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BIOLOGICAL CHARACTERISTICS OF TROUT (*SALMO TRUTTA* L.) SMOLTS GROWN IN RIVER MOŁSTOWA CATCHMENT AREA

CHARAKTERYSTYKA BIOLOGICZNA SMOLTÓW TROCI (*SALMO TRUTTA* L.) WYROSŁYCH W ZLEWNI MOŁSTOWEJ

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The paper presents the following biological characters of trout (*Salmo trutta* L.) smolts grown under natural conditions of the river Mołstowa: length and weight distribution, age, sex ratio, and gonad maturity stage.

INTRODUCTION

The present paper is third in a series of studies on trout (*Salmo trutta* L.) smolts grown under natural conditions of the river Mołstowa, a right-bank tributary of the Rega (Fig. 1).

The first paper in the series dealt with the survival rate of the fish introduced into the Mołstowa (Chełkowski, Chełkowska, in press), while the second one was concerned with the smolt descent, a particular attention being paid to water temperatures on descent

Fig. 1. Localisation of smolt capture sites

(Chełkowski, Chełkowska, in press). In the present paper, length, weight, and age distribution as well as sex ratio and gonad maturity stage are presented*.

MATERIAL AND METHODS

The study materials were obtained from the lower part of the river Mołstowa, in the vicinity of the town of Mołstowo, upstream of a weir terminating the adult trout spawning migration (Chełkowski, 1974). The smolts studied had grown in the Mołstowa catchment area from fry introduced into that part of the area where no natural spawning was known to have taken place. The catches were effected with a fyke net during the smolt descent. A batch of 272 randomly taken individuals (8.5% of the total 3197 individuals) caught in spring 1979 (Table 1) was examined. The batch examined is a fair representation of a general sample (Table 1 and 3). The fish length (*longitudo caudalis*) was measured to the nearest 1 mm. The lengths obtained were assigned to 1-cm length classes; for instance, the 10-cm class comprised those individuals measuring 9.0–9.9 cm, the 11-cm class grouped those measuring 10.0–10.9 cm, and so

Table 1

Characteristics of the materials examined
(no. of individuals)

Analysis performed		length weight	age age – length age – weight
sex	females	119	114
	males	96	88
	indetermined	57	48
	Total	272	250
Age indetermined			22
Grand total		272	272

* The project was commissioned by the Inland Fisheries Institute in Olsztyn under the cooperation agreement No. 63(IV) 1977.

Table 2

Smolt length distribution

Length class (cm)	Sample			
	general		random	
	n	%	n	%
10	1	0.03	1	0.37
11	9	0.28	4	1.47
12	103	3.22	12	4.41
13	351	10.98	42	15.44
14	811	25.37	72	26.47
15	805	25.18	61	22.43
16	533	16.67	43	15.81
17	234	7.35	19	6.99
18	157	4.91	6	2.20
19	81	2.53	4	1.47
20	46	1.44	1	0.37
21	45	1.40	1	0.37
22	14	0.43	3	1.10
23	6	0.18	2	0.75
24	1	0.03	1	0.37
Total	3197	100.00	272	100.00

Table 3

Smolt length (cm)

Sample	n	M±m	δ	V	Range
general	3197	15.2±0.03	1.88	12.38	9.3–23.9
random	272	14.29±0.12	1.99	13.94	9.3–23.9
females	119	14.81±0.21	2.23	15.08	10.4–23.9
males	96	14.23±0.18	1.73	12.13	10.5–19.4

forth. The weights of gutted and non-gutted individuals were recorded to the nearest 0.5 g, while the gonad weight accuracy was 1 mg. All the weight data were collected several days after the capture; thus they concerned starved fishes.

Sex was determined from gonads observed under low magnification. In some cases, particularly in specimens that died on catching or in a storage tank, and in which an advanced autolysis was observed, sex determination proved impossible.

Gonad maturity stage was determined according to the 8-stage Maier scale (Meisner, 1948; Chełkowski, 1974).

