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MORPHOLOGICAL CHARACTERISATION OF SALMON (*SALMO SALAR* L., 1758) AGED 0+, 1+ AND 2+, STOCKED IN POMERANIAN RIVERS

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ABSTRACT

Characterisation of salmon (*Salmo salar*) aged 0+, 1+, 2+, stocked in Pomeranian rivers, involved 25 plastic and 13 meristic characters, the opercular bone arrangement, and coloration. Coloration of body and fins, appearing at the age of 0+ at the fork length of 6-10 cm belonged to the earliest species-specific traits. Typical values of certain species-specific characters, such as tail base width, caudal fin incision (as per cent of *l. caudalis*), and the length of the upper jaw (as per cent of *l. capitis*) were recorded as early as in the fish aged 0+. Other characters, such as the opercular bone arrangement, were observed in those individuals aged 1+ and only in some fish aged 0+. The typical salmon anal fin shape occurred in some of the salmon aged 1+ and 2+ only. The study showed a high variability and significant differences in meristic and plastic characters between individuals grown in various rivers.

Key words: *Salmo salar*, meristic characters, plastic characters, coloration.

INTRODUCTION

The salmon *(Salmo salar*), representing the family Salmonidae, are highly commercially valuable fish that occur in some Pomeranian rivers [2, 8, 9]. The last natural salmon populations in Polish rivers perished in the mid-1980s; stocking the Polish rivers with salmon originating in the Daugava began in 1994 [3]. At present, measures taken to restitute the natural populations are in progress [1, 2, 3, 11]. There is ample literature concerning the

salmon. The data reported pertain most frequently to smolting process, distribution, appearance, and biology of adults [7, 4, 6]. At the genomic level, various salmonids differ in the number of chromosomes [24], protein polymorphism [31], and mitochondrial DNA structure [21]. On the other hand, field identification of the fish requires a straightforward and easy method. Methods involving plastic and meristic characters would be very helpful in this respect. A number of such methods have been developed. However, this work illustrates a case of salmon juveniles originating from another, remote population, that have recently been stocked to new habitats and provides an excellent opportunity to compare the new arrivals with adults and juveniles grown in the rivers that support natural salmon populations.

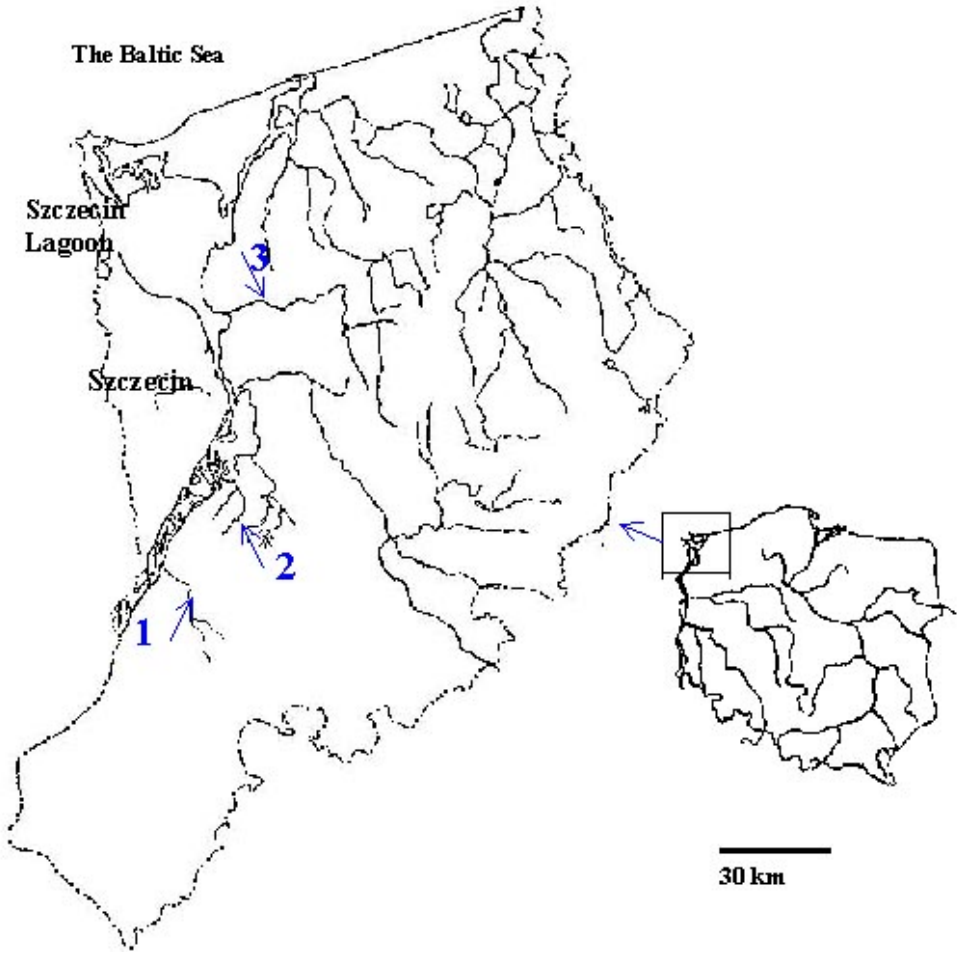
This work was aimed at characterising species-specific characters of salmon juveniles stocked in Pomeranian rivers and at developing criteria aiding in identification of live fish and distinguishing them from other salmonids, particularly the sea trout also present in Pomeranian rivers.

