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Fish systematics

**DESCRIPTION OF THE INFERIOR PHARYNGEAL BONES,
OSSA PHARYNGEA INFERIORA, IN THE COMMON BREAM
ABRAMIS BRAMA (L.) FROM THE SZCZECIN LAGOON
WITH SPECIAL REGARD TO BILATERAL ASYMMETRY**

**CHARAKTERYSTYKA KOŚCI GARDŁOWYCH DOLNYCH,
OSSA PHARYNGEA INFERIORA, ZE SZCZEGÓLNYM
UWZGLĘDNIENIEM ASYMETRII BILATERALNEJ, LESZCZA
ABRAMIS BRAMA (L.) Z ZALEWU SZCZECIŃSKIEGO**

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A biometrical description of the inferior pharyngeal bones *ossa pharyngea inferiora*, collected from 94 common bream *Abramis brama* from the Szczecin Lagoon (on November 1995) is presented. The problem of bilateral asymmetry of the pharyngeal teeth is included separately.

INTRODUCTION

The common bream *Abramis brama* (Linnaeus, 1758) belongs to the family Cyprinidae of the order Cypriniformes. One of the most characteristic features of fishes from the family Cyprinidae is the presence of the pharyngeal teeth. According to Horoszewicz (1960), Grodziński (1971), and Brylińska (1991), their structure, shape and number represent an important systematic characters.

The pharyngeal teeth of the common bream are replaced every year. New teeth are always larger from the old ones (Brylińska and Bryliński 1968). Horoszewicz (1960) notes that the shape of the pharyngeal bones is fixed when the fish length is about 2 cm. The pharyngeal teeth of the common bream are equipped with a small tiny hook, their crowns are squeezed and have a shallow groove (Fig. 1). Dental formula of 5–5 for the pharyngeal teeth of the common bream is of the most frequent occurrence, whereas 6–5 or 5–6 are met rarely (Gąsowska 1962).

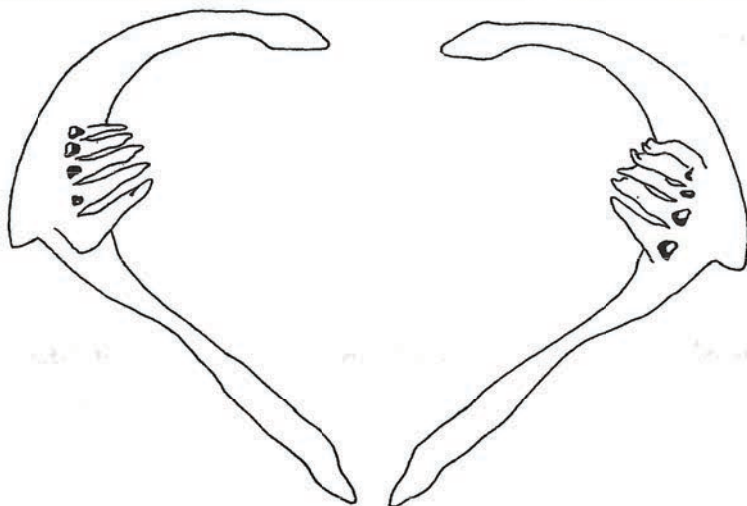


Fig. 1. Pharyngeal teeth of the common bream *Abramis brama*.
Dental formula 5-5 ($\alpha = 59.49\%$)

The general biological, zoological, and morphological problems of symmetry and asymmetry occurring in animals and in the humans are presented, among others by Ludwig (1932), Oppenheimer (1974), Neville (1976), and Bradshaw and Rogers (1993). The asymmetry in fishes was presented extensively by Hubbs and Hubbs (1944). The asymmetry of cranium in the pike was described by Szuba (1971). Ludwig (1932) points out separately to special problem of the asymmetry of the pharyngeal teeth in Cyprinidae.

