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Morphology

VARIABILITY OF MERISTIC CHARACTERS IN BREAM (*ABRAMIS BRAMA* LINNAEUS, 1758) OCCURRING IN VISTULA RIVER

ZMIENNOŚĆ CECH MERYSTYCZNYCH LESZCZA (*ABRAMIS BRAMA* LINNAEUS, 1758) WYSTĘPUJĄCEGO WZDŁUŻ BIEGU RZEKI WISŁY

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Nine populations of bream from the Vistula River, its tributaries, Vistula Lagoon, and certain dam reservoirs were compared in terms of their 8 meristic characters. The significance of differences between mean values of each character found for any two populations was tested by means of analysis of variance, while Student's t test served to analyse the between-populations differences. The studies showed the differences between meristic characters to be insufficient for separating a population differing in several characters from the others.

INTRODUCTION

The aim of the present work was to follow the variability in meristic characters of bream (*Abramis brama* L.), one of the commonest fish species in Poland. The bream occurs in inland water bodies, lowland rivers, and dam lakes. Within its distribution range, the bream forms 3 geographical races (*subspecies*): the Aral-Caspian (*Abramis brama orientalis* Berg, 1849), western (*A. brama brama* Linnaeus, 1758), and south-European (*A. brama danubii* Pavlov, 1956) ones. The subspecies listed differ in their occurrence range as well as in their counts of vertebrae, gill filtration processes, lateral line scales, and anal fin rays. The Polish bream is considered to belong to the western race.

The bream has been subject to extensive studies as a part of the Man and Biosphere programme covering "The species and its productivity within its distribution range", the project being coordinated by the Academy of Sciences of the USSR. The present work is a part of that study.

MATERIALS AND METHODS

The study materials were collected from commercial catches of fishermen's cooperatives operating in 1972–1974 at 9 sites located along the Vistula River, its tributaries, Vistula Lagoon, and dam reservoirs. The collecting sites are shown on a map (Fig. 1). The Goczałkowice Reservoir is located 45 km from the Vistula origin, while the Czchów Reservoir is a compensatory basin for the Rożnów Lake situated on the Dunajec River, a right-side Vistula tributary. The reservoir on the Vistula off Włocławek, 674 km from the river origin, was constructed in 1970. Table 1 summarises data on the material collection: geographical location of the sites, sampling dates, and numbers of fishes.

Eight meristic characters were determined for every specimen collected: ray counts in the dorsal, anal, pectoral and ventral fins, numbers of gill filtration processes, vertebrae, and lateral line scales; the pharyngeal teeth pattern was also determined each time.

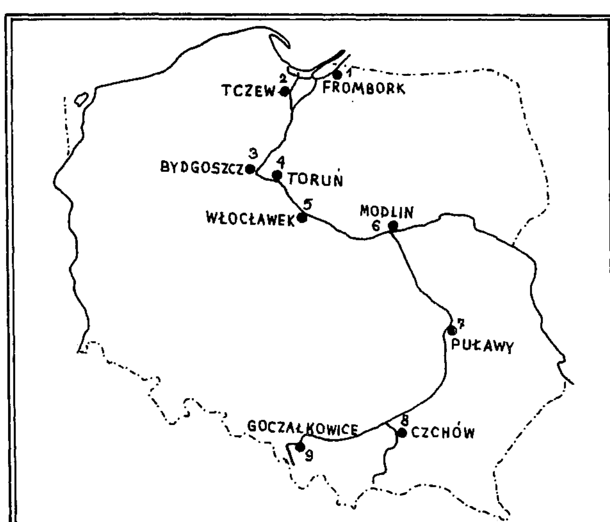

Fig. 1. Place of collected material for investigations

Table 1

Description of materials examined

Collection site	Symbol	Geographic location		Date	Number of individ.	Body length (l.c.) range	Mean $\bar{x}$
		longitude East	latitude North				
Vistula Lagoon, off Frombork	1	19°42′	54°18′	19 Dec. 1974	76	22.4–31.3	26.41
Vistula off Tczew	2	18°45′	54°06′	28 Feb. 1973	106	22.5–30.7	25.40
Vistula off Bydgoszcz	3	18°00′	53°10′	1 Feb. 1972	123	15.9–28.2	21.60
Vistula off Toruń	4	18°35′	53°05′	4 Jan. 1974	126	18.1–29.2	23.87
Vistula off Włocławek	5	19°05′	52°40′	22 Feb. 1973	75	24.7–33.4	27.57
Vistula off Modlin	6	20°42′	52°25′	16 March 1973	162	20.1–31.4	25.07
Vistula off Puławy	7	21°57′	51°25′	8 March 1973	89	22.8–29.4	26.56
Dunajec, Czchów Reservoir	8	20°55′	49°50′	9 Nov. 1973	94	30.2–35.5	33.21
Vistula, Goczałkowice Reservoir	9	18°50′	49°55′	20 April 1974	198	16.7–28.2	21.93
Total					1049		

Table 2

Monthly (May – V, June – VI) and annual ($\bar{x}$) mean water temperatures over 1963–1973 in the Vistula sections studied, according to Anon. (1975)

