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Fish biology

**PERIOD OF DOWNSTREAM MIGRATION OF SEA TROUT
(*SALMO TRUTTA* L.) SMOLTS GROWN IN OSÓWKA STREAM
AND THEIR CHARACTERISTICS**

**OKRES SPŁYWANIA SMOLTÓW TROCI (*SALMO TRUTTA* L.)
WYROŚŁYCH W OSÓWCE ORAZ ICH CHARAKTERYSTYKA**

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Sea trout larvae were released in spring 1984 into the upper sector of Osówka Stream. Smolts of these fish were caught in three consecutive years after larvae release, in a fish trap placed in the middle course of the stream. The materials collected were used to determine period and water temperature at which smolts migrated downstream, as well as smolt length, weight and age composition.

INTRODUCTION

Downstream migration of sea trout (*Salmo trutta* L.) smolts grown in natural conditions in Pomeranian rivers, in this in Osówka Stream, is still an interesting subject to be studied. The phenomenon was studied in Rega and Mołostowa rivers by Chełkowski (1966, 1978) and Chełkowski and Chełkowska (1981). It is still unclear whether sea trout larvae released into upper sector of Osówka Stream remain there until smoltification, and if so then at what water temperature and in what period do they migrate downstream. Their age, length, and weight composition is also unknown. This paper is a continuation of studies on smolts from Osówka Stream (Chełkowski in press).

MATERIAL AND METHODS

Osówka Stream is 13 km long; it is a left-side tributary of lower Oder. Upper sector of this stream was used in the experiment. This sector is 4 km long, with an average slope of 19‰ quite even (Chełkowski in press). On 19 April 1984 sea trout larvae were released into the middle part of this sector. This part was 800 m long, 1.2 m broad. It is denoted by points A-B in Fig. 1. Totally 5402 fish were released in small portions of 3-6 individuals. Calculations showed that 5.6 ind./m² were released.

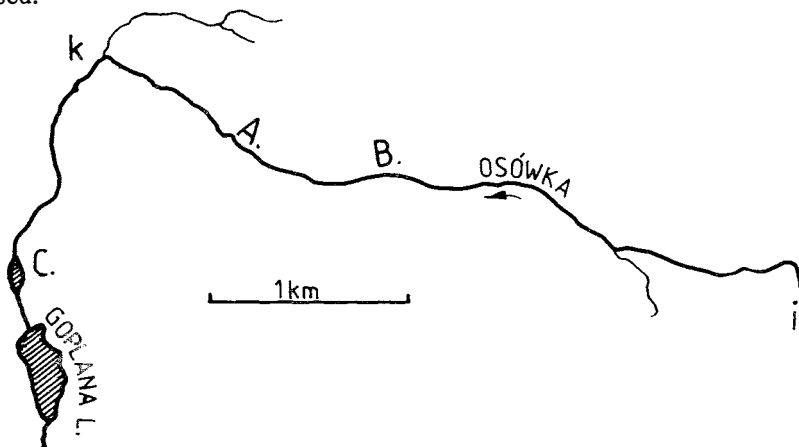


Fig. 1. Upper section of the Osówka. A-B section stocked with sea trout larvae, C — site of smolt capture

According to Chełkowski (1967, 1969, 1974, 1978), Chełkowski and Chełkowska (1982) and Chrzan (1959) age of smolts in Pomeranian rivers was limited to 1-3 years. Due to this, smolts from Osówka were collected in 1985, 1986, and 1987, i.e. in the three consecutive years after the release of larvae. Smolts were caught with a fish trap placed in Osówka Stream, just below Lake Goplana, at point C (Fig. 1) (Chełkowski in press). Chełkowski (1966, 1978) and Chełkowski and Chełkowska (1981) found that smolts migrated downstream only in spring, from 29 March to 8 June. Due to this, the fish trap operated in the three years since 21 March till mid-July. It was controlled and the fish were removed twice daily, at 7.00 and 18.00 hours. Water temperature in °C was measured during morning control. The fish trap consisted of a net sac, with mesh diameter 10 mm, extended over a metal frame. It was placed in the outflow monk from a small ponds (0.2 ha) through which Osówka Stream is flowing (Fig. 1) (Chełkowski in press). The fish species was identified; stage of development was determined for juvenile fish. Parr and smolt stage was distinguished. Fish length (*I. caudalis*) was measured up to 1 mm, and weight before and after gutting was determined up to 0.1 g.

