BOŻENA CHEŁKOWSKA

STUDIES ON MORPHOLOGY AND BIOLOGY OF SALMON,
SALMO SALAR L. IN THE RIVER DRAWA

STUDIA NAD MORFOLOGIĄ I BIOLOGIĄ ŁOSOSIA
SALMO SALAR L. RZĘKI DRAWY

Results of studies on plastic (measurable), meristic (countable), and biological characters of salmon (*Salmo salar* L.) in the river Drawa, a fourth-order tributary of the Odra, are presented. The studies were carried out on 304 salmon individuals caught during 15 spawning seasons (1961–1975). Additionally, seasons of salmon inland migrations are presented.

INTRODUCTION

To date, the river Drawa salmon has not been subject to morphologic studies. It is justified to suppose then that the present work will be of importance when attempting to determine the variability ranges of characters most useful in taxonomy of the species. Kaj (1961) found it purposeful to undertake such studies on the river Drawa salmon. The pertinent research problems presented by Rosa (1965) were in 1974 accepted by the Ana. Kat. Cttee ICES as a model on which to base studies on the Atlantic salmon.

The materials on the Drawa salmon biology are rather abundant but, as can be judged from the literature available, are insufficient in several respects.

A REVIEW OF PREVIOUS STUDIES ON THE DRAWA SALMON

Early information on the occurrence of salmon in the Drawa stems from the late nineteenth century (Gerhardt, 1893; Grotrian, 1901, 1907; Krause, 1911; Seligo, 1926). At that time, however, salmon and trout were not distinguished as separate species (Kaj, 1953); thus the materials are of a minor scientific value only. The papers published

on the Drawa salmon after the World War II dealt mainly with spawning areas and migration range (Chrzan, 1947; Kaj, 1953, 1954; Walczak, 1954), catches and egg yields (Stankiewicz, 1949; Kaj, 1953), and physiography (Kaj, 1948, 1954; Przybył 1976). Salmon-trout quantitative relationships were worked out by Kaj (1954), Iwaszkiewicz (1966), and Chełkowski (1966, 1967), while Żarnecki (1962), Chrzan (1964), and Bartel (1971) studied the Drawa salmon migration. The Drawa salmon biology was treated most extensively by Chrzan (1961, 1962, 1964, 1969), additional information being provided also by Kaj (1962). Recently, the Drawa salmon biology and management have been studied by Chełkowski (1966, 1967a, 1971, 1975) as well as by Chełkowska and Chełkowski (1968–1978).

GENERAL CHARACTERISTICS OF THE DRAWA AND SALMON MIGRATIONS

The Drawa originates in the frontal moraine of the last (Baltic) glaciation, south of Połczyn. The water divide is made up by a highland belt 150–190 m above sea level, constituting the northern boundary of the Drawa catchment relative to the Rega and Parsęta catchment areas. The highest hill in the vicinity of the Drawa springs is 220 m high. A general direction of the Drawa flow is south, from the last glaciation highlands towards the Toruń-Eberswald proglacial stream valley. The total length of the river is 199 km, the straight-line springs-to-mouth distance being 93 km. The river configuration relative to a straight line is 2.1 : 1. The Drawa has 19 tributaries, the catchment area covering 3198.4 km² (Anon., 1949). The catchment relief is belt-like: a frontal moraine belt in the upper part, a bottom moraine in the central part, while the lower part is occupied by a lowland belt constituting, along with the Noteć Lowlands, a so-called Gorzów Valley. The river flow within the frontal moraine section resembles that of a mountain stream. The longitudinal river down grade of the Drawa and its tributaries reaches several (3–5) per mille, the grade decreasing southwards. A mean longitudinal down grade of the Drawa between its spring and confluence with the Noteć is 0.84‰. A characteristic feature of the catchment is a considerable forestation. A mean annual precipitation as measured in Drawno (central part of the Drawa catchment area) is 592 mm, the maximum and minimum precipitation occurring in summer and winter, respectively. Extremal precipitation values for 1881–1930 show a large variability from month to month. The air temperatures in the warmest and coldest months (July and January, respectively) are 17.4°C and 2.0°C, respectively. A mean annual air temperature is 7.4°C (Prawdzcic, 1967). In summer 1977, the tributaries water temperature varied considerably with the air temperature variation, ranging within 8–19°C (26 measurements in streams) and 16.3–21.2°C (19 readings in the lower Drawa). The physico-chemical assays of the lower Drawa water sampled in spring and summer 1975 close to the salmon spawning areas indicated the water to be suitable for a salmonid culture.

The Drawa is connected with the open Baltic via the lower Noteć with which it converges as its right-bank tributary, lower Warta and Odra, and the Szczecin Lagoon.

The Drawa confluence with the Noteć is about 340 km inland off the sea coast, as measured along the rivers and water bodies mentioned above. At Kamienna, 30.8 km upstream of the mouth, a weir totally stopping the preliminary salmon migration is located. A fishway in the weir chamber, modernised as it was in 1950 (Przybył, 1976), fails to fulfill its task. So far, there is no proof whatsoever that the salmon do overcome this obstacle. Salmon spawning grounds are located in the lower Drawa, below Kamienna, as well as in the lower Płociczna, a left-bank Drawa tributary, converging with the Drawa below the dam at Kamienna (Fig. 1). The growth of juveniles takes place in the lower Drawa and Płociczna as well. Smolts from this part of the basin enjoy an open way towards the Baltic. Moreover, a homing migration into the Drawa and Płociczna of the sea-grown salmon is unhampered by any technical obstacle. A serious obstacle for the Drawa salmon migration, however, may be presented by a cooling water run off from a power station near Gryfino, lower Odra, in operation from autumn 1974.

The lower Drawa, particularly its part directly downstream the Kamienna weir, strongly meanders. It is here that, as can be supposed, the lower Drawa salmon spawn. A mean width of this section of the river, with steep banks, is 19 m. A mean flow velocity is about 1 m/s.

Typical flows are as follows: mean, $SQ = 16.48 \text{ m}^3/\text{s}$, mean low, $SNQ = 6.59 \text{ m}^3/\text{s}$, lowest, $NNQ = 3.30 \text{ m}^3/\text{s}$.

Phot. 1 The Lower Drawa River. Region of Salmon spawning grounds.

(Phot. by Z. Chełkowski)

The bottom of the river is sandy with numerous patches of gravel and stones, the latter sometimes large-sized. A mean depth is 1 m. The benthos is dominated by *Gammarus pulex* L. Typical aquatic plants are *Elodea canadensis* Rich. and *Potamogeton* sp. Fish-wise, the lower Drawa is a *Barbus barbus* country, the species contributing markedly to the ichthyofauna of the area. (Photo 1).

Salmon spawning grounds in the Płociczna lie in its lower part past the Lake Ostrowiec and directly down an old eel barrier located 12.8 km from the river mouth (Chełkowska and Chełkowski, 1974). Mean width and depth of the stream in the spawning ground area are 6 m and 0.5 m, respectively. The bottom in the area is muddy with numerous patches of gravel and stones. Banks are well-marked, at places steep and precipitous. Both the benthic fauna and aquatic vegetation are similar to those occurring in the Drawa down the Kamienna weir. (Photo 1a.2).

Phot. 2 The Płociczna River. The left-side affluent of Drawa River. Region of Salmon spawning-grounds.

(Phot. by Z. Chełkowski)

MATERIALS AND METHODS

The studies were carried out on salmon from the lower section of the Drawa, caught during 15 spawning seasons (1961–1975). The fishes were caught with a seine over a 3.7 km-long section of the river, directly past the Kamienna weir (Fig. 1). Additionally, in 1964 and 1965 individuals caught in the lower Drawa by an electric device were examined (Chełkowska and Chełkowski, 1974). All the individuals caught were to be used for reproduction; they were therefore kept in a storage tank until fully mature. After extracting the gonads the fishes were killed and delivered to the market. As from 1965, the market was supplied by those individuals only that had died when kept in cages, the remaining ones being released back to the river (Chełkowska and Chełkowski, 1969–1977).

The initial task was to identify the species; identification was based on Berg (1948), Chełkowski (1964), Jokiel (1958), Schechtel (1925, 1926), and Żarnecki (1961) (Fig. 2). The number of individuals caught over the 15 years of research is presented in Table 1. As

Fig. 1. Route of salmon inland migration; spawning grounds and fishing grounds of salmon

Fig. 2. Drawa salmon during spawning; body outlines a) female No. 119; length 1112 mm; weights: 12900 g (before gutting), 12064 g (gutted) b) male No. 89; length 1080 mm; weights: 10910 g (before gutting), 10220 g (gutted)

seen from the Table, out of the total of 344 individuals of anadromous salmonids, 304 (88.37%) were classified as salmon, and 40 (11.63%) as trout. The total weight of the salmon studied was 3.7 t.

A morphological examination involved analysing plastic (measurable) and meristic (countable) characters as well as shape and proportions of some parts of the body, and fish colouration.

Plastic characters were determined by taking linear measurements as recommended,

Table 1

Salmonid catches in the Drawa
(numbers of individuals caught)

Year	Salmon			Trout
	Females	Males	Total	
1961	22	20	42	2
1962	35	19	54	23
1963	15	17	32	1
1964	13	10	23	3
1965	35	15	50	2
1966	1	—	1	2
1967	4	6	10	—
1968	10	5	15	3
1969	10	5	15	—
1970	11	4	15	1
1971	8	5	13	—
1972	3	1	4	2
1973	3	3	6	1
1974	6	5	11	—
1975	7	6	13	—
	183	121	304	40

for salmonids, by Smitt (1887) (Fig. 3) and Berg (1948). From each individual 25 linear measurements to the nearest mm were taken (Table 2). The measurements are related to the line called „chord” (Chełkowski, 1967). The measurements taken are presented separately for males and for females as differences between the sexes are conspicuous, particularly during their sexual maturity, which stage all the individuals were found to have attained. The differences were referred to by Meissner (1948), Schechtel (1925), Scheuring (1929), Suvorov (1948), and Smidt (1947). Results of the plastic characters measurements are given as absolute values (Table 3) and relative ones according to Smitt (1887) (Table 2). The latter express the plastic characters as per cent of the caudal length (l. caudalis).

Meristic characters were determined by counting relevant morphologic elements. The calculations were made on a total of 42 characters (Table 4) listed by many authors in their studies on migrating *Salmo* species (Berg, 1948; Chełkowski, 1970; Jokiel, 1958; Kaj, 1961a, Rosa, 1965; Schechtel, 1925; Żarnecki, 1961). The technique of counting morphological elements was based on Berg (1948), Gąsowska (1962), and Staff (1950). The number of longitudinal rows of scales above the lateral line was determined beneath the first hard ray of the dorsal fin and beneath the caudal part of the adipose fin, while the number of scales below the line was counted down to the external edge of the ventral fin. Hard and soft rays counts were obtained from the dorsal (D) and anal (A) fins.

Fig. 3. A diagram of salmon plastic characters measurements

Table 2

Plastic characters
(relative values, %)

No.	I tem	Designation Character	Females		Males	
			Smitt index		Smitt index	
			range	%	range	%
1.	ab	Fish length				
2.	ac	Head length	17.87 – 22.07	19.54	19.10 – 27.17	24.22
3.	a ₅ d	Central head part length	10.72 – 13.73	12.08	12.11 – 15.48	13.90
4.	gh	Longitudinal eye diameter	1.91 – 2.36	2.13	2.21 – 2.52	2.35
5.	ef	Transverse eye diameter	1.65 – 2.13	1.88	1.79 – 2.03	1.93
6.	ag	Snout length	6.34 – 8.53	7.33	7.39 – 12.90	11.16
7.	a ₅ i	Upper jaw length	6.31 – 8.42	7.00	6.88 – 9.96	8.80
8.	mn	Upper jaw width	1.08 – 1.60	1.35	1.24 – 1.99	1.53
9.	kl	Lower jaw length	10.35 – 12.66	11.38	14.41 – 17.80	16.02
10.	aq	Snout-dorsal fin distance	36.49 – 47.70	42.63	41.07 – 48.26	45.12
11.	uw	Anterior ventral part length	27.17 – 34.57	30.97	25.92 – 32.10	28.64
12.	aw	Snout-ventral fin distance	44.89 – 56.11	49.82	49.60 – 54.39	52.03
13.	wy	Posterior ventral part length	16.27 – 24.41	20.81	17.50 – 21.55	19.50
14.	γδ	Tail dorsal margin length	9.23 – 13.00	10.73	8.17 – 11.07	9.73
15.	αθ	Tail side length	16.36 – 20.12	17.91	14.08 – 18.59	16.88
16.	zε	Tail ventral margin length	9.35 – 13.77	11.01	8.25 – 11.90	10.18
17.	ξη	Smallest body height	6.16 – 7.67	6.74	5.87 – 7.82	6.81
18.	qr	Dorsal fin base length	9.42 – 11.69	10.45	8.85 – 11.09	10.10
19.	st	Dorsal fin length	7.45 – 10.12	9.03	6.70 – 10.49	9.25
20.	uv	Pectoral fin length	8.01 – 12.17	10.84	9.84 – 13.10	11.10
21.	vx	Ventral fin height	7.99 – 10.42	9.24	8.83 – 11.12	9.65
22.	yz	Anal fin base length	7.06 – 9.62	8.57	7.33 – 8.93	8.01
23.	αβ	Anal fin height	7.74 – 10.32	8.86	7.83 – 10.87	9.44
24.	θb	Shortest caudal fin central rays length	5.71 – 7.83	6.69	5.57 – 9.12	7.10
25.	ιχ	Longest caudal fin rays length	11.56 – 14.56	13.28	11.59 – 14.44	13.29
		Additional measurements:				
26.	g ₁ h ₁	Longitudinal iris diameter	1.35 – 1.81	1.60	1.32 – 1.77	1.55
27.	e ₁ f ₁	Transverse iris diameter	1.32 – 1.81	1.56	1.32 – 1.63	1.49

Table 3

Plastic characters
(absolute values, mm)

