

Zygmunt CHEŁKOWSKI

Fish biology

**THE COURSE OF MIGRATIONS OF SMOLTS OF THE BROWN TROUT  
(*SALMO TRUTTA* M. *TRUTTA* L.) GROWN IN THE RIVERS  
OF POMERANIA**

**PRZEBIEG WĘDRÓWEK SMOLTÓW TROCI WĘDROWNEJ (*SALMO  
TRUTTA* M. *TRUTTA* L.) WYROSŁYCH W RZEKACH POMORZA**

Division of Salmonid Fishes Management, Agricultural University of Szczecin, Poland

In the present report the daily seaward migrations of the brown trout (*Salmo trutta* m. *trutta* L.) smolts, grown in natural conditions in Pomeranian rivers: the Mołstowa, surveyed for one season, the Gowienica—for five seasons, and the Osówka—for two seasons, were analyzed. The intensity of the migrations was related to the water temperatures and the moon phases. The above studies were based on a total of 5593 acquired smolts.

INTRODUCTION

Migrations of smolts of the brown trout (*Salmo trutta* morpha *trutta* Linnaeus, 1758) (Krzykawski et al. 1984), grown in the natural conditions in a number of Pomeranian rivers: the Gowienica, Mołstowa, Osówka, Parsęta, and the Rega were studied by Chełkowski (1978, 1990, 1993), Chełkowski et al. (1981, 1994), and Dębowski et al. (1992). A limited information on the migration of smolts of the Atlantic salmon and the brown trout in the lower Parsęta was provided also by Eichelbaum (1916).

It seems that the results of 24-hour cycle sampling of the trout smolts in the Mołstowa River drainage basin, within one season of their downstream migration, in the Gowienica River for five seasons, and in the Osówka River in two seasons related to the water temperatures and the moon phases may shed more light on the details of such migrations in Pomeranian rivers.

MATERIAL AND METHODS

The present publication was based on the smolts of the brown trout acquired from the three rivers located in the western part of Polish Pomerania, and being a part of the drainage area of the Baltic Sea: the Mołstowa River, the Gowienica River, and the Osówka River. The Mołstowa River is a secondary, right-bank tributary of the Rega River, the Gowienica

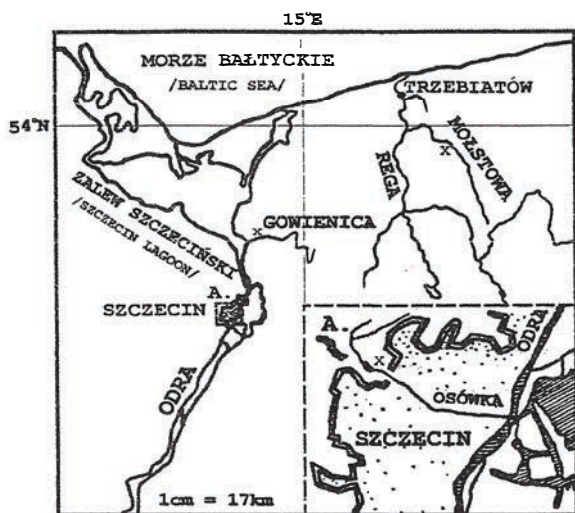


Fig. 1. Location of the Mołstowa, Gowienica, and Osówka rivers and the sampling sites (x) of the trout smolts

empties directly to the Szczecin Lagoon (Oderhaff), and the Osówka is a secondary, left-bank tributary of the lower Odra River (Fig. 1). The smolts of the Mołstowa River represented one sampling season from 21 March to 15 June 1979. The smolts of the Gowienica represented five successive sampling seasons within 1980–1984, lasting from 1 March to 15 July. The smolts of the Osówka, representing two sampling seasons were caught within 21 March–15 July 1985 and within 1 March–15 July 1988.

The Mołstowa River drainage basin covers 377.1 km<sup>2</sup> (Anonymous 1949). The river length is

55 km, and the average adjusted vertical drop rate of the bottom is 1.4‰. Smolts for the present studies were acquired from the lower Mołstowa River in the vicinity of the Mołstówko village. The width of the distinctly shaped river bed, at the trout smolt collection site, was 8 m. The downstream migration of the smolts within the drainage basin all the way down to the capture site, had not been disturbed by any physical obstacles. The shortest water distance from the sampling site to the Baltic Sea is 29 km.