Dependence between fish length and weight was determined from the equation:

$$W = k \times L^n \quad (1)$$

where: W – fish weight before gutting

L – length in mm

K and n – coeffocoents (Szypuła 1982)^x.

RESULTS

In the consecutive years of studies (1985, 1986, 1987) 131 sea trouts were caught in the fish trap placed in Osówka Stream, in this 7 in parr stage and 124 in smolt stage (Table 1). Fish parrs were caught only in spring 1985, and these fish were discarded.

Table 1

Smolts caught in the Osówka (number and %)

Year	Age	Migrating downstream			%
		at night	at day-time	total	
1985	1+	96	15	111	89.5
1986	2+	9	2	11	8.9
1987	3+	2	0	2	1.6
Total		107	17	124	100.0

Smolts in Osówka migrated downstream since 6 April till 11 June in 1985, since 7 April till 7 June in 1986, and since 12 April till 8 May in 1987. Hence, downstream smolt migration lasted since 6 April till 11 June, at water temperature increasing from 5°C to 18°C. 111 smolts were caught in the first year, 11 in the second, and 2 in the third. Taking into account period of larvae release, smolts caught in 1985 were at the age of 1+, in 1986 of 2+, and in 1987 of 3+. One-year old smolts were most numerous (89.5%). Two-year old ones represented 8.9%, and 3+ fish 1.6%.

The fish caught could have been divided into two groups: those migrating at night, between 19.00 and 7.00 hours, and those migrating at day-time, between 7.00 and 19.00 hours. It was found that most smolts (86.3%) migrated at night; only 13.7% undertook downstream migration at day-time. Intensity of migration differed considerably, this being especially noticeable for one-year old fish. And thus, two peaks of downstream migration were observed for this group. The first took place on 4 May.

^{x)} Calculations were made on a microcomputer PC 1521.

31 smolts (27.9%) were caught on this day, at water temperature 5.4°C. The other peak was noted on 12 May, when 15 smolts (12.1%) were caught, at water temperature 13.8°C. It should be noted that these fish migrated at night, between 19.00 and 7.00 hours.

One-year old smolts migrated downstream in three consecutive decades: the third decade of April, and the first and second of May. 102 smolts were caught in this period (91.9%). In the remaining 5 decades (first and second of April, third of May, and first and second of June) only 9 smolts (8.1%) were caught (Table 2). Two- and three-year old smolts migrated in the same period, but they tended to begin downstream migration earlier than one-year old fish. Analysis of the frequency of downstream smolt migration in the three years of studies revealed that most of the fish migrated in three decades: the third of April, and the first and second of May. Totally, 107 smolts (86.3%) were caught in this period, at average water temperature varying in these decades from 6.9 to 14.6°C (Table 3).

Table 2

Smolts caught in the Osówka in different
periods of downstream migration
(number and %)

Year	Month and decade								Total
	Apr			May			Jun		
	1	2	3	1	2	3	1	2	
1985	2	—	16	42	44	6	—	1	111
1986	2	—	2	2	—	—	5	—	11
1987	—	1	—	1	—	—	—	—	2
Total	4	1	18	45	44	6	5	1	124
%	3.2	0.8	14.5	36.3	35.5	4.9	4.0	0.8	100

Table 3

Decade mean water temperature in the Osówka
during downstream smolt migration (°C)

Year	Month and decade								
	Apr			May			Jun		
	1	2	3	1	2	3	1	2	3
1985	10.5	7.4	6.9	7.4	15.8	17.5	16.4	19.5	14.0
1986	4.7	5.4	8.4	13.7	14.6	15.9	11.5	15.4	17.0
1987	4.8	7.4	8.1	10.1	10.3	12.2	13.6	13.5	13.7

It was interesting to note that there was a dependence between smolt downstream migration and average water temperature. Fig. 2 reveals that one-year old smolts migrated most intensively in the first and second decade of May, when water temperature in Osówka Stream increased from 7.4 to 13.9°C. On the other hand, two-year old smolts migrated mostly in the first decade of June, at water temperature 10.4°C, while three-year old ones in the second decade of April and the first of May, at water temperature increasing from 6.7 to 10.3°C.

