scales on the lateral line, over and under the lateral line, number of dorsal, anal, pelvic and pectoral fin rays (hard and soft).

All the collected data were processed using non parametrical multivariate analysis in SAS Programme, moreover for biometric measurements Correspondent Analysis (CA) was conducted using MVSP – 3.1.sp.

RESULTS

The total lengths (Lt) of the examined fish ranged from 83.7 to 194.0 mm; the fish from River Gałęzówka have the greatest average body length (Lb 141.3 mm) and the lowest variability of that feature (SD = 9.18) (Fig. 1). The body weight (W) of the analysed fish varied between 5–74 g, with the highest mean value for the fish from River Gałęzówka (29.8; SD = 6.76). The greatest variability of body length and weight was found for fish from Lake Syczyńskie (Fig. 1, 2). Generally, the average total length and body mass values in the river fish were characterized by the greatest range, i.e. – the highest mean values were those of the River Gałęzówka fish, while the lowest pertained to the fish from the River Kosarzewka. The average values of these characteristics for fish from lakes were intermediate (Fig. 1, 2).

The length – weight relationship of the roach from the lakes and the River Kosarzewka remained in the same range, whereas the lowest coefficient of determination was identified for the group of fish from the Gałęzówka River ($W = 1.957e^{0.019Lt}$; $R^2 = 0.593$) (Fig. 3).

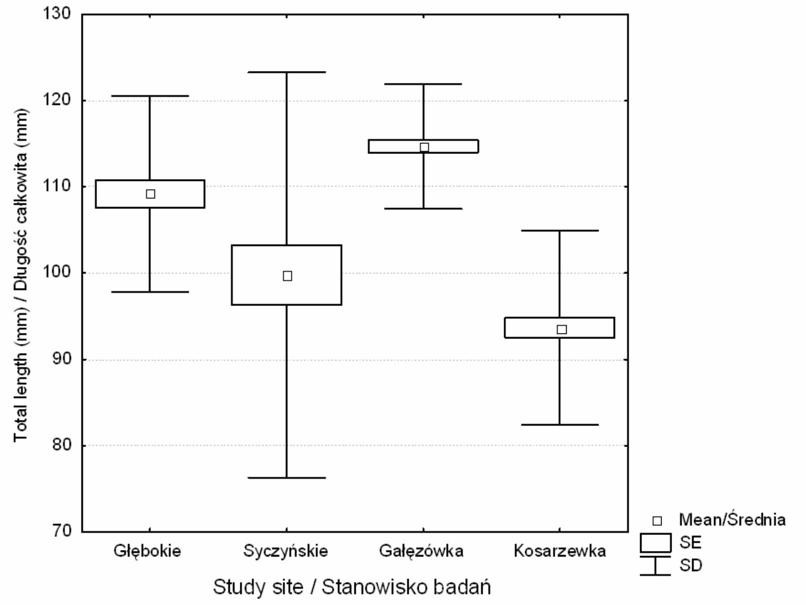

Fig 1. Total length (mm) of roach from different study site
Ryc. 1. Długość całkowita (mm) płoci z różnych siedlisk