The Gowienica River drainage basin covers 364.9 km<sup>2</sup> (Anonymous 1949). The river length is 79.5 km and the average adjusted vertical drop rate of the bottom is 0.84‰. Smolts for the present studies were caught in the lower Gowienica River in the vicinity of the village of Widziensko. The width of the distinctly shaped river bed, at the smolt collection site, was 8.5 m. The downstream migration of the smolts, within the drainage basin, all the way down to the capture site, had not been disturbed by physical obstacles until 1980. Within 1981–1984 the migration was slightly disturbed by a weir retaining water for a trout farm in the village of Łoźnica, located on the main river, 12.1 km upstream from the smolt collection site. The shortest water distance from the sampling site to the Baltic Sea is 48 km.

The Osówka River drainage basin covers some 7.3 km<sup>2</sup>. The length of the Osówka is 13 km, and the average adjusted vertical drop rate of the bottom is about 8.0‰. Smolts for the present studies were acquired from the middle stretch of the Osówka in the proximity of Biała Leśniczówka—a forest community. The seaward migration of the smolts within the

drainage basin, all the way down to the capture site had been undisturbed. The shortest water distance from the sampling site to the Baltic Sea is 70 km.

In the Mołstowa and Gowienica, the smolts were acquired by means of a fyke net, barring the river. In the Osówka the smolts were caught by means of a trap placed in an outlet box on a small, flow-through pond located on the river run. The fishing gear was checked daily at 7:00 and 19:00 and the smolts acquired then were assumed to constitute the daily catch (terms "day" and "daily" refer in the present work to 24-hour periods). At the time of the morning acquisition, the water temperature was recorded to the nearest 0.1°C. The migration periods, as well as the number of the acquired trout smolts in the respective rivers and the respective seasons are shown in Table 1. All catches combined yielded a total of 5 593 brown trout smolts.

**Table 1**

Periods and quantities of the trout smolts acquired in the respective rivers and seasons

River	Year	Description of the smolt migration season				Number of the acquired smolts
		Date Start - End	Number of days	Days of actual migration	Pause days	
Mołstowa	1979	19 April - 8 June	51	47	4	3197
Gowienica	1980	12 April - 12 June	62	56	6	917
Gowienica	1981	24 March - 10 June	79	34	45	110
Gowienica	1982	27 March - 28 May	63	37	26	219
Gowienica	1983	2 April - 31 May	60	49	11	355
Gowienica	1984	9 April - 18 June	71	41	30	409
Osówka	1985	6 April - 11 June	67	25	42	111
Osówka	1988	5 March - 21 May	78	23	55	275
Mean values			66	39	27	
Total						5593

The smolts acquired had grown, in the natural conditions, from the feeding alevins that the upper streams of the drainage basins were stocked with. Only the Osówka smolts acquired in 1988 had grown from 10-week-old fry, previously released to the river.

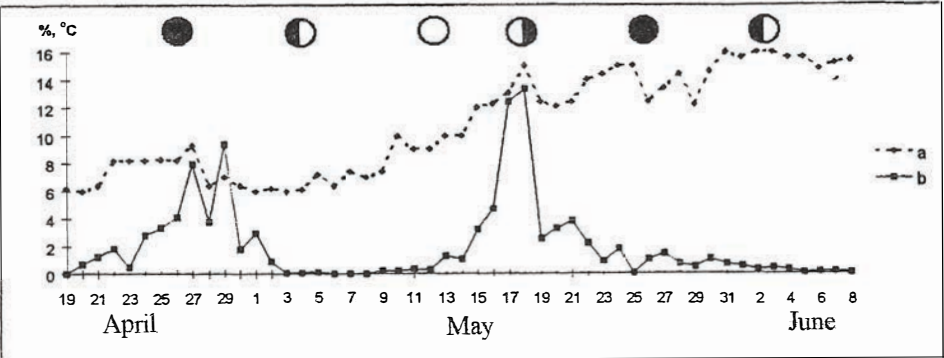
The phases of the moon during the migrations of the trout smolts were determined based on the Astronomical Annals (Anonymous 1979–1985, 1988). The days constituting the half of the periods between the respective ephemerides were considered to belong to a given phase.

The materials presented in the present paper were partly used in the publications of Chełkowski (1990, 1993) and Chełkowski et al. (1981, 1994).