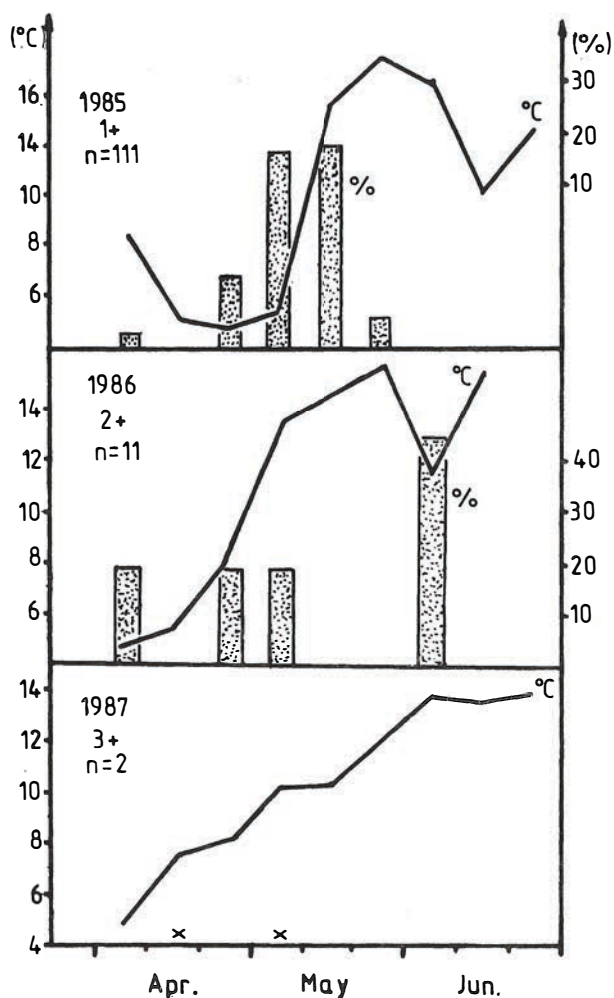


Fig. 2. Frequency of smolt downstream migration in the Osówka against water temperature

These data show that downstream smolt migration in Osówka Stream began in the first decade of April, at water temperature 4.8°C, and ended in the second decade of June, at water temperature 12.3°C. Peaks of migration took place in the first and second decade of May, at water temperature 7.4-14.6°C.

Frequency of smolt migration against water temperature was especially interesting in 1985. It appeared that sufficiently high temperature did not always determine downstream migration. And thus, in the first decade of April 1985 water temperature was relatively high (10.5°C) but only a few fish migrated downstream. On the other hand, Peaks of downstream migration were observed in the first decade of May, when water temperature decreased to 7.4°C, and in the second decade of May, when water temperature reached 13.9°C. It can be concluded that time was more important than water temperature in the stream.

Average length of smolts caught in Osówka Stream ($n = 124$) was 155.2 mm, and average weight 40.7 g for whole fish and 37.8 g for gutted fish (Table 4 and 5). Size of smolts from Osówka ranged from 111 to 260 mm, and from 13.4 to 206.5 g for whole fish, and 12.5-194.5 g for gutted fish.

Average length of one-year old smolts was 149.0 mm. Average weight was 33.3 g for whole fish and 30.7 g for gutted fish. Two-year old smolts reached on the average 200.1 mm in length, their weight being 88.0 g before and 83.2 g after gutting. The respective numbers for three-year old smolts were 252.5 mm, and 195.3 g and 182.8 g.

Table 4

Length of sea trout smolts in the Osówka (mm)

Age	n	\bar{x}	V	Range
1+	111	149	8.7	111–182
2+	11	200	6.6	174–225
3+	2	253	–	245–260
Total	124	155	14.8	111–260

V – coefficient of variation

Table 5

Weight of sea trout smolts in the Osówka

Age	n	\bar{x}	V	Range
before gutting				
1+	111	33	27.4	13–67
2+	11	88	22.4	52–121
3+	2	195		184–207
Total	124	41	66.9	13–207
after gutting				
1+	111	31	28.6	13–60
2+	11	83	23.4	48–114
3+	2	183		171–195
Total	124	38	68.0	13–195

Length range of one-year old smolts was 111-182 mm, and weight range amounted to 13.4-67.4 g for whole fish, and to 12.5-60.0 g for gutted fish. The respective values for two-year old smolts were: 174-225 mm, 52-120.8 g and 48-113.7 g, while for three-year old smolts: 245-260 mm, 184.4-206.5 g and 171.0-194.5 g.

