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Morphological differentiation of the pikeperch *Stizostedion lucioperca* (L.) populations from the Yugoslav part of the Danube

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In order to analyse the intra- and interpopulation homogeneity/heterogeneity of the pikeperch (*Stizostedion lucioperca*), the phenotypic variability of morphological characters was estimated on the basis of a biometric analysis of 31 morphometric and 10 meristic characters in 284 specimens collected at four different sections along the Yugoslav sector of the Danube, during 1986–1989. An ANCOVA of morphological characters, with fish size as a covariate, was performed for analysed samples and between males/females and adults/juveniles respectively. Comparison was also made with the pikeperch samples from the Dnepr and the West Dvina (Zhukov 1965). The results were tested with a GT2-method for multiple unplanned comparison of means, or with a *t*-test where appropriate. The differentiation between populations from three geographically distinct and isolated areas (Danube–Dnepr–Dvina) is much greater than between the four samples from the Danube. The results of the variability analysis of morphological characters and known pikeperch habits (first of all having in mind the so-called "homing" effect — returning to the same spawning place from year to year), suggest that the four samples from the Yugoslav part of the Danube most probably represent four distinct populations. The presence of reproductive isolation still has to be proved through experimental marking. Since this analysis takes into account only the phenotypic variation, it would be necessary to study the genetic differentiation between populations, as well, by biochemical or DNA-sequencing methods.

1. Introduction

Interpopulation variability has a theoretical and practical significance for determination of species plasticity and its abilities to adapt to environmental changes. Morphological differences often occur between pikeperch populations inhabiting the same water body or the same basin. This was particularly studied in the pikeperch populations from rivers, lakes and reservoirs of the former Soviet Union (Polyakov & Kanevskaya 1979). The found differences, however, point to a presence of ecological, but not taxonomical forms of the pikeperch, that are due to different growth rates and

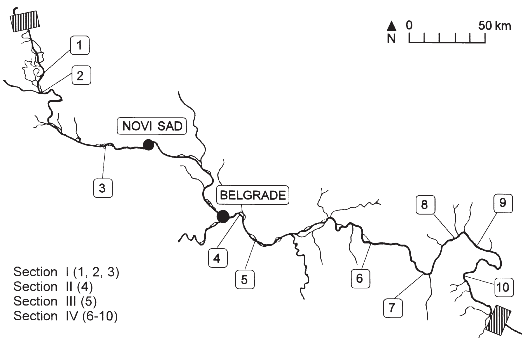

Fig. 1. Analysed localities on the Yugoslav part of the Danube. — 1: Apatin. — 2: Aljmaš. — 3: Begeč. — 4: Višnjica. — 5: Ivanovo. — 6: Golubac. — 7: Donji Milanovac. — 8: Tekija. — 9: Kladovo. — 10: Brza Palanka.

ecological factors, first of all temperature and availability of prey. The variability of morphological characters has not been studied in the pikeperch from the Danube, and this research was aimed at the analysis of the possibility to differentiate populations in habitats with different physical and chemical characteristics.

2. Material and methods

2.1. Study area

The samples of the pikeperch *Stizostedion lucioperca* (L.) were collected at four different sections along the Yugoslav sector of the Danube, during 1986–1989. Sampling was performed at the riverine part of the Danube (section I: localities 1–3, km 1 403–1 276), at the parts of the river near the village Višnjica (section II: locality 4, km 1 163–1 157) and near the village Ivanovo (section III: locality 5, km 1 136), and at the lacustrine part of the Danube (section IV: localities 6–10), along the Iron Gate I and Iron Gate II reservoirs (km 1 042–883) (Fig. 1).

The riverine part encompasses an area susceptible to periodical floods, with the greatest water flow velocity (3.6–4.8 km/h during the period of our investigations) in regard to other sections (Bogdanović 1994). During the floods (spring to mid summer) this area becomes higly productive, with a surface of more than 32 000 ha. The level of fish production is directly dependent upon the level and duration of floods (Stanković & Janković 1971). Water quality corresponds to II–III class[1].

The river part near the village Višnjica is exposed to a great quantity of industrial and sewage waste waters along the right riverbank. During the investigated period the worst water quality was recorded in the river branch of Ada Huja (km 1 163), corresponding to IV class during some months, while near Bela Stena (km 1 157) the quality of water is much better (II–III class).

The river branch Ivanovački Dunavac near Ivanovo represents one of the smaller periodically flooded areas of the Danube. Water flow velocity near the village Grocka (km 1 132) is slower (3.0–3.6 km/h) (Bogdanović 1994) in regard to the riverine part of the Danube. Water quality along this section corresponds to II class during the high water level, with tendency to deteriorate to III class during the low water level.

Water flow velocity in the Iron Gate I and Iron Gate II reservoirs is considerably smaller in regard to all other analysed sections (0.8–3.0 km/h) (Bogdanović 1994). Greater oxygen deficiency and increased contents of phosphates, nitrates, ammonia and dissolved salts were found at this section in comparison with the riverine part of the Danube. Oxygen deficiency and low organic production, in spite of sufficient quantity of nutrients, differ the Iron Gate I reservoir from a true lake system (Perišić, Tutundžić & Miloradov 1990, Perišić & Tutundžić 1992). The reservoir is not stratified due to strong water currents and great oscillations of the water level, while slowing effects increased the sedimentation of suspended particles. Water quality corresponds to II–III/III–II class.

2.2. Material and sampling techniques

The total of 284 pikeperch specimens were analysed, of which 66 mature males, 96 mature females and 122 juveniles. Sample from section I comprised 39 specimens, from section II 178 specimens, from section III 49 specimens, and from section IV 18 specimens. The sampled specimens were 73–960 mm long, weighing 3–7 700 g (digestive tract included). The age of the specimens ranged from 0+ to 12+.

The sampling was performed with several types of commercial gill and seine nets with different mesh diameters,

[1] Freshwaters in Yugoslavia are classified in the following classes, according to their purpose and the level of purity (Decree on classification of interrepublic waters, interstatal waters and waters of the coastal sea in Yugoslavia – Službeni list SFRJ 6/78). — I class: waters that can be used directly, after eventual desinfection, for drinking and food industry, or for salmonid rearing (corresponding to oligosaprobic level). — II class: waters that can be used for bathing and recreation of citizens, for water sports, or for cyprinid rearing, and, after the usual processing (coagulation, filtration, desinfection etc.) for drinking and food industry (corresponding to beta/alpha-mesosaprobic level). — III class: waters that can be used for irrigation, and, after the usual processing, for industries other than the food industry (corresponding to alpha/beta-mesosaprobic level). — IV class: waters that can be used for other purposes after the appropriate treatment (corresponding to alpha-mesosaprobic/polysaprobic level).