Table 4

Length (l) and length increments (t) of smolts
(mm)

Age	Marginal increment		n	l						t						Weight (g)		Actual age
	description	range (mm)		1	+	2	+	3	+	1	+	2	+	3	+	a	b	
1+	P > dk	14–51	142	102	132	–	–	–	–	102	30	–	–	–	–	22	21	1+
1+	P < dk	58–98	35	78	149	–	–	–	–	78	71	–	–	–	–	31	28	2+
2+	P > dk	10–29	67	73	–	141	160	–	–	73	–	68	19	–	–	40	37	2+
2+	P < dk	45–65	4	70	–	127	183	–	–	70	–	57	56	–	–	59	54	3+
3+	P > dk	25–26	2	62	–	130	–	174	200	62	–	68	–	44	26	81	75	3+
Total		n	250	250		73		2		250		73		2		250	250	
		$\bar{x}$		90		140		174		90		68		44		29	27	

Age was determined from scales taken from a spot directly above the lateral line, between the adipose fin and the dorsal one. Age determinations proceeded in a manner suggested by Sych (1971).

The length growth rate was back-read as in the Dahl-Lea method (Nall, 1930), the back readings being based on the fish length and the scale oral radius. The latter was measured to 0.01 mm under a Zeiss measuring microscope.

An annual ring can be detected only after a next annual increment has begun. Therefore the marginal increment ("dk") exists always and the age determined will always be expressed as A+ (Sych, 1967). The actual age was arrived at by analysing the marginal increments (Chełkowski, 1978) (Table 4).

RESULTS

Sex was determined in 215 smolts (Table 1); their number was found to consist of 119 (55.3%) females and 96 (44.7%) males. The numerical prevalence of females in the Rega trout population is thus observable as early as at the smolt stage, this prevalence being, however, not as high as in the Spawning stock of the same population consisting in 69.3% of females and in 30.7% of males (Chełkowski, 1974).

Gonads of the smolts examined were compared to the Maier scale and assigned to the juvenile stage. Further studies on gonads showed the ovaries (n = 55) and testes (n = 19) to make up, on the average, 0.21 and 0.07% of the gutted body weight, respectively. Generally speaking, the ovaries and testes do not exceed 0.42 and 0.12% of the body weight, respectively. Theoretically, variations in gonad maturity indices cover 0.11–0.42% and 0.03–0.12% of the gutted body weight of fmales and males, respectively.

The data on the smolt length distribution indicate females to have their mean length slightly (by 0.58 cm) larger than that of males (Table 3). Additionally, females show a wider length range; the maximum length in males and females is 19.4 and 23.9 cm, respectively (Table 5). Thus it can be inferred that smolt females in the Mołstowa attain a larger body size than males.

The smolt weight was considered an important characteristics as well. The data obtained show the mean weight of females to be slightly higher than that of males, with respect to both gutted and whole specimens (Table 6). A general mean body weight of whole smolts was 29.1 g (7–117.6 g), the mean for gutted smolts being 26.7 g (6.4–107 g). The mean weight of whole smolts proved much lower than that of a similar group of fish from the Rega (M ± m = 81.96 g ± 2.07 g) (Chełkowski, 1978). The weight distribution in length classes, regardless of sex, is presented in Table 7. Mean weights in each length class were also much lower than the relevant values in the Rega population (Chełkowski,, 1978).

Age was determined in 250 individuals (91.9% of the total number of individuals); the remaining 22 specimens with ill-defined annual scale rings were disregarded.

Table 5

Numbers of females and males in length classes

Length class (cm)	Females	Males	Sex indetermined	Total
10	–	–	1	1
11	1	2	1	4
12	1	6	5	12
13	11	12	19	42
14	36	24	12	72
15	30	23	8	61
16	18	16	9	43
17	10	7	2	19
18	4	2	–	6
19	1	3	–	4
20	–	1	–	1
21	1	–	–	1
22	3	–	–	3
23	2	–	–	2
24	1	–	–	1
Total	11 9	96	57	272

Table 6

Smolt weights
(g)

Sex	n	M±m	δ	V	Range
whole fishes					
females	119	33.69±1.627	17.746	52.674	12.0–117.5
males	96	27.81±1.089	10.669	38.364	12.3– 62.7
sex indeterminet	57				
Total	272	29.10±0.878	14.475	49.742	7.0–117.5
gutted fishes					
females	119	30.83±1.506	16.433	53.302	11.0–107.0
males	96	25.58±1.006	9.860	38.546	11.0– 55.7
sex indetermined	57				
Total	272	26.72±0.810	13.363	50.011	6.4–107.0