The objective of the present paper is to present:

- I. Morphometric description of the inferior pharyngeal bones, *ossa pharyngea inferiora*.
- II. Correlation between the length of the fish body and height of the pharyngeal bones.
- III. Asymmetry between bones of the left and the right side expressed by:
 1. Domination of the left side over the right one.
 2. Fluctuation asymmetry according to Van Valen (1962).
 3. The occurrence of two-rowed pharyngeal teeth.

MATERIAL AND METHODS

The material was obtained from the Szczecin Lagoon in the vicinity of Trzebież. This sample comes from a single catch of 29 November 1995. The study was carried out on 94 fishes (6 females, 88 males). The pharyngeal bones were skeletonized from previously frozen fishes stored in the freezer at -15°C . Each fish was measured (fork length) and its age was determined (in the range from 4+ to 7+) before freezing. Determination of age was based on scales.

- I. The measurements were made using slide calliper with the accuracy of 0.1 mm. The height and the width of arch were measured. The height of arch (h) is meant as a distance between the upper (dorsal) and the lower (ventral) end of arch, while the width of arch (a) is a distance connecting the line of the arch height with the most lateral point of arch (Krzykawski et al. 1990). Figure 2 shows diagram of the measurements. The results obtained underwent statistical elaboration. The following statistical parameters were used in the analysis: standard deviation (S), coefficient of variation (V), and standard error (m).
- II. The correlation coefficient (r) and the regression equation between the length of fish (FL) and the height of arch (h) were calculated. The index of arch width (α) was computed. The index represents the ratio between the width of arch and its height and is expressed proportionally.
- III. In order to illustrate asymmetry of the pharyngeal bones of the left and the right side:
 1. A domination of the left or the right measurements for all pairs of bones was presented. To analyse symmetry of bones of the right and the left side of body the Student's t test was used.
 2. The Van Valen's coefficient of fluctuation asymmetry ($1-r^2$) for the arch width (a), the arch height (h) and the arch width index was calculated.
 3. The problem of the occurrence of two-rowed teeth was analysed.

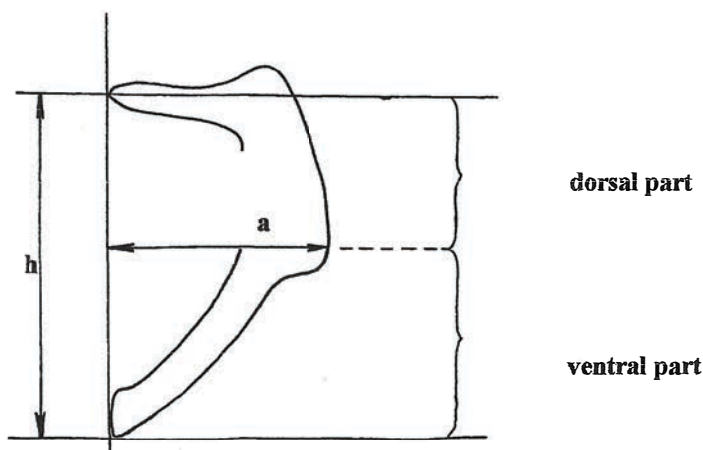


Fig. 2. Diagram of measurements for the height (h) and the width (a) of arches of the inferior pharyngeal bones

RESULTS

I. Morphometric description

Table 1

Statistical characteristic for measurable characters of the pharyngeal teeth of the common bream *Abramis brama*

Character	Range	S	m	V
h (cm)	1.90–2.755	0.170	0.017	7.23
a (cm)	0.985–1.395	0.078	0.008	6.68
α (%)	40.99–59.49	3.150	0.325	6.24

Explanation of statistical symbols: S—standard deviation; m—standard error; V—coefficient of variation

Statistical analysis of the measurements of the inferior pharyngeal teeth is presented in Table 1.

None of the above-mentioned characters assumed the value of the V coefficient equal to 10% (features with the value < 10% were consid-

ered to be of low plasticity). Krzykawski and Gawliński (1986) did not observed characters with the coefficient of variation higher than 10% either (the same value of $V = 6.24$ was noted for the arch width index).