No.	Item	Females			Males			Total		
		M ± m	δ	φ	M ± m	δ	φ	M ± m	δ	φ
1.	ab*	1034.56 ± 8.19	73.74	7.13	1107.15 ± 14.37	98.53	8.90	1061.21 ± 7.99	90.42	8.52
2.	ac	202.32 ± 2.00	18.00	8.90	268.45 ± 4.43	30.38	11.32	226.60 ± 3.49	39.53	17.44
3.	a ₅ d	125.09 ± 1.21	10.93	8.73	153.96 ± 2.23	15.26	9.91	135.69 ± 1.66	18.83	13.88
4.	gh	22.04 ± 0.10	0.89	4.02	25.94 ± 0.27	1.87	7.21	23.47 ± 0.20	2.31	9.83
5.	ef	19.37 ± 0.11	0.95	4.93	21.04 ± 0.32	2.21	10.34	20.12 ± 0.16	1.82	9.05
6.	ag	75.95 ± 0.92	8.26	10.87	123.74 ± 2.33	16.00	12.93	93.50 ± 2.29	25.90	27.70
7.	a ₅ i	72.41 ± 0.73	6.55	9.04	97.57 ± 1.70	11.68	11.97	81.65 ± 1.33	14.99	18.36
8.	mn	13.89 ± 0.15	1.34	9.66	16.96 ± 0.34	2.32	13.69	15.02 ± 0.20	2.30	15.31
9.	kl	117.79 ± 1.24	11.18	9.49	177.51 ± 2.91	19.93	11.23	139.72 ± 2.87	32.53	23.28
10.	aq	440.91 ± 3.49	31.45	7.13	499.89 ± 7.47	51.24	10.25	462.57 ± 4.32	48.88	10.57
11.	uw	320.14 ± 2.69	24.17	7.55	317.19 ± 4.75	32.55	10.26	319.05 ± 2.43	27.45	8.60
12.	aw	515.22 ± 4.23	38.06	7.39	576.34 ± 7.95	54.49	9.45	537.66 ± 4.73	53.51	9.95
13.	wy	215.20 ± 2.32	20.84	9.68	215.57 ± 3.15	21.58	10.01	215.34 ± 1.86	21.03	9.77
14.	γδ	110.94 ± 1.07	9.63	8.68	107.57 ± 1.48	10.15	9.43	109.70 ± 0.88	9.91	9.04
15.	αθ	185.20 ± 1.59	14.28	7.71	186.87 ± 2.85	19.55	10.46	185.81 ± 1.45	16.36	8.80
16.	zε	113.86 ± 1.30	11.68	10.26	112.85 ± 2.21	15.13	13.41	113.49 ± 1.15	13.00	11.46
17.	ξη	69.77 ± 0.61	5.49	7.87	75.36 ± 1.10	7.54	10.00	71.82 ± 0.61	6.85	9.54
18.	qr	108.14 ± 1.01	9.09	8.40	111.79 ± 1.73	11.83	10.58	109.48 ± 0.91	10.29	9.39
19.	st	93.25 ± 0.84	7.58	8.13	102.19 ± 1.32	9.04	8.84	96.53 ± 0.81	9.19	9.52
20.	uv	112.04 ± 1.15	10.35	9.24	122.68 ± 1.63	11.21	9.14	115.95 ± 1.04	11.81	10.19
21.	wx	95.64 ± 0.97	8.73	9.13	106.70 ± 1.45	9.94	9.31	99.70 ± 0.94	10.60	10.64
22.	yz	88.65 ± 0.84	7.52	8.84	88.74 ± 1.36	9.35	10.53	88.69 ± 0.72	8.20	9.25
23.	αβ	91.65 ± 0.95	8.59	9.37	104.21 ± 1.60	10.97	10.53	96.27 ± 1.00	11.27	11.71
24.	θb	69.25 ± 0.78	7.06	10.19	78.45 ± 1.18	8.09	10.31	72.62 ± 0.76	8.65	11.92
25.	ιχ	137.44 ± 1.31	11.78	8.57	147.11 ± 2.14	14.66	9.97	140.99 ± 1.52	17.24	12.23
Additional measurements										
26.	g ₁ h ₁	16.52 ± 0.13	1.17	7.11	17.13 ± 0.17	1.17	6.84			
27.	e ₁ f ₁	16.05 ± 0.12	1.05	6.53	16.51 ± 0.11	1.10	6.67			
n ♀ = 81				n ♂ = 47						

*description of characters: see Table 2.

Table 4

Meristic characters																
No.	Characters		Females				Males				Total					
			M ± m	δ	V	Range	n	M ± m	δ	V	Range	n	M ± m	δ	V	Range
1	No. of scale rows above l.l.	26	21.6			20–25	17	22.4			19–28	43	21.9			19–28
2	No. of scales in l.l.	26	121			118–126	19	121.6			119–126	45	121.3			118–126
3	No. of scale rows below l.l.	26	22.6			18–26	18	22.6			19–26	44	22.6			18–26
4	No. of scale rows on tail above l.l.	72	11.7			11–13	57	11.9			11–14	129	11.8			11–14
5	Dorsal fin hard rays count	68	III			III–IV	44	III			III–IV	112	III			III–IV
6	Dorsal fin soft rays count	68	10.2			8–11	44	9.1			8–10	112	9			8–11
7	Anal fin hard rays count	69	III			III–IV	46	III			III–IV	115	III			III–IV
8	Anal fin soft rays count	69	8.1			7–9	46	8			7–9	115	8			7–9
9	Subbranchial membrane rays count	91	12			11–13	62	11.8			10–13	153	11.95 ± 0.0476	0.5888	4.93	10–13
10	xxx head; number	25	15.8			5–32	25	18.5			8–39	50	16.9			5–39
11	φ (mm) of largest one	25	—			1–11	25	—			1–14	50	—			1–14
12	shape:	25	circular, oval, kidney-like, irregular			—	25	circular, oval, kidney-like, irregular			—	50				—
13	xxx trunk above l.l.; number	25	104			37–230	25	149			81–308	50				37–308
14	φ (mm) of largest one	25	—			2–16	25	—			1–13	50				1–16
15	shape:	25	circular, oval, irreg., star-, clover leaf-like, x, xx-shaped			—	25	circular, oval, irregular, star-, kidney-like			—	50				—
16	xxx trunk below l.l.; number	25	14			2–47	25	15			0–31	50				0–47
17	φ (mm) of largest one	25	—			1–24	25	—			1–24	50				1–24
18	shape:	25	circular, oval, irregular, x-shaped			—	25	circular, oval, irregular, kidney-like			—	50				—
19	xxx tail above l.l.; number	25	18			8–31	25	25			9–53	50				8–53
20	φ (mm) of largest one	25	—			2–6	25	—			2–7	50				2–7
21	shape:	25	circular, oval, irregular, x-shaped			—	25	circular, oval, irregular			—	50				—
22	xxx tail below l.l.; number	25	—			0–1	25	—			0–3	50				0–3
23	φ (mm) of largest one	25	—			1	25	—			6	50				1–6
24	shape:	25	irregular			—	25	circular, irregular			—	50				—
25	xxx dorsal fin; number	25	9			4–14	25	6			4–14	50				4–14
26	φ (mm) of largest one	25	—			1–13	25	—			2–10	50				1–13
27	shape:	25	circular, oval, irregular			—	25	circular, oval, irregular			—	50				—
28	First gill arch processes count	78	20.4			18–24	45	20.6			18–23	123	20.46 ± 0.0975	1.0812	5.28	18–24
29	First gill arch lamellae count: external	72	111.54 ± 0.9488	8.0511	7.22	85–127	43	113.81 ± 0.9851	6.4599	5.68	98–124	115	112.39 ± 0.7038	7.5472	6.72	85–127
30	internal	72	120.00 ± 1.1187	9.4926	7.91	96–138	39	122.92 ± 1.3688	8.5481	6.95	107–138	111	121.03 ± 0.8770	9.2396	7.63	96–138
31	Pyloric processes count	75	73.4			56–98	46	72.7			60–87	121	73.14 ± 0.6561	7.2172	9.87	56–98
32	Vertebrae count											154	59.01 ± 0.0422	0.5239	0.89	57–60
33	Vomer	62					42					104				
34	Premaxilla teeth count	10				3–4	10				6–13	20				3–13
35	Maxilla teeth count	10				6–7	10				5–22	20				5–22
36	Palate bone teeth count	10				8–9	10				10–13	20				8–13
37	Dental bone teeth count	10				8–9	10				4–21	20				4–21
38	Basihyale teeth count	10				6	10				4–8	20				4–8
39	Mature egg weight (mg)	35 ♀	123			86–163										
40	Mature egg diameter (mm)	35 ♀	5.58			5.1–6.22										
41	Fertilised egg weight (mg)	100	145.74 ± 1.2958	1.2958	8.89	104–177										
42	Fertilised egg diameter (mm)	100	6.25 ± 0.0208	0.2078	3.32	5.55–6.78										

l.l. = lateral line

xxx dark marks on the left side of

Suvorov (1948) is of the opinion that other fins should be disregarded in taxonomic studies. The subbranchial membrane rays were counted on the left side of the body. A good agreement between the coloration, numbers, shape, and sizes of pattern marks on both sides of the body was found, for which reason the meristic characters were examined on the left side of the body only. The analyses on the body surface and on the tail were performed separately above and below the lateral line as well as on the head. The boundary between the trunk and tail was adopted as a line running from the distal edge of the adipose fin to the distal edge of the anal one. The presence of marks on fins was recorded as well.

Having extracted a gill arch, numbers of bony processes as well as of external and internal lamellae were determined. The vomer, after extraction along with a large part of the palate was prepared for the examination according to the technique described by Quednau (1935). Similar procedures were employed when dealing with the operculi extracted for a detailed examination. The vertebrae were counted on a suitably prepared spine, i.e., dissected along with a fragment of the basioccipitale and cleansed of the flesh by rinsing with water of about 100°C. Blown up (1:2) X-ray prints of spines were prepared for the 0+ salmon. The prints obtained were further blown up to a size making it possible to count the vertebrae. In the case of the 1+ salmon, 1:1 X-ray blow-ups were made to count the vertebrae. The procedure of the caudal vertebrae counting was based on Johansson's pattern (Dixon, 1948) for herring, *Clupea harengus*(L.), spine (Fig. 4).

Fig. 4. Salmon female caudal vertebrae (1:1); numbers denote consecutive vertebrae

Egg weight and diameter were also recorded. An egg was weighed on torsion scales to the nearest mg, while the diameter was measured as recommended by Bartel (1971a): a mean value determined from two measurements (larger and smaller diameters).

Shapes of the caudal fin and gill arch processes were also considered in the study. Additionally, location of the maxilla relative to the eye, distribution of scales on the tail, and structure of bones forming the operculum were taken into account. The shape of the hook occurring in males' lower jaw was described, as were shapes of the caudal fin marginal bones. Proportions resulting from the axillar process (*processus axillaris*) length being related to the ventral fins were determined after Schechtel (1925). The procedure involved marking the process length on the ventral fin length. Remarks and observations on skin thickness during the spawning migration and the depth of scale setting were recorded. Additional observations concerned the shape of the pseudo-lid, colour of the body, and that of fins.

The list of biological characters studied, covering 20 items, is presented in Table 5. The gonad development was assessed according to an 8-score Maier scale (Meissner, 1948; Chełkowski, 1974). The caudal length (*longitudo caudalis*) was measured, similarly to the procedure employed for the plastic characters, according to the technique described by Smitt (1887), recommended by Berg (1948), and accepted by the ICES (Anon., 1934). The length, from snout to the tips of the caudal fin ventral rays, was measured to the nearest 0.5 cm.

Table 5

Index of biological characters

No.	Character
1	Season of Capture
2	Gonad maturity stage
3	Sex ratio
4	Spawning season
5	Water temperature during spawning
6	Length (l. caudalis)
7	Body weight, gonad products removed
8	Gutted body weight
9	Intestine weight
10	Liver weight
11	Spleen weight
12	Heart weight
13	Gonads weight
14	Viscera to body weight ratio (%)
15	Spawning migration
16	Condition
17	Age structure
18	Length distribution over age
19	Weight distribution over age
20	Salmon with spawning marks

The fish weight was determined to the nearest 10 g, each individual being weighed after its eggs or sperm were taken out (in those fishes to be released) or after gutting, in which case sometimes both weight indices were recorded. The intestine, liver, heart, and gonads were weighed to the nearest g, while the spleen weight was recorded to the nearest 0.1 g.

Apart from the individuals caught from the Drawa, observations on the salmon caught by Polish fishermen in the Szczecin Lagoon and Lower Odra within the years 1973–1975 are considered (Chełkowski et al., 1976; Chełkowski and Chełkowska, 1977, 1978). Those data concern the spawning and post-spawning migrations of the population under study.

In order to determine the spawning salmon condition, their nourishment coefficient was calculated according to the Fulton formula

$$K = \frac{100 \text{ g}}{L^3}$$

where: g = fish weight (g) without viscera, as suggested by Clark (after Suvorov, 1948) and as opposed to Fulton recommending the total weight,
L = fish weight (*l. caudalis*) (cm).

Only the fresh individuals were measured and weighed. The meristic characters, except the specially prepared vomer and spine (see above), were determined on fresh individuals as well.

The age of the salmon examined was also determined, for which purpose 5–10 scales were removed from an area between the dorsal and adipose fins, directly above the lateral line. Of the removed scales, 2–3 were analysed by first producing a plastic trace as described by Sych (1964). The traces were read twice in order to rule out an interpretational error. The first reading was made on a projected image of the scale trace (17.5 x magnification), while the second one was made under a stereomicroscope (16 x or 25 x magnification) in transmitted light. The readings were made on the oral and lateral parts of a scale. An agreement between the two readings should ensure the correct age determination. The readings were repeated, should any discrepancy occur. In case of an irregular sclerite pattern, a new batch of scales was prepared and the procedure repeated. When reading the fish age, the duration of riverine (r) and marine (m) periods in the fish life were recorded. Marginal increments were denoted by „+”. The salmon age can be thus expressed as

$$W = r.m.+$$

The age determination was performed as suggested by Sych (1971). Annual rings and resorption marks were interpreted after a number of authors (Carlin, 1965; Chrzan, 1969; Jokiel, 1958; Jarvi and Menzies, 1936; Meissner, 1948).

Many meristic, plastic, and biological characters were treated statistically (Ruszczyk, 1955) by calculating their mean values (M), standard errors (m), standard deviations (δ), and coefficients of variation (V), according to the generally known formulae.

The results obtained were discussed against the published reports and papers on the salmon in Polish waters. Thus, apart from the Odra catchment (the Drawa included), the literature dealing with the Vistula (Jokiel, 1958; Schechtel, 1925; Żarnecki, 1963) and Pomeranian rivers opening into the Baltic (Chełkowski, 1965) is included. Papers concerning other areas of salmon distribution (Berg, 1948; Neresheimer, 1941; Vogt, Hofer, 1909; and others) were also considered. Particularly suitable for comparative purposes with respect to morphological characters is the paper by Schechtel (1925) on the Vistula salmon, even in spite of a low number of individuals examined by that author.

RESULTS AND DISCUSSION

Morphological characters

Plastic characters

A total of 128 randomly taken individuals (81 females and 47 males) were measured for their plastic characters determination. Those individuals were found to be distributed over 13 length classes (Table 6). Extremal values for females and males ranged within 846–1255 mm and 937–1408 mm, respectively, the means being 1034.56 ± 8.19 mm for females and 1107.15 ± 14.37 mm for males; the mean length of males was larger than

Table 6

Number of salmon individuals subject
to plastic characters analysis

Sex Length class	Females	Males	Total	
			ind.	%
801 – 850	1	–	1	0.78
851 – 900	2	–	2	1.56
901 – 950	7	1	8	6.25
951 – 1000	23	4	27	21.10
1001 – 1050	12	6	18	14.06
1051 – 1100	19	13	32	25.00
1101 – 1150	14	9	23	17.97
1151 – 1200	2	7	9	7.03
1201 – 1250	–	4	4	3.13
1251 – 1300	1	–	1	0.78
1301 – 1350	–	2	2	1.56
1351 – 1400	–	–	–	–
1401 – 1450	–	1	1	0.78
Total:	81	47	128	100.00

that of females. The absolute values for several characters showed the mean lengths of the anterior ventral part (uw), dorsal margin of the tail ($\gamma\delta$), and ventral margin of the tail ($z\epsilon$) to be larger in females, the remaining values being larger in males.

Relative values of each plastic character (considered in relation to the fish caudal length) are listed in Table 2. For example, the head length calculated in this way was found to range, in females, within 17.87–22.07 ($M = 19.54$), the range in males being 19.10–27.17 ($M = 24.22$). The values are very close to those reported by Berg (1948), Schechtel (1925), and Vogt, Hofer (1909) (Table 7).

The analysis of mean values for head characters (Table 2, items 2–9) shows the lengths of the head (ac), central head section (a_5d), snout (ag), maxilla (a_5i) and mandible (kl) to be clearly larger in males. The data on the maxilla (a_5i) and mandible (kl) lengths relative to the body length are similar to those reported by Berg (1948). The remaining mean relative values of the characters studied, i.e., the longitudinal (gh) and transverse (ef) eye diameters and the maxilla width (mn) of males are slightly higher than the respective values in females. The preocular distance (ag) is 3.4 and 4.8 times the longitudinal eye diameter in the Drawa salmon females and males, respectively. The values reported are very similar to those given by Schechtel (1925) and Vogt, Hofer (after Schechtel, 1925).