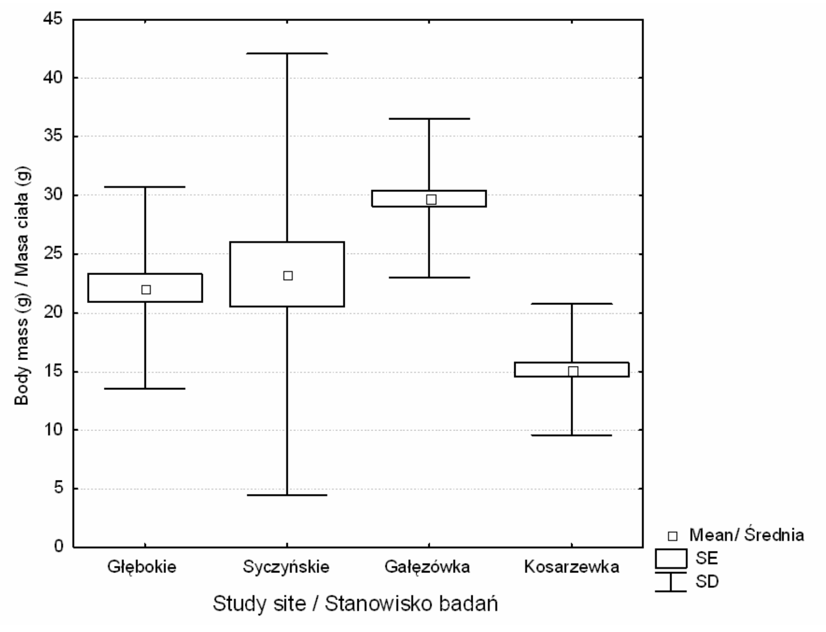

Fig 2. Body mass (g) of roach from different study site
Ryc. 2. Masa ciała (g) płoci z różnych stanowisk badawczych

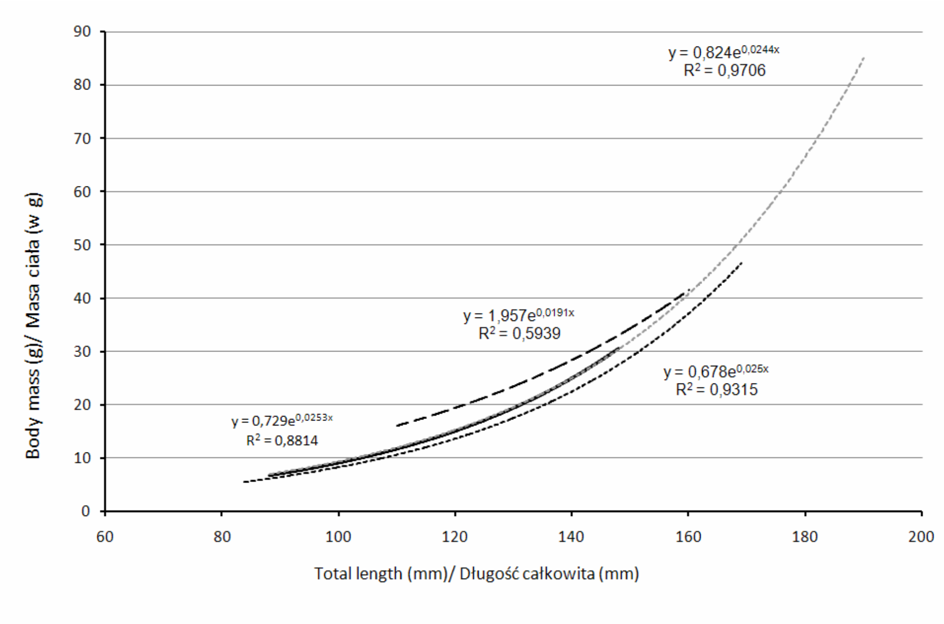

Fig 3. Relationship between total mass (g) and total length (mm) roach from different study site
Ryc. 3. Zależność masy ciała (g) od długości całkowitej (mm) płoci z różnych stanowisk badawczych

The statistical analysis of the values relating to the metric characters of the particular roach populations expressed as per cent indices of body length (Lb) showed that it was the total body length (Lt), the caudal length (Lca) and the torso length (Lto) that were characterized by the smallest coefficient of variation (V) in the four roach populations. With these characteristics the coefficient reached a value of 1% to a maximum of 4%. In all of the examined fish groups the predorsal length (Lp), as well as the anal fin base length and height (Al, Ah) were characterized by the greatest variation (V = 12–15%). Moreover, the jaw length (Lj), exclusively, of the river populations of roach was also characterized by a high coefficient of variation. It reached 17.84% in the case of Kosarzewka River fish and 12.19% for the fish from River Gałęzówka.