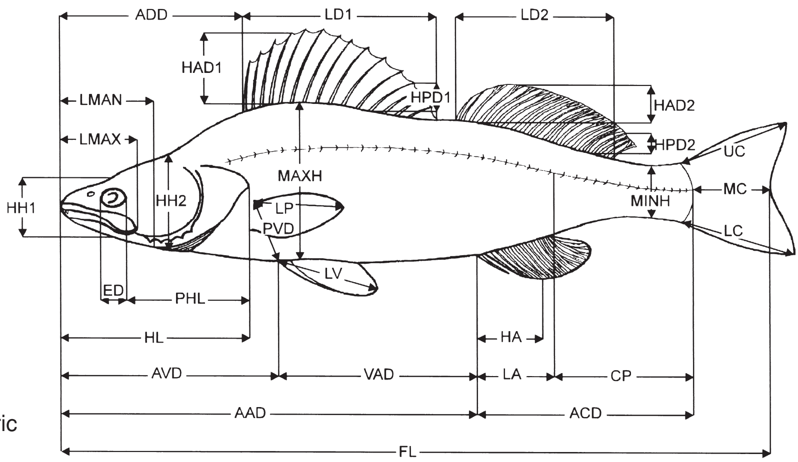

Fig. 2. Analysed morphometric characters.

as well as with an electrical appliance and different angling rods. The sampling at section III was done only with the electrical appliance, angling rods and a hand-net.

2.3 Data analysis

The variability of morphological parameters was estimated according to a biometric analysis of 31 morphometric and 10 meristic characters (Fig. 2). The following morphometric characters were analysed (an acronym is provided for each character):

1) fork length	FL
2) anteanal distance	AAD
3) antedorsal distance	ADD
4) anteventral distance	AVD
5) distance between pectoral and ventral fins	PVD
6) distance between ventral fins and anal fin	VAD
7) length of pectoral fins	LP
8) length of ventral fins	LV
9) length of first dorsal fin basis	LD1
10) height of anterior part of first dorsal fin	HAD1
11) height of posterior part of first dorsal fin	HPD1
12) length of second dorsal fin basis	LD2
13) height of anterior part of second dorsal fin	HAD2
14) height of posterior part of second dorsal fin	HPD2
15) length of anal fin basis	LA
16) height of anal fin	HA
17) distance between anal and caudal fin	ACD
18) length of caudal peduncle	CP
19) maximum body height	MAXH
20) minimum body height	MINH
21) length of upper part of caudal fin	UC
22) length of lower part of caudal fin	LC
23) length of median part of caudal fin	MC
24) head length	HL
25) postocular head length	PHL
26) eye diameter	ED
27) length of maxilla	LMAX
28) length of mandible	LMAN
29) interorbital distance	ID
30) occipital height of head	HH2
31) ocular height of head	HH1

The analysed meristic characters are (with appropriate acronyms):

1) number of gill rakers on first left gill arch	SPBR
2) number of perforated scales in lateral line	LL
3) number of rays in first dorsal fin	D1R
4) number of spiny rays in second dorsal fin	D2SR
5) number of branched rays in second dorsal fin	D2BR
6) number of rays in pectoral fins	PR
7) number of spiny rays in ventral fins	VSR
8) number of branched rays in ventral fins	VBR
9) number of spiny rays in anal fin	ASR
10) number of branched rays in anal fin	ABR

Morphometric characters numbered 1–24 are presented in percents of the standard body length (LS) and those numbered 25–31 in percents of the head length (HL), in order to standardize proportions for fish of different size. The variation range (min–max) is given for each parameter. The mean values, standard deviations and coefficients of variation were calculated, as well as their standard errors (Sokal & Rohlf 1981, Campbell 1989).

An analysis of covariance of morphological characters, with fish size (LS) as a covariate, was done between sections, between males and females, and between adults and juveniles. The results are presented in the form of tables. The homogeneity of variances was tested prior to analyses using a Levene's test, and the normality of distributions with a Shapiro-Wilk's test (STATISTICA 4.5 package). The data for which the variances were not homogeneous and/or the distribution was not normal were *arcsin* transformed.

Because of an unequal number of specimens in the samples the presence of statistically significant differences was tested with a GT2-method for multiple unplanned comparison of means (Sokal & Rohlf 1981), for those morphological characters whose Fs-value from the ANCOVA surpassed the critical F-value for $P < 0.001$.

A *t*-test (Sokal & Rohlf 1981, Campbell 1989) was applied for comparison of the samples from the Yugoslav part of the Danube with the samples from the Dnepr and the West Dvina analysed by Zhukov (1965). The sample from the Dnepr comprised 18 specimens, 125–435 mm long, and that from the West Dvina 49 specimens, 308–640 mm long. The morphometric characters in these samples were expressed in percents of the standard body length or the head length (for characters of the head), which made the comparison with our samples possible.

To calculate the mean coefficients of difference ($\Omega_{x/y}$), we tested our samples with a *t*-test as well. The MCD represents the quotient of the sum of squares of all differences obtained with a *t*-test and the number of analysed characters (Stefanović 1948).

3. Results

The variation ranges (min–max) of the relative values of morphometric and absolute values of meristic characters for each sample are presented in Tables 1–4, with corresponding statistical parameters (means, standard deviations and coefficients of variation). The results of the ANCOVA between the samples from four analysed sections are shown in Table 5, while that between males/females and adults/juveniles are shown in Table 6. The results of the GT2-method for those characters whose *Fs*-value is greater than the critical *F*-value from the

Table 1. Statistical parameters of morphological characters in the pikeperch sample from the section I.

	min	max	mean	± *S.E.*	*S.D.*	± *S.E.*	*C.V.*	± *S.E.*
LS	135.00	850.00	351.74	24.41	150.46	17.15	42.78	4.84
				In % LS:				
FL	107.26	112.77	110.03	0.22	1.33	0.15	1.21	0.14
AAD	60.80	69.84	65.60	0.36	2.20	0.25	3.35	0.38
ADD	30.34	36.96	33.35	0.22	1.33	0.15	4.00	0.45
AVD	30.59	39.68	33.29	0.27	1.65	0.19	4.97	0.56
PVD	5.08	8.91	7.36	0.12	0.74	0.08	9.99	1.13
VAD	28.98	36.36	32.72	0.30	1.87	0.21	5.72	0.65
LP	14.12	18.57	16.19	0.18	1.09	0.12	6.73	0.76
LV	13.53	18.84	17.19	0.19	1.18	0.14	6.89	0.78
LD1	21.18	31.09	26.92	0.33	2.03	0.23	7.52	0.85
HAD1	6.35	15.85	11.32	0.34	2.07	0.24	18.31	2.07
HPD1	7.06	10.74	8.51	0.13	0.80	0.09	9.35	1.06
LD2	22.45	28.57	25.62	0.27	1.67	0.19	6.52	0.74
HAD2	7.92	16.89	12.85	0.29	1.81	0.21	14.05	1.59
HPD2	5.86	11.65	7.72	0.17	1.05	0.12	13.64	1.54
LA	10.42	16.00	13.33	0.19	1.14	0.13	8.57	0.97
HA	7.06	17.04	10.41	0.34	2.12	0.24	20.32	2.30
ACD	35.42	41.38	38.15	0.24	1.47	0.17	3.85	0.44
CP	18.43	24.75	21.77	0.24	1.47	0.17	6.76	0.77
MAXH	17.39	25.21	20.39	0.32	1.96	0.22	9.62	1.09
MINH	7.27	10.42	8.65	0.10	0.59	0.07	6.83	0.77
UC	15.32	23.40	19.82	0.33	2.06	0.23	10.39	1.18
LC	9.41	23.14	16.51	0.50	3.11	0.35	18.82	2.13
MC	7.26	12.77	10.03	0.22	1.33	0.15	13.25	1.50
HL	27.45	33.33	29.27	0.19	1.20	0.14	4.09	0.46
				In % HL:				
PHL	53.24	66.67	59.89	0.51	3.16	0.36	5.28	0.60
ED	10.00	21.43	15.03	0.43	2.66	0.30	17.68	2.00
LMAX	36.84	50.00	40.77	0.41	2.55	0.29	6.26	0.71
LMAN	45.91	64.29	53.16	0.65	3.98	0.45	7.48	0.85
ID	13.33	21.62	16.50	0.30	1.82	0.21	11.03	1.25
HH2	43.75	62.07	49.62	0.65	4.00	0.46	8.05	0.91
HH1	26.92	38.00	32.14	0.39	2.42	0.28	7.54	0.85
				Meristic:				
SPBR	13	15	13.95	0.15	0.93	0.11	6.68%	0.76%
LL	80	105	86.82	0.89	5.47	0.62	6.30%	0.71%
D1R	13	15	14.03	0.11	0.66	0.08	4.70%	0.53%
D2SR	1	3	1.90	0.08	0.50	0.06	26.13%	2.96%
D2BR	20	23	21.38	0.12	0.74	0.08	3.45%	0.39%
PR	14	17	15.51	0.11	0.67	0.08	4.35%	0.49%
VSR	1	1	1.00	0.00	0.00	0.00	0.00%	0.00%
VBR	5	5	5.00	0.00	0.00	0.00	0.00%	0.00%
ASR	2	3	2.90	0.05	0.30	0.03	10.47%	1.19%
ABR	10	13	11.18	0.15	0.90	0.10	8.07%	0.91%