MATERIALS AND METHODS

The salmon used in restitution activities in Polish rivers originates from River Daugava [3]. The stocking material imported was at the stage of eyed eggs. Some of that batch gave rise to a freshwater spawning stock used for reproduction, while the rest, at the smolt stage, were released to rivers; they subsequently returned from the sea as spawners. Gonadal products obtained from individuals from both groups were mixed, incubated, and grown out together. This is the origin of the stocking material used in this work. The very early summer fry were released to the downstream Odra tributaries, to be subsequently harvested by electrofishing or a gill net.

The analysis involved the fish aged 0+, 1+, and 2+ caught in Western Pomeranian rivers (Fig.1). The entire material consists of the stocked salmon from the "Aquamar" Fish Farm at Miastko, the largest Polish centre of salmon stocking material [3]. As stipulated by the artificial spawning technology, the egg and sperm were obtained from numerous individuals, so the newly hatched larvae are genetically diverse, non-uniform. The newly hatched larvae were released to rivers that had been surveyed before [3]. When dealing with trout, the fry generated by gonadal products of spawners caught in a river are released back to the same river. This principle is not, however, applied to salmon as yet since salmon stocking is at present at an early stage of development.

Fig. 1. Area of fish capture : 1 - Pniewa River, 2 - Chojnówka River, 3 - Gowienica River



The analysis presented in this work concerns a total of 182 salmon individuals caught in 1995-1999 (Table 1). The harvested fish were weighed and measured; the external appearance of some of them was described and all were preserved. The preserved individuals were subjected to a conventional morphometric analysis (Table 2) [4, 6, 17, 30] involving 22 linear measurements, 11 meristic characters, opercular bone arrangement as in Brylińska [6], and the anal fish shape [22]. In addition, measurements were taken on the first anal fin ray and a section between the beginning of the first ray and the tip of the last one on that fin (the p-k distance) [19].

Table 1. Summary of materials used in the study

Location	Date of catch	Age	Number (n)	Caudal length (cm)		Body weight (g)		Condition factor	
				mean	S.D.	mean	S.D.	mean	S.D.
Pniewa	09.1995	0+ (parr)	80	10.22	1.02	12.63	3.66	1.13	0.44
Chojnówka	03.1996	1+ (parr)	52	9.98	1.53	12.28	6.04	0.81	0.06
Gowienica	04.1998	1+ (smolt)	29	16.26	1.98	43.54	16.33	0.97	0.07
Gowienica	04.1999	2+ (smolt)	21	18.14	1.43	72.10	17.27	1.13	0.09
Total	182								

Table 2. Morphometric and meristic characters

Character	Character Code	Character	Character Code
Longitudo totalis	Tl	*Numerus radiorum pinnae analis*	A
Longitudo caudalis	Fl	*Numerus radiorum pinnae pectoralis*	P
Longitudo corporis	Sl	*Numerus radiorum pinnae ventralis*	V
Longitudo capitis	lc	*Longitudo basis D*	LD
Altitudo corporis maxima	H	*Altitudo D*	AD
Altitudo corporis minima	h	*Longitudo P*	LP
Latitudo corporis maxima	laco	*Distantia P-V*	P-V
Longitudo pedunculi caudalis	lpc	*Numerus squamarum ordinum longitudinalium*	ll
	hc		s
Altitudo capitis	lac	*Numerus squamarum supra lineam lateralem*	i
Latitudo capitis	lmx	*Numerus squamarum infra lineam lateralem*	squ
Longitudo maxilae superioris	lmd	*Numerus squamarum supra lineam laterales, infra pinnae adiposa*	a, b, c
	pro		Sp.branch.
Longitudo mandibulae	poO	*Numerus spinarum ad arcum branchii**	RB
Spatium praeorbitale	O	*Numerus spinarum ad arcum branchii*	lxA
Spatium postorbitale	pD	*Numerus radiorum branchialis*	p-k
Diameter oculi	D	*Longitudo maximum radiorum pinnae A*	Ap.pyl.
Distantia praedorsalis		*Distantia p-k**	
Numerus radiorum pinnae dorsalis		*Numerus appendicum pyloricorum*	

* Explanation in the text.