The comparison of the relative values of the biometric characteristics of roach populations from different habitats produced slightly higher mean values for the Lake Syczyńskie population. The least varied characteristics expressed as relative values (% Lb) of the features of the fish both from the rivers and the lakes turned out to be the eye diameter (De) (F = 2.26; p = 0.0818) and the length of the caudal peduncle (Cp) (F = 2.38; p = 0.0695), no significant statistical differences having been determined. Additionally, the head depth (Hh) was hardly a variable feature (Tab. 3).

The features which varied the most with regard to the mean value in all examined populations from rivers and lakes turned out to be the head width and the maximum body depth. In both cases, there were significant variations between the average values of these features in all the roach populations.

Table 3. Mean values of weight (in g) and comparatives biometric measurements (in % Lb) of roach from different habitats
Table. 3. Średnie wartości masy (w g) i porównywanych cech biometrycznych dla płoci (w % Lb) z różnych siedlisk

Measure/ Pomiar	Symbol	Głębokie	Syczyńskie	Gałęzówka	Kosarzewka	Mean	F	p
Body mass (in g) / Masa ciała (w g)	W	22.5^{b}	23.5^{b}	29.7^{a}	15.1^{c}	22.8	33.02	<.0001
Total length / Długość całkowita	Lt	125.21^{a}	126.26^{a}	123.10^{b}	125.59^{a}	124.78	11.76	<.0001
Caudal length / Długość ogonowa	Lca	110.20^{b}	111.33^{a}	109.23^{c}	110.33^{b}	110.09	7.41	<.0001
Torso length / Długość tułowia	Lto	78.63^{a}	77.60^{b}	77.10^{b}	76.15^{c}	77.14	11.12	<.0001
Head length / Długość głowy	Lh	22.74^{c}	23.29^{b}	23.61^{b}	24.16^{a}	23.58	13.87	<.0001
Jaw length / Długość pyska	Lj	6.11^{bc}	6.69^{a}	5.82^{c}	6.18^{b}	6.13	11.91	<.0001
Eye diameter / Średnica oka	De	7.11^{b}	7.32^{ab}	7.27^{ab}	7.45^{a}	7.31	2.26	0.0818
Postorbital distance / Odległość zaoczna	Dpe	10.50^{b}	10.93^{a}	10.49^{b}	11.15^{a}	10.77	10.60	<.0001
Head depth / Wysokość głowy	Hh	16.49^{b}	17.60^{a}	16.54^{b}	16.08^{b}	16.56	9.06	<.0001
Head width / Szerokość głowy	Wh	8.86^{d}	9.69^{c}	11.57^{b}	12.06^{a}	10.95	116.28	<.0001
Max. body depta / Max. wysokość ciała	MaxH	25.89^{c}	28.37^{b}	29.43^{a}	25.47^{c}	27.39	61.27	<.0001
Min. body depta / Min. Wysokość ciała	MinH	8.85^{b}	9.65^{a}	8.67^{b}	8.71^{b}	8.88	22.64	<.0001
Predorsal length / Odległość przedgrzbietowa	Lp	52.39^{b}	52.39^{b}	54.12^{a}	54.16^{a}	53.54	3.85	0.0100
Pastdorsal length / Odległość zagrzbietowa	Lpast	36.14^{a}	34.93^{b}	36.31^{a}	34.89^{b}	35.60	11.63	<.0001
Length of caudal peduncle / Długość trzonu ogonowego	Cp	25.50^{a}	17.99^{b}	18.08^{b}	18.20^{b}	19.37	2.38	0.0695
Pectoral fin – pelvic fin distance / Odległośc P–V	P–V	27.27^{b}	26.75^{b}	28.44^{a}	25.79^{c}	27.11	31.44	<.0001
Pelvic fin – anal fin distance / Odległość V–A	V–A	23.91^{a}	23.85^{a}	23.15^{ab}	22.69^{b}	23.25	3.92	0.0091
Dorsal fin base length / Długość płetwy grzbietowej	Dl	13.87^{c}	15.11^{a}	14.68^{ab}	14.54^{b}	14.56	5.93	0.0006
Dorsal fin height / Wysokość płetwy grzbietowej	Dh	20.19^{b}	20.47^{b}	20.35^{b}	22.01^{a}	20.87	18.38	<.0001
Anal fin base length / Długość płetwy odbytowej	Al	11.72^{bc}	12.73^{a}	11.98^{b}	11.26^{c}	11.84	11.20	<.0001
Anal fin height / Wysokość płetwy odbytowej	Ah	12.75^{c}	13.30^{c}	14.11^{b}	15.85^{a}	14.29	42.16	<.0001
Pectoral fin length / Długość płetwy piersiowej	Pl	6.11^{bc}	6.69^{a}	5.82^{c}	6.18^{b}	6.13	11.91	<.0001
Pelvic fin length / Długość płetwy brzusznej	Vl	16.67^{b}	17.91^{a}	16.51^{bc}	16.06^{c}	16.63	15.72	<.0001