Table 3 (items 26 and 27) contains additionally mean values of the longitudinal (g_1h_1) and transverse (e_1f_1) diameters of the eye iris, the eye diameters (gh and ef) being disregarded when drawing conclusions, in spite of Smitt's recommendations regarding studies of this kind. The interpretation of those values cannot be accurate owing to difficulties encountered when measuring the diameter of the eye located in the eye socket and protected, over a large area, by a special cover. For this reason the iris was measured, the measuring procedure ensuring a higher accuracy. As shown by the data, the longitudinal (g_1h_1) and transverse (e_1f_1) iris diameters make up 1.6% and 1.56 % of the fish length, respectively, in females, and 1.55% and 1.49%, respectively, in males (Table 2, items 26 and 27). The body length (ab): total head length (ac) ratio of the Drawa salmon is very similar to that of the Vistula salmon (Schechtel, 1925; Vogt Hofer after Schechtel, 1925).

In addition to the eight head measurements, the same number of them was taken on the trunk. A review of relative means shows the anterior ventral length (uw), snout end-ventral fin distance (aw), posterior ventral length (wy), tail shank dorsal margin length ($\gamma\delta$), tail shank lateral length ($\alpha\vartheta$), and tail shank ventral margin length ($z\epsilon$) to be larger in females. On the other hand, males show slightly higher values of the snout end-dorsal fin distance (aq) and the least body height ($\xi\eta$) (Table 2, items 10–17). The tail dorsal margin length ($\gamma\delta$) is in the Drawa salmon less than twice that of the least body height ($\xi\eta$), which is consistent with the values reported by Berg (1948); similar is the case of the least body height ($\xi\eta$) as expressed as a percentage of the anterior tip of the pectoral fin (P)-anterior tip of the ventral fin (V) distance (uw).

Plastic characters of the fins were analysed on 8 examples. Among the mean relative values of the plastic characters, the following ones were larger in males: dorsal fin height (st), pectoral fin length (uv), ventral fin height (wx), anal fin height ($\alpha\beta$), and the length

Table 7

Comparison of salmon plastic characters

River, author Description of character	Sex	Drawa (present study)	Vistula (Schechtel, 1925)	wg Berga (1948)	Vogt Hofer after Schechtel 1925
Head length (ac) as % body length	females males total	17.87 (19.54) 22.07 19.1 (24.22) 27.17	17.8 24.4	18.9 – 24.6	19.6 21.5
Upper jaw length (a ₅ i) as % body length (ab)	females males total	6.31 (7) 8.42 6.88 (8.8) 9.96		6.6 – 8.7	
Lower jaw length (kl) as % body length (ab)	females males total	10.35 (11.38) 12.66 14.41 (16.02) 17.8		11.0 – 15.7	
Preocular distance (ag) longer than longitudinal eye diameter (gh) by the factor of	females males	3.4 x 4.8 x	3.0 – 3.75 x 4.8 – 5.4 x		3.7 x 4.25 x
Body length (ab): total head length (ac) ratio	females males	5.1 : 1 4.1 : 1	5.6 : 1 4.1 : 1		5.11 : 1 4.66 : 1
Tail dorsal margin length (ξη) larger than smallest body height (γδ) by the factor of	females males total	1.6 : 1 1.4 : 1 > 2 x		usually > 2 x	
Smallest body height (ξη) as % P–V distance (uw)	females males total	21.8 23.8		20.7 – 27.2	
Smallest body height (αδ) larger than anal fin height (ξη) by the factor of	females males total	1.3 x 1.4 x		2.5 – 1.3 x	
P–V distance (uw) longer than pectoral fin length (uv) by the factor of	females males total	2.8 : 1 2.6 : 1 < 2 x		< 2 x	
Adipose fin end-caudal fin first rays distance (γδ) relative to anal fin height (αβ)	total	always < od A		always < od A	
Tail ventral margin length (αβ) longer than anal fin height (ze) by the factor of	females males total	1.24 x 1.08 x		1.5 – 0.9 x	

of the shortest central rays in the caudal fin (vb). Slightly larger in females were the mean values of lengths of the dorsal and anal fin bases (gr and yz, respectively). On the other hand, lengths of the longest rays of the caudal fin (zx) were similar in males and females (Table 2, items 18–25). The least body height ($\xi\eta$) is, on the average, 1.3 times and 1.4 times the anal fin height ($\alpha\beta$) in females and males, respectively. The data are consistent with the lower values reported by Berg (1948); his upper values seem to have been overestimated. The P-V (pectoral fin anterior tip-ventral fin anterior tip) distance is more than twice the pectoral fin length (uv), similarly to Berg's (1948) data. The distance from the adipose fin posterior tip to the first rays of the caudal fin ($\gamma\delta$) both in the present study and in Berg (1948) always exceeds the anal fin height ($\alpha\beta$). The tail shank ventral line is 1.24 and 1.08 times the anal fin height ($\alpha\beta$) in females and males, respectively, similar values being reported by Berg (1948).

The data presented above allow to separate 9 characters reflecting the sexual dimorphism of the salmon studied. Females show high mean values of the anterior ventral length (uw) and posterior ventral length (wy). On the other hand, the mean relative values of the head length (ac), central head part length (a_5d), snout length (ag), maxilla length (a_5i), mandible length (kl), snout end-dorsal fin distance (aq), and snout end-ventral fin distance (aw) are larger in males. When the ranges of those characters are compared, the mandible length (kl) only shows differing relative values, the ranges of the remaining relative values overlapping. Thus sexual dimorphism is most conspicuously reflected by the mandible length (kl), head length (ac), and snout end-dorsal fin distance (aq).

Meristic characters

The data on meristic characters, summarised in Table 4, show the following scale pattern to occur in the Drawa salmon, sex disregarded:

- above the lateral line: 19–28 rows ($M = 21.9$),
- on the lateral line: 118–126 rows ($M = 121.3$),
- below the lateral line: 18–26 rows ($M = 22.6$), and
- on the tail from the adipose fin posterior margin to the lateral line: 11–14 rows ($M = 11.8$).

The dorsal fin was found to contain 3–4 hard rays ($M = 3$) and 8–11 soft rays ($M = 9$), while the anal fin had 3–4 hard rays ($M = 3$) and 7–9 soft ones ($M = 8$).

When the number of scales covering the body of the Drawa salmon is compared to the data given by other authors, a large similarity can be seen in spite of certain differences (Table 8). The same conclusion applies to the hard and soft rays counts in the dorsal and anal fins.

With respect to the number of subbranchial membrane rays, 10–13 ones were being found ($M \pm = 11.95 \pm 0.0476$), i.e., a little more than 11–12 rays found by Berg (1948).

Marks were counted on the body surfaces of 25 females and 25 males. On the left side of the head 5–39 (most frequently 15–18) dark circular, oval, kidney-like or irregular

Table 8

Comparison of meristic characters of salmon

Description of character		River Author	Drawa (present study)	Warta Kaj (1962)	Vistula Schechtel (1925)	Vistula Jokiel (1958)	Berg (1916)	Borne (af- ter Sche- chtel (1925)	Bruee af- ter Sche- chtel (1925)	W. Heinaf- ter Nemes- heimer i (1941)	Henckng (1929)	Kulmatycki after Jokiel (1958)	Meiner (1948)	Neres- heimer (1941)	Nitzsche and Heim (1932)	Quednau (1935)	Vogt- Hofer (1909)	Chełko- widi (1965)
No. of scale rows above lateral line			19-28	22-26	25		22-26											
No. of scale rows in lateral line			118-126	114-138	130-138		115-130										128-138	
No. of scale rows below lateral line			18-26	18-37	31-37		18-23											
No. of scale rows on tail above lateral line			11-14	11-15	15		11-15											13-14
Dorsal fin rays count:		hard rays	III-IV	III-V			III-V											
		soft rays	8-11	9-12			9-12											
Anal fin rays count:		hard rays	III-IV	III-IV			III-IV											
		soft rays	7-9	7			7-9											
Subbranchial membrane rays count			10-13				11-12											
Black marks on left side of body	Head:	number φ (mm) shape	5-39 1-14 circular, oval, kidney-like, irregular		17-25 3-13 x- and kidney-like, oval													
	Trunk above I.L.:	number φ (mm) shape	37-308 1-16 circular, oval, irregular, x-xxx-like, kidney- and clover leaf shaped															
	Trunk below I.L.:	number φ (mm) shape	0-17 1-24 circular, oval, irregular, x- and kidney-like		10 single or double crosses		no marks or a few											
	Tail above I.L.:	number φ (mm) shape	8-53 2-7 circular, oval, irregular, x- and star-like															
	Tail below I.L.:	number φ (mm) shape	0-3 1-6 irregular, circular															
	Dorsal fin:	number φ (mm) shape	4-14 1-13 circular, oval, irregular	0	marks at least at fin base													
	Caudal fin:	number	0	0	0													
	First gill arch processes count		18-24	17-24	18-22		17-22											18-21
First gill arch lamellae count:	external internal	85-127 96-138		86-88 93-100														
Pyloric processes count		56-98	58-80	63-80		58-77											53-77	62-76
Vertebrae count		57-60				59-60												
Vomer	Lamella		pentagonal, toothless	pentagonal, toothless	toothless; transverse row of 4 teeth at base		pentagonal or hexagonal, toothless			pentagonal toothless	pentagonal, toothless				toothless	pentagonal, toothless	pentagonal, toothless	
	shaft	base	0-5 teeth arranged transversely to shaft															
		shaft proper	0-5 teeth in one row	toothed, 1 row of teeth in posterior part; 1 row of teeth in juveniles			teeth lost in posterior part; 1 row of teeth in juveniles			1 row of teeth	1 row of teeth				teeth present	several teeth in one row	1 row of teeth	
Premaxilla teeth count			3-13															
Maxilla teeth count			5-22															
Palatebone teeth count			8-13															
Dentalebone teeth count			4-21															
Basibale teeth count			4-8															
Fertilized egg weight (g)			0.146		0.163							0.15						
Fertilized egg diameter (mm)			5.6-6.8	5.7	6.1 (6.25) 6.9		5.7-6.2	5.7-6.2				6.25	5-7				5-7	

marks of 1–14 mm diameter were found. On the trunk above the lateral line 37–308 dark marks 1–16 mm in diameter were counted, the means for females and males being 104 and 149, respectively. These marks were of various shapes: circular, oval, irregular, star-, x-, xx-, clover leaf-, or sometimes kidney-like. The latter shape occurs, however, on the anterior part of the body only, nearby the upper part of the cleithrum. The marks are much more scarce below the lateral line, the means for females and males being 14 and 15, respectively. Many individuals have no marks or a few only, while sporadically the number of those marks can reach 47. The diameter of those marks below the lateral line ranged widely (1–24 mm); they were similar in shape to those above the line. The dark marks are most numerous in the anterior part of the body. Dark marks are also visible on the surface of the tail; they are usually more numerous above the lateral line (18–53), 0–3 being counted below the line. They are 2.7 mm in diameter above the lateral line and 1–6 mm below it. The marks are of the same shape on the upper and lower parts of the body: circular, oval, irregular, x- or star-like. The presence of 11–14 dark marks was recorded also on the dorsal fin. They usually occur on the lower part of the fin, at times on its very base. Their diameter ranges within 1–13 mm, the shapes being circular, oval, or irregular. The number of marks on various parts of the body or on fins is related to their numbers on other parts of the fish. For instance, if the marks are numerous on the trunk above the lateral line, they are also abundant on other parts of the body. The marks are absent on the remaining fins of the Drawa salmon, i.e., the caudal, ventral, and pectoral ones. Some data on the description and distribution of black marks, a characteristic feature of the Vistula salmon coloration, are given by Schechtel (1925) and Berg (1948). Some relevant information can be additionally gained from a photograph showing the head and anterior part of a spawning Vistula salmon body, presented by Jokiel (1958). The observations made by the authors mentioned above are basically similar to the nature of marks (numbers, size, shape, and distribution) on the Drawa salmon. According to Berg (1948), dark marks occur above the lateral line and are scarce or absent altogether below the line, similar to the Drawa salmon. In the Salmon of the Vistula, the nature of marks on the dorsal fin is similar to that of the Drawa salmon as well (Schechtel, 1925). Contrary to the above, observations, Kaj (1962) found no marks on salmon fins. Both in the Vistula salmon (Schechtel, 1925) and in the present study no marks were observed on the caudal fin behind the scale range.

The first external gill arch was examined, the gill processes and lamellae counts on the external and internal parts of the arch being recorded. The results for females and males turned out to be similar. The gill arch was found to house 18–24 processes ($M \pm m = 20.46 \pm 0.0975$) and differing numbers of lamellae: 85–127 ($M \pm m = 112.39 \pm 0.7038$) and 96–138 ($M \pm m = 121.03 \pm 0.8770$) on the external and internal side, respectively. The first gill arch processes count (18–24) in the Drawa salmon is within the ranges given by other authors (17–24). Schechtel (1925) recorded the lamellae counts in the Vistula salmon, his lower limits being similar to those in the present study, upper limits on both sides of the arch being, however, much higher in the Drawa salmon.

MALES

Fig. 5. Salmon vomers (1:1). A = ventral projection; B = lateral view. Fish lengths: 940 mm (female No. 90); 968 mm (female No. 122); 965 mm (female No. 96); 994 mm (female No. 65); 967 mm (female No. 123); 1103 mm (female No. 127); 954 mm (male No. 104); 1120 mm (male No. 118); 1030 mm (male No. 94); 1182 mm (male No. 78); 1232 mm (male No. 129)

The pyloric processes counts are similar in males and females, ranging within 56–98 ($M \pm m = 73.14 \pm 0.6561$). According to various authors, the counts in the salmon range within 53–80. Thus the lower limit of the Drawa salmon count lies within the range given by other authors, the upper one turning out to be the highest value among those recorded in the literature.

The largest difficulties were encountered when determining the vertebrae counts due to a high cost of the salmon delivered to the market. Therefore only 9 spines of adult individuals could have been examined. Additionally, 145 spines of juvenile salmon reared in the Stocking Center Jazwiny and originating from the Drawa salmon eggs obtained in autumn 1972 were studied (Chełkowska and Chełkowski, 1976). Those individuals died in the culture. A total of 154 individuals were used when determining the vertebrae count. The latter was found to range within 57–60 ($M \pm m = 59.1 \pm 0.0422$), while Berg gave the range of 59–60. The comparison shows the upper limits to be identical, the lower ones differing somewhat.