ANCOVA are presented in Table 7. The results of a comparative analysis with the samples from the Dnepr and the West Dvina (Zhukov 1965), according to the *t*-test, are presented in Table 8.

3.1. Meristic characters

The number of gill rakers on the first left gill arch (SPBR) ranges from 13 to 15, the mean value being 13.6 and the mode equals to 13 (found in 56.0% of the analysed specimens). The analysis of covariance showed that *Fs*-values do not surpass the critical value for $P < 0.001$ between analysed samples. The difference between the samples from the Danube and the West Dvina was also not found (data for the Dnepr were not provided).

The number of perforated scales in the lateral line (LL) is 79–105, the mean being 86.8, and the mode is 86 (in 18.2% of the specimens). The *Fs*-value do not surpasses the critical *F*-value between the samples from the Danube. The sample from the Dnepr statistically differs from the samples from sections II and III, while that from the West Dvina differs from the samples from sections I, II and III.

The number of spiny rays in the first dorsal

Table 2. Statistical parameters of morphological characters in the pikeperch sample from the section II.

	min	max	mean	± *S.E.*	*S.D.*	± *S.E.*	*C.V.*	± *S.E.*
LS	92.00	790.00	281.52	8.90	118.38	6.28	42.05	2.23
In % LS:								
FL	107.09	113.73	110.48	0.10	1.31	0.07	1.18	0.06
AAD	56.62	69.97	64.61	0.15	1.98	0.10	3.06	0.16
ADD	29.71	37.37	32.80	0.10	1.39	0.07	4.25	0.23
AVD	28.85	35.43	32.06	0.08	1.11	0.06	3.46	0.18
PVD	5.61	9.93	7.23	0.05	0.65	0.03	9.01	0.48
VAD	27.04	38.97	32.68	0.15	1.93	0.10	5.91	0.31
LP	14.47	19.72	16.89	0.08	1.04	0.06	6.14	0.33
LV	14.61	20.21	17.61	0.09	1.16	0.06	6.60	0.35
LD1	21.59	30.16	26.52	0.13	1.68	0.09	6.33	0.34
HAD1	8.64	15.57	12.44	0.09	1.26	0.07	10.13	0.54
HPD1	5.11	9.35	7.38	0.07	0.89	0.05	12.08	0.64
LD2	21.66	26.23	24.00	0.08	1.06	0.06	4.40	0.23
HAD2	10.26	17.65	13.44	0.09	1.21	0.06	9.01	0.48
HPD2	4.29	8.64	6.76	0.06	0.73	0.04	10.86	0.58
LA	9.93	15.66	12.71	0.06	0.81	0.04	6.39	0.34
HA	8.51	15.75	12.21	0.08	1.11	0.06	9.11	0.48
ACD	32.91	49.68	36.95	0.13	1.77	0.09	4.80	0.25
CP	18.92	25.00	22.02	0.09	1.20	0.06	5.44	0.29
MAXH	14.70	26.47	19.42	0.12	1.61	0.09	8.30	0.44
MINH	6.31	12.96	8.05	0.07	0.89	0.05	11.11	0.59
UC	12.77	24.65	19.49	0.15	2.04	0.11	10.45	0.55
LC	12.06	23.73	18.05	0.13	1.72	0.09	9.55	0.51
MC	7.09	13.73	10.48	0.10	1.31	0.07	12.49	0.66
HL	27.16	33.45	30.19	0.09	1.14	0.06	3.79	0.20
In % HL:								
PHL	50.00	69.57	59.12	0.25	3.34	0.18	5.65	0.30
ED	11.11	24.05	17.13	0.20	2.61	0.14	15.24	0.81
LMAX	36.36	47.14	43.08	0.12	1.61	0.09	3.74	0.20
LMAN	48.22	67.46	56.28	0.24	3.24	0.17	5.75	0.30
ID	12.71	40.51	14.94	0.19	2.59	0.14	17.32	0.92
HH2	39.09	60.23	47.46	0.20	2.65	0.14	5.59	0.30
HH1	23.74	35.75	31.15	0.13	1.72	0.09	5.51	0.29
Meristic:								
SPBR	13	15	13.57	0.06	0.76	0.04	5.58%	0.30%
LL	79	93	86.90	0.21	2.76	0.15	3.17%	0.17%
D1R	13	16	14.13	0.05	0.63	0.03	4.46%	0.24%
D2SR	1	3	1.54	0.04	0.55	0.03	35.70%	1.89%
D2BR	19	24	21.80	0.07	0.89	0.05	4.10%	0.22%
PR	14	17	15.67	0.05	0.64	0.03	4.09%	0.22%
VSR	1	1	1.00	0.00	0.00	0.00	0.00%	0.00%
VBR	5	5	5.00	0.00	0.00	0.00	0.00%	0.00%
ASR	2	3	2.06	0.02	0.23	0.01	11.20%	0.59%
ABR	10	14	12.16	0.05	0.70	0.04	5.79%	0.31%

fin (D1R) is 13–16, the mean is 14.1, while the mode is 14 (in 65.0% of the specimens). This character does not show any statistically significant difference between analysed samples from the Danube. The sample from the Dnepr differs from the samples from sections I, II and III, as well as from the sample from the West Dvina. This is the only meristic character that distinguishes the samples from the Dnepr and the West Dvina.