Year	Month	Vistula section symbol (in table 1)					
		2	3	4	5	6	7
1963	V	16.5	14.1	17.1	17.2	17.0	17.3
	VI	19.5	18.9	20.0	19.5	19.3	20.0
	$\bar{x}$	9.9	10.0	10.1	10.1	9.9	10.7
1964	V	14.9	13.8	13.3	15.1	14.4	15.3
	VI	21.4	20.2	22.8	22.3	22.5	22.8
	$\bar{x}$	9.7	9.9	9.9	9.8	9.6	10.2
1965	V	12.2	11.4	12.3	12.2	11.9	13.2
	VI	17.5	16.7	17.7	17.4	17.4	17.9
	$\bar{x}$	9.2	9.3	9.1	9.0	8.8	9.4
1966	V	15.8	12.7	16.1	16.2	16.0	16.6
	VI	19.2	16.4	19.3	19.1	19.0	17.8
	$\bar{x}$	9.9	9.6	10.0	10.1	9.7	10.3
1967	V	15.3	13.6	15.5	15.5	15.8	14.9
	VI	18.2	17.8	18.3	18.2	18.4	17.7
	$\bar{x}$	10.6	10.6	10.5	10.6	10.4	10.6
1968	V	14.8	13.7	14.5	14.8	14.5	15.2
	VI	20.0	18.2	20.0	20.2	20.1	19.9
	$\bar{x}$	10.3	10.4	10.0	10.2	9.8	10.3
1969	V	15.8	13.0	16.3	17.0	16.6	17.3
	VI	18.5	17.4	19.3	19.8	19.3	18.6
	$\bar{x}$	9.3	9.4	9.5	9.7	9.4	9.7
1970	V	14.0	12.2	14.3	14.6	14.3	14.1
	VI	18.4	17.3	18.8	19.0	19.0	18.3
	$\bar{x}$	9.0	8.9	9.3	9.5	9.1	9.4
1971	V	14.8	13.8	15.4	15.7	15.6	15.1
	VI	18.8	17.9	19.0	19.5	19.0	18.8
	$\bar{x}$	9.7	9.7	10.0	10.4	9.6	10.2
1972	V	13.8	12.5	14.7	15.3	15.3	14.5
	VI	18.5	17.3	18.8	19.5	19.6	19.0
	$\bar{x}$	9.6	9.7	10.1	10.4	9.6	9.7
1973	V	14.0	12.2	14.3	14.4	15.3	14.7
	VI	18.6	17.2	18.3	18.3	18.5	17.2
	$\bar{x}$	9.9	9.7	10.1	10.3	9.8	9.0

For the sake of clarity, each character was denoted by a symbol used hereafter in the text and tables. Both hard and soft rays were counted in fins. While the hard rays counts remained stable in each generation and population, numbers of soft rays varied and therefore only they were analysed. All the filtration processes on the first gill arch were counted. Vertebrae counts were read from X-ray prints made specially for the purpose, Weber's apparatus (4 vertebrae) being included and the urostyl disregarded. No clear anomalies in the vertebral structure, fusion or distortion of any spinal segment, was found in the present study.

The pharyngeal teeth were counted from both sides. Additionally, the length (to 1 mm), weight (to 5 g), and age of each individual examined were determined, the age being read from annual rings on scales taken from the first two rows above the lateral line, under the dorsal fin.

Analysis of variance (ANOVA) was used to test the meristic character variability. The between-populations differences for the total material and the between-generations ones for each population were tested. The differences between sexes were disregarded as they had been found to be associated with generations. Differences arising from the time and place of birth were looked for on the assumption that they might have affected the final results. The calculations were performed on an Odra 1204 computer at the Computer Centre, Academy of Agriculture and Technology, Olsztyn. The ANOVA was run at $\alpha = 0.01$; if a calculated value of F exceeded the tabulated value of $F_{0.01}$, the difference was considered significant. Between-populations comparisons were additionally performed using Student's t test, a statistical procedure allowing to detect the significance, if any, of differences between means of two samples. Should the difference obtained exceed the LDP (Least Difference Proven) value, it was considered significant.

DESCRIPTION OF HABITATS

The Vistula is Poland's largest river measuring 1068 km. Its drainage area covers 193 911 km^2. The Vistula catchment basin consists in 40% of mountainous and highland area and in 60% of lowlands (Anon., 1975). Water quality in Poland is monitored by Centres for Environmental Studies and Control, their reports serving to evaluate the degree of cleanness of the Vistula.

The cleanest (Class 1) waters are those from the origins to the Goczałkowice Reservoir; they are permitted for municipal purposes and salmonid breeding. Past the Reservoir down to 170 km (the Dunajec mouth) the water is most polluted as textile plants, metal mills, coal and ore mines, oil refinery and chemical plants discharge their wastes into the river. From the Dunajec mouth down to the Skrwa mouth (170 to 650 km) the Vistula water belongs to class 3 considered sufficient for industrial purposes, irrigation and horticulture. Farther on, down to the mouth, the Vistula water reaches class 2 sufficient for non-salmonid rearing, animal husbandry and recreation purposes.

When at full swell, the Goczałkowice Reservoir covers the area of 3200 ha (ca 2500 ha at a mean swell); the maximum depth at the dam is ca 15 m. The Reservoir has been stocked with pikeperch, bream, and pike (Wajdowicz, 1958).

The total area of the Czchów Reservoir is 346 ha, while its utility area covers 234.6 ha. The Reservoir is 8.5 km long, its mean and maximum depths being 3.4 and 12.5 m, respectively. The Reservoir has not been stocked with bream; the species has immigrated into it from the Rożnów Reservoir.

The dam reservoir off Włocławek covers 70.4 km^2; its mean and maximum depths are 5.5 and 12 m, respectively, its axial length being 58.6 km. The reservoir is a flow-through water body of a poorly developed shore line. Bettom sediments here show high contents of phenols, oil and fats, while fatty slicks or continuous films are observed on the surface (Bierwagen, 1973). Among the reservoirs studied, that off Włocławek is the most polluted.

Temperature effects on the duration of hatching and formation of vertebrae, fin rays, and lateral line scales have been stressed by many authors publishing experimental data (Orska, 1956; Taning, 1944, 1950) and comparing natural populations from various areas (Chabanaud, 1929; Hubbs, 1922; Schmidt, 1930). Table 2 summarises temperature data for both the spawning season and the whole year for the Vistula sections studied. The table entries were compiled from reports prepared by the Institute of Meteorology and Water Management. No temperature data exist for populations from the Vistula Lagoon, Czchów and Goczałkowice Reservoirs. The data obtained indicate higher temperatures, both annual means for 1963–1973 and those recorded in May-June, i.e., during bream spawning, to occur in the Vistula off Toruń and Włocławek.

Mean annual temperatures for various parts of the Vistula differ from year to year; in some years (1963, 1967, 1968, 1971) annual means exceeded the decade mean, while in other years (1965, 1970) the reverse was true. In 1963 and 1969, monthly means for May and June (the bream spawning period in most Polish waters) were higher than those recorded in other years.