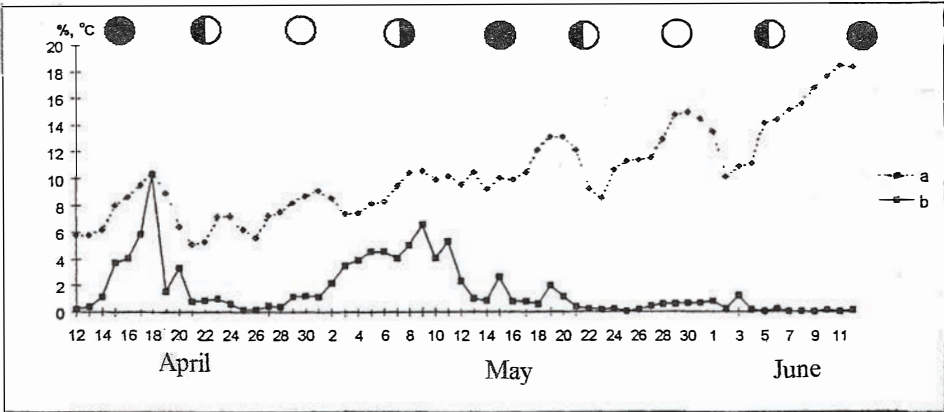
## RESULTS

The materials presently analyzed enabled to construct graphs of the daily relative abundance (in % of the total catch of a season) of the smolts migrating downstream within the respective eight studied seasons, with relation to the water temperature and the moon phases (Fig. 2 A-H).