The number of spiny rays in the second dorsal fin (D2SR) is 1–3, the mean being 1.6, and the mode is 2 (in 55.1% of the specimens), while the number of branched rays (D2BR) is 19–24, with the mean of 21.7 and the mode of 22 (in 46.7% of the specimens). Analysis of covariance for spiny rays (D2SR) showed that *Fs*-values surpass the critical value for $P < 0.001$ between analysed samples from the Danube, and GT2-method results indicate that a significant difference exist between sections I/II, II/IV and III/IV. For branched rays (D2BR) *Fs*-values do not surpass critical values between any of the sample pairs from the Danube, but it differs the sample from the West Dvina from those from sections I, II and III.

The number of rays in the pectoral fins (PR) is 14–17, the mean value being 15.6, and the mode is

Table 3. Statistical parameters of morphological characters in the pikeperch sample from the section III.

	min	max	mean	± *S.E.*	*S.D.*	± *S.E.*	*C.V.*	± *S.E.*
LS	62.90	305.00	149.08	8.36	57.94	5.88	38.86	3.93
				In % LS:				
FL	108.45	115.46	111.77	0.23	1.59	0.16	1.42	0.14
AAD	56.64	67.62	63.35	0.32	2.23	0.23	3.52	0.36
ADD	30.07	37.68	33.96	0.24	1.64	0.17	4.83	0.49
AVD	28.99	35.90	32.68	0.20	1.42	0.14	4.34	0.44
PVD	5.37	9.22	7.47	0.11	0.75	0.08	10.05	1.02
VAD	28.67	36.19	32.03	0.23	1.61	0.16	5.01	0.51
LP	15.12	19.69	17.28	0.16	1.11	0.11	6.44	0.65
LV	15.85	21.55	18.80	0.18	1.26	0.13	6.71	0.68
LD1	20.99	28.97	25.36	0.27	1.85	0.19	7.28	0.74
HAD1	10.74	16.55	13.70	0.19	1.30	0.13	9.51	0.96
HPD1	4.62	8.46	6.77	0.15	1.02	0.10	15.07	1.52
LD2	20.98	27.57	24.09	0.21	1.47	0.15	6.09	0.61
HAD2	11.97	17.57	14.87	0.18	1.23	0.12	8.25	0.83
HPD2	4.20	8.13	6.39	0.12	0.85	0.09	13.30	1.34
LA	11.06	15.21	13.12	0.12	0.86	0.09	6.57	0.66
HA	11.64	18.82	13.93	0.20	1.37	0.14	9.80	0.99
ACD	32.17	42.20	37.92	0.30	2.08	0.21	5.50	0.56
CP	17.48	25.77	22.41	0.25	1.77	0.18	7.88	0.80
MAXH	14.71	21.98	18.83	0.23	1.60	0.16	8.50	0.86
MINH	6.03	9.78	8.22	0.10	0.66	0.07	8.07	0.82
UC	15.74	32.28	22.84	0.47	3.24	0.33	14.20	1.43
LC	17.14	29.43	21.25	0.42	2.91	0.30	13.70	1.38
MC	8.45	15.46	11.77	0.23	1.59	0.16	13.51	1.36
HL	27.97	34.50	31.82	0.20	1.41	0.14	4.42	0.45
				In % HL:				
PHL	48.39	63.49	55.22	0.49	3.36	0.34	6.09	0.62
ED	15.28	25.00	19.77	0.41	2.81	0.29	14.23	1.44
LMAX	37.05	48.80	43.45	0.33	2.31	0.23	5.31	0.54
LMAN	47.37	62.12	55.07	0.42	2.94	0.30	5.34	0.54
ID	12.50	18.90	14.97	0.17	1.20	0.12	8.01	0.81
HH2	42.03	54.52	46.67	0.34	2.37	0.24	5.07	0.51
HH1	30.00	42.86	33.44	0.30	2.07	0.21	6.18	0.62
				Meristic:				
SPBR	13	15	13.65	0.12	0.85	0.09	6.20%	0.63%
LL	80	92	86.06	0.40	2.79	0.28	3.24%	0.33%
D1R	13	16	14.16	0.09	0.62	0.06	4.36%	0.44%
D2SR	1	2	1.61	0.07	0.49	0.05	30.22%	3.05%
D2BR	20	24	21.86	0.12	0.86	0.09	3.92%	0.40%
PR	14	17	15.55	0.09	0.64	0.07	4.12%	0.42%
VSR	1	1	1.00	0.00	0.00	0.00	0.00%	0.00%
VBR	5	5	5.00	0.00	0.00	0.00	0.00%	0.00%
ASR	2	3	2.14	0.05	0.35	0.04	16.33%	1.65%
ABR	10	13	12.14	0.09	0.64	0.06	5.26%	0.53%

16 (in 57.3% of the specimens). Analysis of covariance showed that there are no significant differences between the samples from the Danube. The *t*-test analysis of mean values shows that there are very significant differences between all four samples from the Yugoslav part of the Danube and the samples from the Dnepr and the West Dvina.

The number of rays in ventral fins (VSR, VBR) is the most stable meristic character in the pikeperch. All analysed specimens have 1 spiny and 5 branched rays.

The number of spiny rays in the anal fin (ASR) is 2–3, with the mean of 2.2, and the mode of 2 (in 79.6% of the specimens), while the number of branched rays (ABR) is 10–14, with the mean of 12.00, and the mode of 12 (in 51.5% of the specimens). Analysis of covariance showed that *Fs*-values surpass the critical *F*-value for $P < 0.001$ between the sample pairs from the Danube. GT2-method results revealed significant differences between the samples from sections I/II, I/III, I/IV, II/IV and III/IV in regard to the number of spiny rays (ASR), and between the samples from sections I/II in regard to the number of branched rays (ABR). Results of the *t*-test revealed differences between the samples from the Dnepr and the West Dvina and the samples from sections II and III.

Table 4. Statistical parameters of morphological characters in the pikeperch sample from the section IV.