$^{a, b, c, d}$ – Statistical differences – means in the row significant of the same letters – no significant differences ($p < 0.05$)
$^{a, b, c, d}$ – Różnice statystyczne – średnie w wierszach oznaczone takimi samymi literami nie różnią się statystycznie ($p < 0,05$)

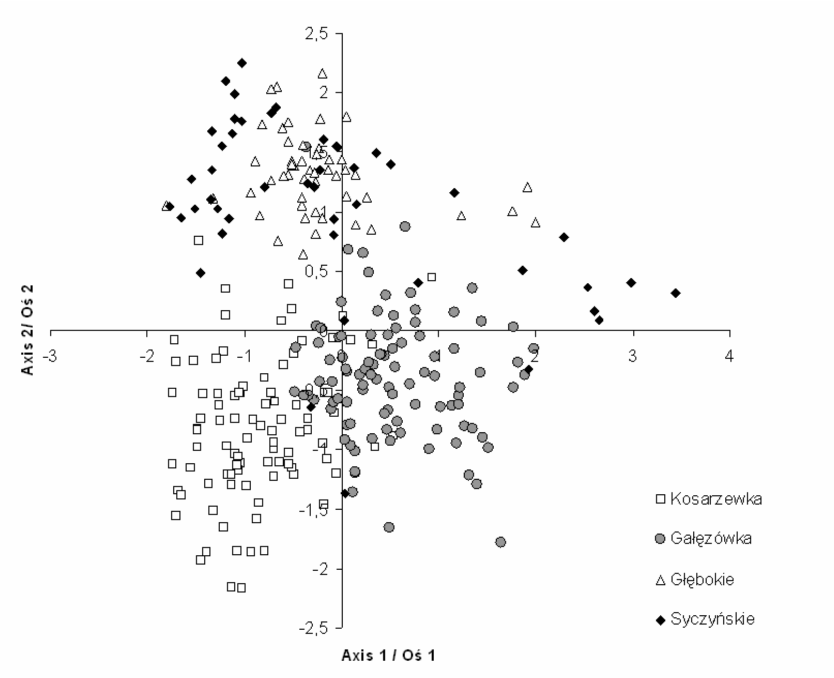

Fig 4. Correspondence Analysis of biometric features of roach from different habitats
Ryc. 4. Analiza korespondencyjna (CA) cech biometrycznych płoci z różnych siedlisk

Table 4. Correspondence Analysis (CA) – values of factorial first 5 axes contributions for biometric measurements of roach from different habitats
Tabela 4. Analiza korespondencji (CA) – wartości silni pierwszych 5 osi składowych dla pomiarów biometrycznych płoci z różnych siedlisk