Table 7

Smolt weight distribution over lengths classes
(g)

Length class (cm)	n	Before gutting	After gutting
10	1	7.0	6.4
11	4	11.6	10.4
12	12	15.2	13.8
13	42	18.1	16.6
14	72	23.4	21.5
15	61	28.8	26.4
16	43	33.2	30.7
17	19	41.8	38.5
18	6	53.2	48.5
19	4	52.9	49.0
20	1	62.7	55.7
21	1	79.5	72.8
22	3	84.7	78.3
23	2	103.4	96.4
24	1	117.5	107.0
Total	272	29.1	26.7

Annual rings were found to emerge on scales, with some individuals possessing and others still lacking the rings.

Smolt age group 1+ comprised members of the 1+ group with dk $\leqslant$ 51 mm;

age group 2+ comprised members of the 1+ group with dk $\geqslant$ 58 mm and members of the 2+ group with dk $\leqslant$ 29 mm;

age group 3+ comprised members of the 2+ group with dk $\geqslant$ 45 mm and members of the 3+ group with dk $\leqslant$ 26 mm.

Results of the marginal increment analysis are summarised in Table 4. The data show all the 1-year-old smolts to have had newlyestablished marginal increments. On the other hand, most 2-yr-old smolts showed new marginal increments, while a number of individuals displayed previous year's increments. The first group consisted of 67 individuals (65.7%), while the other of 35 ones (34.3%). Among the 3-yr-old smolts, those with the previous year's increments prevailed (4 specimens), 2 individuals having the current year's increments.

A similar distribution of individuals with marginal increments over age groups was found in smolts of the Rega (Chełkowski, 1978). As seen in the report, smolts stay in the river for 1 to 3 years (Table 8). Most numerous were the 1-yr-old smolts (56.8%), the 2-and 3-yr-old ones ranking next in a decreasing order (40.8% and 2.4%, respectively). A similar percentage distribution occurred in males and females. The age structure presented differs from that reported by Chrzan (1959) and Chełkowski (1969, 1974), the

Table 8

Smolt age

Age	1	2	3	Total
	no. of individuals			
females	59	50	5	114
males	48	39	1	88
total	107	89	6	202
sex indetermined	35	13	–	48
grand total	142	102	6	250
	%			
females	51.7	43.9	4.4	100
males	54.6	44.3	1.1	100
grand total	56.8	40.8	2.4	100

latter based on scales of adult fishes occurring in the western Pomeranian rivers, including the Mołstowa (Table 9). The populations analysed by the authors mentioned were dominated by 2-yr-old smolts; among the smolts analysed, the group of 1-yr-old ones was found to prevail. Assuming, after Carlin (1958, 1959), a low survival rate of "small" smolts (1-yr-old) during the post-smolt phase until the "adult" stage, the results obtained do not contradict the data of Chrzan (1959) and Chełkowski (1969, 1974).

The length and weight distribution over age groups are presented in Table 10. Mean lengths and weights in age groups are similar in females and males. The table contains also the length and weight data for the whole period of study, regardless of fish sex. The data show the 1+ smolts to measure 13.2 cm and weight 22.5 g (before gutting). The 2+ ones measure 15.6 cm and weight 36.5 g, while 18.9 cm and 66.2 are the values for the 3+ smolts.

Back calculations show the smolts to attain mean lengths of 90, 140, and 174 mm in their first, second, and third year of life, respectively (Table 4). The obvious conclusions is that the highest increment is obtained in the first year of life in the river, the second year ranking next, while the lowest increment is recorded in the third year.

