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Fish biology

**JUVENILE TROUT (*SALMO TRUTTA* L.) SURVIVAL RATE FROM HATCHED FISH
RELEASE TO SMOLTING IN RIVER MOŁSTOWA BASIN**

**STOPIEŃ PRZEŻYCIA MŁODZIEŻY TROCI (*SALMO TRUTTA* L.)
OD WSIEDLENIA WYLĘGU DO SMOLTYZACJI W ZLEWNI MOŁSTOWEJ**

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The survival rate of juvenile trout (*Salmo trutta* L.), from the introduction of newly hatched fish until smolting, under natural conditions of the River Mołstowa was determined.

INTRODUCTION

The study was aimed at determining the survival rate of juvenile trout (*Salmo trutta* L.) over the period from the release of newly hatched fish to smolting, under natural conditions of Pomeranian rivers in order to conclude on the purposefulness of stocking. The project was carried out in the River Mołstowa, a right-bank tributary of the Rega (Fig. 1), stocked since 1958 with an annual average of 330 thou. individuals of juvenile trout (Chełkowski, 1974). Descending smolts were being caught downstream. The experiment was carried out in that part of the area where no natural spawning was taking place*.

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MATERIALS AND METHODS

Fig. 1. The river Rega catchment area
 • smolt capture site

The Mołstowa begins in the Lake Klepnicko situated at about 77 m above sea level, on the Baltic glaciation frontal moraine, and terminates its 49 km long course in the lower Rega inflowing directly to the Baltic. The Mołstowa is one of the few North-West Pomeranian rivers not polluted with industrial waste and insignificantly polluted with municipal effluents. Most of the river's course and tributaries have been regulated. The river carries clean, cool and well-oxygenated waters (Chełkowski, 1974). The river's mean slope (H/L) is 1.57%. The catchment area covers 371.1 km² (Anon., 1949).

Downstream, off the town of Mołstowo, i.e., 7.5 km up the river mouth, there is a weir used for hydroenergetic purposes (a water mill, now defunct). The weir terminates the trout homing migration (Chełkowski, 1974). It can be thus assumed that the trout juveniles found in the catchment area upstream of Mołstowo result from the previous stocking operations. This part of the river basin was used when testing the juvenile trout survival rate from stocking to smolting.

The trout fry was obtained from parents dwelling in the Rega basin, the eggs being incubated at the Goleniów hatchery. Hatched fish at the terminal stage of vitelline sac resorption were used. Eggs were counted according to the Brefoldt technique (number of eggs per 25 cm). Dead eggs and fry were counted as well. The difference between the original stock size and losses comprised the number of newly hatched fish to be used in further stocking operations. The fry were transferred in 50-l non-aerated containers, the fish density in a container depending on water temperature and transportation time as specified by appropriate standards (Anon., 1966). Table 1 summarises the amount of fry and stocking periods in the years preceding the present study

Table 1

Hatched trout released to the Mołstowa catchment area

Date of stocking	No. of individuals
8 May – 14 May 1976	286.640
7 May – 18 May 1977	456.910
14 April – 13 May 1978	390.960
Total	1.134.510

Table 2

The Mołstowa basin area utilised for juvenile trout rearing

Stream name	Length (m)	Mean width (m)	Area (m ²)
Mołstowa, upstream of Mołstowo	41.500		
upper	10.500	2	21.000
central	10.500	3	31.500
lower	10.500	7	80.500
Left-bank tributaries			
Pniewka	9.100	2	18.200
Right-bank tributaries			
Wkra	12.100	2	24.200
Czernica	11.500	2	23.000
Leśny Strumień	6.900	2	13.800
Total:			212.200

(1976, 1977, and 1978). Over those years, the trout fry were released each year into about 18 selected and checked sections of the catchment area, 16 – 25.4 thou. individuals in each. As the Mołstowa basin covered by the experiment is estimated at 212.2 thou. m² (Table 2), an average of 1.8 individuals per 1 m² of the river were released each year (1.4 ind./m² in 1976; 2.2 ind./m² in 1977; 1.8 ind./m² in 1978). Stocking densities were adopted after Sakowicz (1955).