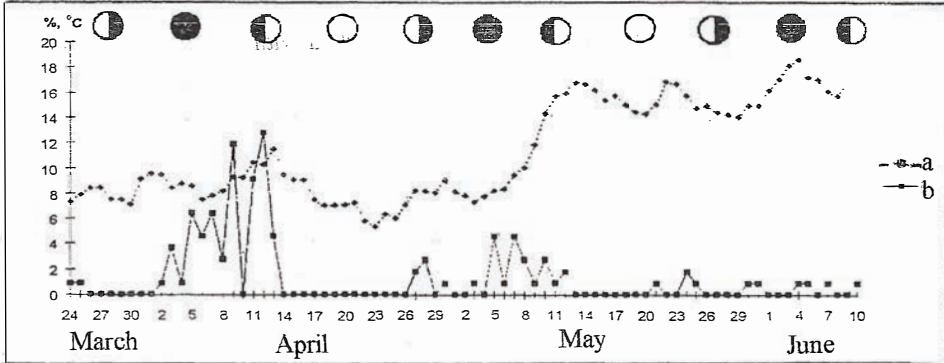
2A. Mołstowa River - season of 1979



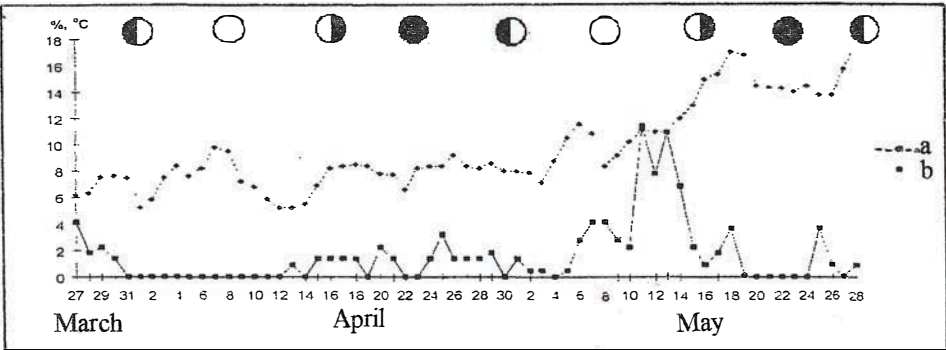
2B. Gowienica River - season of 1980



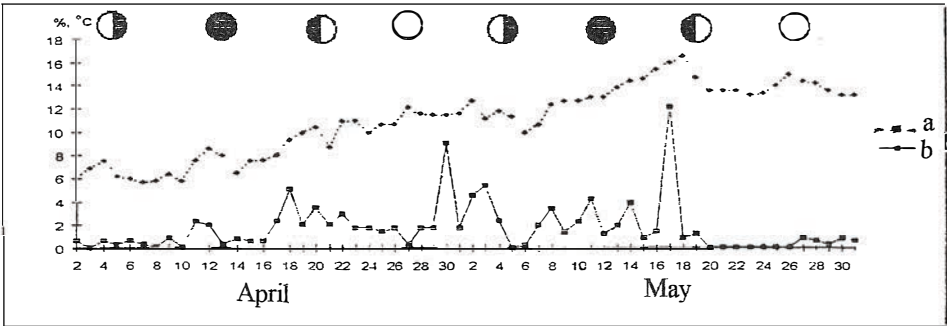
2C. Gowienica River - season of 1981



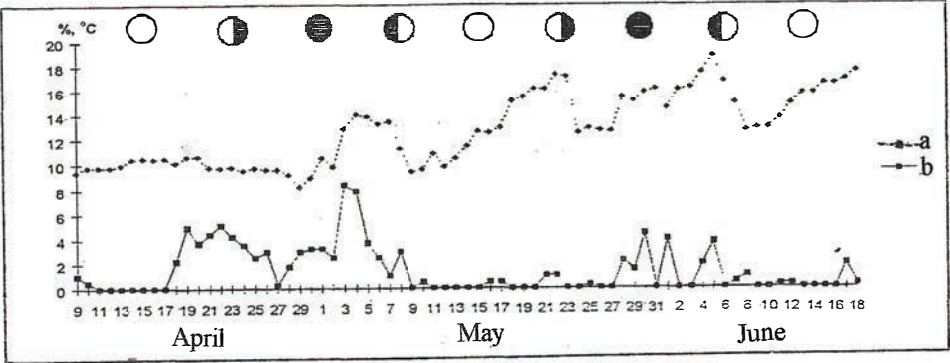
2D. Gowienica River - season of 1982



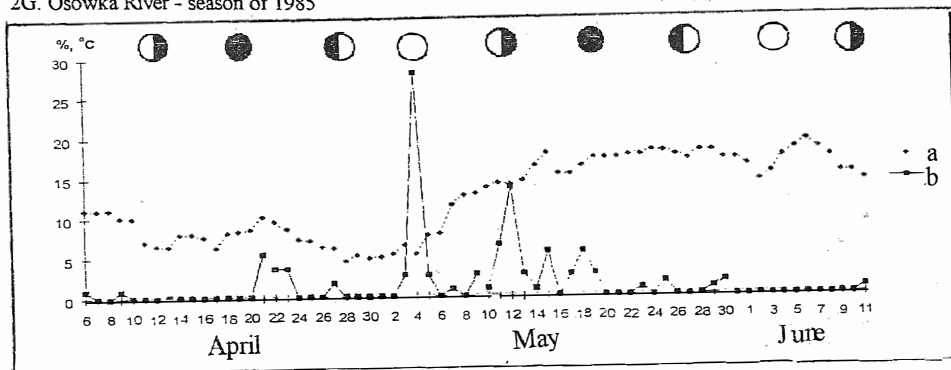
2E. Gowienica River - season of 1983



2F. Gowienica River - season of 1984



2G. Osówka River - season of 1985



2H. Osówka River - season of 1988

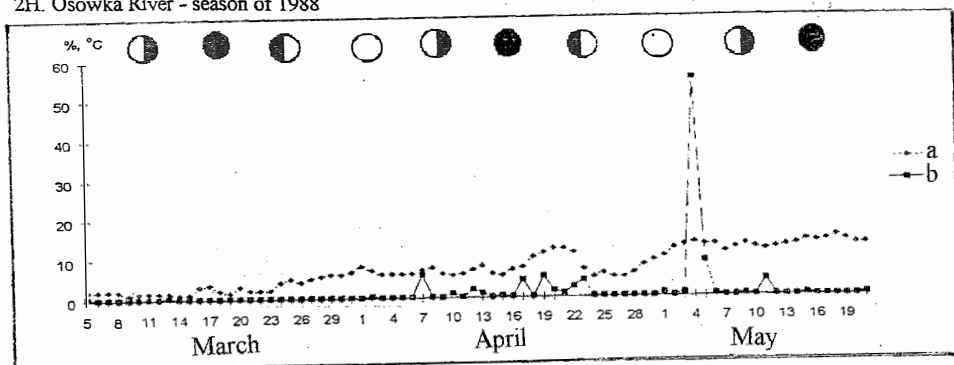


Fig. 2. Daily (24 h) relative abundance values ("b" in %) of the migrating trout smolts in the respective rivers and seasons with relation to the water temperature ("a" in °C) and moon phases (☾—first quarter, ☉—full moon, ☾—last quarter, ☿—new moon)