	min	max	mean	± *S.E.*	*S.D.*	± *S.E.*	*C.V.*	± *S.E.*
LS	230.00	415.00	322.88	13.33	54.98	9.29	17.03	2.84
In % LS:								
FL	108.47	113.04	109.92	0.34	1.42	0.24	1.29	0.21
AAD	62.65	66.67	64.58	0.26	1.06	0.18	1.64	0.27
ADD	29.64	33.91	31.97	0.30	1.22	0.21	3.83	0.64
AVD	30.77	32.94	31.96	0.18	0.74	0.13	2.33	0.39
PVD	6.15	8.25	7.37	0.17	0.68	0.12	9.29	1.55
VAD	31.33	34.28	32.60	0.23	0.93	0.16	2.85	0.48
LP	15.25	16.87	16.03	0.14	0.56	0.10	3.52	0.59
LV	15.38	18.70	17.32	0.30	1.25	0.21	7.21	1.20
LD1	24.56	29.38	27.68	0.39	1.60	0.27	5.77	0.96
HAD1	9.79	13.48	11.74	0.27	1.12	0.19	9.52	1.59
HPD1	7.73	10.49	9.41	0.21	0.85	0.14	9.01	1.50
LD2	23.73	26.15	24.66	0.18	0.74	0.12	2.98	0.50
HAD2	9.23	16.52	12.99	0.46	1.90	0.32	14.62	2.44
HPD2	6.15	8.20	7.19	0.15	0.63	0.11	8.71	1.45
LA	12.28	15.22	13.43	0.23	0.95	0.16	7.09	1.18
HA	6.15	13.11	9.70	0.54	2.23	0.38	22.96	3.83
ACD	36.07	39.13	37.68	0.24	0.98	0.17	2.60	0.43
CP	20.34	23.08	21.48	0.24	0.98	0.16	4.54	0.76
MAXH	18.53	22.03	19.85	0.26	1.07	0.18	5.40	0.90
MINH	7.65	9.57	8.36	0.15	0.61	0.10	7.35	1.22
UC	15.79	20.87	18.72	0.36	1.50	0.25	8.02	1.34
LC	12.65	19.13	15.05	0.48	1.97	0.33	13.05	2.18
MC	8.47	13.04	9.92	0.34	1.42	0.24	14.28	2.38
HL	27.32	30.43	28.66	0.22	0.92	0.16	3.22	0.54
In % HL:								
PHL	57.89	65.22	60.80	0.53	2.17	0.37	3.56	0.59
ED	13.04	18.57	15.99	0.42	1.73	0.29	10.83	1.80
LMAX	31.58	44.94	39.71	1.00	4.11	0.70	10.36	1.73
LMAN	50.15	61.50	54.51	0.85	3.49	0.59	6.40	1.07
ID	15.46	19.13	16.85	0.29	1.21	0.20	7.17	1.20
HH2	49.48	52.94	51.85	0.31	1.27	0.21	2.45	0.41
HH1	29.41	38.57	33.14	0.71	2.91	0.49	8.78	1.46
Meristic:								
SPBR	13	15	14.13	0.15	0.60	0.10	4.24%	0.71%
LL	85	94	87.75	0.78	3.23	0.55	3.68%	0.61%
D1R	13	15	14.13	0.15	0.60	0.10	4.24%	0.71%
D2SR	2	3	2.38	0.12	0.48	0.08	20.38%	3.40%
D2BR	21	22	21.13	0.08	0.33	0.06	1.57%	0.26%
PR	14	16	15.38	0.17	0.70	0.12	4.53%	0.75%
VSR	1	1	1.00	0.00	0.00	0.00	0.00%	0.00%
VBR	5	5	5.00	0.00	0.00	0.00	0.00%	0.00%
ASR	2	3	2.50	0.12	0.50	0.08	20.00%	3.33%
ABR	11	12	11.63	0.12	0.48	0.08	4.16%	0.69%

3.2. Morphometric characters

The results of the analysis of covariance of morphometric characters in four samples from the Danube showed that *Fs*-values for $P < 0.001$ surpass the critical value ($F_{0.001[3,280]} = 5.42$) in 17 characters, which are marked with an asterisk in the Table 5. The differences in mean values of these characters, tested with the GT2-method, are shown in Table 7. Differences with absolute values greater than MSD-values for $P < 0.01$ ($m_{0.01[4,280]} = 3.14$) are also marked with an asterisk.

Table 5. The ANCOVA of morphological characters (LS as a covariate) in the pikeperch samples from the Yugoslav part of the Danube ($P < 0.001$).

dfb = 3 dfw = 278	Mean square Effect	Mean square Error	*F*
	Morphometric:		
FL	3.32E – 04	1.46E – 04	2.27
AAD	1.64E – 03	4.13E – 04	3.96
ADD	1.32E – 03	1.87E – 04	7.08*
AVD	1.95E – 03	1.55E – 04	12.56*
PVD	1.70E – 04	4.58E – 05	3.72
VAD	2.58E – 04	3.46E – 04	0.74
LP	2.91E – 04	8.94E – 05	3.25
LV	8.58E – 05	8.34E – 05	1.03
LD1	5.30E – 04	2.82E – 04	1.88
HAD1	5.07E – 04	1.28E – 04	3.97
HPD1	2.11E – 03	7.86E – 05	26.89*
LD2	2.62E – 03	1.55E – 04	16.85*
HAD2	4.66E – 04	1.32E – 04	3.51
HPD2	6.70E – 04	5.78E – 05	11.60*
LA	6.01E – 04	7.84E – 05	7.67*
HA	4.56E – 03	1.56E – 04	29.29*
ACD	2.51E – 03	2.95E – 04	8.52*
CP	1.29E – 04	1.83E – 04	0.70
MAXH	3.87E – 04	1.94E – 04	2.00
MINH	3.76E – 04	6.69E – 05	5.62*
UC	4.21E – 03	3.27E – 04	12.88*
LC	5.36E – 03	3.22E – 04	16.64*
MC	3.32E – 04	1.46E – 04	2.27
HL	1.82E – 03	1.09E – 04	16.62*
PHL	1.87E – 03	4.31E – 04	4.34
ED	7.19E – 04	2.44E – 04	2.95
LMAX	7.85E – 03	4.14E – 04	18.98*
LMAN	1.08E – 02	1.11E – 03	9.72*
ID	2.91E – 03	5.22E – 04	5.57*
HH2	5.57E – 03	6.30E – 04	8.85*
HH1	4.84E – 03	3.38E – 04	14.34*
	Meristic:		
SPBR	2.01E + 00	6.46E – 01	3.11
LL	1.80E + 01	9.11E + 00	1.97
D1R	1.83E – 01	4.03E – 01	0.46
D2SR	3.21E + 00	2.83E – 01	11.36*
D2BR	3.76E + 00	7.39E – 01	5.09
PR	1.11E + 00	3.97E – 01	2.80
VSR	0.00E + 00	0.00E + 00	0.00E + 00
VBR	0.00E + 00	0.00E + 00	0.00E + 00
ASR	7.45E + 00	7.84E – 02	95.01*
ABR	1.16E + 01	5.19E – 01	22.28*

*Statistically significant

The samples from sections I and II differ significantly in regard to 14 characters. The specimens from section I have higher mean values of AVD, HPD1, LD2, HPD2, LA, ACD, MINH, ID and HH2, and lower of HA, LC, HL, LMAX and LMAN, than from section II. The samples from sections I and III differ in mean values of 9 characters. The specimens from section I have higher mean values of HPD1, LD2, HPD2 and HH2, and lower of HA, UC, LC, HL and LMAX, than from section III. The samples from sections I and IV do not differ significantly in respect to any of the analysed morphometric characters. The samples from sections II and III differ significantly in regard to 8 characters, and from sections II and IV in regard to 6 characters. The specimens from section II have higher mean value of HPD1 than from section III, and of HA, LC, HL and LMAX than from section IV. The characters with lower mean values in the sample from section II than in section III are ADD, HA, ACD, UC, LC, HL and HH1, and lower than in the sample from section IV are HPD1 and HH2. The samples from sections III and IV show differences in mean values of 8 characters. The specimens from section III have higher mean values of ADD, HA, UC, LC, HL and LMAX, and lower of HPD1 and HH2, than from section IV.

The analysis of covariance between males and females showed that there is no sexual dimorphism in analysed samples, since *Fs*-values for $P < 0.001$ do not surpass the critical value ($F_{0.001[1,160]} = 10.80$) in any character (Table 6). On the other hand, the analysis of covariance between juveniles and adults showed that *Fs*-values for $P < 0.001$ surpass the critical value ($F_{0.001[1,282]} = 10.80$) in 3 characters (Table 6). Juveniles have the higher mean value of ED, and lower of LD1 and HPD1.