The first gill arch filtration processes count, excluding the first rudimental arch, is a genetically determined trait helpful in identifying of, e.g., salmonids [5, 6, 17, 18, 23]. To more precisely determine the number, type, and distribution of the processes on the first arch, the arch nodes (sections a and c on the tips of the arch) and well-developed processes (section b in the mid-part) were counted [19].

Owing to the small size of the salmon in this study, the fin ray counts do not distinguish between hard and soft rays.

The measurements were taken with a callipers, to 0.1 mm, on the left side of the body. Mean values, standard deviation, and the fish condition coefficients are presented. The latter was calculated using the formula $K=W \cdot 100 \cdot L^{-3}$ where W is the body weight (g) and L is the fork length (*l. caudalis*; cm) [14]. The head parameters are expressed as % *longitudo capitis*, while body parameters are converted to % *longitudo caudalis* [5, 6], so that the age- and habitat-dependent dynamics of various fish characters could be followed, the habitat dependence being taken as differences between trophic status and environmental conditions of the rivers from which the salmon was harvested [4].

Ranges of the characters studied in the salmon of known age, coupled with habitat characteristics, allow to determine patterns useful in the species identification and will aid in comparisons with salmon individuals from

other areas of Poland. Linking character variability with age and place of origin is an additional factor which will broaden the characteristics of juvenile salmon stocked in Pomeranian rivers. The quantitative parameters expressed as relations (percentages) allowed to analyse statistical significance of differences in selected salmon characters between age groups and between the rivers of origin. The number and distribution of smaller and larger spots on the operculum and on the sides of the body were analysed on both the right and left side.

The morphometric characters were determined from observations under the stereomicroscope. Statistical analyses (ANOVA, Mann-Whitney U test) were run with the Statistica 5.5 software.

RESULTS

Coloration

When describing the external appearance of the juvenile salmon stocked in Pomeranian rivers, a particular attention was paid to coloration of the body and fins as well as to the number, distribution, and colour of larger and smaller spots. The 0+ salmon, measuring (*l. caudalis*) from 4.1 to 10.0 cm were light grey to olive green in colour and bore from 8 to 12 dark-grey, oval juvenile spots. The spots were present on, above, and below the lateral line. The 0-10 spots above the lateral line were red or black. Those on the lateral line, 0 to 6 (most frequently 3-4), were red or red-grey, while the spots below the lateral line (0-3) were most often red. The operculum most frequently showed 2 spots. The dorsal and adipose fins of the salmon aged 0+ lacked spots.
The parr salmon aged 1+ showed 0-13 spots on the dorsal fin, 8-12 on the lateral line, and numerous spots above (16-44) and below (4-12) it; there were also 8-12 juvenile spots. The operculum showed 1-3 round or kidney-shaped black spots.

The smolts aged 1+ and 2+ were similar in coloration. While the adipose fin was colourless, the pectoral, dorsal, and caudal fins were light grey with dark grey rim. The body was silver in colour, with no juvenile spots or spots on and above the lateral line. Some smolts showed a few very fine dark spots above the lateral line. The operculum featured a single spot, while the dorsal fin showed 0-11 spots. The difference in the number of spots between the right and left side of the body ranged from 1 to 4. Beyond the dorsal fin, all the salmon had spots above the lateral line only (Table 3).