Catches of the fish in the Mołstowa in the season of 1979 yielded a total of 3 197 smolts of the brown trout. These smolts were descending within a period of 51 days, between 19 April and 8 June, in the water temperatures ranging from 6.0 to 16.0°C. The smolt migration begun at the last quarter of the moon, lasting through 7 successive ephemerides, and ended at the fool moon.

There had been two major periods of the intensive smolt migration in the Mołstowa. The first, with the relative abundance of 41.6% of the acquired fish, occurred within a period of 20 April–5 May in the water temperatures ranging from 6.0 to 9.3°C. The second, with 58.4% abundance of the acquired smolts, occurred within a period of 9 May–8 June, in the water temperatures of 7.4–16.0°C. Within the periods mentioned above, there were



two peaks in the intensity of migrations. The first, with 21.0-% abundance of the collected fish, occurred within a period of 27–29 April and the second, with 30.4-% abundance of the gathered fish, occurred within 16–18 May. The first peak in the migration intensity of the trout smolts in the Mołstowa, occurred during the new moon phase in the water temperatures of 6.4–9.3°C, while the second peak—in the last quarter of the moon in the water temperatures of 12.3–15.0°C.

There were two pauses during the period of smolt migration. The first, 3-day-long, occurred within 6–8 May, between two major periods of intensive migration. The second, lasting one day only, was reported on 25 May in the final days of the migration (Tabs. 1, 2; Fig. 2A).

Table 2

Riverine temperatures (in °C) at the sampling sites at the time of spring migrations of the trout smolts

River	Year	Migration season Start–End	Temperature range	Average tempe- rature of season	Average tempe- rature of river
Mołstowa	1979	19 April–8 June	6.0–16.0	10.8	10.8
Gowienica	1980	12 April–12 June	5.1–18.4	10.4	11.1
Gowienica	1981	24 March–10 June	5.3–18.6	11.3	
Gowienica	1982	27 March–28 May	5.2–17.7	9.7	
Gowienica	1983	2 April–31 May	5.7–16.5	11.0	
Gowienica	1984	9 April–18 June	8.2–18.7	12.7	
Osówka	1988	6 April–11 June	4.4–19.0	12.1	11.0
Osówka	1985	2 April–21 May	5.5–15.0	9.6	
Range			4.4–19.0		
Mean values			5.7–17.5	11.0	11.0

In the Gowienica River, in the season of 1980, a total of 917 smolts of the trout was acquired. These smolts were migrating downstream within a period of 62 days, between 12 April and 12 June, in the water temperatures ranging from 5.1 to 18.4°C. The smolt migration begun at the new moon, covering 8 successive ephemerides, and ended again at the new moon.

The presently gathered results show the presence of two periods of intensive migration. The first, with 33.7-% abundance of the acquired fish, occurred within a period of 12–25 April in the water temperatures of 5.5–10.4°C. The second, with 50.1-% abundance of the acquired fish, occurred within a period of 26 April–12 May, in the water temperatures ranging from 7.2 to 10.6°C. There were two peaks in the intensity of migrations within the periods mentioned above. The first, with 16.1-% abundance of the collected fish, occurred within 17–18 April and the second, with 34.0-% abundance, occurred within 5–11 May. The first peak in the migration intensity occurred during the new moon phase, in the water temperatures of 9.5–10.4°C, while the second peak occurred at the last quarter of the moon in the water temperatures of 8.2–10.6°C.

During the final days of the smolt migration, four pauses occurred. One 3-day-long within 7–9 June and three 1-day-long on 25 May and 5 and 11 June (Tabs. 1, 2; Fig. 2B).

In the Gowienica River in the season of 1981, a total of 110 smolts of the trout was acquired. In the above-mentioned river the smolts were migrating downstream within a period of 79 days, between 24 March and 10 June, in the water temperatures ranging from 5.3 to 18.6°C. The smolt migration begun at the last quarter of the moon, covering 10 successive ephemerides, and it ended again at the first quarter.