Table 9

Structure of trout smolt age in the Pomeranian rivers
(%)

River	Age			Remarks; author
	1	2	3	
Pomeranian rivers opening to the sea	9.33	84.15	6.52	Chrzan (1949); scales of adult fishes
Western Pomeranian rivers opening to the sea	3.02	91.63	5.35	Chełkowski (1969); scales of adult fishes
The Rega	13.19	78.97	7.84	Chełkowski (1974); smolt scales
The Mołstowa	56.8	40.8	2.4	present study

Table 10

Smolt length and weight distribution over age groups
(cm, g)

Sex	Age	n	Length (cm)	Weight (g)	
				a*	b**
Females	1	59	13.44	24.85	22.69
	2	50	15.84	38.88	35.57
	3	5	19.1	68.82	63.36
	Total	114	14.74	32.93	30.12
Males	1	48	13.26	22.13	20.27
	2	39	15.53	35.13	32.41
	3	1	17.70	53.0	49.40
	Total	88	14.32	28.24	25.98
Sex indetermined	1	35			
	2	13			
	3	–			
	Total	48			
Grand total	1	142	13.21	22.46	20.56
	2	102	15.63	36.53	33.57
	3	6	18.85	66.18	61.03
	Grand total	250	14.33	29.25	26.84

* before gutting ** after gutting

CONCLUSIONS

The Mołstowa smolts have their life span in the river amounting to 1–3 years. The groups of 1-, 2-, and 3-years-old individuals consisted of 56.8, 40.8 and 2.4% of the total number of individuals examined, respectively.

Mean lengths and weights (before gutting) of the 1-, 2-, and 3-years-old individuals are 13.2 cm and 22.5 g, 15.6 cm and 36.6 g, and 18.9 cm and 66.2 g, respectively.

Lengths and weights of females and males are similar in each age group and over the whole period of study. The general mean length and weight were: $M \pm m = 14.3 \pm 0.12$ cm and $M \pm m = 29.1 \pm 0.878$ g, respectively.

Females were found to prevail among the descending smolts. The male: female sex ratio is 0.8.

Gonads of females and males were at the juvenile stage.

REFERENCES

Carlin B., 1955: Tagging of salmon smolts in the River Lagan. Rep. Inst. Freshw. Res. Drottningholm **36**: 57–74.

Carlin B., 1959: Results of salmon smolt tagging in the Baltic area. Rapp. et Proc. – Verb. **147**: 89–96.

Chełkowski Z., 1969' Pogłowie troci (Salmo trutta L.) rzek przymorskich Pomorza. [Trout (Salmo trutta L.) population in the Pomeranian rivers.]. – Przegl. Zool., **XIII**, 1! 72–91.

Chełkowski Z., 1974: Studia nad biologią troci (Salmo trutta L.) rzeki Regi.]Studies on the Rega trout (Salmo trutta L.) biology]. Rozprawy Akad. Roln.: – Szczecin.

Chełkowski Z., 1978: Studies on Trout Salmo trutta L. wild smolts of the River Rega. – Acta Ichthyol. et Piscatoria **VIII**, 2: 41–58.

Chełkowski Z., Chełkowska B., 1981: Descent of trout (Salmo trutta L.) smolts grown in river Mołstowa catchment – area. – Acta Ichthyol. et Piscat. **XI**, 2: (in press).

Chełkowski Z., Chełkowska B., 1981: Juvenile trout (Salmo trutta L.) survival rate from hatched fish release to smolting in river Mołstowa basin. – Acta Ichthyol. et Piscat., **XI**, 2: (in press).

Chrzan F., 1959 – Łosoś i troć w polskich połowach na Bałtyku w latach 1945–1955. [Salmon and trout in Polish Baltic catches in the years 1945–1955]. – Prace Morsk. Inst. Ryb. **10/A**: 153–191.

Meisner W., 1948: Ichtiologia stosowana. [Applied ichthyology]. Gdynia.

Nall G.H., 1930: The life of the sea trout. London.

Sych R., 1967: Oznaczenie wieku troci (Salmo truttaa L.) w okresie formowania się pierścieni rocznych. [Trout (Salmo trutta L.) age determination during annual ring formation]. – Roczn. Nauk Roln., **H-90**, 2: 305–325.

Sych R., 1971: Elementy teorii oznaczania wieku ryb według łusek. Problemy wiarygodności. [Elements of theory of fish age determination from scales. Reliability problems]. – Roczn. Nauk Roln., **H-95**, 1: 7–73.