	Axis 1 / Oś 1	Axis 2 / Oś 2	Axis 3 / Oś 3	Axis 4 / Oś 4	Axis 5 / Oś 5
Percentage / Procent	46.669	7.849	5.866	4.383	4.222
Cum. Percentage / Procent skumulowany	46.669	54.518	60.384	64.766	68.989

The lake and river habitats clearly differentiated several features of the roach. For example, the fish from the rivers had greater average height of the anal fin (significant statistical differences between the rivers were also noted), whereas the fish populations from the lakes were characterized by greater average pelvic fin – anal fin (V-A) distance. Furthermore, the river fish were also noticeable for their statistically significant greater predorsal length – from the tip of the head to the dorsal fin ($F = 3.85$; $p = 0.01$) (Tab. 3).

The correspondent analysis (CA) explained 68.99% of cumulative variability in the study. The two from five axis (Axis 1 and Axis 2) were chosen for the analysis because these two axis showed the highest variability of biometric measures of studied roach populations (Tab. 4).

The CA analysis separated roach populations between lakes and rivers. Both lake populations of roach showed similar distribution of biometric features. However, river populations of roach differed visibly (Axis 1) between studied ecosystems (Fig. 4).

The values of the meristic features showed greater variability in the roach populations of Kosarzewka and Gałęzówka rivers. The meristic features values for the roach from the two rivers and two lakes are shown in Fig. 5. The number of scales on the lateral line of all the examined roach ranged from 36 to 46. However, significantly higher values were recorded for lake populations. The fish from Gałęzówka River were characterized by the highest variation of that feature with the standard deviation of 1.79 (range: 36 to 46). The river populations of roach had statistically fewer scales under the lateral line (Fig. 5).

The statistical analysis of fin ray quantities showed that the lake fish had a statistically higher number of hard and soft rays in the unpaired dorsal and anal fins. On the one hand, in both pairs of the paired fins of Kosarzewka River fish a statistically higher number of hard rays were noted. On the other hand, a statistically higher number of the soft rays in both the aforementioned fins were found in roach of Gałęzówka River (Fig. 5).

DISCUSSION

This work shows which of the morphometric features are different for roach occurring in different habitats, lakes and rivers. In addition, the results have indicated which of their external characteristics are the most visible depending on the living conditions.

From a few studies there are several known factors that may affect the morphological variability of fish. Fish of the same species may be different due to occurrences on other continents [Claytor 1991], different zones of lakes [Dynes *et al.* 1999, Sacotte and Magnan 2006] or due to using different tactics to acquire food and different food sources [Ehlinger 1990, Swain *et al.* 1991]. Several studies were dedicated to the variability between wild and hatchery populations of juvenile coho salmon and Atlantic salmon [Taylor 1986, Swain *et al*. 1991, Von Cramon-Taubadel *et al*. 2005]. According to Imre *et al*. [2002], McLaughlin and Grant [1994], Pakkasmaa and Piironen [2001] and Claytor [1991] water velocity is one of the most important factors affecting on the body shape and fins of fish. This study showed differences in the biometric and meristic characteristics of roach, which occurred in the habitats of standing waters – lakes, and running waters – rivers.

Most authors studied morphological changes of fish depending on habitats based on species from *Salmonidae* family: brook charr (*Salvelinus fontinalis*), Atlantic Salmo (*Salmo salar*), Coho Salmo (*Oncorhynchus kisutch*) and brown trout (*Salmo trutta*). Only a few studies were concerned with other fish species. For example, Brinsmead and Fox [2002] conducted some research on the variations of biometric and meristic features of rock bass (*Ambloplites rupestris*) and pumpkinseed (*Lepomis gibbosus*) and Neat *et al.* [2003] on *Salaria fluviatilis*. Despite being so common, the roach has not inspired too much scientific research on the profiles of its biometric and meristic features. Studies on the roach are limited to a few issues mainly related to its biology. That was the reason for making proportional comparisons of selected plastic features of this particular species.