The comparative analysis with the samples from the Dnepr and the West Dvina revealed significant differences in regard to a greater number of morphometric characters (Table 8). The sample from the Dnepr significantly differs from the samples from the Yugoslav part of the Danube in mean values of 8 morphometric characters. The characters with higher mean values in the sample from the Dnepr are HA, CP, LMAX, ID and HH1, while that with lower mean values are LD1, HL and PHL. The sample from the West Dvina differs from the samples from the Danube in mean values of 16 characters. The specimens from the West Dvina have higher mean values of CP, MAXH, PHL, ID and HH2, and lower of ADD, VAD, LP, LV, HAD1, LD2, HAD2, UC, LC, HL and ED. The samples from the Dnepr and the West Dvina differ in mean values of 9 morphometric characters. The characters with higher mean values in the sample from the Dnepr are ADD, LP, LV, HAD2, HA, LC and ED, while that with lower mean values are LD1 and PHL.

4. Discussion

The comparison of the mean coefficients of difference (MCD) showed that the sample from section III differs the most from all other samples. This difference was the greatest in regard to the sample from section I ($\Omega_{I/III} = 25.54$), then from sections II ($\Omega_{II/III} = 17.04$) and IV ($\Omega_{III/IV} = 14.53$). The value of MCD between the samples from sections I and II was also considerable ($\Omega_{I/II} = 18.73$), contrary to the samples from sections II and IV ($\Omega_{II/IV} = 7.75$). The samples from sections I and IV differ the least from each other ($\Omega_{I/IV} = 2.13$).

The comparison of the MCD-values between samples from the Danube, the Dnepr and the West Dvina revealed that the samples from the Danube and the West Dvina differ the most ($\Omega = 55.82$). Considerably smaller differences were found between

Table 6. The ANCOVA of morphological characters (LS as a covariate)between males/females and adults/juveniles in the pikeperch samples from the Yugoslav part of the Danube ($P < 0.001$).

	Males/Females (dfb = 1 dfw = 159)			Adults/Juveniles (dfb = 1 dfw = 280)		
	Mean square Effect	Mean square Error	*F*	Mean square Effect	Mean square Error	*F*
Morphometric:						
FL	2.57E – 05	9.22E – 05	0.28	2.35E – 05	1.49E – 04	0.16
AAD	7.62E – 04	3.96E – 04	1.92	2.75E – 04	4.27E – 04	0.65
ADD	9.52E – 06	1.65E – 04	0.06	2.98E – 06	2.00E – 04	0.01
AVD	3.74E – 06	1.68E – 04	0.02	7.24E – 05	1.76E – 04	0.41
PVD	6.46E – 06	5.36E – 05	0.12	2.86E – 05	4.73E – 05	0.61
VAD	2.35E – 04	3.57E – 04	0.66	5.17E – 05	3.46E – 04	0.15
LP	2.78E – 05	7.83E – 05	0.35	2.89E – 05	9.19E – 05	0.31
LV	1.34E – 05	6.46E – 05	0.21	1.58E – 07	8.37E – 05	0.00
LD1	1.05E – 04	3.15E – 04	0.33	2.79E – 03	2.75E – 04	10.15 *
HAD1	8.77E – 05	1.44E – 04	0.61	4.96E – 05	1.32E – 04	0.38
HPD1	2.04E – 04	8.71E – 05	2.35	1.65E – 03	9.54E – 05	17.33 *
LD2	4.97E – 04	1.81E – 04	2.75	4.01E – 04	1.82E – 04	2.21
HAD2	9.35E – 06	1.40E – 04	0.07	3.30E – 04	1.35E – 04	2.44
HPD2	1.27E – 05	6.56E – 05	0.19	2.92E – 04	6.37E – 05	4.59
LA	8.91E – 06	9.27E – 05	0.10	5.22E – 04	8.25E – 05	6.32
HA	6.89E – 04	2.06E – 04	3.35	8.74E – 05	2.05E – 04	0.43
ACD	4.26E – 05	1.91E – 04	0.22	5.89E – 05	3.20E – 04	0.18
CP	1.87E – 04	1.48E – 04	1.26	2.03E – 04	1.82E – 04	1.11
MAXH	5.31E – 05	2.01E – 04	0.26	4.97E – 04	1.95E – 04	2.55
MINH	1.77E – 04	3.85E – 05	4.60	3.91E – 05	7.04E – 05	0.56
UC	1.46E – 04	2.41E – 04	0.61	2.50E – 05	3.71E – 04	0.07
LC	1.12E – 04	2.81E – 04	0.40	3.50E – 04	3.78E – 04	0.93
MC	2.57E – 05	9.22E – 05	0.28	2.35E – 05	1.49E – 04	0.16
HL	1.78E – 05	1.04E – 04	0.17	4.86E – 04	1.27E – 04	3.83
PHL	5.02E – 04	3.70E – 04	1.35	2.58E – 03	4.39E – 04	5.87
ED	4.11E – 05	2.03E – 04	0.20	3.22E – 03	2.38E – 04	13.51 *
LMAX	2.04E – 04	6.07E – 04	0.34	2.41E – 03	4.89E – 04	4.92
LMAN	3.11E – 03	1.38E – 03	2.26	3.50E – 05	1.23E – 03	0.03
ID	2.66E – 04	1.74E – 04	1.53	1.54E – 03	5.45E – 04	2.82
HH2	2.08E – 04	7.63E – 04	0.27	2.99E – 05	6.87E – 04	0.04
HH1	2.04E – 05	3.61E – 04	0.06	7.28E – 05	3.89E – 04	0.19
Meristic:						
SPBR	6.94E – 03	6.92E – 01	0.01	6.40E – 01	6.61E – 01	0.97
LL	2.80E + 00	1.17E + 01	0.24	5.62E + 00	9.22E + 00	0.61
D1R	2.01E – 01	4.27E – 01	0.47	8.60E – 01	3.99E – 01	2.16
D2SR	6.13E – 01	3.45E – 01	1.77	6.49E – 03	3.16E – 01	0.02
D2BR	3.09E + 00	7.77E – 01	3.98	2.19E + 00	7.67E – 01	2.85
PR	9.33E-01	3.96E – 01	2.36	1.63E – 01	4.06E – 01	0.40
VSR	0.00E + 00	0.00E + 00	0.00E + 00	0.00E + 00	0.00E + 00	0.00E + 00
VBR	0.00E + 00	0.00E + 00	0.00E + 00	0.00E + 00	0.00E + 00	0.00E + 00
ASR	8.44E – 02	1.98E – 01	0.43	5.26E – 01	1.59E – 01	3.32
ABR	3.86E – 01	6.61E – 01	0.58	5.99E – 02	6.44E – 01	0.09

*Statistically significant

samples from the Danube and the Dnepr (Ω = 13.98), and between samples from the West Dvina and the Dnepr (Ω = 11.67). In regard to the samples from different sections of the Danube, the sample from the Dnepr differs the most from those from sections II (Ω = 14.78) and III (Ω = 14.09), less from that from section I (Ω = 13.75), and the least from that from section IV (Ω = 7.18). The sample from the West Dvina differs the most from the samples from sections III (Ω = 59.73) and II (Ω = 49.12) as well, while the difference with the samples from sections I (Ω = 15.87) and IV (Ω = 6.36) is considerably lower.