II. Correlation

The body length of the studied fish ranged from 25.6 to 36.5 cm. The correlation coefficient between the length of fish (FL) and the height of arch (h) assumes the value of $r = 0.503$ (with the regression equation $y = 0.04x + 0.94$). Tadaiewska and Czarkowski (1994) have obtained similar values of the correlation coefficient for four populations of the common bream from the Vistula River (Puławy: $r = 0.534$, Włocławek: $r = 0.510$, Toruń: $r = 0.540$, Zalew Wiślany: $r = 0.550$). Other populations studied by Tadaiewska and Czarkowski had the r coefficient at the level of 0.25 (Goczałkowice, Bydgoszcz and Tczew), and the population from Czchów: $r = 0.965$ (males) and $r = 0.998$ (females). Horoszewicz (1960) gives the value of $r = 0.980$ for the common bream from the Vistula River. On the other hand, the common bream from the Szczecin Lagoon, studied by Krzykawski and Gawliński (1986), had the r coefficient equal to 0.963 (with the regression equation $y = 0.06x + 0.36$).

The value of the arch width index (α) amounts to 50.61 % (ranging 40.99–59.49%). The value of that index given by other authors were very similar: after Krzykawski and Gawliński (1986)—51.88%, with the range of 44.00–62.50% for the common bream from the Szczecin Lagoon; after Tadaiewska and Czarkowski (1994)—50.67 to 53.05%, for 9 populations of the common bream from the Vistula River; and after Horoszewicz (1960)—47.90%, also for the common bream from the Vistula River. The obtained values being within the range of 50.00% mean that the width of arches (a) is roughly two times smaller than their height (h). Obviously, there are some individual differences which come up even

to 10.00% from the average of 50.00%, but Horoszewicz (1960) is of the opinion that the common bream is a species with great stability in the shape of arch.

III. Asymmetry

1. Table 2 shows domination of the left or the right measurements for particular pairs of bones.

Table 2

Domination of particular measurements of the inferior pharyngeal bones of the common bream *Abramis brama*

Character	L > R	L = R	L < R	Dominant side	Student's t test
h	47	3	44	L	0.231
a	29	34	31	—	0.061
α	44	1	49	R	0.282

The obtained results of linear measurements (with the low variation) indicate the occurrence of some bilateral asymmetry. Additional analysis of the material with the Student's t test ($t > 3$, significant differences) shows no directional asymmetry.

2. The intensity of fluctuation asymmetry for the height of arch (h) of the inferior pharyngeal bones of the right and the left side (Van Valen 1962) assumes the value $(1-r^2) = 0.143$, for the width of arch (a)—0.168, and for the arch width index—0.377 (Tab. 3).

Table 3

The intensity of fluctuation asymmetry for particular measurements according to Van Valen (1962)

Character	Correlation coefficient (r)	Van Valen's coefficient $(1-r^2)$
h	0.9253	0.143
a	0.9116	0.168
α	0.7891	0.377

The present authors' own findings do not indicate clear occurrence of the right-sided or the left-sided inferior pharyngeal bones, but Hubbs and Hubbs (1944) treat the pharyngeal teeth as left-sided asymmetric. Szuba (1971) and Bieniek-Roszak (1978) also dealt with bones of the fish cranium. Szuba (1971), when studying bones of the cranium of the pike, showed them to be right-sided to a certain degree. Bieniek-Roszak (1978), dealing with the European whitefish, found that there existed asymmetry

between the right and the left side of cranium in the majority of examined bones, and symmetry was found only in few cases.