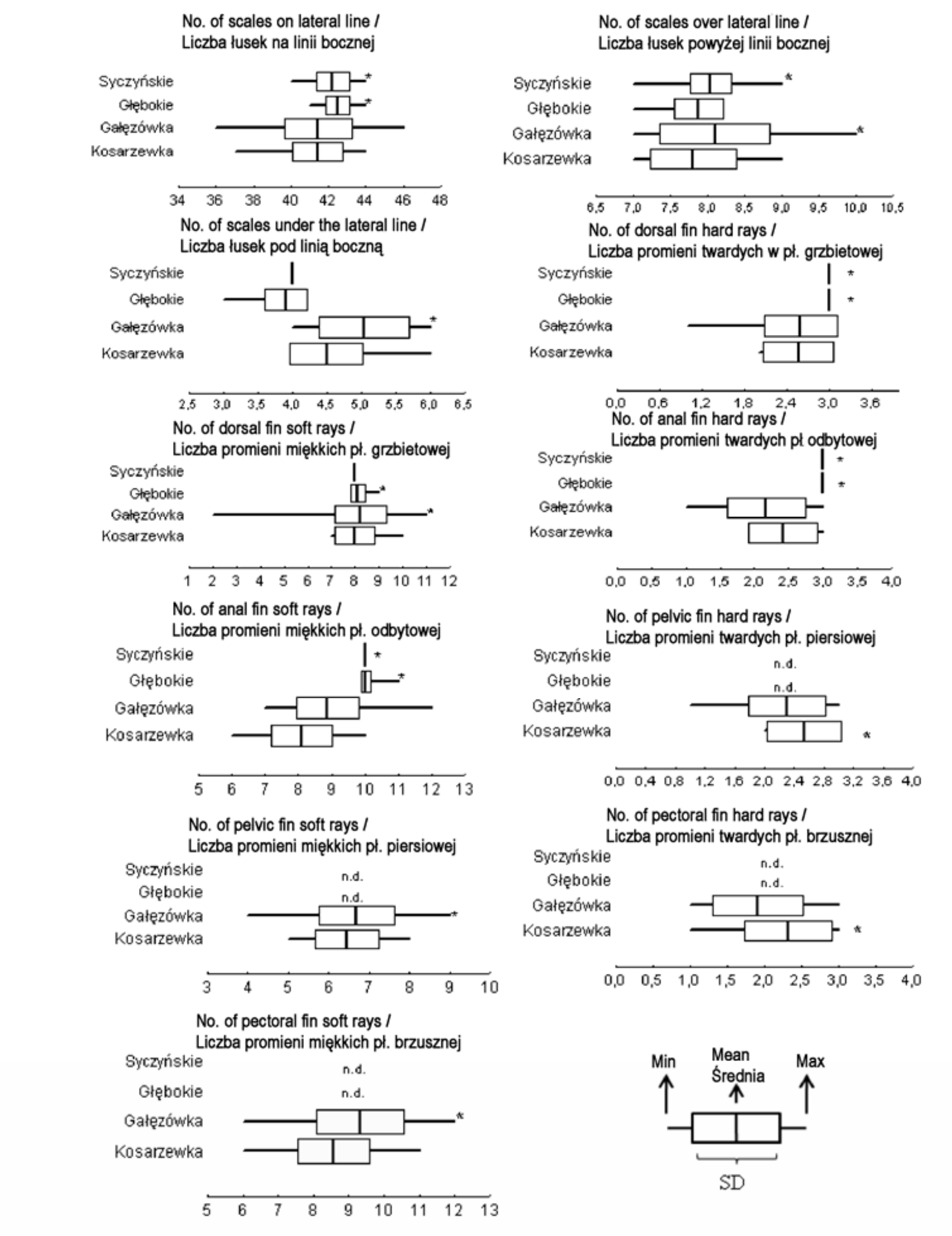

Fig. 5. Mean, standard deviations (SD) and ranges of meristic characters of roach from two lakes and two rivers (Głębokie Lake n = 50, Syczyńskie Lake n = 50, Gałęzówka River n = 100, Kosarzewka River n = 100); * – significant differences ($p < 0.05$); n.d. – no data