Age and size composition of smolts from Osówka Stream is presented in Table 6. It was found that one-year old smolts were most frequent in length classes 130-169 mm (87.39%), two-year old in the class 190-209 mm (63.6%), and three-year ones in 240-269 mm. The table presents also percentage of smolts in particular length classes for the whole period of studies. Length class 130-179 mm was most numerous; it embraced 84.7% of all smolts caught. Only 15.3% of smolts were the fish belonging to the other two classes: 110-129 and 180-269 mm.

It was also possible to estimate growth rate of smolts in particular years of life in Osówka Stream. Data presented in Table 7 reveal that the highest growth in length took place in the first year of life (1+ fish). Growth in length of 2+ and 3+ fish represented only 25% of the growth rate of 1+ fish. On the other hand, weight of 2+ fish increased 1.63-fold (whole fish) compared to 1+ fish, and weight of 3+ fish increased 1.98-fold compared to 2+ fish. Hence, rate of growth in length decreased with time, whereas rate of growth in weight increased.

Table 6

Frequency distribution of sea trout smolts (n)
from the Osówka in age groups and length classes

Length mm	Age			Total
	1+	2+	3+	
110-119	2			2
120-129	3			3
130-139	13			13
140-149	40			40
150-159	34			34
160-169	10			10
170-179	7	1		8
180-189	2	1		3
190-199		3		3
200-209		4		4
210-219		1		1
220-229		1		1
230-239				—
240-249			1	1
250-259				—
260-269			1	1
Total	111	11	2	124

Table 7

Growth in length (mm) and weight (g) of sea trout from the Osówka
in age groups (before gutting – bg; after gutting – ag)

Age	Length	bg	ag
1+	149.0	33.3	30.7
2+	51.1	54.1	52.5
3+	52.4	107.3	99.6

Table 8 presents smolt weight in particular length classes, separately for whole and gutted fish. Fig. 3. presents length-weight relationship calculated from equation (1). Value of the coefficient $n = 3.14195$ points to an even increase of body weight as the fish length increased. To obtain a full picture, weight of whole fish was also calculated for 16 1-cm length classes (115, 125 ... 265 mm) basing on equation (1) and on the obtained coefficients. The results were very close to empirical data presented in Table 8.

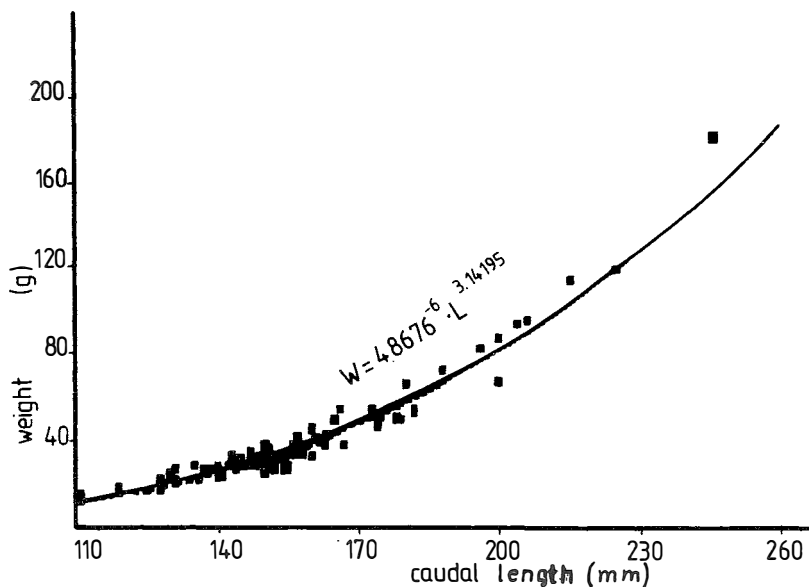


Fig. 3. Length-weight relationship of whole (non-gutted) sea trout
smolts from the Osówka