3. The number of the pharyngeal teeth occurring on particular bones is very interesting if it comes to an asymmetry. The one-rowed teeth with dental formula of 5-5 (at least 80% of examined teeth) prevailed in the presently examined material, similarly as in that of the other authors and this formula should be considered as the primary one. A different construction of the dental formula has been caused most frequently by the occurrence of addi-

tional teeth building the second row of teeth. In the studied common bream from the Szczecin Lagoon, the two-rowed teeth with the formulas of 1.5–5 (2.12% of all teeth, 2 specimens), 5–5.1 (2.12% of all teeth, 2 specimens) and 2.5–5.2 (1.06% of all teeth, 1 specimen) were noted besides the one-rowed ones. Krzykowski and Gawliński (1986), who also examined common bream from the Szczecin Lagoon, noted 8.3% of individuals with dental formula of 1.5–5 and 8.3% of fish with the formula of 5–4, although the latter had the one-rowed teeth. Skóra (1969) also found the two-rowed teeth in the common bream from the water reservoir at Goczałkowice—5.42% of studied teeth had the formula of 5.1–5 and 3.33% had 5–5.1. The two-rowed teeth were also found in different populations from the Vistula River. Tadjewska and Czarkowski (1994) stated the following formulas: 1.5–5 for 8.34% of population from Goczałkowice, 5–5.1 for 5.09% of fish from Bydgoszcz, 1.5–5.1 for 2.62% of individuals from Cichów, 1.5–5.2 and 1.6–5.1 for 3.84% of the bream from Modlin and 2.5–5 and 2.5–5.1 for 4.14% of fish from Tczew. Three populations have also had the formula of 5–4 (3.28 % from Toruń, 1.69% from Bydgoszcz and 4.19% from Tczew). The common bream with the two-rowed teeth are also found in other countries. Lukin (1971) found 104 (14.8%) common bream with the two-rowed teeth among 702 studied fish in the Kujbysev Water Reservoir, out of which 51% had teeth with formula of 5–5.1, 1% with 5–5.2, 35% with 1.5–5, and 13% with 1.5–5.1. The common bream from the same reservoir were studied in 1963–66 by Suvorova (1975), who also noted the two-rowed teeth in 5% of the studied fish in 1963, 25.7% in 1964, 19.1% in 1965, and 6.8% in 1966. Šutov (1967) found 13.8% of fish with the two-rowed teeth (53% of 5–5.1, 28% of 1.5–5, 19% of 1.5–5.1) in the population of the common bream from Seliger Lake. The list of particular formulas found in the pharyngeal dentition of the common bream is presented in Table 4.

Several ways were used to explain the occurrence of the two-rowed teeth. Lukin (1971) claims that the number and type of two-rowed teeth may pertain to local populations. Suvorova (1975) considered a possibility that the common bream with the two-rowed teeth is a hybrid from a common bream and a white bream. The studies proved, however, that the common bream with the two-rowed teeth did not differ morphologically from the one with the one-rowed teeth, while it was distinctly different from the white bream. Golubcov and Ilin (1983) also demonstrated a non-hybrid origin of the common bream with the two-rowed teeth in the electrophoretic analysis of proteins and selected enzymes. Pleyer (1980) suggested that the occurrence of such teeth is the results of hybridization of the common bream and the roach, but comparison of results from the studies of Skóra on the common bream (1969) and the roach (1964) from the reservoir at Goczałkowice does not indicate either that the occurrence of the two-rowed teeth is caused by a possibility of hybridising the common bream with other species. Differences found in

dentition could be also assigned to a difference in the size of particular specimens, but it appeared that the common bream with the body length of about 30 cm occurred most frequently in the materials of all authors mentioned here. Żukowski (1962) indicated that the bream being in the class of about 30 cm (at least 5+) were just the most numerous ones in the catch, and Skóra (1969) stated that all morphological features studied (including values which concern the pharyngeal teeth) diminished with the age, what would confirm the increase of stability in the body shape of the common bream with the age. Our own conclusions confirm also that the studied specimens of the common bream constitute as much representative sample as possible.