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CHARAKTERYSTYKA BIOLOGICZNA SMOLTÓW TROCI (*SALMO TRUTTA L.*) WYROSŁYCH W ZLEWNI MOŁSTOWEJ

Streszczenie

W pracy przedstawiono długość, ciężar i wiek z uwzględnieniem płci oraz stan rozwoju gonad smoltów troci (*Salmo trutta* L.) wyrosłych w warunkach naturalnych rzeki Mołstowej. Smolty pochodzą z zarybień zlewni Mołstowej wylęgiem troci i to tej części zlewni, w której nie odbywa się tarło naturalne. Połowu smoltów dokonywano żakiem skrzydłowym, wykorzystując okres spływania ich do morza. Do badań przeznaczono losowo 272 osobniki tj. 8,5% ogólnej ilości (n = 3197) sztuk pozyskanych wiosną 1979 r. w Mołstowej (Tabela 2). Długość (*l. caudalis*) smoltów mierzono z dokładnością do 1 mm, ciężar ryb wypatroszonych i niewypatroszonych badano z dokładnością do 0,5 g, a gonad z dokładnością do 1 mg.

Wiek smoltów określano na podstawie łusek. Wiek rzeczywisty smoltów weryfikowano na podstawie analizy przyrostów krawędziowych.

Okres życia rzecznego smoltów Mołstowej obejmuje 1 do 3 lat. Na jednoroczne przypada 56,8%, na dwuletnie 40,8% i na trzyletnie 2,4% badanych ryb. Jednoroczne smolty osiągają średnią długość 13,2 cm i średni ciężar przed wypatroszeniem 22,5 g, dwuletnie długość 15,6 cm i ciężar 26,6 g oraz trzyletnie długość 18,9 i ciężar 66,2 g. Długości i ciężary samic i samców w grupach wieku i za cały okres badań są bardzo podobne. Średnia ogólna długość badanych ryb wyniosła $M \pm m = 14,3 \pm 0,12$ cm, a średni ciężar ogólny $M \pm m = 29,1 \pm 0,878$ g. Wśród zstępujących smoltów stwierdzono przewagę ilościową samic. Ogólnie rzecz biorąc na jedną samicę przypada 0,8 samca. Gonady smoltów zarówno samic jak i samców znajdowały się w stadium młodocianym.

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БИОЛОГИЧЕСКАЯ ХАРАКТЕРИСТИКА СМОЛТОВ КУМЖИ (SALMO TRUTTA L.) ВЫРОСШИХ В БАССЕЙНЕ р. МОЛСТОВОЙ

Р е з ю м е

В работе представили длину, вес и возраст, пол а также стадии развития гонад смолтов кумжи (Salmo trutta L.) выросших в бассейне р. Молстовой.

Смолты выросли из личинок кумжи выпускаемых в бассейне р. Молстовой. Высадку молоди кумжи производили в той части бассейна реки где не происходит натуральный нерест. Вылов смолтов производили ставной ловушкой исспользуя период их скатывания к морю. Для исследований случайно отобрали 272 экз., т.е. 8,5% от общего количества (n = 3197) рыб выпловленных весной 1979 г. в р. Молстовой (таб.2). Длина смолтов измерялась с точностью до 1мм, вес рыб целых и выпотрошеных измеряли с точностью до 0,5г, а гонад до 1 мг.

Возраст смолтов определяли на основании анализа чешуй. Действительный возраст смолтов подвергался проверке на основе анализа крайних приростов.

Период речной жизни смолтов р. Молстовой охватывает 1-3 года. Смолты в возрасте одного года составляют 56,89%, в возрасте 2 лет- 40,8% и 3 лет - 24% исследуемых рыб. Смолты в возрасте 1 года достигают длины средней 13,2 см и среднего веса целой рыбы 22,5г: в возрасте 2 лет - 15,6 см и 26,6г веса, в возрасте 3 лет - 18,9 см длины и 66,2г веса. Длина и вес самок и самцов в возрастных группах и за весь период исследований очень сходен.

Средняя общая длина исследованных рыб составила $M \pm m = 14,3 \pm 0,12$ см, а средний общий вес $M \pm 29,1 \pm 0,878$г. Среди скатывующихся смолтов обнаружили количественный перевес самок. В общем на 1 самку приходится 0,8 самца. Гонады смолтов самок и самцов находились на ранней стадии развития.

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