The daily shares of the relative abundance of the descending smolts, within the above season, prove the existence of two separate periods of intensive migration. The first, with involvement of 63.8% of the acquired smolts, occurred within a period of 2–13 April in the water temperatures ranging from 7.5 to 11.4°C. The second, with 25.4% abundance of the smolts, occurred within a period of 27 April–12 May in the water temperatures ranging from 7.3 to 16.0°C. Within the periods mentioned above, there were peaks in the intensity of migrations. The first with 38.2% abundance of the collected fish, occurred within 9–13 April and the second, with 12.8% abundance, occurred within 5–8 May. The first peak in the migration intensity of the trout smolts, occurred during the first quarter in the water temperatures of 9.2–11.4°C, while the second peak—at the new moon in the water temperatures of 8.2–10.0°C.

During the period of smolt migration as many as 12 pauses occurred in their descent. One 13-day-long within 14–26 April, one 8-day-long within 13–20 May, one 7-day-long from 26 March to 1 April, one 4-day-long within 26–29 May, one 3-day-long within 1–3 June, three 2-day-long within 1–2, 22–23 May, and 8–9 June, and four 1-day-long, within: 29 April, 4 and 20 May, and 6 June (Tabs. 1, 2; Fig. 2C).

In the Gowienica River in the season of 1982, a total of 219 of the trout smolts was acquired. In the Gowienica, the smolts were migrating downstream within a period of 63 days, between 27 March and 28 May, in the water temperatures in the river ranging from 5.2 to 17.7°C. The smolt migration begun at the new moon, covering 9 successive ephemerides, and ended at the first quarter.

As it is evident from the processed materials, there was one high intensity period of migration of the acquired smolts, with 61.4% abundance, within 6–18 May in the water temperatures of 8.4–17.1°C. The migration intensity peak, with 37.0% abundance of the acquired fish, occurred within 11–14 May, between the full moon and the last quarter, in the water temperatures in the Gowienica within 11–12°C.

During the migration period of the smolts, there were 8 pauses in their descent. One 13-day-long between 31 March and 12 April, one 6-day-long within 19–24 May, one 2-day-long within 22–23 April, and five 1-day-long on: 14, 19, 30 April, 4, 27 May (Tabs. 1, 2; Fig. 2D).



In the Gowienica River in the season of 1983, a total of 355 smolts of the trout was acquired. In the Gowienica, the smolts were migrating downstream within a period of 60 days, between 2 April and 31 May, in the water temperatures ranging from 5.7 to 16.5°C. The smolt migration begun at the last quarter of the moon, covering 8 consecutive ephemerides, and ended again at the last quarter.

The dynamics of the daily catch abundance of the studied smolts proves the existence of three periods of intensified migration. The first with 24.1-% abundance of the acquired fish, occurred within 17–26 April in the water temperatures of 8.0–10.9°C. The second, with 26.1-% abundance of the acquired smolts occurred between 28 April and 4 May, in the water temperatures of 11.2–12.7°C. The third period of intensified migration, with 36.4% abundance, occurred within a period of 7–9 of May, in the water temperatures of 10.7–16.5°C. There were intensity peaks during the periods of intensified migration. The first peak, with 5.1-% abundance of the acquired smolts, occurred on 18 April at the first quarter of the moon, in the water temperature of 9.3°C. The second peak of the migration intensity, with 22.8-% abundance, occurred within a period of 30 April–4 May, between the full moon and the last quarter, in the water temperatures of 11.2–12.7°C. The third peak in the migration, with 12.1-% abundance, occurred on 17 May, at the first quarter, in the water temperatures of 16.0°C.

During the period of smolt migration there were 5 pauses in their seaward descent. One 7-day-long within 20–26 May and four 1-day-long on: 3, 8, 10 April and 5 May (Tabs. 1, 2; Fig. 2E).

In the Gowienica River in the season of 1984, a total of 409 of the trout smolts was acquired. In the Gowienica, the smolts were migrating downstream within a period of 71 days, between 9 April and 18 June, in the water temperatures ranging from 8.2 to 18.7°C. The smolt migration begun at the first quarter of the moon, covering 10 successive ephemerides, and ended at the last quarter.