Table 8

Weight (g) of sea trout smolts from the Osówka in length classes (a) and values calculated from equation [1] for the whole fish (b)

Length class	n	\bar{x}	Range	\bar{x}	Range	\bar{x}
		weight before gutting		weight after gutting		weight before gutting
a						b
115	2	16.5	13.4–19.5	15.0	12.5–17.5	14.5
125	3	19.7	17.9–23.0	17.9	16.0–21.1	18.9
135	13	25.0	21.0–28.7	22.8	19.5–26.2	24.0
145	40	29.8	25.8–36.5	32.3	22.0–32.0	30.1
155	34	33.9	26.7–42.7	31.6	24.5–40.2	37.1
165	10	43.6	34.3–56.2	39.3	31.7–47.8	45.1
175	8	52.5	48.0–57.7	48.7	44.2–52.9	54.3
185	3	66.0	55.4–75.1	61.1	52.0–71.3	64.7
195	3	83.5	80.1–85.2	78.5	75.5–80.0	76.3
205	4	88.4	70.1–97.6	83.2	65.0–92.5	89.3
215	1	116.2	—	110.5	—	103.7
225	1	120.8	—	113.7	—	119.6
235	—	—	—	—	—	137.1
245	1	184.0	—	171.5	—	156.3
255	—	—	—	—	—	177.2
265	1	206.5	—	194.5	—	200.0

The data collected were also used to study smolt length during downstream migration. Smolts were grouped separately for consecutive periods (decades) in particular years (age groups), and their average length and range of variations were calculated (Table 9). It was found that average smolt length in consecutive periods of downstream migration decreased, this being especially noticeable for one-year old fish. As regards this fish group, the biggest specimens (165 mm) migrated first, whereas smaller ones (131 mm) were the last to undertake downstream migration. Decreasing smolt length in consecutive periods of downstream migration was also noticeable in particular length classes. No such relationship was found for older fish.

Table 9

Length (mm) of sea trout smolts from the Osówka
in age groups and periods downstream migration

Age (year)	Period of down- stream migration in decades	n	\bar{x}	Range
1+ (1985)	Apr 1-10	2	165.0	150-180
	Apr 11-20	—	—	—
	Apr 21-30	16	157.6	130-182
	May 1-5	42	147.8	111-179
	May 11-20	44	146.5	125-178
	May 21-31	6	144.5	119-160
	Jun 1-6	—	—	—
	Jun 11-20	1	131.0	131
	Total	111		
2+ (1986)	Apr 1-10	2	196.0	196
	Apr 11-20	—	—	—
	Apr 21-30	2	198.5	197-200
	May 1-10	2	190.0	174-206
	May 11-20	—	—	—
	May 21-30	—	—	—
	Jun 1-10	5	206.4	188-225
	Total	11		
3+ (1987)	Apr 1-10	—	—	—
	Apr 11-20	1	260.0	260
	Apr 21-30	—	—	—
	May 1-10	1	245.0	245
	Total	2		

COMPARISON OF THE RESULTS WITH DATA FROM OTHER POMERANIAN RIVERS

Among smolts caught in a fish trap placed in Osówka Stream there were also some fish in parr stage. Their percentage amounted to 5.3%. Parr fishes were caught also in other rivers. According to Chełkowski and Chełkowska (1981) 1.4% parr fish were caught in a fish trap placed in Mołstowa River. Length (l.c.) of fish in parr stage was 96-125 mm in Osówka Stream and 90-140 mm in Mołstowa River. Hence, size of juve-

nile parr fishes and their percentage were similar in the two rivers. Also size of smolts was similar: 111-260 mm in Osówka Stream and 93-239 mm in Mołstowa River (Chełkowski and Chełkowska 1981). Juvenile parrs were partly smaller than smolts, but partly fitted the size range of smolts in both rivers. Hence, it is still unknown whether parr fishes migrating to lower river sectors would smoltify in the next or still in the same year.

Smolts in Osówka migrated downstream in spring, similarly as smolts in another Pomeranian rivers: Rega and Mołstowa (Chełkowski 1978, Chełkowski and Chełkowska 1981). Period of most intensive downstream migration, i.e. from the 2nd decade of April till the 2nd decade of May, was also similar in Osówka, Rega and Mołstowa (Chełkowski 1978, Chełkowska and Chełkowski 1981), at water temperature 7-15°C.