The stocking localities used in the previous years (1969–1975) were checked as to the utility of a given habitat for the fish growth, the presence of juvenile trout being looked for in particular. Control catches were performed with a hand-operated net provided with a 3-m long codend. The results thus obtained allowed to correct stocking plans accordingly. For instance, a left-bank Mołstowa tributary of Brodziec was excluded from the stocking operations because of its too low flow rate, periodic dry-out summer water

Table 3

Smolt fishing (no. of individuals caught)

Date	Catch		Total
	Night	Day	
1	2	3	3
21.03.1979	0*		
22. "			
23. "	0		
24. "			
25. "			
26. "	0	0	
27. "			
28. "			
29. "	0		
30. "			
31. "	0	0	
1.04.1979			
2. "	0		
3. "			
4. "			
5. "	0	0	
6. "			
7. "			
8. "	0		
9. "			
10. "	0	0	
11. "			
12. "			
13. "	0		
14. "			
15. "	0	0	
16. "			
17. "			
18. "	0	0	
19. "	1	0	1
20. "	22	0	22
21. "	40		40
22. "	59	0	59
23. "	15		15
24. "	88	0	88
25. "	107		107
26. "	130	0	130
27. "	253		253
28. "	119	0	119
29. "	299		299
30. "	56	0	56

cd, tab. 3

1	2	3	4
1.05.1979	94		94
2. „	29	0	29
3. „	3		3
4. „	2	0	2
5. „	5		5
6. „	0	0	
7. „	0		
8. „	0	0	
9. „	7		7
10. „	6	0	6
11. „	10		10
12. „	9		9
13.05.1979	42	0	42
14. „	32		32
15. „	102		102
16. „	29	121	150
17. „	294	102	396
18. „	427	0	427
19. „	81	0	81
20. „	103	0	103
21. „	121	0	121
22. „	70	0	70
23. „	28	0	28
24. „	57		57
25. „	no fishing		
26. „	33		33
27. „	45	0	45
28. „	22		22
29. „	16		16
30. „	32	0	32
31. „	22		22
1.06.1979	17	0	17
2. „	9		9
3. „	14	0	14
4. „	9		9
5. „	2	0	2
6. „	5		5
7. „	5		5
8. „	3	0	3
9. „	0		
10. „	0		
11. „	0		
12. „	0		
13. „	0		
14. „	0	0	
15. „	0		
Razem:	2974	223	3197

* no individual caught

temperatures reaching 24°C at times, and – most important – because of the absence of juvenile trout. Similarly, a small left-bank Mołstowa tributary off the town of Brojce was eliminated, too, as municipal wastes were found to be discharged there.

In 1979, the smolts were caught with a fyke net (Świniarski, 1975) partitioning the 15-m wide river upstream of the old weir where the river banks are steep and the bottom is flat and sandy. The fyke net used consisted of two 10-m long 2.5-m high wings made of 15-mm mesh size netting and a long codend made of 10-mm mesh size netting. This type of gear allowed to catch juvenile trout from about 9 cm body length on.

The smolt descent in the River Rega, for which the Mołstowa is a tributary, takes place from late March till the end of the first decade of June (Chełkowski, 1978). Therefore the Mołstowa smolts were being caught within the period of 21 March – 15 June. The net remained in water from dusk till dawn. At the same time, daytime catches (from dawn till dusk) were attempted. The first smolt was caught at night, 18/19 April. Subsequent nocturnal catches proved very abundant. On the other hand, the daytime fishing was found futile except for that on 16, 17, and 18 May (Table 3).

During the nights of 30 April/1 May and 12/13 May, a second similar gear was monted some 50 m downstream of the first one. The experiment was aimed at finding out the percentage of descending smolts that by-passed the gear. The results are presented in Table 4; about 10% of the descending smolts were found to have escaped the net.

It was often necessary to clean the gear during its working time and remove debris, mostly alder leaves. At times, the circumstances made it then imperative to terminate the working day earlier than usual. Due to that and some other causes (for instance, no fishing operations on 25 May), the quantity of escaping smolts may be higher than assessed. It can be assumed that about 20% of smolts descending in the Mołstowa in 1979 were missed.

Prior to the analyses, the smolts were narcotised in the water solution of MS-222, and subsequently identified to species. The developmental stage (parr, pre-smolt, smolt) (Chełkowski, 1966) was determined each time. Checked fishes were returned to the river down of the weir so that they could not be recaptured.