RESULTS

The variability of meristic characters in the nine bream population studied was determined by calculating the range of values and standard deviation for each character (Table 3). The between-generations differences were assessed by means of Snedecor's F test (Table 4), while the between-populations variability was tested by Student's t (Tables 5–11). Table 12 contains data on the pharyngeal teeth formula variability. The bream individuals examined showed the presence of three hard rays each in the dorsal and anal fins, and two each in the pectoral and ventral ones.

Table 3

Variability of meristic characters in Vistula bream populations studied

Meristic character	Bream population studied											
	1 n = 76			2 n = 106			3 n = 123			4 n = 126		
	Range	$\bar{x}$	σ	Range	$\bar{x}$	σ	Range	$\bar{x}$	σ	Range	$\bar{x}$	σ
D	8–10	8.94*	0.32	8–10	8.99	0.25	8–10	9.13**	0.46	8–10	8.97	0.23
A	22–28	25.25	1.25	21–29	25.26	1.43	22–29	25.72	1.23	21–28	25.07*	1.42
V	7–8	7.90	0.29	7–8	7.97	0.29	7–9	7.89	0.40	6–9	7.95	0.35
P	12–16	13.88	0.80	12–16	13.83	1.10	12–15	13.56*	0.72	12–16	13.63	0.93
sp. br.	20–26	23.05**	1.31	16–25	21.13	1.74	17–25	20.54	1.88	17–25	21.37	3.10
vt.	41–44	43.13	0.57	41–45	43.63**	0.85	42–45	43.05	0.44	41–46	43.44	2.26
ll.	53–57	54.90**	1.14	50–59	54.04	1.85	50–57	53.33	2.45	48–58	53.37	2.43

$\bar{x}$ = arithmetic mean

σ = standard deviation

* = lowest mean

** = highest mean

cd. table 3

5 n = 75			6 n = 162			7 n = 89			8 n = 94			9 n = 198		
Range	$\bar{x}$	σ	Range	$\bar{x}$	σ	Range	$\bar{x}$	σ	Range	$\bar{x}$	σ	Range	$\bar{x}$	σ
8–10	9.01	0.25	8–10	9.01	0.26	8–10	9.02	0.30	8–10	8.97	0.29	8–10	9.04	0.25
23–28	25.08	1.09	21–29	25.28	1.62	21–27	25.35	1.35	22–29	26.42**	1.56	22–30	26.26	1.42
7–9	7.96	0.30	6–9	7.95	0.31	6–9	8.00	0.42	7–9	8.02**	0.20	6–9	7.95	0.25
12–16	13.74	0.93	12–17	13.97	1.00	12–17	13.96	1.01	12–17	14.60**	1.03	12–16	13.72	0.83
18–25	22.37	3.73	16–26	21.70	3.34	17–24	22.23	3.60	17–24	21.38	3.96	16–25	19.88*	2.60
41–44	42.89	1.74	41–45	43.01	1.23	42–45	43.03	2.02	42–44	43.05	1.75	42–46	42.65*	1.77
51–57	54.06	2.41	51–59	53.84	4.59	51–57	53.78	2.26	51–59	53.52	2.38	48–58	52.95*	1.90

D number of dorsal fin soft rays
A number of anal fin soft rays
V number of ventral fin soft rays
P number of pectoral fin soft rays
sp. br number of filtration processes on gill arch
ll number of lateral line scales
vt number of vertebrae

Table 4

Between-generations differences as calculated with Snedecor's F test for bream populations studied

Meristic character	Bream population								
	1	2	3	4	5	6	7	8	9
D	●			●					
A									
V									
P		●	●	x			●		
sp.br.			x	●					x
vt.		x							
l.l.									

● = difference significant at $\alpha = 0.05$
x = difference significant st $\alpha = 0.01$

D number of dorsal fin soft rays
A ,, of anal ,, ,, ,,
V ,, of ventral ,, ,, ,,
P ,, of pectoral ,, ,,
sp.br. number of filtration processes on gill arch
l.l. number of lateral line scales
vt ,, of vertebrae

Table 5

Analysis of significance of differences between mean numbers of dorsal fin soft rays in bream populations studied (1–9)

Population	1	2	3	4	5	6	7	8	9
		$\bar{x}_1 - \bar{x}_2$							
1	x	+0.05	+0.19*	+0.03	+0.07	+0.07	+0.08	+0.03	+0.10
2	−0.05	x	+0.14	−0.02	+0.02	+0.02	+0.03	−0.02	+0.05
3	−0.19	−0.14	x	−0.16	−0.12	−0.12	−0.11	−0.16	−0.09
4	−0.03	+0.02	+0.16	x	+0.04	+0.04	+0.05	0.00	+0.07
5	−0.07	−0.02	+0.12	−0.04	x	0.00	+0.01	−0.04	+0.03
6	−0.07	−0.02	+0.12	−0.04	0.00	x	+0.01	−0.04	+0.03
7	−0.08	−0.03	+0.11	−0.05	−0.01	−0.01	x	−0.05	+0.02
8	−0.03	+0.02	+0.16	0.00	+0.04	+0.04	+0.05	x	+0.07
9	−0.10	−0.05	+0.09	−0.07	−0.03	−0.03	−0.02	−0.07	x

$\bar{x}_1 - \bar{x}_2$ = difference between mean numbers of rays in populations 1 and 2

* = difference significant if $\bar{x}_3 - \bar{x}_1 > \text{LDP}$

LDP (Least Difference Proven) = 0.18

Fin soft rays number variability

The number of soft rays in the dorsal fin (D) in the bream populations studied ranged from 8 to 10; the mean ranged from 8.94 (the Vistula Lagoon) to 9.13 (the Vistula off Bydgoszcz) (Table 5). The between-generations comparison in terms of the dorsal fin soft rays number revealed significant differences to occur in two populations: the Vistula Lagoon and off Toruń, no significant differences occurring between generations of the remaining populations.