It was also found that smolts in Osówka as well as in Mołstowa (Chełkowski et al. 1981) migrated mostly at night, less at day-time.

Average length of smolts migrating downstream in Osówka was 155.2 mm. It was slightly higher than in Mołstowa River (152 mm, Chełkowski and Chełkowska 1981). Also average weight was higher in Osówka: 40.7 g for whole fish and 37.8 g for gutted fish, compared to Mołstowa: 33.7 g for whole fish and 26.7 g for gutted fish (Chełkowski et al. 1981).

Table 10

Comparison of age composition of sea trout smolts in Pomeranian rivers (%)

River	Age			References
	1+	2+	3+	
Mołstowa	56.8	40.8	2.4	Chełkowski Z., Chełkowska B., 1982
Osówka	89.5	8.9	1.6	this study

Table 11

Comparison of weight (g) of sea trout smolts from Pomeranian rivers in age groups

Age	before gutting		after gutting	
	Mołstowa*	Osówka**	Mołstowa*	Osówka**
1+	22.5	33.3	20.6	30.7
2+	36.5	88.0	33.6	83.2
3+	66.2	195.3	61.0	182.8

* Chełkowski Z., Chełkowska B., 1982; ** this study

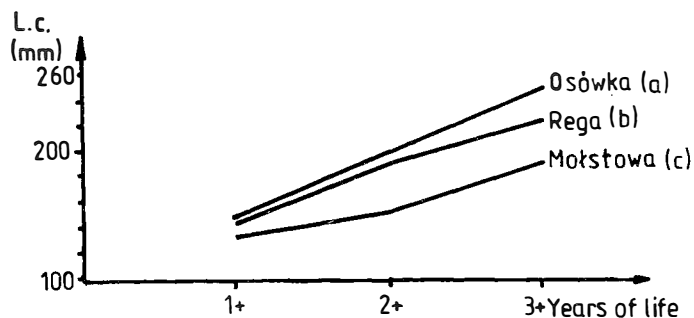


Fig. 4. Comparison of descending smolt lengths (mm) in age groups (this study – a, Chełkowski 1978 – b, Chełkowski Z., Chełkowska B., 1982 – c)

Table 12

Comparison of length frequency distribution (%) of sea trout smolts from Pomeranian rivers in length classes

Length class (mm)	Mołstowa*	Osówka**
90–99	—	—
100–109	0.3	—
110–119	3.2	1.6
120–129	11.0	2.4
130–139	25.4	10.5
140–149	25.2	32.3
150–159	16.7	27.4
160–169	7.4	8.1
170–179	4.9	6.5
180–189	2.5	2.4
190–199	1.4	2.4
200–209	1.4	3.2
210–219	0.4	0.8
220–229	0.2	0.8
230–239	—	—
240–249	—	0.8
250–259	—	—
260–269	—	0.8
Total	100.0	100.0

* Chełkowski Z., Chełkowska B., 1982; ** this study

Age composition was also compared. Both in Mołstowa and Osówka the fish grew in natural conditions (Chełkowska and Chełkowski 1981). Table 10 reveals that one-year old smolt were most numerous in the two rivers, two-year old less so, and three-year old the least.

Table 13

Comparison of weight (g) of sea trout smolts from
Pomeranian rivers in length classes (weight before
gutting – bg; weight after gutting – ag)

Length class (mm)	Rega*	Mołstowa**		Osówka ***	
	bg	bg	ag	bg	ag
90– 99		7.0	6.4		
100–109		11.6	10.4		
110–119		15.2	13.8	16.5	15.0
120–129	19.5	18.1	16.6	19.7	17.9
130–139	–	23.4	21.5	25.0	22.8
140–149	31.5	28.8	26.4	29.8	32.3
150–159	38.3	33.2	30.7	33.9	31.6
160–169	41.7	41.8	38.5	43.6	39.3
170–179	54.1	53.2	48.5	52.5	48.7
180–189	66.6	52.9	49.0	66.0	61.1
190–199	76.2	62.7	55.7	83.5	78.5
200–209	84.2	79.5	72.8	88.4	83.2
210–219	98.2	84.7	78.3	116.2	110.5
220–229	110.5	103.4	96.4	128.8	113.7
230–239	122.6	117.5	107.0	–	–
240–249	137.0	184.0	–	171.5	–
250–259	177.6	–	–	–	–
260–269	–	–	–	206.5	194.5