Table 4

Control tests of gear performance

Date	No. of individuals caught		Total	% of smolts evading main gear
	main net	control net		
30 April/1 May	86	8	94	8.5
12/13 May	37	5	42	11.9
Total:	123	13	136	9.6

RESULTS

The 1979 experimental catches in the Mołstowa yielded a total of 3197 trout smolts in the length classes of 10 to 24 cm ($M \pm m = 15.2 \pm 0.03$ cm). Most of these juvenile trout were full smolts, a few individuals only not reaching this stage yet. Additionally, 47 trout parrs of 9–14 cm length range were obtained; these were disregarded.

As mentioned before, about 20% of the smolts descending down the Mołstowa could not have been caught. Adding their number to that already known from actual catches it can be concluded that a total of 3836 (3197+639) smolts descended in 1979.

An open question is the calculation of the survival rate over the period from hatching to smolting with respect to the juveniles released to the Mołstowa. Should the Mołstowa stocking in consecutive years (1976–1978) be quantitatively similar (Table 1), it would have been simple to calculate the survival rate from the descending smolts number found in 1979. The survival rate can be calculated from a proportion, whereby a single year stocking is related to 100 as the 1979 descending smolts number to x . Basically, all the smolts grown in the river from a single season's stocking should be obtained and related to the quantity of hatched fish placed in the river, or all the smolts from 3 consecutive stocks grown in the river should be obtained and related to the total amount stocked over that period; such data are, however, lacking. To justify the proportion used it should be borne in mind that the group of smolts descending in 1979 consisted of 1-yr-old ones stocked in 1978, 2-yr-old ones introduced in 1977, and 3-yr-old ones released in 1976, which is consistent with results of studies on the smolt age structure in Pomeranian rivers, the Rega included (Chrzan, 1959; Chełkowski, 1966, 1969, 1974). Assuming similar numbers of smolts in each age group to descend in the three consecutive years, the number of the fish descending in 1979 amounted to 1/3 of all the descending smolts, that were introduced in 1976, 1977, and 1978. Therefore the proportion given above can be accepted. However, the numbers of fish released each year differed from one another, which complicates our calculations of the juvenile trout survival rate. Further calculations were aided by the age distribution of smolts migrating down the Mołstowa in 1979 as determined from a sample of 250 individuals (Chełkowski and Chełkowska, in press). Readings of scales showed the 1-, 2-, and 3-yr-old trout to contribute 57.6, 40.0, and 2.4%, respectively. From this age structure, the repartition of smolts descending in 1979 to various age groups can be assessed. Thus the group of the 3836 descending smolts consisted of 2210 (57.6%) 1-yr-old ones, 1534 (40.0%) 2-yr-old ones, and 92 (2.4%) 3-yr-old ones. Therefore, the stocking operations in 1976 produced 92 3-yr-old smolts amounting to 0.03% of the original number released; the 1977 stocking yielded 1534 2-yr-old smolts amounting to 0.34% of the original number, and the 1978 release produced 2210 1-yr-old smolts making up 0.57% of the original number.

If 0.57% of the 1-yr-old smolts from the 1978 stocking were obtained, it is supposed that similar percentages of the 1-yr-old smolts were obtained from the 1977 and 1976 stocking operations. Thus the assessments resulted in 2604 and 1634 1-yr-old smolts obtained from the 1977 and 1976 stockings, respectively.

Table 5

Expected results of stocking operations
(no. of individuals)

Year	No. of hatched fish released	No. of smolts obtained			Total
		1-yr-old	2-yr-old	3-yr-old	
1976	286.640	1634	975	92	2701
1977	456.910	2604	1534	137	4275
1978	390.960	2210	1329	117	3656
Total:	1.134.510	6448	3838	346	10.632

Table 6

The Mołstowa basin area per 1 smolt

Year of stocking	No. of hatched fish released	No. of smolts obtained	Area per 1 smolt (m ²)
1976	286.640	2701	79
1977	456.910	4275	50
1978	390.960	3650	58
Mean			62

The 1977 stocking operation produced 0.34% of the 2-yr-old smolts. Assuming the same percentage in other years of release it was concluded that the 1976 and 1978 releases resulted in 975 and 1329 2-yr-old smolts, respectively.

Similarly (based on the amount of 0.03% of smolts produced by the 1977 operation), the numbers of 3-yr-old smolts produced by the 1977 and 1978 releases were calculated as 137 and 117, respectively.