Descriptions of the vomer given by Berg (1948), Vogt, Hofer (1909), and other authors deal with the shape of the lamella and the number of teeth on the lamella and the main part of the bone. In the present study, vomers of 104 Drawa salmon individuals (62 females and 42 males) were examined, 12 vomers representative of the collection being presented in Fig. 5. The hitherto-used division of the vomer into a lamella and a shaft is totally insufficient when discussing the details of this bone in the salmon, the Drawa salmon in particular. It is necessary to distinguish two additional parts: a neck, mentioned by Neresheimer (1941), and a shaft base. The outline of a typical vomer of the Drawa salmon is shown and described in Fig. 6. The toothless lamella, as can be seen, has contours resembling a pentagon. On the shaft base, below a narrower part forming a neck, 0–3 and 0–5 teeth in females and males, respectively, are found. In most cases, however, both females and males show 1 or 2 teeth, sometimes only traces of lost teeth being seen. Such a row of teeth is rather irregular, usually transverse relative to the shaft. The teeth counts on the shaft are 0–2 (mostly 1) in females and 0–5 (mostly 1–2) in males. The bone shaft teeth are arranged in a single row, with the exception of one male vomer (Fig. 5, No. 104) which shows, although not very clearly, the teeth to be arranged in two rows. On the shafts of many vomers traces (teeth sockets) of lost teeth are seen (Fig. 5, Nos. 123 and 65). Most often, however, the female and male vomers look like those presented in Fig. 5 Nos. 127 and 78, respectively. The present studies as well as the works by other authors (Berg, 1948; Henking, 1929; Kaj, 1962; Neresheimer, 1941; Nitzsche and Hein, 1932; Quednau, 1935; Vogt-Hofer, 1909; Schechtel, 1925) show the vomer lamella to be pentagonal in shape. Eight authors found the lamella to be toothless as is the case with the Drawa salmon. On the other hand, the details on teeth arrangement on the remaining part of the Drawa salmon vomer differ markedly from those described by other authors, the differences concerning mainly the shaft base. The Drawa salmon has 0–5 teeth on the shaft base, arranged transversely relative to the shaft teeth row. These observations are not confirmed by the authors mentioned, except for Schechtel (1925) referring to the Vistula salmon. On the other hand, Schechtel mentions the presence of

teeth on the lamella. It should be emphasised, however, that it is not clear what he meant when writing about the lamella: most probably he meant the shaft base with teeth present on it. The presence of a few teeth in a single row on the shaft itself is consistent with observations by the authors mentioned above.

Apart from the vomer, teeth are present on the promaxilla (3–13) maxilla (5–22), palate (8–13), dental (4–21) bones and on the basihyale (4–8). During spawning, the teeth – particularly those present on the promaxilla and on the frontal part of the dental bone – are much larger in males than in females. These teeth are arranged in a single row, most often directed slightly backwards. The teeth counts on the mouth cavity bones listed above are usually higher in males than in females. The teeth on each mouth cavity bone in the salmon from the present study are similar to those examined by Neresheimer (1941). On the other hand, the teeth count on the basihyale is always even and ranges within 4–8, while it is odd (always 5) in Neresheimer's (1941) study.

The weight and diameter of mature eggs were also treated as meristic characters. The eggs left in the abdomen of 35 females to be delivered to the market were analysed. Each female yielded, if possible, 100 randomly taken eggs. A mean weight of a mature egg was 123 mg (the range of 83–163 mg); the egg diameter was found to range within 5.1–6.22 mm (mean of 5.58 mm). Additionally, weights and diameters of fertilised eggs were recorded, for which purpose 100 eggs were taken on random, the eggs having been resting in the California apparatus for about 24 h after fertilisation. The eggs were placed on a blotting paper and weighed directly after the external water had been removed. The egg weight ranged within 104–177 mg ($M \pm m = 145.74 \pm 1.2958$). The mean weight of a fertilised egg of the Drawa salmon (0.146 g) is similar to Kulmatycki's (after Jokiel, 1958) and Jokiel's (1958) calculations for the Vistula salmon (0.15–0.163 g). The diameter of the same eggs was found to range within 5.55–6.78 mm ($M \pm m = 6.25 \pm 0.0208$). The Drawa salmon egg diameter after fertilisation and swelling proved very similar to the data reported by other authors (Borne and Brauer, after Schechtel, 1925; Jokiel, 1958; Meisner, 1948; Kaj, 1962; Kulmatycki, after Jokiel, 1958; Schechtel, 1925; Vogt-Hofer, 1909).

Characters of shape

A characteristic feature of the caudal fin in all the mature Drawa salmon is a slight indentation visible always on the fin spread bow-like. Sometimes the indentation in the upper and lower parts of the fin is considerable, the edges of fin rays forming an almost straight line: the missing part of the caudal fin is a rather regular trapezium, which particularly applies to large females and males (Fig. 2). The caudal fin margin in mature salmon is slightly concave, which is consistent with observations by Berg (1948), Schechtel (1925), and Kaj (1962) (Fig. 2). The marginal bones of the caudal fin in females, and particularly in males, form at times the so-called creases. Similarly, as observed by Schechtel (1925), the Vistula salmon have their caudal fin marginal bones form clear creases, particularly well-visible in large males.

Scales covering the body are present on the tail, forming there a bow-like or almost circular area. Similarly, Schechtel (1925) observed the scale pattern on the tail to be bow-like.

When examining the first gill arch and counting its processes, the shapes of the latter were paid attention to. The shape of the processes both in the central and marginal parts of an arch was thorn-like. The processes differed in length, the longest ones being located in the middle; the marginal processes are shorter. The thornlike shape of filtration processes of the Drawa salmon is similar to that described by Johanson and Löfting (after Neresheimer, 1941), Henking (1929), and Kaj (1962).

Next the position of the maxilla tip relative to the eyeball was determined. Measurements were taken with a transparent ruler placed just next to the eyeball (on the side of the operculum) and perpendicular to the line forming the lower part of the body. Thus the maxilla tip, the snout closed, reaches the eyeball posterior margin or slightly past it; similar is the description given by Berg (1948) and Kaj (1962).

Fig. 6. A diagram of vomer

The pseudo-eyelid is shaped like a blunt cone. The eye diameter-largest pseudolid width ratio exceeds 3, as calculated from measurements taken on 15 females and 15 males. An identical result was obtained by Schechtel (1925) for the Vistula salmon.

When identifying the sexually mature fish, it was frequently difficult to determine the operculum characters. Schechtel (1925) provides such characteristics for his salmon. In order to investigate the problem, 6 pairs of the operculi of the mature Drawa salmon were

obtained, one of them — mucus and flesh removed — being presented in Fig. 7. A closer examination of the operculi showed the operculum and interoperculum to overlap from without with the suboperculum, the preoperculum covering partly the operculum and interoperculum, while the suboperculum ramus reaches, from within, the preoperculum. The description presented indicates the interoperculum in its external outline to wedge between the operculum and preoperculum and to separate the suboperculum, which is consistent with Schechtel's (1925) observations. It should be stated, however, that the internal outline of the bone differs from the external one. Identification of the salmon from the external outlines of bones making up the branchial cover, as in Schechtel (1925), was fully justified. It is, however, very difficult to determine the external outline of the operculum bones, particularly during the pre-spawning period. This is particularly evident in males, covered at that time with a thick layer of mucus and having a considerably thickened skin.

All the males caught during their spawning migration in inland waters, particularly during the spawning itself, showed the front part of their lower jaw to form a hook. The hook is so large that the snout cannot be closed completely, despite a recess appearing between the bones of the jaw. The upper part of the hook, directed backward, is palpable in the closed snout under the skin of its upper part. The shape of the jaw of the spawning Drawa salmon is very similar to that of the Vistula salmon described by Schechtel (1925) and Jokiel (1958).

As already mentioned in the Methods section, the axillar process length-ventral fin length ratio was analysed. All the salmon individuals examined for this character ($n = 50$: 25 females and 25 males) show their ventral fin length to be more than three times that

Fig. 7. Opercular bones (1:1) of a salmon female (1040 mm length). A: internal view of operculum on left side of head, B: internal view of operculum on right side of head; P = preoperculum, O = operculum, S = suboperculum, I = interoperculum

of the axillary process, which is identical with the finding of Schechtel (1925): in the Vistula salmon, the process, at its longest, reaches $1/3$ of the ventral fin length.

Scales of those females caught in late summer and early autumn were found to be easily removed from their skin pockets, the removal of scales during spawning being more difficult. The ascending females are covered with a small amount of mucus, its quantity increasing visibly on spawning and being reduced again in the descending fish. Scales of males migrating to spawn can be removed from their skin but not so easily as in females, whereas during spawning scales are placed deep in the thickened skin. It is very difficult to obtain the scales. When the skin is thin, mucus occurs in small amounts; during spawning, the thickening skin is covered by a thick layer of opaque and dense mucus.

Characters of colour

The materials examined allow to follow changes in body coloration of the salmon during the spawning migration, spawning itself, and post-spawning migration.

The homing females caught in the Szczecin Lagoon and lower Odra in mid-summer are silver-coloured, with a darker dorsal part and lightly lighter abdomen; they have a low number of poorly visible marks. No mating appearance is observed. In early autumn, the general coloration becomes more steel-like, with a dark dorsal part and a darkened abdomen, the dark marks increasing in number and becoming more conspicuous. A similar coloration was observed in those females caught in early spring as kelts in the Szczecin Lagoon; their general coloration was darker, steel-lead. The female skin becomes clearly darker on spawning, the overall colour becoming steel-lead, too. Numerous, well-marked marks appear at that stage. Most individuals, additionally, show a low number of fine pink-orange marks, a typical element of the mating appearance.

The overall colour of the males caught at the beginning of their spawning migration in the Szczecin Lagoon is somewhat darker, the lower part of the body being light yellow. Compared to the females, a higher number of darker and better-visible marks occur on the head and the sides of the body. The body and marks colours are more contracting than in the females. The males lack a well-marked mating appearance. During spawning, males take on a much more intensive colour. A characteristic feature of the mating appearance is pink-orange coloration of the skin both on the dorsal part, on the sides of the body, and particularly on the ventral sides. Numerous dark marks show pink rims, particularly on the head near the pre- and suboperculum. Very numerous pink dots are scattered all over the body. It should be added that the upper part of the head and the anterior part of the body takes on a green or dark-olive hue. The dorsal and adipose fins show their coloration to be similar to the respective parts of the body. The paired fins and the caudal fin are steel-grey. With regard to their coloration, the Drawa salmon resemble those described by Schechtel (1925), Berg (1948), Jokiel (1958), Kaj (1962), and Chełkowski (1965). Interesting findings were recorded by Kaj (1962) and Chełkowski (1965); they observed the spawning salmon to take on a dark-grey hue. A similar

feature was noticed in the Drawa salmon males and to a lesser degree in females, the feature occurring not only during spawning but also in those individuals ascending the Odra. Kaj (1962) observed red dots, particularly well-visible on the head and on the anterior part of the trunk, to appear during spawning. Similar but finer red dots are observed in the spawning Drawa salmon males, the dots being almost evenly distributed all over the body. The presence of dots is accompanied by a red-orange, seldom with a light violet hue, skin coloration, particularly well-visible on the ventral side. The description of such colour occurring in salmon is provided also by Schechtel (1925). According to Jokiel (1958), the salmon ascending the Vistula are silver-coloured with a poorly developed mating appearance. Similar observations were made on the Drawa salmon caught in the onset of their spawning migration in the Szczecin Lagoon and lower Odra.

Eggs produced by females spawning for the first time are orange, the colour changing to yellow-orange in eggs produced by the females repeating their spawning. According to Kaj (1962), the Drawa salmon eggs are orange to yellow-orange, which fully corresponds with the present observations.

BIOLOGICAL CHARACTERS

Fishing seasons

The fishing for salmon in the Drawa was observed to commence in early November, usually just after the fishes had appeared on their spawning grounds (Chełkowski, 1967a; Chełkowska and Chełkowski, 1968–1977). The data for 1967–1975 show the fisheries to proceed basically from Nov. 7 until Dec. 2, the attempts being made to continue fishing until mid-December. The number of individuals caught is given in Table 9, the table showing also the fishing season duration. Particularly abundant were the catches in the second decade of November.

Gonad development and spawning season

When examining the Drawa salmon for their maturity stage, it was found out that males were being ready to spawn while females were at varying stages of maturity: from almost mature (V+) to spent (VIII) individuals (Table 10). Most of the females caught were ready to spawn (VI) and almost mature (V) (69.3%), the remaining 30.7% being made up by semi-spent (VII) and spent (VIII) ones. Thus about one third of the females had started to spawn or finished spawning prior to capture. Gonad development by fishing seasons is summarised in Table 11. The semi-spent individuals were usually captured in the first decade of November, while the first totally spent ones were fished in the third decade of the same month. It follows then that the salmon begins to spawn

Table 9

Salmon catches (no. of ind.) in years and decades

Sex	Year	Month decade	Nov.			Dec.			Total
			1	2	3	1	2	3	
Females	1967			3	1				4
	1968		1	6	2	1			10
	1969		3	4	3				10
	1970			4	5	2			11
	1971			4	4				8
	1972		1	2					3
	1973			3					3
	1974			4	2				6
	1975			3	3	1			7
Total:			5	33	20	4			62

Males	1967		1	4	1				6
	1968		1	4					5
	1969		2	2	1				5
	1970			4					4
	1971		1	2	2				5
	1972		1						1
	1973			3					3
	1974			4	1				5
	1975			4	2				6
Total:			6	27	7				40
Grand total:			11	60	27	4			102

about the end of the first decade of November. Owing to the fact that the catches tended to dwindle in the first decade of December, as evidenced by the absence of males and the presence of 4 females (2 spent ones, 1 semi-spent, and 1 read to spawn), the spawning season can be assumed to proceed from the first decade of November through the first decade of December. The gonad development over the period of fishing shows the spawning to be at its peak in the second and third decades of November. Chrzan's (1969) observations showed the Drawa salmon spawning to take place from November until the end of the first decade of December, and even through mid-December. The present observations are basically consistent with those reported by that author as the first semi-spent female was caught as early as in the first decade of November, the first spent one being obtained in the second decade. On the other hand, the last female ready to spawn was caught in the first decade of December; additionally, the catches from that

Table 10

Drawa salmon females gonad maturity
distribution (no. of individuals)

Year		Maier scale stage				Total
		V	VI	VII	VIII	
1967		3	1			4
1968			6	3	1	10
1969		6		3	1	10
1970		2	5	3	1	11
1971		2	4	2		8
1972			2		1	3
1973			3			3
1974		4		2		6
1975			5	1	1	7
Total:	ind.	17	26	14	5	62
	%	27.4	41.9	22.6	8.1	100.0

time contained one semi-spent female and two spent ones. Generally speaking, the Drawa salmon spawning proceeds from mid-November until mid-December. According to Schechtel (1925), the Vistula salmon spawns somewhat later, in December. Berg maintains that salmon egg laying can be extended over an even longer period, from October until February.

Table 11

Number of females caught within 1967 – 1975
by decades and their gonad maturity stage

Month	Decade	Gonad maturity stage				Total
		V	VI	VII	VIII	
November	I	3	1	1	–	5
November	II	13	13	5	2	33
November	III	1	11	7	1	20
December	I	–	1	1	2	4
Total:		17	26	14	5	62

Sex ratio in the spawning population

During the subsequent 15 spawning seasons the salmon were caught in the same stretch of the river, and – additionally – twice at spawning grounds in other parts of the lower Drawa. Therefore the catches seem to be a suitable material for an analysis of the sex ratio of the spawning population.

Over the whole period of study, females were found to prevail numerically (183 against 121 males) (Table 1), the sex ratio (females:males) being thus 1.5:1. A similar females-to-males ratio (1.9:1) was recorded in this population by Chrzan (1969). On the other hand, Jokiel (1958) found the ratio to be 3:1 in the lower Vistula. All the observations, however, demonstrate the numerical dominance of females. Other data (Table 12) show the males to be earlier more abundant than females on their spawning grounds.

Table 12

Salmon females and males in catches

Month		November			December	Total
Sex	Decade	I	II	III	I	
Females	no. of ind.	5	33	20	4	62
	%	8.1	53.2	32.3	6.4	100.0
Males	no. of ind.	6	27	7	–	40
	%	15.0	67.5	17.5	–	100.0

Artificial spawning seasons and amounts of eggs obtained

The females caught were subject to artificial spawning. The results in Table 13 show the eggs to be removed during the second and third decades of November and the first decade of December. Most eggs (66.6%) were obtained in the third decade of November, the remaining percentages being 17.0 and 16.4 for the second decade of November and the first decade of December.