Table 3. Salmon coloration

Character			0+ *		1+ [1] **		1+ [2] 2+	
			mean range	S.D.	mean range	S.D.	mean range	S.D.
Spots	on dorsal fin		0	0	7.43 0-13	4.35	6.13 0-11	5.17
	above the lateral line	L	1.7 0-6	2.6	26.0 16-42	8.4	1.55 0-4	1.57
		R	1.8 0-10	3.7	26.4 16-44	7.7	2.91 0-5	1.97
	on the lateral line	L	2.6 0-6	1.7	10 8-12	1.4	0	0
		R	1.9 0-6	1.8	10.2 9-12	0.9	0	0
	below the lateral line	L	1 0-3	1.1	8 5-12	2.4	0	0
		R	0.6 0-3	1.1	8.5 4-12	2.5	0	0
	on the of the opercular bones	L	1 0-2	0.5	1.6 1-3	0.8	1 0-1	0.50
		R	1.0 0-2	0.5	1.73 1-3	0.65	1	-
Larval spots		L	9.36 8-12	0.91	8-12	0.54	0	0
		R	9.32 8-12	0.90	8-12	0.76	0	0

L- left side of the body; R - right side of the body; [1] salmon from Chojnówka River; [2] salmon from Gowienica River;
* Coloration 13 indywiduals; ** Coloration 11 indywiduals.

Operculum

Opercular bone arrangement is a species-specific salmonid trait. In salmon, the interopercular bone is wedged between the pre- and subopercular ones. This arrangement was observed in a few individuals aged 0+, the pattern being very clear and concordant with the literature data [6, 22] in the salmon aged 1+ and 2+.

Plastic characters

When analysing plastic characters of salmon, a particular attention should be paid to those traits that make it possible to differentiate between salmon and trout. The juvenile head length was found to range within 19.82-25.70% of *l. caudalis*; the minimum body height range was 4.66-9.24% of *l. caudalis*; the upper jaw length range was 31.36 - 51.28% of *l. capitis;* the pre-opercular distance differed from the eye diameter by a factor of 0.8-1.71. The following plastic characters were increasing from age 1+ to 2+: the tail base length (as % of *l. caudalis*) as well as the head height, lengths of upper and lower jaws, and pre- and post-opercular distances (all as % of *l. capitis*). On the other hand, the head length, P-V distance, and pectoral fin length (all as % of *l. caudalis*) as well as the eye diameter (as % of *l.capitis*) were decreasing with age. Relative to other age groups, smolts aged 2+ featured a shorter, narrower, and higher head, longer jaws (both upper and lower), longer tail base, and shorter pre-dorsal distance, the two smolt groups showing a longer pre- and post-orbital distances (as % of *l. caudalis* and *l. capitis*), compared to the parr salmon. The anal fin shape typical of the adult salmon, with non-overlapping first and last ray, was observed in 43.3 and 72.72% of the salmon aged 1+ and 2+, respectively (Table 4). The first anal fin ray in all individuals aged 0+ was longer than the p-k distance (Table 5).

Table 4. Relative length of various parts of the salmon body

Character	0+		1+ [1]		1+ [2]		2+	
	mean range	S.D.	mean range	S.D.	mean range	S.D.	mean range	S.D.
Plastic characters, as % *longitudo caudalis*								
Longitudo totalis	107.16 94.62-118.23	2.79	104.77 103.09-108.18	1.02	106.11 104.00-108.09	1.15	104.14 102.06-106.12	1.05
Longitudo capitis	22.77 19.82-25.70	1.16	23.82 22.06-25.61	0.85	22.98 21.53-24.56	0.85	20.91 20.00-22.70	0.59
Altitudo corporis maxima	21.32 16.88-29.07	1.72	19.23 16.25-21.74	1.09	20.59 18.90-22.54	0.85	20.04 15.53-22.87	1.44
Alttitudo corporis minima	7.36 4.66-8.95	0.72	8.47 7.32-9.43	0.46	7.85 7.19-8.77	0.36	8.29 6.85-9.24	0.47
Latitudo corporis maxima	12.69 10.45-17.50	1.29	11.40 9.41-13.33	0.95	13.58 11.72-16.54	1.30	11.12v 8.22-13.16	1.08
Longitudo pedunculi caudalis	12.31 9-73-19.21	2.01	15.60 12.79-18.64	1.26	15.75 13.67-17.61	1.00	18.07 13.46-20.12	1.54
Longitudo maxilae superioris	8.63 6.79-10.16	0.77	10.23 9.09-11.24	0.44	9.54 8.70-11.00	0.55	9.67 7.76-11.04	0.66
Longitudo mandibulae	9.82 8.07-11.40	0.73	12.43 10.91-14.14	0.60	11.48 10.56-12.28	0.47	11.43 9.59-12.64	0.65
Distantia praedorsalis	40.30 34.07-44.47	1.86	41.43 37.50-43.52	1.50	41.09 39.00-42.40	0.83	39.21 31.96-40.88	1.90
Distantia P-V	-	-	28.43 25.61-31.40	1.19	28.23 26.09-30.00	1.10	27.60 21.92-29.35	1.68
Longitudo basis D	12.79 10.25-16.43	1.09	12.13 9.52-13.64	0.83	12.87 10.40-14.08	0.74	11.49 9.13-12.76	0.91
Altitudo D	14.42 11.48-17.34	1.28	17.32 14.81-20.22	1.14	16.01 13.89-18.63	1.20	14.44 11.87-15.98	0.91
Longitudo P	19.28 15.80-21.86	1.27	16.87 11.86-20.00	1.29	18.05 15.83-21.05	1.33	14.38 11.42-15.51	0.86
Plastic characters, as % *longitudo capitis*								
Alitudo capitis	64.15 52.21-76.92	5.01	66.21 59.09-73.33	3.41	58.97 51.52-64.52	3.18	68.61 62.22-73.81	3.35