* Chełkowski 1978; ** Chełkowski Z., Chełkowska B., 1982; *** this study

Graph of smolt length (1+, 2+, and 3+ age groups) shows that fish from Osówka Steram were bigger than in Rega and Mołstowa rivers (Chełkowski 1978, Chełkowski and Chełkowska 1981) (Fig. 4). The same trends were noted for fish weight in particular age groups. Table 11 shows that smolts from Osówka were heavier than those from Mołstowa River (Chełkowski and Chełkowska 1981).

Frequency distribution in size classes of smolts from Osówka and Mołstowa (Chełkowski and Chełkowska 1981) is compared in Table 12. In Osówka Stream, smolts in five 1-cm classes (130-179 mm) were most numerous. In Mołstowa River they were also most numerous in five 1-cm classes, but within the range 120-169 mm. These length classes embraced 88.7% of smolts in Osówka Stream and 85.6% in Mołstowa River.

Moreover, comparisons were made of smolts grown in natural conditions in Osówka, Rega and Mołstowa rivers. Materials grouped in 1-cm classes (Chełkowski 1978, Chełkowski and Chełkowska 1982) showed considerable similarities between the three rivers (Table 13).

CONCLUSIONS

Studies showed that juvenile sea trout remained in upper sector of Osówka Stream since the period of their release as larvae till smoltification. Only a small part of the introduced sea trout migrated a year later downstream still in parr stage.

Smolts grown in natural conditions of upper Osówka undertook downstream migration in spring, in the period 6 April – 11 June, at water temperature increasing from 5°C to 16°C. Most intensive migration took place between 3rd decade of April and 2nd decade of May, at average water temperature from 6.9 to 14.6°C 86.3% smolts migrated in this period.

Bigger sized smolts began their migration earlier than smaller individuals.

Smolts migrated mainly at night (86.5%), less at day-time (13.5%).

Sea trout juveniles smoltified in Osówka Stream at the age of 1+, 2+ and 3+. Smolts aged 1+ were most numerous (89.5%), 2+ were less frequent (8.9%), and 3+ were rare (1.6%).

Average length of smolts from Osówka Stream was 155.2 mm, and average weight 40.7 g before and 37.8 g after fish gutting.

Average length of one-year old smolts amounted to 149 mm, and weight to 33.3 g before and 30.7 g after gutting. The respective values for two-year old smolts were: 200 mm, 88 g and 83.2 g, and for three-year old: 252.5 mm, 195.3 g and 182.8 g.

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OKRES SPŁYWANIA SMOLTÓW TROCI (*SALMO TRUTTA* L.)
WYROŚLYCH W OSÓWCE ORAZ ICH CHARAKTERYSTYKA

STRESZCZENIE

w eksperymencie wykorzystano górny, 4 km długi, bieg Osówki do którego wiosną 1984 roku wsiedlono 5402 sztuki wylęgu troci. W kolejnych następnych trzech latach łowiono spływające smolty na smołówkę usytuowaną w dolnym biegu potoku. Okazało się, że smolty spływają wiosną w okresie od 6 kwietnia do 11 czerwca, przy temperaturze wody rosnącej od 5° do 18°C. Z badań nad długością smoltów w czasie spływania wynika, że większe spływają we wcześniejszym okresie a mniejsze w późniejszym. Smolty spływają głównie nocą (86.5%) a w mniejszym udziale dniem (13.5%). Młodzież troci wyrosła w górnej Osówce smoltuje w wieku 1+, 2+ i 3+. Udział smoltów jednorocznych z Osówki okazał się najliczniejszy, dwurocznych był już mniejszy a trzyrocznych najmniejszy. Smolty osiągają średnią długość (l.c) 155.2 mm i masę 40.7g, jednoroczne 149 mm i 33.3 g, dwuroczne 200 mm i 88 g a trzyroczne 252.5 mm oraz masę 195.3 g.

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