Based on the data for 1967–1975, an attempt to determine the economic fecundity of the Drawa salmon was made. The calculations were based on the number of females producing the eggs obtained, i.e., those individuals that were almost mature, mature, and semi-spent, making up a total of 57 (Table 11). As seen from Table 13, those females supplied a total of 103.7 l of roe.

In order to determine the number of individuals, data reported by Chełkowski and Chełkowska (1968–1977) were taken advantage of: they found 4800–6700 eggs ($M = 5694$) per l in different years. These calculations served to establish the economic

Table 13

Artificial spawning seasons and amount of roe obtained (1)

<div> <div>Month Decade</div> <div>Year</div> </div>	Spawning season and amount of roe			Total
	November		December	
	II	III	I	
1967		11.5		11.5
1968	9.5		8.5	18.0
1969		9.5	2.5	12.0
1970		18.0	3.0	21.0
1971		17.0		17.0
1972	2.0	2.5		4.5
1973	3.5	2.0		5.5
1974	2.6	4.1	0.5	7.2
1975		4.5	2.5	7.0
Total (1):	17.6	69.1	17.0	103.7
%	17.0	66.6	16.4	100.0

fecundity of a single female (10 359 eggs), but they cannot be treated as representing the total fecundity of salmon females. An example justifying this statement is provided by a female delivered to the market just before attaining the full maturity. The female was found to be affected by ovaries inflammation, the condition making it impossible to release eggs, both naturally and artificially. The ovaries of that female were found to contain a total of 24 760 eggs. The female's length and total weight were 107.2 cm and 11.977 kg, respectively, the gutted weight being 8.6 kg. The full ovaries weighed 3.095 g, a single egg was found to weigh 0.125 g.

Water temperature of the Drawa during salmon spawning

Water temperatures of the Drawa during salmon spawning seasons are summarised in Table 14. The temperatures at that time were found to range within 1–8.5°C.

Salmon length

Extremal and mean length values as well as the length distribution were worked out on the materials collected (304 individuals). The total, female, and male length ranges of the spawning salmon were 760–1408 mm ($M \pm m = 1053.4 \pm 5.8829$); 810–1255 mm ($M \pm m = 1015.9 \pm 5.7212$); and 760–1408 mm ($M \pm m = 1100 \pm 9.9926$), respectively

Table 14

Drawa water temperature during salmon fishing season

Year	Month Decade	Seasons of capture				Water temperature range on spawning (°C)
		November			December	
		I	II	III	I	
1967		x	x	x		7.5 – 3.9
1968		x	x	x	x	6.5 – 3.0
1969		x	x	x		7.0 – 4.0
1970			x	x	x	5.0 – 3.0
1971		x	x	x		7.0 – 1.0
1972		x	x			8.5 – 3.2
1973			x			6.3 – 5.6
1974			x	x		6.0 – 3.0
1975			x	x	x	5.0 – 1.5

(Table 15). Thus the mean length of males was by about 10 cm (94.3 mm) larger than of females. The salmon length distribution is presented in Table 16. Most abundant (70.07%) was the 95–114 cm length class. The female and male length classes cover 90–114 cm and 95–124 cm, respectively. To sum up, the length classes above and below 90 cm contain 95.4 and 4.6% of the individuals examined.

Table 15

Salmon length (l. caudalis) (mm)

Sex	n	$M \pm m$	δ	v	Range
Females	183	1015.9 ± 5.7212	77.3953	7.6184	810–1255
Males	121	1110.2 ± 9.9926	109.9185	9.9008	760–1408
Total:	304	1053.4 ± 5.8829	102.5719	9.7372	760–1408

According to Chrzan (1969), the Drawa salmon length ranges within 84–144 cm; thus the widest length range of the spawning salmon in the river can cover 76–144 cm. An identical range in the same population was found by Kaj (1962). Similar is the case of the salmon in the Vistula, as shown by Schechtel (1925), Jokiel (1958), Żarnecki (1963), and in the Pomeranian rivers opening to the Baltic (Chełkowski, 1965). The Warta salmon are different in this respect, but only in the lower limit of the range (49 cm) Przybył (1976), which, however, seems to be an underestimate. No individual attaining 150 cm has been ever found in the Drawa, the value being mentioned by Berg (1916) (Table 17). Mean lengths of the Drawa salmon, as calculated by Chrzan (1969) and by the present author,

Table 16

Salmon length frequency distribution

Length class	Females		Males		Total	
	no. of ind.	%	no. of ind.	%	no. of ind.	%
75 – 79	–	–	1	0.83	1	0.33
80 – 84	2	1.09	3	2.48	5	1.64
85 – 89	7	3.83	1	0.83	8	2.63
90 – 94	24	13.11	2	1.65	26	8.55
95 – 99	53	28.96	8	6.61	61	20.07
100 – 104	30	16.39	17	14.05	47	15.46
105 – 109	38	20.77	21	17.35	59	19.41
110 – 114	22	12.02	24	19.83	46	15.13
115 – 119	6	3.28	17	14.05	23	7.57
120 – 124	–	–	17	14.05	17	5.59
125 – 129	1	0.55	3	2.48	4	1.32
130 – 134	–	–	6	4.96	6	1.97
135 – 139	–	–	–	–	–	–
140 – 144	–	–	1	0.83	1	0.33
Total:	183	100.00	121	100.00	304	100.00

are very similar. It is interesting to note that similar also are the values recorded for the salmon occurring in the Vistula (Jokiel, 1958) and in the Pomeranian rivers (Chełkowski, 1965) (Table 18).

Table 17

Comparison of salmon lengths and weights

River	Author	Length (cm)	Weight (kg)
Drawa	Present study	76 – 140.8	4.2. – 23.2
Drawa	Chrzan (1969)	84 – 144.0	4.8 – 24.0
Drawa	Kaj (1962)	96 – 125.0	5.5 – 15.0
Warta	Przybył (1974)	49 – 111.7	1.75 – 19.7
Vistula	Seligo (1896)	120 – 125	16
Vistula	Schechtel (1925)	96 – 129.0	8 and above
Vistula	Żarnecki (1963)	67 – 110.0*	4.27 – 18.0
Vistula		74 – 125.0**	
Vistula	Jokiel (1958)	76 – 130.0	6.3 – 23.0
Vistula	Berg (1948)	100 – 150.0	
Pomeranian rivers	Chełkowski (1965)	88.5–122	6.4 — 16.1

* winter group

** summer group

Table 18

Mean salmon lengths (cm)

River and author		Females	Males	Total
Drawa	present study	101.6	111.0	105.3
	Chrzan (1969)	105.9	115.2	109.1
Vistula	Jokiel (1958)	101.3	117.7	103.7
Pomeranian rivers	Chełkowski (1965)	100.5	103.3	101.9

Further interesting materials for comparative studies on salmon populations are obtained from length distributions of the Drawa and Vistula salmon (Fig. 8). Within the 80–115 cm length classes the frequencies of females are very similar in the two rivers. On the other hand, the lowest classes (75–80 cm) contain the Vistula salmon females only, the highest classes (115–130 cm) being made up by the Drawa salmon females. The Drawa salmon males occur within the 75–145 cm length range, the corresponding range for the Vistula salmon males being 100–130 cm only. Frequency curves plotted for the Drawa and Vistula salmon, regardless of sex, show a considerable similarity within the range of 75–130 cm, the 130–145 cm classes being represented by the Drawa salmon only. Thus the Drawa houses salmon individuals attaining larger sizes than those in the Vistula. According to Chrzan (1969), more than 77% of the Drawa salmon spawning stock is made up by individuals larger than 100 cm, 67.7% being the corresponding percentage found in the present study. In the Vistula salmon spawning stock, 60% of all individuals are longer than 100 cm (Jokiel, 1958).

Salmon weight

The materials collected allowed to determine the fish weight. Artificially spawned fishes (102 females and 72 males) as well as gutted ones (85 females and 52 males) were weighed. The mean weight of spent fish was 12 082 g, 10 201 g being the gutted fish mean weight. Mean weights of spent and gutted females were 10 381 and 8722 g, respectively; the respective means for males were 14 491 g and 12 619 g. Thus males are observed to have larger weights than females (Table 19). The mean male weights in length classes proved higher than the respective means for females. An individual weight of a spent female was found to range within 5700–16 600 g, the range of gutted female individual weight being 4800–12 500 g; the respective ranges for males were 4250–22 300 g and 5300–23 200 g. According to Chrzan (1969), the Drawa salmon weights after spawning ranged within wide limits of 4.8–24.0 kg, 4.2–24.7 kg being the range found in the present study; thus the Drawa salmon weight range is 4.2–24.7 kg

Fig. 8. Length frequency distribution of salmon in the rivers Drawa and Vistula

Table 19

Salmon weight distribution over length classes

Length class (cm)	Females				Males			
	Roe removed		Gutted		Sperm removed		Gutted	
	n	g	n	g	n	g	n	g
75 – 79					1	4250		
80 – 84	1	6200	1	4800	3	5091		
85 – 89	5	7630	2	5102			1	5300
90 – 94	17	7350	7	6842			2	6650
95 – 99	29	8797	26	7469	4	9356	3	7006
100 – 104	15	9300	12	8535	11	10695	6	10683
105 – 109	21	11046	20	9843	8	13450	13	11145
110 – 114	10	11545	14	10583	16	14339	9	12034
115 – 119	4	13825	2	12150	9	17183	10	15236
120 – 124					12	18295	5	16500
125 – 129			1	12500	3	20100		
130 – 134					5	19452	2	20615
135 – 139								
140 – 144							1	23200
Total:	102	10381	85	8722	72	14491	52	12619
Range		5700–16600		4800–12500		4250–22300		5300–23200

(Table 20). The Drawa (Kaj, 1962) and Vistula salmon weights (Schechtel, 1925; Jokiel, 1958; Żarnecki, 1963) as well as those for the Pomeranian rivers opening into the Baltic (Chełkowski, 1965) are confined to the same range. On the other hand, the Warta salmon weight range (Przybył, 1976) overlaps with the Drawa one in its upper limit only, the lower limit being much smaller (1.75 kg). In spite of doubts risen by Przybył's data on small lengths and weights of salmon from the Warta catchment, the Drawa being a part of the area, they should be treated as reliable. This statement is confirmed by the length and weight (72.5 cm and 1.79 kg when gutted) of a female kelt caught on March 31, 1973 in the Szczecin Lagoon off Kamień Pomorski (Chełkowski et al., 1976).

The Drawa and Vistula salmon mean weight exceeds 12 kg. The data on weights of various salmon populations demonstrate no other population in the Baltic catchment to attain such high weights (Table 20).

Table 20

Mean salmon weights (kg)

River		Author	Females	Males	Total
Polish rivers	Drawa	present study *	10.4	14.5	12.1
			8.7	12.6	10.2
	Vistula	Chrzan 1969 *	9.3	13.9	
		Jokiel 1958 ***	11.0	15.9	12.2
	Pomeranian rivers	Chełkowski ** 1965	9.2	10.4	9.8
Swedish rivers	Torne	Dahl (1933) ***			10.0
	Lule				10.8
	Ume				9.3
	Angerman				10.5
	Indal				9.5
	Ljuna				9.3
	Morrum				8.3

* – roe and sperm removed

** – gutted

*** – weight on capture

The fish to be delivered to the market were dissected and the entrails removed; thus weights of the following organs were determined: intestine, liver, spleen, heart, and gonads. The data presented show mean weights of the intestine, liver, spleen, and heart to be 145.8, 130, 15.1, and 25.6 g, respectively, regardless of sex (Table 21).

The complete weight analyses of 25 females and 21 males allowed to calculate weights of the viscera relative to the body weight. The viscera of artificially spawned females and

Table 21

Weight (g) of salmon viscera

Organ	Females			Males			Total		
	n	M	range	n	M	range	n	M	range
Intestine	39	131.9	75–285	22	170.5	91–278	61	145.8	75–285
Liver	39	117.3	63–215	22	152.7	51–290	61	130.0	51–290
Spleen	27	11.3	5–28	22	19.8	6–36	49	15.1	5–36
Heart	34	21.9	13–38	22	31.1	15–52	56	25.6	13–52

males were found to make up, on the average 8.65 and 6.02%, respectively, of the body weight before gutting, 9.55 and 6.42% being the percentages of the female and male viscera weights, respectively, of the gutted body weight. In view of all that, adding the estimated 6.42% (1489 g) of the gutted male weight to the largest male gutted weight (23 200 g), the largest salmon individual weight found in the present study is about 25 kg (24 689 g).

When the spawned females were dissected, mature eggs were being found in the body cavities. The females examined contained from 9 to 1585 eggs and the serous fluid present in relatively large quantities, particularly in kelts containing low numbers of eggs (Table 22). To determine the number of eggs remaining in the body cavities of females, 10-g samples of roe were taken. The number of eggs found in a sample served to calculate the total number of eggs remaining in female bodies. The numbers of eggs were found to range within 78–10 160 (a mean of 2950). It is supposed that those eggs could be used in reproduction. The unused eggs remaining in the female bodies and subject to artificial fertilisation made up 28.5% of the economic fertility. On the other hand, the females totally spent under natural conditions in the river contained low (about 100) numbers of eggs.

A weight analysis was also performed on the spent salmon gonads (Maier scale stage VIII); the weight range of ovaries without eggs was found to be 71–399 g ($M = 157.4$ g), the empty testes range being 146–650 g ($M = 458$ g).