If meristic (discontinuous) and morphometric (continuous) characters are considered separately, it is noticeable that meristic characters, being more reliable than morphometric, emphasize the difference between the sample from the Danube and the samples from the Dnepr and the West Dvina. It has been experimentaly proved that meristic characters are genetically fixed within narrow limits and that their minor aberrations during the ontogenetic development can be ascribed to phenotypic plasticity, i.e. to the influence of different environmental factors, first of all temperature during the so-called sensitive period, which is different for each species (Lindsey 1954, Sinovčić 1982). Polyakov and Kanevskaya (1979) analysed the interpopulation variability of morphological characteristics in the pikeperch samples from different waters of the former Soviet

Table 7. GT2-method results: MSD values (above the diagonal) and differences between group means (below the diagonal) ($P < 0.01$).

Morphometric:														
ADD	I	II	III	IV	**AVD**	I	II	III	IV	**HPD1**	I	II	III	IV
I		0.80	0.97	1.76	I		0.70	0.85	1.54	I		0.50	0.61	1.11
II	0.55		0.73	1.63	II	1.23*		0.64	1.43	II	1.13*		0.46	1.03
III	0.61	1.16*		1.72	III	0.61	0.62		1.51	III	1.74*	0.61*		1.09
IV	1.38	0.83	1.99*		IV	1.33	0.10	0.72		IV	0.90	2.03*	2.64*	
LD2	I	II	III	IV	**HPD2**	I	II	III	IV	**LA**	I	II	III	IV
I		0.69	0.84	1.52	I		0.45	0.55	0.99	I		0.49	0.60	1.08
II	1.62*		0.63	1.41	II	0.96*	0.41	0.92		II	0.62*		0.45	1.01
III	1.53*	0.09		1.49	III	1.33*	0.37		0.97	III	0.21	0.41		1.06
IV	0.96	0.66	0.57		IV	0.53	0.43	0.80		IV	0.10	0.72	0.31	
HA	I	II	III	IV	**ACD**	I	II	III	IV	**MINH**	I	II	III	IV
I		0.78	0.94	1.70	I		0.99	1.21	2.18	I		0.45	0.55	1.00
II	1.80*		0.71	1.59	II	1.20*	0.91	2.03		II	0.60*		0.41	0.93
III	3.52*	1.72*		1.67	III	0.23	0.97*		2.14	III	0.43	0.17		0.98
IV	0.71	2.51*	4.23*		IV	0.47	0.73	0.24		IV	0.29	0.31	0.14	
UC	I	II	III	IV	**LC**	I	II	III	IV	**HL**	I	II	III	IV
I		1.28	1.56	2.82	I		1.24	1.51	2.73	I		0.67	0.81	1.47
II	0.33		1.17	2.62	II	1.54*	1.13	2.54		II	0.92*		0.61	1.37
III	3.02*	3.35*		2.77	III	4.74*	3.20*		2.68	III	2.55*	1.63*		1.45
IV	1.10	0.77	4.12*		IV	1.46	3.00*	6.20*		IV	0.61	1.53*	3.16*	
LMAX	I	II	III	IV	**LMAN**	I	II	III	IV	**ID**	I	II	III	IV
I		1.13	1.37	2.48	I		1.85	2.25	4.07	I		1.27	1.54	2.78
II	2.31*		1.03	2.31	II	3.12*	1.69	3.79		II	1.56*		1.16	2.59
III	2.68*	0.37		2.43	III	1.91	1.21		4.00	III	1.53	0.03		2.73
IV	1.06	3.37*	3.74*		IV	1.35	1.77	0.56		IV	0.35	1.91	1.88	
HH2	I	II	III	IV	**HH1**	I	II	III	IV					
I		1.57	1.91	3.45	I		1.09	1.32	2.38					
II	2.16*		1.43	3.21	II	0.99		0.99	2.22					
III	2.95*	0.79		3.39	III	1.30	2.29*		2.34					
IV	2.23	4.39*	5.18*		IV	1.00	1.99	0.30						
Meristic:														
D2SR	I	II	III	IV	**ASR**	I	II	III	IV	**ABR**	I	II	III	IV
I		0.30	0.36	0.66	I		0.16	0.19	0.35	I		0.40	0.49	0.89
II	0.36*		0.27	0.61	II	0.84*		0.14	0.32	II	0.98*		0.37	0.83
III	0.29	0.07		0.65	III	0.76*	0.08		0.34	III	0.34	0.02		0.87
IV	0.48	0.84*	0.77*		IV	0.40*	0.44*	0.36*		IV	0.45	0.53	0.51	

*Statistically significant

Union, and they also have found that meristic characters are less variable than morphometric. The meristic characters that distinguish the samples from the Danube and the Dnepr are LL, D1R, PR and ABR, while LL, D2BR, PR and ABR distinguish the samples from the Danube and the West Dvina. Only D1R distinguishes the samples from the Dnepr and the West Dvina. All of these five characters have low within samples variability and can be considered as reliable in intra- and interpopulation analyses. The characters that have particular significance for the differentiation of populations are LL, D1R, D2BR and PR, whose means differ only between the samples from three geographically distant aquatic systems, and not between the samples from four sections of the Yugoslav part of the Danube. Polyakov and Kanevskaya (1979) emphasize the significance of LL and D1R in interpopulation analyses in the pikeperch. In regard to meristic characters the samples from four sections of the Yugoslav part of the Danube significantly differ in the values of D2SR, ASR and ABR. The characters D2SR and ASR have the highest within samples variability of all meristic characters and therefore are not suitable for estimation of population homogeneity/heterogeneity in the pikeperch. In the analyses of the pikeperch populations in the waters of the former Soviet Union these two characters were not used for comparisons (Zhukov 1965, Polyakov & Kanevskaya 1979).

Twenty five morphometric (continuous) characters were used in comparisons between the three geographically distinct aquatic systems (Table 8), since data for some of the characters were not provided for the samples from the Dnepr and the

Table 8. *t*-test results and MCD values. — A: Yugoslav part of the Danube (sections I, II, III and IV). — B: the Dnepr (Zhukov 1965). — C: the West Dvina (Zhukov 1965), ($P < 0.001$).