Table 4. cont.

Latitudo capitis	54.04 46.46-69.30	6.16	49.68 42.86-54.55	2.68	51.09 46.88-54.84	2.02	50.16 45.95-58.97	3.16
Longitudo maxilae superioris	37.87 31.36-43.04	2.70	43.00 38.10-46.43	2.16	41.50 38.71-45.83	1.91	46.57 42.22-51.28	2.21
Longitudo mandibulae	43.05 36.86-49.57	2.70	52.24 46.15-61.54	2.66	50.02 45.45-54.84	2.46	54.84 51.28-58.54	1.74
Spatium praeorbitale	25.67 21.37-31.05	1.72	25.27 20.00-30.43	2.36	27.65 23.33-31.25	1.70	28.13 25.00-30.77	1.57
Spatium postorbitale	51.61 47.62-55.56	2.09	51.61 47.62-55.56	2.09	54.21 50.00-59.38	2.14	55.58 52.78-58.54	1.49
Diameter oculi	22.87 18.86-16.19	1.63	23.20 19.35-26.32	1.68	20.96 18.75-25.00	1.59	19.81 17.17-23.53	1.68
Plastic characters, as % *longitudo totalis*								
Longitudo capitis	21.26 18.44-25.11	1.20	22.74 20.98-24.74	0.83	21.66 20.39-23.26	0.90	19.87 15.35-22.16	1.20
Plastic characters, as % *P-V*								
Altitudo corporis minima	-	-	29.83 25.00-33.33	1.83	27.84 25.64-30.30	1.40	30.09 27.59-33.33	1.43
Plastic characters, as % *diameter oculi*								
Spatium praeorbitale	1.13 0.91-1.45	0.11	1.09 0.8-1.5	1.5	1.32 1.00-1.50	1.2	1.42 1.12-1.71	1.3

[1] Salmon from Chojnówka River; [2] Salmon from Gowienica River.

Table 5. Salmon anal fin measurements

Character	0+		1+ [1]		2+	
	mean	S.D.	mean	S.D.	mean	S.D.
Anal fin first ray (cm)	1.07	0.29	1.77	0.3	2.31	0.17
p-k section * (cm)	1.03	0.3	1.74	0.28	2.37	0.18
Difference ** (cm)	0.04	0.03	-0.22	0.1	-0.06	0.1

[1]Salmon from Gowienica River.
*p-k: the section between the beginning of the anal fin first ray and the end of the terminal ray (cm).
** Difference between the length of the anal fin first ray and the p-k section (cm).

Meristic characters

The juvenile salmon gill arches showed the presence of nodular processes (2-4) at the end of the gill arch as well as the well-developed bony processes (11-19), the total number of all the processes on the first gill arch ranging from 16 to 22 (Table 6).

The salmon examined were similar in their mean fin ray counts. The mean number of scales on, above, and below the lateral line were similar in age groups 0+ and 1+, the means in the salmon aged 2+ being somewhat higher. The number of sub-branchial membrane rays ranged from 9 to 14. The mean pyloric caeca counts ranged from 63.59 (1+) to 67.50 (2+), the absolute range being 51 - 77 (Table 6).