Spawning migrations

Spawning migrations were followed basing on the salmon caught in the Szczecin Lagoon and Lower Odra. It is supposed that the salmon caught in that area are representative of the stock spawning in the Drawa. Out of the total of 2864 anadromous salmonid individuals examined that constituted the catch obtained in the Polish sector of the Szczecin Lagoon and Lower Odra over 1973–1975, 46 were found to belong to *Salmo salar* (Table 23) Chełkowski et al., 1976; Chełkowski and Chełkowska, 1977,

Table 22

Salmon gonad weight (g)

No.	Females					Males		
	Fish length (mm)	Gutted weight (g)	Ovary weight (g) (mature eggs removed)	Mature eggs weight (g)	No. of mature eggs	Fish length (mm)	Gutted weight (g)	Gonad weight (g)
1	846	4800	119	38	441	860	5300	233
2	892	5005	105	942	9823	937	7050	274
3	940	6800	176	—	—	954	7200	620
4	940	7800	105	510	4131	970	7020	146
5	941	6600	169	48	485	1030	10400	455
6	965	8400	123	980	7938	1030	12600	535
7	967	6746	113	582	5439	1035	9800	232
8	968	7200	113	140	109	1053	8520	220
9	973	7100	111	9	78	1060	11150	391
10	975	6455	71	—	—	1060	11250	450
11	985	6950	92	—	—	1080	10220	333
12	985	8300	110	220	1654	1085	12200	420
13	994	7300	144	195	1196	1095	12200	400
14	995	8200	165	255	2142	1108	12300	412
15	998	9300	122	21	142	1120	12550	465
16	1009	6500	88	513	4932	1143	13000	535
17	1012	8400	189	242	2016	1150	13650	515
18	1025	9400	186	171	1305	1155	16900	722
19	1055	9600	105	570	4731	1163	16960	702
20	1072	8600	—	3095	24760	1182	15200	620
21	1082	9100	257	397	3544	1187	17150	575
22	1085	9500	398	351	2700	1209	16200	454
23	1093	10600	166	217	1539	1215	17200	382
24	1103	11952	160	117	897	1232	17200	713
25	1105	11400	300	410	3321	1311	19030	650
26	1110	10300	150	16	136			
27	1148	10400	232	1585	10160			
28	1173	11900	183	253	1946			
M	1015	8379	157.4	475.4	2950	1100	12450	458

Table 23

Salmon catches (no. of ind.) in the Szczecin Lagoon
and lower Odra

Year	Month Decade	Fish in post-spawning migration									Fish in spawning migration												Total			
		III			IV			V			VIII			IX			X			XI				XII		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		1	2	3
Females																										
1973				1													2	2			1					6
1974						2						1			2		2		1							8
1975				1		2	1	1						1		1		1					1			9
Total				2		4	1	1				1			3		5	2	2		1			1		23
Males																										
1973														1	4	1	3									9
1974															2	3	1		1							7
1975															2	2	1	1	1							7
Total														1	8	6	5	1	2							23
Grand total:				2		4	1	1				1		1	11	6	10	3	4		1			1		46

1978). A detailed examination of the condition, abdominal flesh thickness, gonad maturity stage and intestinal fat cover allowed to divide the salmon caught into 2 groups: those migrating to spawn and post-spawning individuals. The studies show the salmon spawning migration in inland waters to proceed within the period from the second decade of August until the third decade of October. Additionally, 2 ready to spawn salmon females were caught: one in the first decade of November in the Stepnica Cove, the other in the second decade of November in the lower Odra off Gryfino. It can be supposed that the female caught in November would have spawned in the river Gowienica opening into the Stepnica Cove, as the salmon was found to occur in that river, too (Chełkowski, 1968a). On the other hand, the occurrence of the fully mature female off Gryfino might have resulted from a disturbed course of its migration due to the release of heated water from the Gryfino power station (Chełkowski, 1970a). The most abundant catches made up of the ascending salmon were obtained in September (52.7%) and October (39.5%). Low numbers of individuals were present in the August, November, and December catches, 2.6% each. The peak of spawning migration is in the third decade of September and in the first decade of October. On the other hand, kelts occurred in the Szczecin Lagoon catches from the third decade of March until May 1; the latter observation concerning females only, as no male kelts had been found in catches in the area. Resorption marks on scales show males to repeat spawning, too, low numbers of males relative to those of females being found to descend to the sea via the lower Odra and Szczecin Lagoon. It is assumed from the data on catches that the salmon presence in the inland waters during spawning is limited to 9 months (September – May) at the longest.

The salmon ascent from the Baltic to the Szczecin Lagoon and lower Odra lasts basically two and a half months (mid-August through late October), the descent in the areas mentioned taking place in the end of winter and early spring.

Gonads of the ascending fish, found to be at the Maier scale stages IV, V, and V+, show the salmon to commence their spawning in autumn; according to Berg (1934, 1937) and Żarnecki (1963, 1964), they belong to the summer form. Migrations and spawning of salmon of the Vistula (Schechtel, 1925; Żarnecki, 1963; Jokiel, 1958) and Pomeranian rivers (Chełkowski, 1965) have a similar timing. Berg (1948) is also of the opinion that the salmon ascends the rivers in summer to lay eggs in autumn-winter (October-February). The salmon with almost mature gonads (Maier scale stage V+ according to Jokiel, 1958) ascends the lower Vistula as early as from the second decade of July until September, that is at least one to two months earlier than the salmon of the Odra catchment. In two Finnish rivers (Nordquist, 1906) the main ascent of salmon takes place still earlier, in late June (Table 24). Żarnecki (1963) provides an evidence that the Vistula salmon with immature gonads migrate in September-November. Such a possibility is also suggested by Nordquist (1906), Berg (1948), and Nikolski (1954). Such salmon have not been encountered in the Odra catchment so far.

As observed by Jokiel (1958), the lower Vistula kelts descended to the sea in mid-November, that is earlier than the Drawa salmon.

Table 24

Season of salmon spawning migration

River	month Author	6	7	8	9	10	11	12	Remarks
Drawa	present study			*	**	**			gonads developed
Vistula	Schechtel (1925)				*	*			gonads developed
Vistula	Jokiel (1958)		**	*	*				gonads developed
Vistula	Żarnecki (1963)				**	**	*		gonads developed
					**	**	**		gonads under – developed
Pomera- nian rivers	Chełkowski (1965)			*	*	*	*		gonads developed
Finnish rivers	Nordquist (1906)	*	**						
	Berg (1934)		*	*	*				

* – period of migration

** – mein period of migration

Condition

In order to follow changes in the salmon condition, the Fulton-Clark condition coefficients were calculated for the specimens caught during their spawning and post-spawning migrations in the Szczecin Lagoon and lower Odra as well as for those caught during spawning in the Drawa.

The calculations demonstrated the adult salmon condition to vary considerably during their migration in inland waters. A mean female coefficient is the highest (0.95) during the spawning migration, slightly lower (0.78) and minimum (0.70) values being found at spawning and during the post-spawning migration, respectively. Similarly, the highest value for males (1.04) was recorded during the spawning migration and a slightly lower one (0.91) at spawning (Table 25). It is thus concluded that the salmon condition deteriorates during the spawning migration.

Numerical values of the Fulton-Clark coefficients for the Vistula (Jokiel, 1958; Schechtel, 1925) and Drawa salmon migrating to spawn are summarised in Table 26. The salmon migrating to spawn in the Vistula and Drawa are observed to be of a similar condition. Both the Drawa and Vistula males show a better condition (higher coefficients) during their migration and spawning than the females.

Table 25

Migrating salmon condition

Sex	Period of life	n	M $\pm$ m	δ	ϑ
Females	spawning migration	13	0.95 $\pm$ 0.0301	0.1086	11.38
	spawning	85	0.78 $\pm$ 0.008	0.0735	9.36
	post-spawning migration	8	0.70 $\pm$ 0.045	0.1273	18.25
Males	spawning migration	22	1.04 $\pm$ 0.019	0.0889	8.55
	spawning	52	0.91 $\pm$ 0.014	0.1020	11.25
	post-spawning migration	—	—	—	—

Table 26

Salmon condition coefficients

Period of life	Drawa (present study)		Vistula			
			Schech- tel (1925)	Jokiel (1958)		
	Females	Males	Females	Females	Males	Total
Spawning migration — summer	0.95	1.04			1.08	1.0 —1.13
Spawning — autumn	0.78	0.91	0.77			0.97—1.0
post-spawning migration — winter, spring	0.70				0.95	

Age

An important issue in the salmon biology is the age of sexual maturity, determined by examining scales from the spawning stock. Scales of 304 individuals caught in the Drawa were examined, 5.6% of that number being rejected owing to interpretational difficulties encountered. Thus the age was determined for 287 individuals (94.4%). The analysis performed showed 266 individuals to have not spawned and 21 ones to possess spawning marks (Table 27). Thus 92.7% of the spawning stock was made up by the „recruitment”,

Table 27

Results of scale examinations (no. of individuals)

Fish group	Females	Males	Total
First spawning	152	114	266
Spawning marks present	19	2	21
Age nondefined	12	5	17
Total:	183	121	304

the „residue” being 7.3%. Results of scale examinations for reading the age of fishes ascending to their first spawning and of those repeating spawning are given separately. The Drawa salmon juveniles were found to have remained in the river for one or two years before attaining the smolt stage. The recruitment part of the spawning stock consisted in 75.19% of 1-yr-old individuals and in 24.81% of 2-yr-old ones. Percentage indices for each sex show the 1-yr-old individuals to be more numerous among males than among females. On the other hand, the percentage of 2-yr-old females was slightly higher than that of males (Table 28). According to Chrzan (1969) and Kaj (1961), the Drawa juveniles remain in the river for 1 or 2 years, which is also confirmed by the present studies. Moreover, the present observations confirm the fact of most smolts' descent after

Table 28

Age of salmon in first spawning
(Sea life and riverine life, yr)

Sex	Smolt age	Years of sea life				Total, smolts	
		2+	3+	4+	5+	no. of ind.	%
Females	1	80	26	2	—	108	71.05
	2	19	22	3	—	44	28.95
	Total	99	48	5	—	152	100.00
Males	1	42	46	4	—	92	80.7
	2	9	11	1	1	22	19.3
	Total	51	57	5	1	114	100.0
Grand total:		150	105	10	1	266	
%		56.39	39.47	3.76	0.38		100.00

Table 29

Smolt contribution to age groups (%)

River	Years of life		1	2	3	4	5
	Author						
Drawa	Present study		75.19	24.81			
	Chrzan	(1969)	75	25			
	Kaj	(1961)	*	*			
Vistula	Jokiel	(1958)	70	30			
	Żarnecki	(1963)		90	10		
Mörum S Sweden	Alm	(1934)	7.5	80	12.5		
Kalx N Sweden	Alm			11.6	68.3	19.6	0.5

* – presence

a one-year-long period of presence in the river. Similar observations in this respect were made by Jokiel (1958) (Table 29). On the other hand, Żarnecki (1963) found a longer, 2–3 years, period of the Vistula salmon's presence in the river. Similarly to the situation in 11 Scottish rivers according to 14 authors referred to by Gardner and Michael (1976) and in Swedish rivers (Alm, 1934), no smolt that would have stayed in the Drawa for 3 or more years was found.

The period of sea life of the fishes before their first spawning lasts within the age of 2+ to 5+, 2+ to 4+ being the period for females and 2+ to 5+ for males. Over the whole period of study, the sea life of most fishes examined was 2+ and 3+, the percentages of 4+ and 5+ individuals being low. When the sea life of the salmon is analysed with respect to sex, most females are found to remain in the sea until the age 2+, while most males do not being their ascent before the age 3+ and 2+.

The duration of sea life of the Vistula and Drawa salmon are compared in Table 30. No fishes of 1+ age of sea life were found in the spawning stock of the Drawa (present

Table 30

Salmo frequency over sea life age groups (%)

River	Years		1 +	2 +	3 +	4 +	5 +	6 +
	Author							
Drawa	Present study			56.39	39.47	3.76	0.38	0.8
	Chrzan	(1969)	0.4	36.4	50.4	11.3	1.5	
	Jokiel	(1958)		2.5	70.0	22.5	4.2	
	Żarnecki	(1963)	4.7	82.4	12.9			

study) and Vistula (Jokiel, 1958). Chrzan (1969) found a low number of such fishes (0.4%), males only. Somewhat more (4.7%) individuals in this age group are reported by Żarnecki (1963) among the Vistula salmon. Further comparisons of the present observations and those made by Chrzan (1969) demonstrate the majority of the Drawa salmon spawning stock to belong to the sea life age groups 2+ and 3+, which is consistent with the age of the Vistula salmon population (Żarnecki, 1963). On the other hand, Jokiel (1958) found the Vistula salmon to belong to the age groups 3+ and 4+, which means a longer period of sea life.

Table 31

Age of salmon in first spawning

Sex	3+	4+	5+	6+	7+	Total no. of ind. %
no. of ind.	80	45	24	3	—	152
Females %	52.65	29.61	15.79	1.97	—	100
no. of ind.	42	55	15	1	1	114
Males %	36.84	48.24	13.16	0.88	0.88	100
no. of ind.	122	100	39	4	1	266
Total %	45.87	37.59	14.66	1.50	0.38	100

An individual age is determined by combining the periods of riverine and sea life, which is presented in Table 31. The Drawa salmon is shown to reach sexual maturity at the age 3+ to 7+. Most numerous are the 3+ and 4+ individuals, smaller amounts of the 5+ ones being found. The remaining age groups, 6+ and 7+, are represented by a very low number of individuals (1.88%). Generally, 83.46% of all the individuals were found to belong to the groups 3+ and 4+, 14.66% representing the age group 5+. Females were found to be more numerous in the group 3+, while males in the 4+ one. The data presented indicate females to have commenced spawning earlier and in larger numbers of

Table 32

Salmon frequency over age groups

River	Author	Years of life						
		2+	3+	4+	5+	6+	7+	8+
Drawa	Present study		45.87	37.59	14.06	1.50	0.38	
	Chrzan (1969)	0.4	20.1	55.0	18.5	4.9	0.4	
Vistula	Jokiel (1958)				65.5	24.5	8.2	1.8

individuals than males. A considerable similarity of the present data and those reported by Chrzan (1963) from the same river is observed, except for the age group 2+ represented by a very low percentage of males, while the Vistula salmon, according to Jokiel (1958), matures as late as after 5+ years of sea life, that is much later than the Drawa salmon (Table 32).

Length and weight distribution

The individuals ascending to spawn for the first time served to calculate lengths and weights in various years of life. Results of these calculations, the smolt age included, are presented in Tables 33 and 34. The data show males to attain larger size and weight in the succeeding years of sea life.

Table 33

Salmon length (mm) in age groups

Years of sea life	Sex	Smolt age				Total	
		n	1	n	2	n	
2+	females	80	965	19	982	99	969
	males	42	1033	9	1039	51	1034
3+	females	26	1114	22	1083	48	1086
	males	46	1141	11	1210	57	1154
4+	females	2	1106	3	1127	5	1119
	males	4	1276	1	1315	5	1284
5+	females	—	—	—	—	—	—
	males	—	—	1	1408	1	1408

The female length distribution curve proved bimodal (Fig. 8), one peak occurring in the 95–100 cm class and the other in the 105–110 cm one. The male curve is not so clear-cut, a peak being, however, observed in the 110–115 cm class and another one in the 120–125 cm class, while still other peak occurred in the 130–135 cm class. The female peaks seem to be connected with the sea life ages 2+ and 3+, while the male ones with the sea life ages 2+, 3+, and 4+.

The Drawa and Vistula salmon populations are compared in terms of the individual length and weight distributions over the years of sea life (Tables 35 and 36). The data show the Drawa salmon length and weight in the subsequent years of sea life to be always somewhat larger than those of the Vistula salmon.

Table 34

Weight of salmon in first
Spawning over years of life

Years of sea life	Sex	Smolt age				Total	
		1 yr		2 yr		n	g
		n	g	n	g		

Whole fish

2+	females	53	8.440	6	8.416	59	8.438
	males	22	10.462	6	10.629	28	10.498
3+	females	18	11.844	7	11.900	25	11.860
	males	31	15.931	8	17.131	48	16.177
4+	males	4	18.975			4	18.975

Gutted fish

2+	females	28	7.346	14	7.897	42	7.529
	males	20	10.315	3	10.050	23	10.280
3+	females	9	9.547	15	10.138	24	9.916
	males	16	14.048	5	16.606	21	14.657
4+	females	1	11.000	3	9.817	4	10.112
	males			1	22.200	1	22.200
5+	males			1	23.200	1	23.200

Table 35

Salmon length (cm) in different years of sea life

River	Author	Years of life				Remarks
		2+	3+	4+	5+	
Drawa	present study	96.9	108.6	111.9		females
		103.4	115.4	128.4	140.8	males
Vistula	Jokiel (1958)	86.8	98.6	104.2	109.7	females

Table 36

Salmon weight (kg) in different years of sea life

River	Author	Years of sea life				Remarks
		2+	3+	4+	5+	
Drawa	Present study	8.4	11.9			spent females
		10.5	16.2	19.0		spent males
	Present study	7.5	9.9	10.1		gutted females
		10.3	14.7	22.2	23.2	gutted males
	Chrzan (1969)	8.5–9	13.5			spent fish
Vistula	Jokiel (1958)	7.6	10.8	13.4	14.9	ascending females

Salmon with spawning marks

Among the spawning salmon caught in the Drawa for age readings, 21 individuals had already spawning marks (Table 37), 15 females and 2 males showing a single spawning mark each, and 4 females had 2 marks each. The individuals with a single mark undertook their spawning migration for the second time, whereas those with 2 marks ascended to spawn for the third time. A closer examination of scales showed that out of the 15 females with a single mark 6 were going to spawn immediately after one season of feeding in the sea, 9 undertaking spawning after 2 feeding seasons, i.e., with a one-year rest. Among the males, one individual undertook spawning a year after the last one and the other after two years, i.e., with a one-year rest. Four females only showed two spawning marks, the females spawning in consecutive years without any resting period. The particulars on the individuals with spawning marks can be found in Table 38.