The generations born in 1967 and 1970 (the Vistula Lagoon) and in 1966 and 1967 (off Toruń) showed higher numbers of soft rays than those born in 1970 (the Vistula Lagoon) and 1969 (off Toruń). These results are not fully consistent with thermal changes in water (Table 2).

No marked differences in terms of the dorsal fin soft rays number were found to exist between the bream populations living up- and down-stream. Significant differences occurred between populations 3 and 1 (the Vistula Lagoon and the Vistula off Bydgoszcz) (Table 5), the bream from the latter locality showing a higher number of rays.

The number of soft rays in the anal fin (A) in the Vistula bream populations studied ranged from 21 to 30 (Table 3), the mean ranging from 25.07 (the Vistula off Toruń) to 26.42 (the Czchów Reservoir).

The populations studied showed no significant between-generations differences in their anal fin soft rays numbers (Table 4). Two up-stream populations (from the Czchów and Goczałkowice Reservoirs) were found to differ with respect to this character from the remaining populations.

The number of soft rays in the ventral fin (V) ranged in the populations studied from 6 to 9 (Table 3), the mean ranging from 7.89 (off Bydgoszcz) to 8.02 (the Czchów Reservoir).

The bream populations studied showed no significant between-generations differences in their ventral fin soft rays numbers (Table 4); similarly, no significant between-populations differences were found with respect to this character (Table 7).

The number of soft rays in the pectoral fin (P) ranged in the populations studied from 12 to 17 (Table 3), the mean ranging from 13.56 (off Bydgoszcz) to 14.60 (the Czchów Reservoir). Significant between-generations differences were found in the Vistula bream populations occurring off Tczew, Bydgoszcz, Toruń, and Puławy. Older generations of these four populations showed higher numbers of the pectoral fin soft rays. The between-generations differences found are not consistent with thermal changes, and might be associated with the water pollution, increasing in these parts of the river. The Czchów Reservoir population is significantly different from the others in its higher mean pectoral fin soft rays count amounting to 14.60.

Filtration processes number variability

The number of filtration processes in the bream populations studied ranged from 16 to 26 (Table 3), the mean ranging from 19.88 (the Goczałkowice Reservoir) to 23.05 (the Vistula Lagoon).

Table 6

Analysis of significance of differences between means number of anal fin soft rays in bream populations studied (1–9)

Population	1	2	3	4	5	6	7	8	9
		$\bar{x}_1-\bar{x}_2$							
1	x	+0.01	+0.47	−0.18	−0.17	+0.03	+0.10	+1.17*	+1.01*
2	−0.01	x	+0.47	−0.17	−0.18	+0.02	+0.09	+1.16*	+1.00*
3	−0.47	−0.46	x	−0.65	−0.64	−0.44	−0.37	+0.70	+0.54
4	+0.18	+0.19	+0.65	x	+0.01	+0.21	+0.28	+1.35*	+1.19
5	+0.17	+0.18	+0.64	−0.01	x	+0.20	+0.27	+1.34*	+1.18*
6	−0.03	−0.02	+0.44	−0.21	−0.20	x	+0.07	+1.14*	+0.98*
7	−0.10	−0.09	+0.37	−0.28	−0.27	−0.07	x	+1.07	+0.91*
8	−1.17	−1.16	−0.70	−1.35	−1.34	−1.14	−1.07	x	−0.16
9	−1.01	−1.00	−0.54	−1.19	−1.18	−0.98	−0.91	+0.16	x

$\bar{x}_1-\bar{x}_2$ = difference between mean numbers of rays in populations 1 and 2

* = difference significant if $\bar{x}_8-\bar{x}_1 > LDP$

LDP (Least Difference Proven) = 0.84

Table 7

Analysis of significance of differences between mean numbers of ventral fin soft rays in bream populations studied (1–9)

Populations	1	2	3	4	5	6	7	8	9
		$\bar{x}_1 - \bar{x}_2$							
1	x	+0.07	–0.01	+0.05	+0.06	+0.05	+0.10	+0.12	+0.05
2	–0.07	x	–0.08	–0.02	–0.01	–0.02	+0.03	+0.05	–0.02
3	+0.01	+0.08	x	+0.06	+0.07	+0.06	+0.11	+0.13	+0.06
4	–0.05	+0.02	–0.06	x	+0.01	0.00	+0.05	+0.07	0.00
5	–0.06	+0.01	–0.07	–0.01	x	–0.01	+0.04	+0.06	–0.01
6	–0.05	+0.02	–0.06	0.00	+0.01	x	+0.05	+0.07	0.00
7	–0.10	–0.03	–0.11	–0.05	–0.04	–0.05	x	+0.02	–0.05
8	–0.12	–0.05	–0.13	–0.07	–0.06	–0.07	–0.02	x	+0.07
9	–0.05	+0.02	–0.06	0.00	+0.01	0.00	+0.05	–0.07	x

$\bar{x}_1 - \bar{x}_2$ = difference between mean numbers of rays in populations 1 and 2

LDP (Least Difference Proven) = 0.19

Table 8

Analysis of significance of differences between mean numbers of pectoral fin soft rays numbers in bream populations studied (1–9)

Populations	1	2	3	4	5	6	7	8	9
1	x	$\bar{x}_1-\bar{x}_2$ −0.05	−0.32	−0.25	−0.14	+0.09	+0.08	+0.72*	−0.16
2	+0.05	x	−0.27	−0.20	−0.09	+0.14	+0.13	+0.77*	−0.11
3	+0.32	+0.27	x	+0.07	+0.18	+0.41	+0.40	+1.04*	+0.16
4	+0.25	+0.20	−0.07	x	+0.11	+0.34	+0.33	+0.97*	+0.09
5	+0.14	+0.09	−0.18	−0.11	x	+0.23	+0.22	+0.86*	−0.02
6	−0.09	−0.14	−0.41	−0.34	−0.23	x	−0.01	+0.63*	−0.25
7	−0.08	−0.13	−0.40	−0.33	−0.22	+0.01	x	+0.64*	−0.24
8	−0.72	−0.77	−1.04	−0.97	−0.96	−0.63	−0.64	x	−0.98
9	+0.16	+0.11	−0.16	−0.09	+0.02	+0.25	+0.24	+0.98*	x

$\bar{x}_1-\bar{x}_2$ = difference between mean numbers of rays in populations 1 and 2

* = difference significant if $\bar{x}_8-\bar{x}_1 > LDP$

LDP = (Least Difference Proven) = 0.56

The between-generations comparison of the filtration processes counts in the populations studied revealed significant differences to occur off Bydgoszcz, Toruń, and in the Goczałkowice Reservoir (Table 4). Various generations of the same bream population were found to differ in their filtration processes counts, older individuals showing higher counts. Similar was the case in some populations (off Tczew and Bydgoszcz) with respect to their pectoral fin soft rays numbers.