Ryc. 5. Średnia, odchylenie standardowe (SD) i zakres wartości cehc merystycznych płoci z dwóch jezior i dwóch rzek (Głębokie n = 50, Syczyńskie n = 50, Gałęzówka n = 100, Kosarzewka n = 100); * – różnice statystyczne ($p < 0.05$); n.d. – brak danych

Generally, roach individuals from lake and from river, had a small body size and the greatest variation in length and weight were observed in fish from Lake Syczyńskie (Fig. 1 and 2). The biometric and meristic features for the roach from the four habitats were not much different from the ones reported by other authors [Szczyglińska 1980 a]. The only exception was the length of the caudal peduncle (Cp) of roach from Lake Głębokie which had higher values (Tab. 3). Such results confirm the observations of McLaughlin and Grant [1994] and Imre *et al.* [2002], where juvenile brook charr in higher water velocity had lower values of caudal peduncle than fish from slow-running waters. In addition, as reported Neat *et al*. [2003] precisely on the values of length of caudal peduncle of *Salaria fluviatilis* were seen in the basic differences in body proportions. Similarly, in cases of the rock bass and pumpkinseed [Brinsmead and Fox 2002], the river fish were characterized by a more massive length of the caudal peduncle and a slimmer body.

Roach populations from lakes were characterized by slightly higher values of the biometric features than river populations. According to Neat *et al*. [2003] populations may vary considerably among themselves, while by his observation, lake fish had a lower ratio values and in addition were more similar. The body shape of the roach from rivers and lakes analyzed in this study showed that the environment, in which the fish lived, had an effect on the proportions of their body (Tab. 3, Fig. 4). According to Dynes *et al.* [1999] longer body length posterior was observed in pelagic fish, which was connected with their tactics of searching and of feeding. The impact of the reservoir, specifically on roach morphology becomes evident while comparing the results of our own research with those of Szczyglińska [1980 b]. Her results have shown that the roach from heated water reservoirs had greater body depth and exceeded studied populations of roach by an average of about 6%.

Significant for the shape of the body is also the water flow velocity. Many authors have reported some features variating depending on this parameter, particularly the length of the head and body depth. In the higher water velocity, fish had a higher body and longer head [Pakkasmaa and Piironen 2001, Solem *et al.* 2006]. According to McLaughlin and Grant [1994] and Imre *et al*. [2002] this parameter can influence the body shape and form of juvenile Salmonides. Brook charr from high-velocity water had smaller maximum body depth and caudal peduncle depth than fish reared in the low-velocity treatment.

In the present study, the eye diameter (De) and the head depth (Hh) turned out to be the least changeable features. According to [Brinsmead and Fox 2002], the eye diameters (De) as well as the jaw lengths also had slightly higher values in lake fish. As for the roach, a higher value of jaw length (Lj) was found only in the roach from Lake Syczyńskie (Tab. 3). However, the fish from that lake were characterized by the highest variability and slightly higher percentage values of several of the biometric features. This may be the result of the specificity of this lake. According to Kornijów *et al*. [2002 a,b], Lake Syczyńskie is extremely hypertrophic with a high amount of nutrients, coming mainly from surrounding arable lands. It is possible that due to the fact that visibility in the lake Syczyńskie is very poor [Kornijów *et al.* 2002 b] these fish have proportionately, slightly larger eyes. As reported Czerniejewski and Keszka [2007] for some species, especially planktivorous, eye size is important. The authors studying the morphology of vendace *Coregonus albula* (L.) found that the eye diameter depended on habitat conditions and distribution of plankton.