Table 4

Proportion of the two-rowed formulas in dentition of the common bream *Abramis brama*

Site of catch Author	Formulas of two-rowed dentition					
	1.5-5	5-5.1	1.5-5.1	2.5-5.2	5-5.2	other
Szczecin Lagoon present results (1995)	2.12	2.12	—	1.06	—	—
Szczecin Lagoon Krzykowski and Gawliński (1986)	8.3	—	—	—	—	8.3% of fishes had the formula 5-4
Goczałkowice Reservoir Skóra (1969)	5.42	3.33	—	—	—	—
Vistula River—8 sites Tadajewska and Czarkowski (1994)						
—Goczałkowice	8.34					
—Czchów	1.31	1.31	2.62			3.84 (1.5-5.2 and 1.6-5.1)
—Modlin	1.92	1.92				
—Włocławek	4.56	2.27				
—Toruń	1.64	4.92				
—Bydgoszcz	1.69	5.09				
—Tczew		2.07				4.14 (2.5-5 and 2.5-5.1)
—Wisła Lagoon		1.50				
Seliger Lake Šutov (1967)	4.05	6.90	2.85	—	—	—
Kujbyšev Reservoir Lukin (1971)	5.1	7.50	2.06	—	0.14	—

With no other reasons for the occurrence of the two-rowed teeth in the common bream, it should be rather admitted that the occurrence of such teeth represents a kind of bilateral asymmetry.

CONCLUSIONS

- I. A morphometric characteristics of the pharyngeal bones is presented, that includes the height of arch (h : min = 1.950, max = 2.755), the width of arch (a : min = 0.985, max = 1.395), the index of arch width (α : min = 40.99, max = 59.49) and the coefficient of variation (V : $h = 7.23$, $a = 6.68$, $\alpha = 6.24$).
- II. Correlation between the body length of the common bream and the height of pharyngeal bones: $r = 0.503$; $y = 0.04x + 0.94$. The width of arches (a) is approximately two times smaller than their height (h). The index of arch width (α) is equal to 50.61%.
- III. Bilateral asymmetry:
 1. No directional asymmetry (lack of specific direction of asymmetry) was found.
 2. The existing fluctuation asymmetry, determined according to the Van Valen's formula, for particular linear measurements is as follows:
 - the height of arch (h)—0.143
 - the width of arch (a)—0.168
 - the index of arch width (α)—0.377.
 3. A bilateral asymmetry was found in the form of two-rowed dentition.

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CHARAKTERYSTYKA KOŚCI GARDŁOWYCH DOLNYCH *OSSA PHARYNGEA INFERIORA*, ZE SZCZEGÓLNYM UWZGLĘDNIENIEM ASYMETRII BILATERALNEJ, LESZCZA *ABRAMIS BRAMA* (L.) Z ZALEWU SZCZECIŃSKIEGO

STRESZCZENIE

Opracowanie zawiera analizę, pod względem opisu morfologicznego, zależności korelacyjnej i asymetrii, kości gardłowych dolnych leszcza *Abramis brama* (L.) z Zalewu Szczecińskiego. Opisano 94 pary kości. Analizie poddano podstawowe wymiary liniowe — wysokość (h) i szerokość (a) łuku kości gardłowych oraz indeks szerokości łuku (α). Uzyskane wyniki opracowano statystycznie. Zbadano korelację między wysokością łuku (h) a długością ryby (l.c.). Asymetrię przedstawiono w trzech ujęciach: dominacji strony lewej lub prawej, stopnia asymetrii fluktuacyjnej wg Van Valena i uzębienia dwuszerowego. W wyniku badań stwierdzono brak wysokiej zmienności przy poszczególnych wymiarach kości, co podwyższa walory występowania asymetrii bilateralnej. Wraz ze wzrostem długości ciała leszcza proporcjonalnie rośnie wysokość kości gardłowych ($r = 0,503$; $y = 0,04x + 0,94$), szerokość łuków (a) jest w przybliżeniu dwa razy mniejsza od ich wysokości (h); indeks szerokości łuku $\alpha = 50,61\%$. Stwierdzono brak określonej dominacji jednej ze stron (brak asymetrii kierunkowej). Zbadano natomiast asymetrię fluktuacyjną określoną wzorem van Valena $1 - r^2$ w odniesieniu do wysokości i szerokości łuków: h — 0,143; a — 0,168; α — 0,377; poza tym opisano dwuszerowość uzębienia jako pewien wariant fenomenu asymetrii bilateralnej.

Received: 4 March 1997

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