During the seaward migration of the smolts, two distinct periods of the intensity were visible. The first, with 33.2-% abundance of the acquired smolts, occurred within 18–26 April, in the water temperatures of 9.5–9.8°C. The second, with 39.6-% abundance, occurred within the period of 28 April–8 May, in the water temperatures of 8.2–14.0°C. There were two peaks during the periods of the intensified migration. The first peak, with 22.3-% abundance of the acquired smolts, occurred within 19–23 April in the water temperatures of 9.7–10.6°C and at the last quarter of the moon. The second peak in the migration, with 19.8-% abundance, occurred within 3–5 May, in the water temperatures of 12.9–14.0°C, at the new moon.

There were as many as 11 pauses in the smolt migration during their descent. One 7-day-long within 11–17 April, one 5-day-long within 11–15 May, one 4-day-long within

13–16 June, one 3-day-long within 18–20 May, four 2-day-old within: 23–24, 26–27 May, and 2–3, 9–10 June, and three 1-day-long on 9, 31 May and 6 June (Tabs. 1, 2; Fig. 2F).

In the Osówka River in the season of 1985, a total of 111 smolts of the trout migrating downstream was acquired within a period of 67 days, between 6 April and 11 June, in the water temperatures within the range of 4.4–19.0°C. The smolt migration begun at the fool moon, covered 9 successive ephemerides, and ended at the last quarter.

Analysis of the daily frequency of the smolt acquisition in the Osówka revealed three periods of intensified migrations. The first high intensity period, with 12.6-% abundance of the acquired smolts, occurred within 21–23 April, in the water temperatures of 8.4–10.0°C. The second high intensity period, with 33.4-% abundance, occurred within 3–5 May in the water temperatures of 5.4–7.6°C. The third and the most intensive period with 43.2-% abundance, occurred within 9–19 May, in the water temperatures of 12.6–17.6°C. There were three peaks in the migration intensity during the high intensity periods. The first peak, with 5.4-% abundance of the acquired smolts occurred on 21 April, in the water temperature of 10°C, at the new moon. The second peak of migration intensity with 27.9-% abundance, occurred on 4 May, in the water temperatures of 5.4°C, at the fool moon. The third peak of the migration intensity, with 19.8-% abundance, occurred within 11–12 May, in the water temperatures of 13.8–14.0°C, at the last quarter of the moon.

There were 11 pauses during the migration of the brown trout smolts. Two 11-day-long within 10–20 April and 31 May–10 June, one 5-day-long within 28 April–2 May, three 3-day-long within: 24–26 April, 20–22 May, and 26–28 May, one 2-day-long within 7–8 April, four 1-day-long on: 6, 8, 16, and 24 May (Tabs. 1, 2; Fig. 2G).

In the Osówka River in the season of 1988, a total of 275 smolts of the trout was acquired on their seaward movement within a period of 78 days, between 5 March and 21 May, the longest stretch of a season described to date. The catches yielded 2 smolts on the end of the calendar winter (5 and 13 March) as well as 273 smolts in the spring within 2 April and 21 May. In the spring, the smolt migration begun at the fool moon, covered 7 successive ephemerides and ended at the first quarter. The spring migration of the smolts occurred in the water temperatures of the river ranging from 5.5 to 15.0°C. The smolt acquired on 5 March migrated at the fool moon, in the water temperature of 2.0°C, while that caught on 13 March witnessed the last quarter, in the water temperature of 1.5°C.

During the analyzed season, there were three periods of the high migration intensity of the smolts. The first with 5.8-% abundance of the acquired smolts, occurred on 7 April, in the water temperature of 7.0°C. The second, with 18.8-% abundance, occurred within 17–23 April, in the water temperatures of 5.0–12.0°C. The third, with 64.7-% abundance, occurred within 3–6 May, in the water temperatures of 13.0–13.5°C. During the periods of the high intensity of migration, there were intensity peaks. The first, 1-day-long peak,

occurred at the last quarter of the moon. The second peak in the migration intensity, with 6.5-% abundance of the acquired smolts, occurred within 19–20 April, in the water temperatures of 11.0–12.0°C, at the new moon. The third peak with 63.6-% abundance of the acquired smolts, occurred within 4–5 May at the fool moon, in the water temperatures of 13.0–13.5°C.