Marked differences in the filtration processes numbers are found between populations distributed along the course of the Vistula. Significant differences between the mean numbers occur for the Vistula Lagoon population vs. those from off Tczew, Bydgoszcz, and from the Goczałkowice Reservoir, and also for the latter vs. those from off Włocławek, Modlin, and Puławy (Table 9).

The Vistula sections off Włocławek and Puławy are known for their marked industrial pollution. Away from these sections, the filtration processes counts tend to decrease, the lowest mean (19.88) being found in the Goczałkowice Reservoir individuals, i.e. those inhabiting the cleanest water. It should be noted that the meristic character discussed is the most variable among those analysed in the present study.

Vertebrae number variability

The numbers of vertebrae in the bream individuals examined ranged from 41 to 46 (Table 4), the mean ranging from 42.65 (the Goczałkowice Reservoir) to 43.63 (off Tczew) (Table 3).

The between-generations comparisons revealed significant differences to occur in the population from off Tczew (Table 4), the remaining ones showing no significant differences between generations. The highest counts in the population from off Toruń were found in the 1964 and 1967 generations, while the 1965 one showed the lowest count. These differences are not consistent with a known tendency for higher vertebrae numbers at lower temperatures on spawning (Jensen, 1939, 1944; Jordan, 1891; Taning, 1944). The between-populations comparisons revealed significant differences to occur between the populations from off Tczew and Goczałkowice Reservoir (Table 10).

Variability in lateral line scales number

The numbers of lateral line scales in the bream populations studied were found to vary from 48 to 59 (Table 3), the mean ranging from 52.95 (the Goczałkowice Reservoir) to 54.90 (the Vistula Lagoon).

The populations studied showed no significant between-generations differences (Table 4). Significant between-populations differences were found for those populations inhabiting the origins of the river and its terminal section (Table 11): the Vistula Lagoon population with its mean of 54.90 lateral line scales differed significantly from the Goczałkowice Reservoir one with a mean of 52.95 (Table 3).

Table 9

Analysis of significance of differences between mean numbers of gill processes in bream populations studied (1–9)

Populations	1	2	3	4	5	6	7	8	9
		$\bar{x}_1-\bar{x}_2$							
1	x	−1.92	−2.51	−1.68	−0.68	−1.35	−0.82	−1.67	−3.17
2	+1.92*	x	−0.59	+0.24	+1.24	+0.57	+1.10	+0.25	−1.25
3	+2.51*	+0.59	x	+0.83	+1.83	+1.16	+1.69	+0.84	−0.66
4	+1.68	−0.24	−0.83	x	+1.00	+0.33	+0.86	+0.01	−1.49
5	+0.68	−1.24	−1.83	−1.00	x	−0.67	−0.14	−0.99	−2.49
6	+1.35	−0.57	−1.16	−0.33	+0.67	x	+0.53	−0.32	−1.82
7	+0.82	−1.10	−1.69	−0.86	+0.14	−0.53	x	−0.85	−2.35
8	+1.67	−0.25	−0.84	−0.01	+0.99	+0.32	+0.85	x	−1.50
9	+3.17*	+1.25	+0.66	+1.49	+2.49*	+1.82*	+2.35*	+1.50	x

$\bar{x}_1-\bar{x}_2$ = difference between mean numbers of processes in populations 1 and 2

* = differences significant if $\bar{x}_1-\bar{x}_2 > \mathrm{LDP}$

LDP (Least Difference Proven) = 1.75

Table 10

Analysis of significance of differences between mean numbers of vertebrae in bream populations studied (1–9)

Population	1	2	3	4	5	6	7	8	9
		$\bar{x}_1 - \bar{x}_2$							
1	x	+0.50	−0.08	+0.31	−0.24	−0.12	−0.10	−0.08	−0.48
2	−0.50	x	−0.58	−0.19	−0.74	−0.62	−0.60	−0.58	−0.98
3	+0.08	+0.58	x	+0.39	−0.16	−0.04	−0.02	0.00	−0.40
4	−0.31	+0.19	−0.39	x	−0.55	−0.49	−0.41	−0.39	−0.79
5	+0.24	+0.74	+0.16	+0.55	x	+0.12	+0.14	+0.16	−0.24
6	+0.12	+0.62	+0.04	+0.43	−0.12	x	+0.02	+0.04	−0.36
7	+0.10	+0.60	+0.02	+0.41	−0.14	−0.02	x	+0.02	−0.38
8	+0.08	+0.58	0.00	+0.39	−0.16	−0.04	−0.02	x	−0.70
9	+0.48	+0.98*	+0.40	+0.79	+0.24	+0.36	+0.38	+0.70	x

$\bar{x}_2 - \bar{x}_1$ = difference between mean vertebrae numbers in populations 2 and 1

* = difference significant if $\bar{x}_2 - \bar{x}_9 > \text{LDP}$

LDP (Least Difference Proven) = 0.90

Table 11

Analysis of significance of differences between mean numbers of lateral line scales in bream populations studied (1–9)