	A/B	A/C	B/C	B/I	B/II	B/III	B/IV	C/I	C/II	C/III	C/IV
					Morphometric:						
AAD	1.90	1.13	2.31	3.41	2.07	0.46	1.59	1.35	0.86	3.38	0.67
ADD	0.09	4.05 *	4.12 *	1.32	2.14	3.68 *	2.33	4.18 *	3.16	5.66 *	0.26
AVD	1.55	3.12	0.66	0.94	2.35	0.51	2.09	0.35	4.19 *	1.50	3.20
VAD	2.46	4.82 *	0.71	2.34	2.65	1.04	1.98	3.80 *	4.90 *	2.36	3.19
LP	2.21	9.30 *	3.87 *	0.49	2.39	3.49 *	0.99	3.80	9.35 *	9.03 *	2.83
LV	2.52	11.32 *	3.86 *	0.10	1.89	5.77 *	0.31	4.46 *	9.85 *	12.28 *	2.30
LD1	5.34 *	0.36	4.94 *	5.41 *	5.53 *	2.89	5.09 *	1.58	0.87	2.91	2.16
HAD1	0.32	5.93 *	3.06	2.78	0.45	3.15	1.63	0.75	5.67 *	9.39 *	0.34
LD2	0.65	3.90 *	1.25	3.32	0.02	0.22	1.35	6.55 *	2.69	2.31	3.60 *
HAD2	1.71	9.54 *	8.35 *	3.18	2.41	3.18	1.33	3.43 *	8.75 *	12.53 *	1.77
LA	0.34	0.25	0.43	1.61	0.37	1.08	1.40	1.61	1.42	0.94	1.26
HA	5.35 *	0.36	4.67 *	7.68 *	5.42 *	0.31	4.82 *	4.78 *	0.29	6.02 *	2.98
CP	6.07 *	3.91 *	2.62	5.71 *	6.08 *	4.08 *	5.28 *	3.71 *	3.94 *	1.79	3.51
MAXH	2.36	7.65 *	2.25	0.13	2.46	3.58 *	0.89	2.25	7.57 *	7.77 *	3.04
MINH	2.15	1.89	0.81	1.28	2.88	1.47	0.35	0.14	2.29	1.63	0.93
UC	2.63	9.90 *	2.37	1.75	1.36	6.10 *	0.15	5.70 *	7.60 *	10.24 *	1.78
LC	1.09	7.02 *	4.34 *	3.46	1.69	3.92 *	4.38 *	0.52	6.40 *	10.02 *	2.29
MC	1.68	3.02	3.00	2.88	2.06	1.15	2.06	0.07	2.18	6.01 *	0.23
HL	3.39 *	6.29 *	1.63	0.56	2.93	7.62 *	1.84	1.23	5.75 *	10.22 *	0.67
PHL	3.45 *	3.79 *	5.20 *	4.43 *	4.13 *	0.97	4.41 *	0.27	2.29	8.25 *	0.85
ED	0.96	12.39 *	5.85 *	4.27 *	1.18	3.33	2.17	0.43	8.55 *	11.03 *	1.72
LMAX	8.60 *			9.14 *	7.57 *	4.07 *	3.44				
ID	4.09 *	3.37 *	1.91	0.96	4.54 *	4.55 *	0.23	1.08	3.99 *	4.06 *	1.47
HH2	2.86	7.55 *	0.43	0.87	3.14	3.78 *	1.07	1.96	8.05 *	8.37 *	1.14
HH1	5.45 *			4.17 *	6.43 *	2.53	1.61				
					Meristic:						
SPBR		0.54						1.86	0.35	0.67	2.11
LL	4.09 *	9.69 *	1.67	2.81	3.92 *	4.56 *	1.68	4.93 *	9.37 *	9.20 *	3.10
D1R	6.18 *	0.86	4.63 *	4.40 *	6.10 *	5.57 *	3.22	1.19	0.79	0.57	0.49
D2BR	0.65	8.69 *	2.24	0.32	0.84	0.97	0.99	4.30 *	8.59 *	7.25 *	2.64
PR	7.52 *	21.53 *	1.11	6.87 *	7.64 *	7.10 *	5.38 *	14.14 *	21.08 *	16.11	6.83 *
VBR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ABR	3.57 *	8.26 *	1.54	0.19	4.31 *	3.98 *	1.45	1.66	9.41 *	8.16 *	3.51
MCD	13.98	55.82	11.67	13.75	14.78	14.09	7.18	15.87	49.12	59.73	6.36

*Statistically significant

West Dvina. The samples from the Danube, the Dnepr and the West Dvina significantly differ in the values of 20 morphometric characters, while the four samples from the Danube differ in the values of 13 characters. Ten characters are different exclusively between the samples from three aquatic systems — VAD, LP, LV, LD1, HAD1, HAD2, CP, MAXH, PHL and ED, and three characters between the samples from the Danube — AVD, LA and MINH. Other ten characters are different both between the samples from three aquatic systems and between the samples from the Danube — ADD, LD2, HA, UC, LC, HL, LMAX, ID, HH2 and HH1.

From the presented results it can be said that the differentiation between populations from three geographically distinct and isolated areas is much greater than between the four samples from the Danube, as expected.

Varieties of the pikeperch have not been described in the present literature, except for the pikeperch from Lake Balaton (Deelder & Willemsen 1964). Russian ichthyologists (Berg, Bogdanov, Kozhin & Rass 1949, Belyj 1965) distinguish two biological types of the pikeperch — sedentary and semi-migratory. The latter migrates up- and downstream the river twice a year, entering brackish waters around the river mouth. The main migration occurs before spawning, and another before wintering, although it was noticed that it sometimes stays in the sea during winter. Berg *et al.* (1949) cite that populations from different rivers may show some biological differences, e.g. in growth, maturity, migration time, etc. However, in waters of western Europe no significant biological differences were found from one area to another (Deelder & Willemsen 1964). Nonetheless, it is well-known that all species of the genus *Stizostedion* form multiple populations in the same aquatic system, first of all in larger rivers and lakes, which "home" to their own spawning grounds (Spangler *et al.* 1977). The resulting heterogeneity of spawning sites represents a protective mechanism against certain highly variable environmental factors (Spangler *et al.* 1977).

Experiments with tagging of pikeperches in lakes Vänern (Puke 1952) and Ijssel (Willemsen 1977) also showed that they tend to return to their spawning places from year to year. Collette *et al.* (1977) cite that the pikeperch forms clearly distinguishable spawning populations, which was proved by experimental tagging, as well. Lind (1977) has analysed the pikeperch populations in Finnish waters, and he found that different areas of the same large water bodies can be inhabited by isolated populations, which tend to migrate seasonally due to the changes in the habitat. His findings were also confirmed by monitoring of marked specimens. Migrations in rivers and brackish waters, under the influence of altered environmental conditions, were observed in central and eastern Europe (Deelder & Willemsen 1964). However, apart from some exceptionally long migrations of 82 km registered by Lind (1977) and 120 km by Svärdson and Molin (1973), the average migration distances of the pikeperch do not surpass 10-20 km (Puke 1952, Collette *et al.* 1977, Lind 1977, Rundberg 1977, Willemsen 1977).

The above data imply that population heterogeneity in the pikeperch is determined by reproductive behaviour and microhabitat preferences of spawners. Our results of the variability analysis of morphological characters and presented data from literature (first of all having in mind the so-called "homing" effect — returning to the same spawning place from year to year), suggest that four samples from the Yugoslav part of the Danube most probably represent four distinct populations. The intrapopulation variability at sections I and IV needs further research, considering the extent of these two sections. The presence of reproductive isolation still has to be proved through experimental marking. However, at present we cannot say anything about the genetic basis of this variability. Since this analysis takes into account only the phenotypic variation, it would be necessary to study the genetic differentiation between populations, as well, by biochemical (electrophoresis) methods or DNA-sequencing methods.

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