The data presented allow to calculate the total amount of the 1-, 2-, and 3-yr-old smolts produced by the stocking operations in 1976, 1977, and 1978. Out of 1 134 510 hatched individuals, 10 632 trout smolts can be expected (Table 5). Therefore the juvenile trout survival rate from hatched fish release to smolting is estimated at 0.94%.

The calculated value corresponds fairly closely with the juvenile trout survival rate for the period from hatching to smolting under natural conditions in Polish rivers, as calculated tentatively by Sych and Bartel (1979).

Additionally, the data obtained allow to calculate the drainage area per 1 smolt produced. Assuming the 1976 release of 286 640 individuals to yield 2701 smolts, 79 m² of the Mołstowa drainage area produce 1 smolt (212 200 m²:2701 smolts). Similar calculations were made for the 1977 and 1978 releases and their results are presented in Table 6. As it turns out, the area per 1 smolt ranges from 50 to 79 m², with a mean of 62 m².

CONCLUSIONS

The release of hatched trout to the Mołstowa basin preceded by testing the suitability of the streams in question for rearing trout juveniles proved successful.

The studies showed the juvenile trout survival rate in the Mołstowa, from hatched fish release to smolting, to be 0.94%.

The 62 m² area of the Mołstowa basin was found to produce 1 smolt.

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Streszczenie

Przedmiotem pracy było określenie stopnia przeżycia młodzieży troci od wsiedlenia wylęgu do smoltyzacji w rzece Mołstowej. Połowów smoltów dokonywano żakiem skrzydłowym w dolnej części zlewni wykorzystując okres ich spływania do morza. W eksperymencie wykorzystano tę część zlewni w której nie odbywa się tarło naturalne.

Liczbę oraz okres zarybiania wylęgiem przedstawiono w tab. 1. Ogólnie rzecz biorąc wsiedlano

średnio rocznie 1,8 sztuk wylęgu na m^2 potoku. Miejsca zarybień w latach poprzedzających opisywaną akcję poddawane były weryfikacji co do przydatności danego środowiska wodnego do odrostu wsiedlanych ryb.

Połów w 1979 r. dostarczył 3197 smoltów. Poza tym stwierdzono, że około 20% smoltów spływających Mołstową do morza nie było pozyskanych. Na tej podstawie stwierdzono, że ogólna ilość smoltów schodzących w sezonie 1979 r. wyniosła 3836 sztuk.

Następnie obliczono stopień przeżycia wsiedlonej młodzieży. Do obliczeń włączono strukturę wieku smoltów ($n = 250$). Z uzyskanych obliczeń wynika, że stopień przeżycia młodzieży troci w Mołstowej od wsiedlenia i wylęgu do smoltyzacji wyniósł 0,94%, a na wyprodukowanie 1 smolta przypadło $62 m^2$ powierzchni zlewni.

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СТЕПЕНЬ ПЕРЕЖИВАЕМОСТИ МОЛОДИ КУМЖИ (SAIMO
TRUTTA L.) ОТ ВСЕЛЕНИЯ МАЛЬКА ДО ФОРМИРОВАНИЯ СТАДИИ
„СМОЛТ” В РЕКЕ МОЛСТОВОЙ

Р е з ю м е

Предметом работы было определение степени переживаемости молоди кумжи от момента вселения малька до образования стадии „смолт” в реке Молстовой. Лов смолтов вели комбинированной ловушкой (вентерь) в низовье реки во время их ухода к морю. Эксперимент проводили в той части реки где не наблюдалось естественное икротечение кумжи.

Количество и период зарыбления мальком представлено в табл.1. Ежегодно вселяли в среднем 1,8 штук малька на 1 кв. метр ручья. Зарыбленные места в годах предшествующих отлову подвергались проверке относительно пригодности данной водной среды для жизни вселенных рыб.

Улов в 1979 году составил 3197 смолтов (табл.3). Кроме того установлено, что около 20% смолтов уходящих рекой Молстовой к морю не отлавливалось. На этой основе установлено, что общее количество смолтов уходящих в 1979 г. составило 3836 штук.

В дальнейшем была рассчитана степень переживаемости молоди. В расчет включили структуру возраста смолтов ($n=250$).

Из полученных расчетов следует, что степень переживаемости молоди кумжи в р. Молстовой с момента вселения малька до образования стадии „смолт” составляет 0,94% а на производство одного смолта приходилось $62 m^2$ поверхности водосборного бассейна.

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