The size and shape of fins is one of the features which depends on the speed of water flow and may be a deciding factor in facilitating the movement of fish in rivers. Smaller fins in rivers may facilitate swimming and overcoming current, however, Brinsmead and Fox [2002] tested this hypothesis in the case of rock bass populations and pumpkinseed did not confirm it. On the other hand fish from large rivers had larger fins than fish from small rivers [Pakkasmaa and Piironen 2001]. In the present study unpaired fins usually turned out are higher in the river populations (significantly higher in the case of dorsal fins of the fish in the Kosarzewka River). This is confirmed by the observation of McLaughlin and Grant [1994] and Imre *et al*. [2002], where the fish reared in the high-velocity treatment had a larger caudal fin maximum height than fish reared in the low-velocity treatment. In addition, Swain *et al*. [1991] observed that the deeper bodies and slightly larger fins are typical for swimmers which could sustain swimming for long periods of time.

In the present study, paired fins (pectoral and pelvic) in the lake roach populations were usually longer (Tab. 3). Roach from the lake must be using slower food searching tactics. According to Ehlinger [1990] these tactics are strongly correlated with size of pectoral fins. In fish which are using a slower searching tactic, pectoral fins are longer. Greater sizes of paired fins in stagnant water populations were confirmed by Sacotte and Magnan [2006] in lake littoral populations of brook charr and also by Brinsmead and Fox [2002] in lake population of rock bass.

River and lake populations differed strongly between pectoral and pelvic fin distance. The greater distances between fins have roach populations from lakes, which were confirmed for the same species by Szczyglińska [1980a]. Based on the results obtained by that author, the roach from heated reservoirs showed greater distance between the pectoral and pelvic fins by about 2% of the body's length.

The present research comparing the meristic features of the roach populations showed that the lake fish were characterized by lower variability (Fig. 5). It may result from the fact that those are closed populations, especially Lake Syczyńskie which comprises only 1% of its basin and lacks tributaries [Harasimiuk *et al.* 1998]. Differences in the meristic features of isolated populations of fish were also observed by Nakamura [2003] by examining Japanese charr (*Salvelinus leucomaenis*) populations which were divided by a dam. He found differences in the number of dorsal and anal fin rays, as well as in the number of scales on the lateral line between the closed fish populations in the river. The present research also discovered the highest variation in the number of scales of the river roach population – that of the Gałęzówka River (Fig. 5).

In conclusion, populations of roach from lakes were characterized by slightly higher values of the biometric features and lower variability of the meristic features than river populations of roach. Sizes of unpaired fins were larger in the river population while the pectoral fins and pelvic were usually longer in the population of roach from the lake populations. Among the examined morphological characteristics of roach the eye diameter and the head depth turned out to be the least changeable features. These studies confirm the fact that the bodies of fish are very plastic, and often change their shapes and proportions under the influence of environmental parameters. These in turn depend on the type of water, whether is it standing water like a lake, or running water like a river.

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Streszczenie. W badaniach porównano morfologię płoci (*Rutilus rutilus* (*L.*)) z czterech populacji pochodzących z siedlisk o różnej prędkości przepływu wody: z rzek i jezior. Analizie poddano 23 cechy biometryczne i 11 cech merystycznych. Porównywane populacje wykazywały niewielką zmienność w przypadku cech merystycznych, natomiast środowisko życia wpływało na wybrane cechy biometryczne. Płocie pochodzące z jezior charakteryzowały większe wartości cech biometrycznych. Najmniej zmiennymi cechami okazały się średnica oka, długość trzonu ogonowego i wysokość głowy. Największe różnice pomiędzy populacjami stwierdzono w przypadku szerokości głowy i szerokości ciała. Ryby z rzek posiadały wyższe płetwy i większą odległość przedgrzbietową. Populacje jeziorowe płoci posiadały większe odległości pomiędzy płetwami piersiowymi i brzusznymi. Dodatkowo ryby z jezior charakteryzowała mniejsza zmienność cech policzalnych w porównaniu z rybami z rzek.

Słowa kluczowe: morfologia ryb, biometria ryb, populacje jeziorowe i rzeczne, płoć, *Rutilus rutilus* (L.)