The final calculations show that 11.1% of the 171 females caught had spawning marks (8.8% with one and 2.3% with two marks); the percentage of individuals with marks among the 116 males caught was 1.8% (one mark only). It is concluded that females repeat spawning about 6 times more frequently than males.

When analysing the Drawa salmon spawning stock structure, the percentage of fishes with spawning marks was found to amount to 7.3% (Table 39) against 12.5% recorded by Chrzan (1969). Both studies reveal the presence of females and males with two spawning marks, the males being very few. Individuals with 3 marks each, females only occurred sporadically. The Vistula salmon spawning stock also contained individuals with spawning marks, their percentage being 8.4% (Jokiel, 1958). In the Drawa, the salmon repeat spawning after one or two feeding seasons in the sea. No individuals staying longer in the sea were found, which contradicts Berg's (1948) assumption of such a possibility.

Table 37

Age of salmon with spawning marks

Sex	Age		No. of ind.	Spawning at sea of life	Total no. of ind.
	River	Sea			
a) Single spawning marks					
Females	no rest				
	1	3+	1	3	6
	1	4+	1	4	
	2	3+	2	3	
	2	4+	2	4	
	1-yr-long rest				
	1	4+	4	3	9
	2	4+	4	3	
	2	5+	1	4	
Males	no rest				
	2	4+	1	4	1
	1-yr-long rest				
	2	4+	1	3	1
b) Double spawning marks					
Females	no rest				
	1	4+	3	3; 4	4
	2	4+	1	3; 4	
Total	Females				19
	Males				2

As mentioned earlier, the artificially spawned and tagged salmon individuals were released back to the Drawa. A tagged female was recaptured the next year in the spawning ground (Chełkowska and Chełkowski, 1976). The scales of the female after the first and the second spawning present an interesting material, both in terms of calculating the duration of sea life and owing to a poorly visible first spawning mark (Fig. 9).

Table 38

Characteristics of salmon with spawning marks

Sex	Age		Length (mm)	Weight (g)		Spawning at sea life age of
	River	Sea		Whole	Gutted	

a) Single spawning mark

Females	no rest					
	1	3+	1012	—	8.400	3
	1	4+	1076	—	9.400	4
	2	3+	941	—	6.600	3
	2	3+	1010	8.100	—	3
	2	4+	1102	—	9.800	4
	2	4+	1255	—	12.500	4
	1-yr-long rest					
	1	4+	1060	11.500	—	3
	1	4+	1070	9.750	—	3
	1	4+	1078	—	10.400	3
	1	4+	1157	—	12.400	3
	2	4+	1078	—	10.200	3
	2	4+	1090	—	10.900	3
	2	4+	1096	—	11.100	3
	2	4+	1110	10.625	—	3
	2	5+	1173	—	11.900	4
Males	no rest					
	2	4+	1120	10.500	—	4
	1-yr-long rest					
	2	4+	1260	21.800	—	3

b) Double spawning marks

Females	no rest					
	1	4+	1065	9.250	—	3; 4
	1	4+	1100	12.500	—	3; 4
	1	4+	1150	11.000	—	3; 4
	2	4+	1148	10.400	—	3; 4

Fig. 9. A blow-up of xeroxed Drawa salmon scale. A. female; length: 91 cm; weight: 7100 g (without eggs); age 2.2+; tagged (P.MIR 16623) in December 1974 and released into the Drawa. B. female caught in the Drawa on Nov. 14, 1975 near the previous year's release site; length: 100.5 cm weight: 6050 g (after spawning) age: 2.3+; spawning mark poorly visible

Table 39

Percentage of salmon with spawning marks in reproductive stocks

River	Author	Total %	Single mark	Double marks
Drawa	Present study	7,3	5.9	1.4
	Chrzan (1969)	12.5	11.75	0.75
Vistula	Jokiel (1958)	8.4		

SYNOPSIS OF THE RESULTS

The absolute values of plastic characters of the Drawa salmon (Table 3) showed the mean lengths of the ventral anterior part of the body (uw), tail dorsal and ventral margins ($\gamma\delta$) and ($z\epsilon$), respectively to be larger in females, the means for the remaining characters being larger in males.

When comparing the relative values of plastic characters in males and females (Table 2), 9 characters that seem to reflect the sexual dimorphism of the salmon studied can be separated. Thus the lengths of the ventral anterior and posterior parts (uw and wy) are larger in females. Mean relative values of the following lengths are larger in males: head (ao), central head part ($a_5 d$), snout (ag), upper jaw ($a_5 i$), lower jaw (kl), snout-dorsal fin (aq), and snout-ventral fin (aw). A comparison of ranges showed the lower jaw length (kl) only to have differing ranges of the relative values, the remaining ranges overlapping. The strongest differences between sexes are reflected in the lower jaw length (kl) as well as in the head length (ac) and the snout-dorsal fin distance (ag). The smallest body height ($\xi\eta$) as a percentage of P-V (uw) is 21.8 and 23.8 for females and males, respectively. The pre-ocular length (aq) is 3.4 and 4.8 times longer than the longitudinal eye diameter (gh) in females and males, respectively. The smallest body height ($\xi\eta$) is less than two times smaller than the tail dorsal margin length ($\gamma\delta$) both in females and males. The anal fin height ($\alpha\beta$) is 1.3 and 1.4 times the smallest body height ($\xi\eta$) in females and males, respectively. The P-V distance (uw) is more than twice as long as the dorsal fin (uw) regardless of sex. The tail dorsal margin length ($\gamma\delta$) is always, both in females and males, larger than the anal fin height ($\alpha\beta$). The tail ventral margin length ($z\epsilon$) is 1.2 and 1.08 times longer than the anal fin height ($\alpha\beta$) in females and males, respectively.

The numbers of rows of scales can be summarised by the following formula: $Squ.19-28/118-126/18-26/11-14$.

The following formula is applicable to the fin rays counts: D III-IV 8-11; A III-IV 7-9.

The subbranchial membrane rays count was determined as 10-13.

Phot. 3 The Płociczna River — the left-side affluent of Drawa River. Region of Salmon spawning-grounds.

(Phot. by Z. Chełkowski)

Dark marks on the left side of the body demonstrated the following pattern:

- head: 5–39 marks 1–14 mm diameter; circular, oval, kidney-like or irregular in shape;
- trunk above the lateral line: 37–308 marks 1–16 mm diameter: circular, oval, irregular, star-like, x- or xx-shaped, clover leaf, kidney-like in the anterior part of the body close to the upper part of the cleithrum;
- trunk below the lateral line: 0–47 marks, 1–24 mm diameter, shaped as those above the lateral line;
- tail above the lateral line: 8–53 marks 2–7 mm diameter, circular, oval, irregular, x-shaped;
- tail below the lateral line: 0–3 marks 1–6 mm diameter, shapes as above the lateral line;
- lower part of the dorsal fin: 4–14 marks 1–15 mm diameter, circular, oval, or irregularly shaped.

The gill processes counts ranged within 18–24, all the processes being bony; 85–127 and 96–138 first gill arch external and internal lamellae, respectively, were recorded.

The pyloric processes and vertebrae counts were 56–98 and 57–60, respectively.

The vomer lamella is pentagonal, toothless; 0–5 teeth in the vomer base, the teeth being irregularly arranged, usually placed transversely to the vomer shaft; 0–5 teeth in a single row on the vomer shaft. Apart from the toothed vomer, teeth are present on the promaxilla (3–13), jaws (5–22), palate (8–13), and dental (4–21) bones as well as on the basihyale (4–8).

A mature non-fertilised egg weighs 86–163 mg, its diameter ranging within 5.1–6.22 mm. A mature fertilised egg weighs 104–177 mg, its diameter being 5.55–6.78 mm.

The caudal fin has a bow-like indentation. Scales on the tail cover a bow-shaped or almost circular area.

The jaw bone reaches to or beyond the posterior eye margin. The interopercular bone ramus in its external outline wedges in between the opercular and preopercular bones and separates the subopercular bone. The spawning males have their jaws curved hook-like up and backward. The hook is palpable through the skin on the upper part of the closed snout. Marginal bones of the caudal fin form so-called creases. The ventral fin is more than three times longer than the axillar process. The pseudo-lid is cut-cone shaped. The eye diameter-largest lid width ratio exceeds 3.

The colour pattern is as follows. The spawning females are steel-lead coloured with a few pink-orange marks, the colour of spawning males being always more intensive. The pink-orange colouration of the skin is present both on the dorsal part and on the sides of the body, being particularly well-visible on the ventral part. Numerous dark marks have pink rims, particularly on the head near the preoperculum and operculum. Very numerous pink dots occur all over the body. The upper part of the head and the anterior part of the dorsal side are green or olive-green, particularly in males. The dorsal and ventral fins are of a colour resembling that of the respective part of the body. The paired fins and the caudal one are grey-steel in colour. The roe is orange, sometimes yellow-orange, particularly in those females repeating spawning.

The Drawa salmon spawning migration in inland waters, the Szczecin Lagoon and lower Odra, takes place in September and October, that is immediately before spawning. The post-spawning migration of kelts in the same waters covers the period of the third decade of March – first decade of May. The joint duration of the spawning and post-spawning migrations is not longer than 10 months.

The Drawa salmon spawns in November and in the first decade of December at water temperatures ranging within 1–8.5°C, the peak spawning occurring in the second and third decades of November. Spawning in the Drawa proceeds at 1–1.5 m depth on coarse gravel-covered bottom, the flow exceeding 1 m s⁻¹, while in the Płociczna the respective values of depth and flow are 0.20–0.50 m and 1.5 m s⁻¹, the bottom being also covered by coarse gravel. The male to female ratio in the Drawa spawning grounds is 1:1.5. Males are more numerous in the spawning grounds at the beginning of the spawning, females being more numerous later on. Females arrive at the spawning grounds and start spawning immediately, while males remain there for a much longer time.

The spawning salmon length (*longitudo caudalis*) was found to range within 760–1408 mm, 95.4% and 4.6% of the specimens examined measuring more and less than 90 cm, respectively.

Mean weights of whole and gutted spent individuals were 12 082 and 10 201 g, respectively. Mean weights of females after removal of eggs and gutted were 10 381 and 8722 g, respectively, the respective weights of males without sperm and gutted being 14 491 and 12 619 g.

Phot. 4 The Salmon of Drawa River (male in spawning dress, l. caudalis 140.8 cm)

(Phot. by M. Zdziarski)

The economic fecundity of the Drawa salmon females was 10 359 eggs.

The following values of the Fulton-Clark condition coefficients were calculated: 0.95 for females migrating to spawn; 0.78 for spawning females; 0.7 for spent females (post-spawning migration); 1.04 for males migrating to spawn, and 0.91 for spawning males.

The salmon examined were found to live in the river for 1–2 years, the sea life age being 2+ to 5+.

The spawning stock consists of recruitment (92.7%) and residue (7.3%). Both females and males repeat spawning, females repeating it more often than males.

CONCLUSIONS

1. The materials collected (344 individuals) were found to contain 7.6 times more salmon (*Salmo salar* L.) than trout (*Salmo trutta* L.).
2. Results of the present studies on morphological characters of the Drawa salmon correspond to the typical form of salmon (*Salmo salar* L.).
3. Percentage ratios of plastic characters calculated for the salmon examined indicate to differences between the female and male body formation. Mean lengths of the anterior ventral part as well as of the dorsal and ventral margins of the tail were linearly larger in females, the lengths of the remaining 21 plastic characters being larger in males.
4. The period of spawning migration of the salmon with gonads advanced in their development (Maier scale stage IV-VI), September – October in the Szczecin Lagoon and lower Odra, points out to the Drawa population belonging to the typical summer form of salmon.
5. The Drawa salmon examined has a shorter riverine life (up to the smolt stage) and a higher growth rate than other populations.
6. The analysis of scales of 287 salmon individuals showed a 12.7:1 ratio of the individuals spawning for the first time vs. those repeating to spawn, which indicates the spawning stock to consist mainly of those individuals spawning for the first time.
7. The magnitude of catches recorded over 15 years (1961–1975) indicate a clear decline in the abundance of salmon spawning in the Drawa.
8. Results obtained and observations made during the present study justify the necessity of introducing procedures aimed at increasing the salmon stock, such as:
 - protection of descending smolt and kelts and ascending fish during their migrations in inland waters;
 - release of the salmon used for artificial reproduction back to the Drawa.

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STUDIA NAD MORFOLOGIĄ I BIOLOGIĄ ŁOSOSIA *Salmo salar* L. RZEKI DRAWY

Streszczenie

Opracowanie niniejsze miało na celu ustalenie cech morfologicznych (plastycznych, merystycznych) i biologicznych łososa (*Salmo salar* L.) rzeki Drawy.

Opracowane wartości bezwzględne cech plastycznych łososi z Drawy wykazały, że średnie długości przedniej części brzucha (uw), długość grzbietowego brzegu trzonu ogonowego ($\gamma\delta$) i długość brzuszego brzegu trzonu ogonowego ($\gamma\epsilon$) są liniowo większe u samic. Natomiast pozostałe długości dwudziestu jeden badanych cech okazały się większe u samców.

Porównując wartości względne cech plastycznych można wyróżnić dziewięć cech, które zdają się odzwierciedlać dymorfizm płciowy badanych łososi. W tym względzie długość przedniej części brzucha (uw) i długość tylnej części brzucha (wy) są większe u samic. Samce natomiast przeważają jeśli chodzi o średnią wartość względną długości: głowy (ac), średniej części głowy (a₅d), pyska (ag), górnej szczęki (a₅i), dolnej szczęki (kl), od końca pyska do płetwy grzbietowej (aq) i od końca pyska do płetwy brzusznej (aw). Biorąc dla porównania zakresy wahań okazało się, że wśród badanych cech jedynie długość dolnej szczęki (kl) posiada różne wartości względne. Natomiast zachodzą na siebie

zakresy wahań wartości względnych pozostałych cech. Do najważniejszych różnic odzwierciedlających dymorfizm płciowy należy zaliczyć wspomnianą już długość dolnej szczęki (kl) oraz na dalszym miejscu długość głowy (ac) i odległość od końca pyska do płetwy grzbietowej (aq). Najmniejsza wysokość ciała ($\xi\eta$) w procentach długości P-V (uw) wynosi 21,8 dla samic i 23,8 dla samców. Średnica podłużna oka (gh) mieści się w odległości przedocznej (ag) 3,4 razy u samic i 4,8 razy u samców. Najmniejsza wysokość ciała ($\xi\eta$) mieści się w linii grzbietowego brzegu trzonu ogonowego ($\gamma\delta$) zarówno w przypadku samic jak i samców. Najmniejsza wysokość ciała ($\xi\eta$) mieści się w wysokości płetwy odbytowej ($\alpha\beta$) 1,3 razy u samic i 1,4 u samców. Długość płetwy piersiowej (uv) mieści się w linii P-V (uw) więcej niż dwa razy bez różnicy na płęć. Długość grzbietowego brzegu trzonu ogonowego ($\gamma\delta$), zarówno u samic jak i u samców, jest zawsze większa od wysokości płetwy odbytowej ($\alpha\beta$). Wysokość płetwy odbytowej ($\alpha\beta$) mieści się w linii brzuszego brzegu trzonu ogonowego ($\zeta\epsilon$) 1,2 razy u samic i 1,08 u samców. Liczbę rzędów łusek można wyrazić formułą: $Squ. 19-28/118-126/18-26/11-14$, natomiast liczbę promieni w płetwach formułą: $D\text{ III-IV } 8-11; A\text{ III-IV } 7-9$.