Population	1	2	3	4	5	6	7	8	9
		$\bar{x}_1 - \bar{x}_2$							
1	x	–0.86	–1.57	–1.53	–0.84	–1.06	–1.12	–1.38	–1.95
2	+0.86	x	–0.71	–0.67	+0.02	–0.20	–0.26	–0.52	–1.09
3	+1.57	+0.71	x	+0.04	+0.73	+0.51	+0.45	+0.19	–0.38
4	+1.53	+0.67	–0.04	x	+0.69	+0.47	+0.41	+0.15	–0.42
5	+0.84	–0.02	–0.73	–0.69	x	–0.22	–0.28	–0.54	–1.11
6	+1.06	+0.20	–0.51	–0.47	+0.22	x	–0.06	–0.32	–0.89
7	+1.12	+0.26	–0.45	–0.41	+0.28	+0.06	x	–0.26	–0.83
8	+1.38	+0.52	–0.19	–0.15	+0.54	–0.32	+0.26	x	–0.57
9	+1.95*	+1.09	+0.38	+0.42	+1.11	+0.89	+0.83	+0.57	x

$\bar{x}_1 - \bar{x}_2$ = difference between mean lateral line scales numbers in populations 1 and 2

* difference significant if $\bar{x}_1 - \bar{x}_2 > LDP$

LDP (Least Difference Proven) = 1.62

Table 12

Pharyngeal teeth formulae in bream populations studied

	Formula dentium					
Population	5–5	5–4	4–5	6–5	4–4	
1	76					76
2	97	6	3			106
3	112	3	6		2	123
4	121	2	3			126
5	72	1	2			75
6	158	2	2			162
7	89					89
8	88	2	4			94
9	188	3	4	3		198
Total	1001	19	24	3	2	1049
%	95.42	1.81	2.29	0.29	0.19	100.00

Pharyngeal teeth formula variability.

The bream shows most often a single row of pharyngeal teeth, their formula being 5–5. This was the most frequent pattern (95.4%) among the individuals examined.

Additionally, other patterns (5–4, 4–5, 4–4) were observed, as presented in Table 12. None of the individuals examined had teeth arranged in two rows.

DISCUSSION

Meristic characters of an individual remain stable throughout its life span. Among conspecific individuals and within a population each character can vary to a certain extent. The more enhanced is variability among conspecific populations and within a population, the more restricted is gene flow. When two populations are isolated by the geographic location of their habitats, their genetic variability may go so far as to give rise to emergence of different characters sufficient to separate subspecies. It is not, however, always that the between-populations differences allow to establish subspecies, even if the populations in question differ in one or several characters, because of an overlap in variability ranges. The variability in meristic characters is affected by various environmental factors acting either individually, e.g., temperature (Hubbs, 1922; Taning, 1950), space (Chabanaud, 1929; Fage, 1911), light (Vladykov, 1934), or combined.

The mean number of dorsal fin soft rays in the bream populations studied, when compared with literature data, is very similar to that found in other rivers (Gąsowska, 1962, 1968; Vladykov, 1931; Žukov, 1958). The range (8–10 rays) found in this study is identical to the literature data.

Similarly, the range of anal fin soft rays numbers (21–30) found in the Vistula bream populations is the same as that reported in the literature (Gąsowska, 1962, 1968; Šapošnikova, 1948; Žukov, 1958, 1965).

The literature reports on data on the ventral fin soft rays numbers in the bream. The numbers seldom vary in other fish species (Vladykov, 1934).

No literature data were found for the bream pectoral fin soft rays number, therefore no comparison can be offered here.

The bream individuals examined were found to possess from 16 to 26 gill processes; the literature records a range from 17 (Potapova, 1954) to 30 (Pavlov, 1956). A number of workers observed a narrower range of gill processes on the first gill arch (Berg, 1949; Gąsowska, 1962, 1968; Jankovič, 1966; Sapošnikova, 1948; Žukov, 1958, 1965). The gill processes count is considered a key taxonomic character, particularly in salmonids (Szczerbowski, 1970). It is often associated with water oxygen content. In many cases there is an other direct relationship: those fishes of higher vertebrae and rays counts show a higher number of gill processes (Vladykov, 1934).

The vertebrae count range found in the bream populations studied is narrower than that reported in the literature for riverine bream. Žukov (1965) found 37–47 vertebrae in the Dnieper bream, while the range found in this study was 41–46.

The vertebrae bumber remains stable throughout an individual's life span. A reverse relationship between the vertebrae count and water temperature has been known for a long time. The fishes from northern, colder waters are found to show a higher number of vertebrae than the conspecific individuals from southern, warmer water bodies. This principle has been recognised as a scientific law since Jordan's studies, in 1868, on a large number of fish spęcies (Jordan, 1891).

The fishes inhabiting open waters are usually observed to have higher numbers of vertebrae than those from the inshore zone, the relationship being determined by Schmidt (1916) who, when studying local races of the Atlantic cod (*Gadus callarias* L.), examined 20 000 individuals from 114 stations. The author mentioned found the mean number of vertebrae to decrease from North to South and from West to East.

The North-South decreasing tendency in the bream vertebrae count was described by Soloveva (1954). If the water temperature changes no more than from 3 to 6°C resulting in changes in the vertebrae count (ca 1–5), this difference, according to Taning (1944) is sufficient to recognise a fish race. Experimental studies showed the differences to exceed a mean parental vertebrae count by 3–2 (Taning, 1950).

In the bream populations studied, the number of lateral line scales varied from 48 do 59, the range being closest to that found for bream inhabiting the Caspian and Aral Seas basin (49–57).

Numbers of those scales change in bream similarly to changes in the vertebrae counts. On the other hand, the formation of scales is ontogenetically delayed compared to the vertebrae. A number of authors (Heincke, 1898; Soloveva, 1954; Petit, 1930; Vladykov, 1931) found the fishes from southern regions to develop a lower number of the lateral line scales than the individuals from northern areas.

The literature (Gąsowska, 1968; Rolik, 1967; Šutov, 1967) reports findings of bream with pharyngeal teeth arranged in two rows. These findings may concern natural inter-specific or intergeneric hybrids. The bream populations in Poland were also found to include individuals with two rows of pharyngeal teeth (Chmiel, 1976); those populations were, however, lacustrine. Perphaps the species composition of lacustrine ichthyofaunas as well as spawning conditions act in favour of crossing.