Table 6. Meristic characters

Character	0+		1+ [1]		1+ [2]		2+	
	mean range	S.D.	mean range	S.D.	mean range	S.D.	mean range	S.D.
First gill arch sections								
a	2.63 1-4	0.88	-	-	2.38 2-3	0.5	2.00 1-3	0.63
b	15.13 11-19	2.13	-	-	12.44 12-13	0.51	15.18 13-17	0.98
c	1.42 0-3	0.72	-	-	2.19 2-3	0.4	1.36 1-2	0.50
a+c	4.05 2-6	1.11	-	-	4.56 4-5	0.51	3.36 2-4	0.67
a+b+c	19.18 16-22	1.77	-	-	17.13 16-18	2.75	17.45 15-20	2.16
Numerus radiorum pinnae D	11.39 10-13	0.74	11.50 10-12	0.54	12.34 11-13	0.67	11.76 11-12	0.44
Numerus radiorum pinnae A	9.16 8-10	0.51	9.81 9-11	0.49	9.79 8-11	0.56	9.76 9-10	0.44
Numerus radiorum pinnae P	13.29 12-15	0.62	13.08 13-14	0.27	12.66 11-13	0.55	12.43 12-14	0.60
Numerus radiorum pinnae V	8.96 8-9	0.19	9	0.00	9.07 8-10	0.46	9.14 8-10	0.48
Numerus squamarum in linea lateralis	118.18 112-126	3.65	116.58 112-124	1.75	114.00 106-119	2.95	119.57 113-126	2.99
Numerus squamarum supra lineam laterales	21.96 18-26	1.46	19.79 19-22	0.82	21.14 19-23	0.83	22.81 21-25	1.08
Numerus squamarum infra lineam laterales	19.67 16-22	1.66	18.04 17-19	0.66	19.97 17-22	1.32	23.00 21-24	0.84
Numerus squamarum supra lineam laterals, infra pinnae adiposa	10.99 10-12	0.43	10.27 9-12	0.91	11.17 9-15	0.89	13.62 11-15	0.67
Numerus radiorum branchialis	11.75 10-14	0.93	10.92 9-12	0.62	11.34 9-12	0.77	10.86 10-12	0.73
Numerus appendicum pyloricorum	64.65 51-77	6.15	63.59 56-73	4.54	-	-	67.50 58-77	5.92

[1] Salmon from Chojnówka River; [2] Salmon from Gowienica River.

Table 7. Statistical significance of differences between the analysed characters of salmon aged 0+, 1+ 2+ (ANOVA; Mann-Whitney U test; Statistica 5.5)

Charakter	0+/1+[1]	1+[1]/1+[2]	1+[1]/2+	1+[2]/2+	Charakter	0+/1+[1]	1+[1]/1+[2]	1+[1]/2+	1+[2]/2+
D	*au	I	*au	I	laco/ Fl	I	I	*au	I
A	I	*au	*au	*au	pD/ Fl	I	I	I	I
P	I	I	I	*au	lpc/ Fl	I	I	I	I
V	*au	*au	*u	*au	lmx/ Fl	I	I	I	*au
s	I	I	I	I	lmd/ Fl	I	I	I	*au
i	I	I	I	I	hc/ lc	I	I	I	I
squ.	I	I	I	I	lac/ lc	I	I	*au	*au
ll	*au	I	I	I	lmx/ lc	*au	I	I	I
RB	I	I	*au	I	lmd/lc	I	I	I	I
a	-	-	-	I	pro/ lc	*au	I	I	*au
b	-	-	-	I	poO/ lc	I	I	I	*a
c	-	-	-	I	h/ P-V	-	I	*au	I
a+c	-	-	-	I	P-V/ Fl	-	I	*u	*au
Sp. Branch.	-	I	I	I	lc/ Tl	I	*u	I	I
Tl/ Fl	I	I	*u	I	pro/ O	*au	I	I	I
lc/ Fl	I	I	I	I	LD/ Fl	I	I	I	I
H/ Fl	I	I	I	*u	AD/ Fl	I	I	I	I
h/ Fl	I	I	*au	I	LP/ Fl	I	*u	I	I

[1] Salmon from Chojnówka River, [2] Salmon from Gowienica River.
*no significant difference ($p< 0.05$), I – difference significant($p <0.05$), a – ANOVA,
u – Mann-Whitney U test.

As shown by the results of statistical analysis, the salmon aged 0+, 1+ and 2+ differed significantly ($p<0.05$) in most characters analysed (Table 7), which points to a high variability among the stocked salmon in their freshwater phase of life.

DISCUSSION

Control catches of the parr and smolt salmon in selected rivers showed high survival rates of both groups (30 and 7.5%, respectively) [12]. The successful introduction of the species is evidenced also by gradually increasing catches of adults [2, 3]. For this reason, studies on plastic and meristic characters and colour may be an important component of the characteristics of the salmon introduced into Pomeranian rivers. Papers by numerous authors [6, 7] deal much more frequently with descriptions of adults the species-specific characters of which are well developed and pronounced.