Liczbę promieni w błonie podskrzelowej określono na 10–13. Charakterystyka ciemnych plam na lewej stronie ciała ryby:

głowa: liczba plam 5–39, średnica 1–14 mm, kształt kolisty, owalny, nerkowaty, nieregularny; tułów nad linią naboczną: liczba plam 37–308, średnica 1–16 mm, kształt kolisty, owalny, nieregularny, gwiazdki, pojedynczego lub podwójnego ichta, listka koniczyny, niekiedy nerkowaty lecz tylko w przedniej części ciała w rejonie górnej części kości skublowej; tułów pod linią naboczną: liczba plam 0–47, średnica 1–24 mm, kształt jak nad linią naboczną; trzon ogona nad linią naboczną: liczba plam 8–53; średnica 2–7 mm, kształt kolisty, owalny, nieregularny, ichta; trzon ogona pod linią naboczną: liczba plam 0–3, średnica 1–6 mm, kształt jak nad linią naboczną; płetwa grzbietowa na dolnej powierzchni: liczba plam 4–14, średnicy 1–15 mm, kształt kolisty, owalny, nieregularny.

Stwierdzono 18–24 wyrostków skrzelowych, wszystkie ościste, płatków na pierwszym łuku skrzelowym po stronie zewnętrznej – 85–127, po stronie zaś wewnętrznej 96–138.

Liczba wyrostków odźwiernikowych zawiera się w granicach 56–98 sztuk, kręgów 57–60.

Blaszka lemieszka jest pięciokątna, nieuzębiona, u podstawy trzonu występują zęby w ilości 0–5, przy czym są one ustawione nieregularnie na ogół poprzecznie do trzonu. Na trzonie zaś występują zęby w ilości 0–5 ustawione w jednym szeregu.

Poza uzębionym lemieszem występują u łososia zęby na kości przedszczękowej w liczbie 3–13, kości szczękowej 5–22, podniebieniowej 8–13, zębowej 4–21 i języku 4–8.

Ciężar dojrzałego, niezapłodnionego jaja wynosi 86–163 mg, średnica 5,1–6,22 mm; ciężar dojrzałego, zapłodnionego jaja wynosi 104–177 mg, średnica 5,55–6,78 mm.

Płetwa ogonowa jest wycięta łukowato. Łuski na trzonie ogona tworzą pole o brzegu łukowatym lub prawie kolistym.

Kość szczękowa sięga poza tylną krawędź oka lub dochodzi do niej. Ramię kości międzypokrywowej w zarysie zewnętrznym wciną się między kość pokrywową i przedpokrywową, oddzielając kość podpokrywową.

U samców w okresie tarła szczęka zakrzywia się hakowato ku górze i do tyłu. Przy zamkniętym pysku hak jest wyczuwalny poprzez skórę na górnej stronie pyska. Kości brzeżne płetwy ogonowej tworzą tak zwane „kanty”. Długość wyrostka pachwinowego mieści się ponad trzy razy w długości płetwy brzusznej. Pseudopowieka posiada kształt tępego stożka. Stosunek średnicy oka do największej szerokości powieki przekracza wartość 3.

Charakter barw jest następujący. Samice w okresie tarła posiadają stalowo-łutowianą barwę z nielicznymi plamami o odcieniu różowopomarańczowym. Samce w okresie tarła posiadają barwę zawsze bardziej intensywną od samic. Występują różowopomarańczowe przebarwienia skóry zarówno

na części grzbietowej jak i bokach, a szczególnie widoczne po stronie brzusznej. Wiele ciemnych plam posiada różowe obwódki, szczególnie na głowie w rejonie kości przedpokrywowej. Występują również bardzo liczne różowe punkty na całym ciele. Górna część głowy i przednia część grzbiegu ma odcień zielony lub ciemnooliwkowy zwłaszcza u samców. Barwa płetwy grzbietowej i tłuszczowej łososia zbliżona jest koloritem do tych części ciała, w których jest umiejscowiona. Płetwy parzyste i ogonowe są szarostalowe. Barwa ikry – pomarańczowa, niekiedy, zwłaszcza u samic powtarzających tarło, żółtopomarańczowa.

Wędrówka tarłowa łososi rzeki Drawy w wodach śródlądowych, w Zalewie Szczecińskim i Dolnej Odrze przypada we wrześniu i październiku tj. w okresie bezpośredniego poprzedzającym tarło. Wędrówka potarłowa keltów w tych samych wodach przypada na okres od III dekady marca do I dekady maja. Wędrówka tarłowa i potarłowa obejmuje łącznie okres nie dłuższy niż dziewięć miesięcy.

Tarło łososia w Drawie odbywa się w listopadzie i pierwszej dekadzie grudnia przy temperaturze wody wahającej się od 8,5°C do 1°C. Przy czym najintensywniejsze tarło przypada w II i III dekadzie listopada. Łosoś odbywa tarło w Drawie na głębokości 1–1,5 m, w dzień z frakcjami grubego żwiru, przy przepływie wody ponad 1 m/sek, w Płocicznej na głębokości 0,20–0,5 m, również w dzień z grubym żwirem przy przepływie około 1,5 m/sek. Stosunek samców do samic na tarliskach w Drawie określono jak 1:1,5. Samce pojawiają się na tarlisku liczniej na początku tarła, a samice występują liczniej w późniejszym okresie. Samice wpływają w rejon tarlisk i spieszenie przystępują do tarła, samce natomiast pozostają na tarlisku przez znacznie dłuższy okres.

Długość (*longitudo caudalis*) łososi biorących udział w tarle wahała się od 760 do 1408 mm. Powyżej 900 mm wystąpiło 95,4% badanych okazów a w grupie poniżej tego wymiaru – 4,6%.

Średni ciężar tarlaków wytartych wyniósł 12 082 g, a dla ryb wypatroszonych – 10 201 g. Średni ciężar samic po pozyskaniu produktów płciowych wyniósł 10 381 g, a po wypatroszeniu – 8722 g, średni zaś ciężar samców niewypatroszonych wyniósł 14 491 g, a po wypatroszeniu – 12 619 g.

Płodność gospodarcza samic łososi z Drawy wyniosła 10 359 jaj.

Kondycja wyrażona współczynnikiem Fultona-Clarka przybiera wartość: u samic z okresu wędrówki tarłowej – 0,95; tarła – 0,78 i okresu wędrówki potarłowej – 0,7; natomiast u samców z okresu wędrówki tarłowej – 1,04 i tarła – 0,91.

Wiek łososi: rzeczny okres życia 1 do 2 lat; morski 2+ do 5+. Stado tarłowe składa się w 92,7% z uzupełnienia i 7,3% reszty lub pozostałości. Tarło powtarzają samice i samce, lecz samice 6 razy częściej w stosunku do samców.

Божена Хелковска

ИЗУЧЕНИЕ МОРФОЛОГИИ И БИОЛОГИИ ЛОСОСЯ (*SALMO SALAR L.*) РЕКИ ДРАВЫ

Резюме

Целью настоящей работы было: установить морфологические (пластические, меристические) и биологические признаки лосося (*Salmo Salar L.*) р. Дравы.

Полученные абсолютные значения пластических признаков лосося р. Дравы показали, что средняя длина передней части брюха (uw), длина спинного края хвостового стебля ($\gamma\delta$) и длина вентрального края хвостового стебля ($z\epsilon$) длиннее у самок. Длина остальных 21 исследованных признаков оказалась большей у самцов.

Сравнивая относительные значения пластических признаков можно выделить 9 признаков, которые, кажется отражают половой диморфизм исследованных лососей. Длина передней части брюха (uw) и длина задней части брюха (wy) — больше у самок. Самцы превосходят по таким признакам как среднее значение относительной длины: головы (ac), средней части головы (a_{5d}), рыла (ag), верхней челюсти (a_{51}), нижней челюсти (kl), расстояния от конца рыла до спинного плавника (aq), и расстояния от конца рыла до брюшного плавника (aw). Сравнивая диапазон колебаний длин нашли, что среди исследованных признаков только длина нижней челюсти (kl) имеет дифференцированные относительные значения. Диапазон колебаний относительных значений остальных признаков перекрывается. К числу главных отличий отображающих половой диморфизм необходимо зачислить упомянутую выше длину нижней челюсти (kl) а также в меньшей степени длина головы (ac) и длина от конца рыла до спинного плавника (aq). Наименьшая высота тела ($\xi\eta$) как процентная доля длины $P-V$ (uw) равняется 21,8 для самок и 23,8 для самцов. Продольный диаметр глаза (gh) помещается в преоптическое расстояние (ag) 3,4 раза у самок и 4,8 раза у самцов. Наименьшая высота тела ($\xi\eta$) вмещается в длину спинного края хвостового стебля ($\gamma\delta$) у особей обоих полов. Наименьшая высота тела ($\xi\eta$) вмещается в высоту анального плавника ($\alpha\beta$) 1,3 раза у самок и 1,4 у самцов. Длина грудного плавника (uv) помещается в расстоянии $P-V$ (uw) больше чем 2 раза, независимо от пола. Длина спинного края хвостового стебля ($\gamma\delta$) и у самок и у самцов всегда больше чем высота анального плавника ($\alpha\beta$). Высота анального плавника ($\alpha\beta$) вмещается в длину вентрального края хвостового стебля ($z\epsilon$) 1,2 раза у самок и 1,08 у самцов. Число рядов чешуй можно отразить формулой: $19-28/118-126/18-26/11-14$, число же лучей в плавниках формулой: $DIII-IV$ 8-11; $AIII-IV$ 7-9. Число лучей в поджаберной оболочке определено как 10 - 13.

Характеристика темных пятен на левой стороне тела рыбы:

- голова: число пятен 5 - 39, диаметр 1-14 мм, формы пятен: круглая, овальная; почкообразная, нерегулярная,
- туловище над боковой линией: количество пятен 37 - 308, диаметр 1-16 мм; формы: круглая, овальная, нерегулярная, звездочки, одинарного или двойного X, лист клевера, иногда почкообразный, но только в передней части тела в районе верхней части "cleithrum",
- туловище ниже боковой линии: количество пятен 0-47, диаметр 1-24 мм формы пятен как над боковой линией,
- хвостовой стебель выше боковой линии: число пятен 8-53, диаметр 2-7 мм, формы: круглая, овальная, нерегулярная, "X",
- хвостовой стебель ниже боковой линии: число пятен 0-3, диаметр 1-6 мм, формы как над боковой линией,
- спинной плавник на нижней поверхности: число пятен 4-14, диаметр 1-6мм, формы: круглая, овальная, нерегулярная.

Обнаружили 18-24 жаберные тычинки, все костные, лепестков на первой жаберной дуге на наружной стороне - 85 - 127, на внутренней стороне - 96 - 138.

Число пылорических придатков в границах 56 – 98, позвонков 57 – 60.

Головка сошника пятиугольная, без зубов, на основании рукоятки зубы в количестве 0 – 5 размещены нерегулярно, обычно поперечно рукоятке, На рукоятке зубы в количестве 0 – 5 размещены в одном ряду.

Кроме зубов на сошнике у лосося зубы растут на предчелюстной кости в количестве 3–13, на челюстной кости – 5 – 22, нёбной кости 8–13, зубной кости 4 – 21, на языке 4 – 8.

Зрелое, неоплодотворенное яйцо весит 86 – 163 мг, диаметр 5,1 – 6,22 мм, вес зрелого, оплодотворенного яйца 104 – 177 мг, диаметр 5,55 – 6,78 мм.

Хвостовой плавник дугообразно подрезан. Чешуя на стебле хвоста образует поле с краем в форме дуги или почти круглое.

Челюстная кость заходит за задний край или достигает его.

Ручка межкрышечной кости в наружной обрисовке врезается между крышечную и предкрышечную кости отделяя подкрышечную кость.

У самцов в период нереста челюсть искривляется крюкообразно вверх и к тылу. При закрытом рыле крюк чувствуется сквозь кожу на верхней стороне рыла. Крайние кости хвостового плавника образуют так называемые „углы". Длина „processus axilliaris" вмещается более чем 3 раза в длине брюшного плавника. „Ложная века" имеет форму тупого конуса. Отношение диаметра глаза к самой большой ширине веки превышает значение 3.

Характер окраски: самки в период нереста имеют стальносвинцовую окраску с немногими пятнами розовооранжевого оттенка, самцы в период нереста имеют окраску всегда более интенсивную чем самки. Розовооранжевые перекрашенные пятна на коже находятся как на дорсальной части так и по бокам, и особенно видимы на вентральной стороне. Многие темные пятна имеют розовые каймы, особенно на голове в районе предкрышечной кости. Обнаружили также многочисленные розовые точки на теле рыбы. Верхняя часть головы и передняя часть спины имеют зеленый оттенок или темнооливковый, особенно у самцов. Цвет спинного и жирового плавников не отличается от цвета тех частей тела в которых они находятся. Парные плавники и хвостовой плавник имеют серостальной цвет. Окраска икры – оранжевая, иногда, особенно у самок повторяющих нерест – желтооранжевая.

Нерестовая миграция лососей р. Дравы в пресных водах, в Щепинском заливе и нижней Одре приходится на сентябрь и октябрь т.е. непосредственно в период предшествующий нересту. Посленерестовая миграция кельтов в тех же водоемах выпадает на период с III декады марта по I декаду мая. Нерестовая и посленерестовая миграции в общей сложности охватывают период не более 9 месяцев.

Нерест лосося в р. Драве происходит в ноябре и в I декаде декабря при температуре воды в пределах 8,5° до 1°С. При чем наиболее интенсивный нерест имеет место в II и III декаде ноября. Лосось нерестится в Драве на глубине 1,0 – 1,5 м, на дне покрытом фракциями грубого гравия, при скорости течения около 1 м/с. В р. Плочичной нерест имеет место на глубине 0,2 – 0,5 м/с, также на дне с грубым гравием при скорости течения около 1,5 м/с. Соотношение самцов и самок на нерестилищах р. Дравы определили как 1 : 1,5. Самцы появляются на нерестилищах в большем количестве в начале переста самки преобладают в более поздний период. Самки приходят в

район нереста и спешно приступают к нересту, самцы же остаются на нерестилище значительно дольше.

Длина (л.с) лососей принимающих участие в нересте колебалась от 760 до 1408 мм. Особей длиной свыше 900 мм было 95,4% среди исследуемых лососей, остальные были размером меньше 900 мм. Средний вес рыб после нереста составил 12082 г, а после потрошения - 10201 г. Средний вес самок после получения половых продуктов составил - 10381 г., а после потрошения - 8722 г. Средний вес самцов после нереста составил - 14491 г., а после потрошения - 12610 г. Рабочая плодовитость самок лосося р. Дравы составила 10359 г.

Упитанность отображена коэффициентом по Фультону - Кларку имеет значения: у самок периода нерестовой миграции - 0,95, нереста - 0,78, периода посленерестовой миграции - 0,7; у самцов периода нерестовой миграции - 1,04, периода нереста - 0,91.

Возраст лососей: речной период жизни от 1 до 2 лет, морской - 2+ до 5+.

Нерестовое стадо состоит в 92,7% из пополнения и 7,3% остатка или остаточности. Нерест повторяют самки и самцы, но самки 6 раз чаще чем самцы.

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