Values of meristic characters under study versus literature data for three bream subspecies

The three bream subspecies differ in their distribution as well as in their numbers of vertebrae, gill processes, lateral line scales, and anal fin rays.

Table 13 summarises values of the meristic characters for the three bream subspecies and the Vistula bream studied.

According to Berg (1949), *Abramis brama* L. occurs in the part of Europe bordered by the Pyrenees and Alps; the range covers the basins of the North, Baltic, Black, Caspian, and White Seas.

Abramis brama orientalis Berg occurs – according to Berg (1949) – within the Caspian and Aral Seas basins, while *A. brama danubii* Pavlov is reported by Pavlov (1956) as occurring in the Danube.

The bream inhabiting the Vistula waters occurs within the geographic range of *A. brama brama* L. and it ascribed to the western race. Its meristic characters (numbers of anal fin soft rays and gill processes on the first gill arch), and particularly the ranges of their values in the Vistula populations studied, as well as the literature data do not make it possible to determine the exact ranges of the values for the three bream forms, nor do they allow to assign the populations studied to one of the races, namely the western one. The arithmetic means of such meristic characters as numbers of the lateral line scales and vertebrae are closer to mean values found for *A. brama orientalis* Berg, an Aral-Caspian form. With respect to their arithmetic means of gill processes, the populations studied come close to the third race, the South-european bream *A. brama danubii* Pavlov. Thus it is difficult to assess the exact status of the Vistula bream populations with regard to the three bream subspecies, owing to the vague distinction between the latter with their ranges of meristic characters frequently overlapping.

CONCLUSIONS

1. The bream populations studied may be described by the following ranges of their meristic characters: D III 8–10; A III 21–30; V II 6–9; P II 12–17; Sp.br. 16–26; vt 41–46; 11 48–59, os.ph. 5–5.

Table 13

Values of meristic characters in threee bream subspecies and in Vistula populations studied

Meristic character	Subspecies of bream				Vistula populations			
	Abramis brama L.		Abramis brama orientalis Berg		Abramis brama danubii Pavlov			
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
D	9–10	9	9–10	9.0	9–10	9	8–10	9.0
A	24–30	27.4	23–28	25.7	25–28	25.8	21–30	25.6
l.l.	51–60	55.2	49–57	52.6	50–56	52.7	48–59	53.7
sp. br.	19–24	22.5	22–30	25.6	18–26	22.5	16–26	21.5
vt	45–46	46.0	43–44	43.4	38–43	40.5	41–46	43.0

D number of dorsal fin soft rays
A number of anal fin soft rays
l.l. number of lateral line scales
sp. br. number of filtration processes on gill arch
vt number of vertebrae

2. The bream populations studied were found to possess highly variable meristic characters. Due to frequent overlaps between the ranges of characters, the populations studied cannot be assigned to any one of the three bream subspecies.
3. The between-generations and – populations differences allow no clear trends associated with various generations within a population and various populations affected by different environmental conditions to be discerned.
4. It was found impossible to separate a single population differing from the others in several characters studied.

REFERENCES

Anonim, 1975: Atlas zanieczyszczenia rzek w Polsce 1973. [Atlas river pollution in Poland in 1973]. Wrocław, Instytut Kształtowania Środowiska, Oddział we Wrocławiu.

Anonim, 1974: Zestawienie średnich miesięcznych i rocznych temperatur wody za lata 1963–1973 dla wybranych profili. [Monthly and annual water mean temperature for 1963–1973 at selected profiles]. (Manuscript). Instytut Meteorologii i Gospodarki Wodnej, Warszawa 1974. Maszynopis.

Berg L.S., 1949: Ryby presnych wod SSSR i sopredelnych stran. Moskwa-Leningrad, Akad. Nauk SSSR, 2: 469–926 [in Russian].

Bierwagen H., 1973: Ocena wpływu zanieczyszczeń organicznych powstających przy przerobie ropy naftowej na jakość wody Wisły. [Assessment of the impact of organic pollution resulting from crude oil processing on the Vistula water quality]. (Manuscript). IMiGW – Oddział Gospodarowania Wodą – Zakład Chemii i Biologii Wody. Warszawa, (maszynopis).

Chabanaud I., 1929: La taxonomie, la morphologie et la bonomie des Soleides de genre Pegusa. – Ann. Inst. Oceanog. Paris. VII, 6: 215–261.

Chmiel M., 1976: Zmienność cech merystycznych leszcza (Abramis brama L.) z kilku zbiorników Polski, (maszynopis). [Variability of meristic characters of bream – Abramis brama L. from several Polish water bodies]. (manuscript).

Fage L., 1911: Recherches sur la Biologie de l'Anchois (Engraulis encreassicholus Linné), races – age migrations. – Ann. Inst. Oceanog. Paris, II, 4: 1–40.

Gąsowska M., (Red.), 1962: Krągłouste i ryby. Cyclostomi et Pisces. Warszawa–Kraków.

Gąsowska M., 1968: The biometric comparison of the bream Abramis brama (Linnaeus) (Teleostei, Cyprinidae) from polish water with the bream other european countries, Vestnik. – Sc. spol. zool. (Acta soc. zool. Bohemoslov) 32, 4: 319–336.

Gąsowska M., 1968: Niektóre naturalne mieszańce międzyrodzajowe ryb z rodzaju karpiowatych (Cyprinidae) wód Polski. [Some natural inter-generic cyprinid hybrids from Polish waters]. – Annales zoologici. XXVI, 11: 298–321.

Heincke F., 1898: Naturgeschichte des Herings. Teil I. Die Lokalformen und die Wanderungen des Herings in den Europäischen Meeres. – Abhandl., deutsch, Vereins II. C, XXXVI: 11–138.

Hubbs C.L., 1922: Variation in the number of vertebrae and other meristic characters of fishes corelated with the temperature of the water development. – Am. Nat., 56: 360–372.

Jankovič D., 1966: Taksonomska istraživanija na dunavskoj devenči (Abramis brama danubii Pavlov, 1956). – Archiv. Bioloskih Nauka, Beograd. XVIII, 2: 191–200. (in Yugoslavian).