In terms of their colour, the juvenile salmon in Polish rivers are similar to descriptions presented by other authors and concerning selected features, e.g., the presence of red and black spots on the sides of the body [28], and arrangement and number of juvenile spots on the operculum [15, 29]. The coloration and spot pattern of salmon examined in this study is in agreement with the description provided by Šustov [29]. The adipose fin in the Pomeranian rivers' salmon was colourless, which agrees with the description published by Schmidt [26]. The Pomeranian salmon featured from 0 to 3 spots on the operculum, while Šustov [29] reported 1 - 4. The number of juvenile spots in this study was 8-12, other authors reporting 10 - 12 [26, 29] and 7 - 13 [6].

Species-diagnostic characters typical of salmon, e.g., the narrow tail base and the caudal fin incision were visible as early as in the salmon aged 0+. According to Brylińska [6], the salmon head length is equal to, or slightly larger than, the largest body height; it was the case in all the salmon groups examined. The juvenile salmon head was 4.71; 4.4; 4.62, and 5.0 times smaller than the total body length in the salmon aged 0+ and 1+ from the Chojnówka, 1+ from the Gowienica, and 2+, respectively; the adult salmon head length is smaller than the total body length by a factor of 4-5 [6]. The eye diameter in the salmon examined accounted for 22.87, 20.96 and 19.81% of *l. capitis* in age groups 0+, 1+ (from the Gowienica), and 2+, respectively, the percentages being higher than those typical of the adults (14-19%) [6]. The lowest body height to P-V distance ratio was higher than that in the adults: 20.7-27.2 [5]. The upper jaw of the juvenile salmon was proportionally longer than in the adults, as it accounted for 6.79-11.24% of *l. caudalis* in the former versus 6.6-8.7% in the latter [5]. The lower jaw was 8.07-14.14% of *l. caudalis* in the juveniles and 11-15.7% in the adults [5].

The body width of the juvenile salmon was larger than the half of the largest body height, while the corresponding proportion in the adults does not exceed the half of the largest body height [6]. The upper jaw of the salmon examined reached most often to ½ of the eye (or slightly farther in larger fish), but did not extend beyond the eye; according to Šustov [29] and Schmidt [26], the upper jaw extends to the mid-point of the eye only. The relatively smaller head and longer tail base of the salmon smolts, compared to the parr, were similar to the description of smolts [10].

According to Krzykawski et al. [22], rays of the distal part of the salmon anal fin and the most proximal ray do not overlap. In contrast, in the salmon aged 0+ examined in this study, the most distal and the most proximal rays of the anal fin overlapped or the rays touched each other. On the other hand, a half of the fish aged 1+ and more than 70% of the individuals aged 2+ showed the anal fin shape to correspond to the description rendered by Krzykawski et al. [22]. The character in question is thus age-related and is not useful in species identification of the juvenile salmon.

The characteristic arrangement of the opercular bones, corresponding to the literature descriptions [6, 22] was clearly visibly in individuals aged 1+ and older, while few of those aged 0+ showed it.

Meristic characters are the best diagnostic criterion in species identification [6, 17]. The fin ray formula and that of scale count in the adult salmon are as follows:

D III-V 9-12, *A* III-V 7-10, *P* 14-15, 14-15 *V* I-II 7-9, *l. l.* 114 $\frac{22-26}{18-37}$ 138 [5, 16, 27]. The juvenile fin rays could not be divided into hard and soft ones, but – taking into account the total ray count – the values for the dorsal and anal fins were lower than, and those in the pectoral and ventral fins close to, the corresponding counts found in the adults. Ranges of scale counts on and below the lateral line were narrower in the juveniles than in the adults; the upper value of the range in the latter was usually higher. The scale count above the lateral line was very similar to the range recorded in the adults, the lower value of the range being lower in the juveniles. The number of scales in a transverse row above the lateral line below the adipose fin was in smolts aged 2+ similar to that in the adults [6].

Holčik [17], Rosenfeld [25], and Brylińska [6] list the number of processes on the first gill arch among characters useful in species identification. The Pomeranian salmon juveniles showed an average of 19.23 processes (range: 16-22). As reported by Gąsowska [16] and Berg [5], there are 17-24 processes in the adult, while Chełkowska [7] found an average of 20.46 (range: 18-24). The juvenile salmon's first gill arch featured nodular processes, located at the arch tips, and well developed bony processes. The literature, too, describes the processes on the first gill arch of the salmon as bony [6, 7]. A narrower range and a slightly lower mean number of nodular processes in the smolts aged 2+, compared to the fish aged 1+ may indicate that some nodular processes were transforming into bony ones.