Jensen J., 1939: Fluctuations in the Racial Charakters of the Plaice and the Dab. – Journal du Conseil 14.

Jensen J., 1944: On specific constancy and segregations into races in Sea-fishes. Ibid. XIX, 8.

Jordan D.S., 1891: Relations of Temperature to vertebrae among fishes. No 845. – Proc. U.S. Wat. Mus. 14: 107–120.

Orska J., 1956: The influence of temperature on the development of the skeleton in teleosts. – Zoologica Poloniae, 7, 3.

Pavlov P.I.,1956: Pridunaiskii leshch v sravnenii s dneprovskim. – Zool. Zh. 35(6): 891–896.

Potapova O.I., 1954: Lešč kak obiekt černogo rybnogo chozjaistva karelo-finskoi SSR. Petrozavodsk. Gos. Izdatelstvo Kar-Fin. SSR: 86–95. [in Russian].

Rolik H., 1967: O niektórych naturalnych krzyżówkach ryb karpiowatych (Pisces, Cyprinidae) w Polsce. [On some natural crossing of cyprinid fishes in Poland]. Fragmenta Faunistica, XIV, 6: 153–167.

Schmidt H., 1916: Second report on eel investigations. – Cons. per. inter, Exp. Mer. Rapp. et Proc. – Verb, XXIII: 1–26.

Schmidt J., 1930: Racial investigations. X. The Atlantic cod (Gadus callarias L.) and local races of the same. – C-R Trav. Lab. Carlsberg 18, 6: 1–72.

Soloveva, H.S., 1954: Lešč reki Kamy. – Ucz. Zap. Charkowskiego Instituta, VIII, 4: [in Russian].

Šapošnikova G.H., 1948: Lešč i perspektivy ego suščestvovanija v vodochranilišče na Volge. – Trudy zool. Inst., Leningrad, 8(3): 467–502. [in Russian].

Szczerbowski J., 1970: Wybrane elementy biologii siei i ich aspekt gospodarczy. [Selected elements of biology of ablen and their economic aspect]. – Zesz. nauk. WSR Olsztyn, ser. C. supl. 1: 1–50.

Šutov V.A., 1967: Lešč dvurjadnymi gołotučnymi zubami w bassejne ozera Seliger. – Dokłady Akad. Nauk, SSR, 173, 3, B5: 715–717. [in Russian].

Taning A., 1944: Experiments on meristic and other charakters in fishes. 1. On the influence of temperature on some meristic characters in sea front and the fixation period the these charakters. – Medd. Konm. Danmarks Fiskeriog Havunders. Fiskeri 11,3.

Taning A., 1950: Influence of the Environment on Number of Vertebrae in Teleostean Fishes. – Nature, 165, 4184.

Wajdowicz Z., 1958: Zbiornik Goczałkowicki jako obiekt gospodarki rybackiej. I. Charakterystyka zbiornika i jego rybacka ocena. [The Goczałkowice Reservoir as fishes management area. I. The Reservoir description and fisheries assessment]. – Biul. Zakł. Biol. Stawów. PAN, Kraków.

Vladykov V.D., Petit G., 1930: Sur quelques poissons d'eau douce d'Albanie. – Bull. Soc. Zool. de France, LV: 383–409.

Vladykov V.A., 1931: Poisson de la Russie Sous-Carpathique (Tchecoslavaquie). – Mem. Soc. Zool. 29: 217–374.

Vladykov V.A., 1934: Environment and taxonomic charakters of fishes. Royal Canadian Institute No 43. September 1934, XX, 1.

Žukow P.J., 1958: Ryby basejna Nemana. Ak. Nauk Bieloruskoi SSR, Mińsk: 1–191. [in Russian].

Žukow P.J., 1965: Ryby Belorusii, 1–415, Mińsk. [in Russian].

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ZMIENNOŚĆ CECH MERYSTYCZNYCH LESZCZA (*ABRAMIS BRAMA* LINNAEUS, 1758) WYSTĘPUJĄCEGO WZDŁUŻ BIEGU RZEKI WISŁY

Streszczenie

Określono 8 cech merystycznych z 9 populacji leszcza zebranych wzdłuż dopływów i samego biegu rzeki Wisły. Dla określenia zmienności cech merystycznych posłużono się analizą wariancji. Analizowano zebrany materiał łącznie dla badanych populacji, oraz osobno poszczególne pokolenia każdej populacji. Między pokoleniami jednej populacji najczęściej zmienna jest liczba promieni miękkich w płetwie piersiowej i liczba wyrostków filtracyjnych. Natomiast istotne różnice między populacjami występują w liczbie promieni miękkich w płetwie odbytowej i piersiowej oraz w liczbie wyrostków filtracyjnych. Badane populacje leszcza z rzeki Wisły mają następujące wartości cech merystycznych: D.III.8–10; A.III.21–30; V II 6–9; P.II 12–17; sp.br. 16–26; vt. 41–46; 11 48–59; os.ph. 5–5.

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ИЗМЕНЧИВОСТЬ МЕРИСТИЧЕСКИХ ПРИЗНАКОВ ЛЕЩА (ABRAMIS BRAMA LINNAEUS, 1758) ИЗ РЕКИ ВИСЛА

Резюме

Определили 8 меристических признаков у 9 популяций леща, собранных в притоках а также вдоль течения реки Висла. Для определения изменчивости меристических признаков использовали анализ варианции. Собранный материал анализировали в общем для исследованных популяций а также раздельно отдельные поколения каждой популяции. Между поколениями одной популяции найболее часто изменяется количество мягких лучей в грудном плавнике и количество фильтрационных тычинок. Существенные различия между популяциами наблюдаются в количестве мягких лучей анального и грудного плавников а также в количестве фильтрационных тычинок. Исследованные популяции леща из реки Висла имеют следующие значения меристических черт: D III 8–10; A III 21–30; V II 6–9; P II 12–17; sp.br. 16–26; vt 41–46; II 48–59; os. ph. 5–5.

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