The sub-branchial membrane ray count is species-specific in salmonids, hence it is used for identification of intraspecific taxa [25]. The Pomeranian salmon juveniles showed an average of 11.19 (9-14) sub-branchial membrane rays, other averages and ranges being reported in the literature: 11.95 (10-13) [7] or a range of 11-12 [6]. The sub-branchial membrane ray counts in the salmon juveniles examined varied within a broad range, hence the character does not seem to be of much use in identification.

Important in identification of salmon is osteological analysis, examination of the vomer in particular, which has been for many years dealt with in many papers [13]. The analysis of vomer structure showed the teeth to be arranged in a single row, the number of teeth decreasing from the mean of 19 (range: 17-24) in juveniles to 3 (range: 2-4) in adults. The vomer in a few juveniles and 80% of adult salmon was toothless [20].

The pyloric caeca count is, too, one of meristic characters useful in species identification [6, 17]. The pyloric caeca count in the salmon juveniles examined (51-77) was similar to that reported for the adults: 58-77 [5], 56-98 [7], 52-95 (unpublished data of the authors). The coefficient K of the population was found to increase with length and to decrease as the parr were transformed into smolts, hence – due to varying fish body length – it was of marginal value in this study.

CONCLUSIONS

The analysis of salmon, aged 0+, 1+ and 2+ , stocked in Pomeranian rivers showed a high intraspecific variability of the species, the variability being seen both in plastic and meristic characters. The study showed some diagnostic species-specific characters, such as the operculum bone arrangement, anal fin shape, and the scale count in a transverse row below the adipose fin, to be at a formative stage in salmon juveniles. For this

reason, an appropriate characterisation of salmon juveniles calls for analysing a set of characters; a correct interpretation is possible only when this approach is adopted. A combination of plastic, meristic, and coloration-related characters allows to identify the stocked salmonid juveniles to species with a high degree of certainty. The study made it possible to pinpoint the following typical salmon characters:

1. Coloration was one of the earliest species-specific characters.
   Salmon aged 0+: 8 - 12 juvenile spots; 0 - 7 spots (most often 3 - 4) on the lateral line; 0 - 3 spots below the lateral line; 0 - 2 spots (most often 2) on the operculum; no spots on the dorsal and adipose fins.
   The parr salmon aged 1+ carried 8 - 12 juvenile spots, 0 - 13 spots on the dorsal fin; 16 - 44 spots above the lateral line; 8 - 12 spots on the lateral line; 4 - 12 spots below the lateral line; 1 - 3 spots on the operculum.
   Coloration of smolts aged 1+ and 2+ was similar: body silver in colour, no juvenile spots, 0 - 11 spots on the dorsal fin; occasionally few fine dark spots, irregular in shape, above the lateral line; no spots on and below the lateral line. The pectoral, dorsal, and caudal fin light-grey with dark-grey edges.
2. The caudal fin with a large incision; tail base narrow (4.66 - 9.43% of *l. caudalis)*
3. The upper jaw extending to the mid-point of the eye or slightly farther.
4. The fin ray count formulae and those of scale count in various age groups were as follows:

parr 0+: *D* 10-13, *A* 8-10, *P* 12-15, *V* 8-9, *l. l.* 112 $\frac{18-26}{16-22}$ 126,

parr 1+: *D* 10-12, *A* 9-11, *P* 13-14, *V* 9, *l. l.* 112 $\frac{19-22}{17-19}$ 124,

smolt 1+: *D* 10-13, *A* 8-11, *P* 11-13, *V* 8-10, *l. l.* 106 $\frac{19-23}{17-22}$ 119,

smolt 2+: *D* 11-12, *A* 9-10, *P* 12-14, *V* 8-10, *l. l.* 113 $\frac{21-25}{21-24}$ 126

5. The scale counts in a transverse row from the lateral line to the adipose fin were as follows: parr 0+: 10-12 (10.99)
   parr 1+: 9-12 (10.27)
   smolt 1+: 9-15 (11.17)
   smolt 2+: 11-15 (13.62)
6. 16-22 processes on the first gill arch.
7. 9-14 sub-branchial membrane rays.
8. 51-77 pyloric caeca.
9. Ranges of ray counts in the dorsal and anal fins were lower than those in the adults, the pectoral and ventral fin ray counts being similar to those in the adults. Ranges of scale counts on and below the lateral counts were narrower than those in the adults, the ranges of scale counts above the lateral line being similar to those in the adults.
10. A characteristic arrangement of opercular bones was possible to observe in those individuals aged 1+ and only in some aged 0+.

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