There were 14 pauses during the smolt migration. One 19-day-long within 14 March–1 April, two 7-day-long within: 6–12 March and 24–30 April, one 5-day-long within 16–20 May, one 4-day-long within 3–6 April, one 3-day-long within 12–14 May, two 2-day-long within 8–9 April and 7–8 May, and six 1-day-long on: 11, 14, 16, 18 April and 2, 10 May (Tabs. 1, 2; Fig. 2H).

### The course of the daily migrations of the trout smolts

The migrations of the trout in the Mołstowa, Gowienica and the Osówka rivers in the eight analyzed seasons covered periods between 51 and 79 days, and occurred within 5 March and 18 June—a period of 106 days. The shortest migration season, namely 51-day-long, occurred in the Mołstowa River in 1979, between 19 April and 8 June. The longest season, covering 79 days, occurred in the Gowienica in 1981, between 24 March and 10 June. The average migration period was 66 days (Tab. 1).

Only a small fraction of the migration periods occurred on the end of calendar winter, while the decisive reminder occurred in spring. In winter there were only 2 smolts, acquired from the Osówka on 5 and 13 March 1988. The smolts migrating in winter constituted 0.73% of all fish acquired in the Osówka during the above-mentioned migration season ( $n = 275$ ) and at the same time constituted 0.04% of the total catch of the present studies ( $n = 5\,593$ ).

On the other hand, the spring migrations of the smolts in the eight studied seasons covered a period from 24 March to 18 June (Tab. 2) and yielded 99.6% of the studied fish. The daily shares of the smolts acquired in spring enable the distinction of the three migration periods: the early (initial) and the late (closing), both with small abundance of the acquired fish, and the main—with very high numbers of the fish. Within 20 days of the early period, lasting from 24 March to 14 April and within 13 days of the late period between 6 and 18 June, a total of 213 fish was acquired (176 and 37 respectively). The above constitutes 3.81% of the acquired smolts (3.15% and 0.66% respectively). On the other hand, in the main period of the smolt migration, covering 52 days between 15 April and 5 June, a total of 5378 fish was acquired, constituting 96.15% of the total catch.

The daily shares of the acquired smolts of the total catch of the present survey, in the early and the late periods of the migration, ranged from 0 to 0.5%. In the main period of the migration they amounted anywhere from 0.2 to 8.14%. The average daily share for the ear-

ly and the late periods combined, was as little as 0.1%. On the other hand, in the main period of the migrations it was 18.5 times higher and equaled 1.85%.

The daily shares of the total catch of the present survey suggest the existence of three high intensity periods with the peaks of migration intensity. The first high intensity period with 37.13-% abundance of the acquired smolts occurred within 25 April–1 May, the second with 11.7-% abundance—within 2–7 May and the third with 40.1-% abundance—within 8–23 May (Fig. 3).

In the Gowienica, however, in the season of 1982, there was only one 13-day-long high intensity period in the smolt migration, involving 61.4% of the individuals.

In the Molstowa, in the season of 1979, there were two high intensity periods of the smolt migration. The first, 16-day-long, with 41.6-% abundance of the acquired smolts and the second 31-day-long, with 58.4-% abundance. The above two figures combined, constitute 100% of the smolts acquired in the season.

In the Gowienica, in the season of 1980, there were two high intensity periods in the smolt migration. The first, 14-day-long with 33.7-% abundance of the acquired smolts and the second, 17-day-long with 50.1-% abundance of the fish. The above-mentioned high intensity periods of the migrations constituted 83.8% of the smolts acquired within the season.

In the Gowienica, in the season of 1981, there were two high intensity periods in the migration. The first, 12-day-long with 63.8-% abundance of the acquired smolts and the second, 16-day-long with 25.4-% abundance of the fish. The above two high intensity periods of the migrations constituted 89.2% of the smolts acquired within the season.

In the Gowienica, in the season of 1984, there were also two high intensity periods in the migration of the trout smolts. The first, 9-day-long with 33.2-% abundance of the acquired smolts and the second, 11-day-long with 39.6-% abundance of the fish. These two high intensity periods combined, constituted 72.8% of the smolts acquired within the season.

In the Gowienica, in the season of 1983, there were three high intensity periods in the smolt migration. The first, 9-day-long with 24.1-% abundance, the second, 17-day-long with 50.1-% abundance, and the third, 13-day-long with 36.4-% abundance of the acquired smolts. These three high intensity migration periods combined, constituted 86.6% of the smolts acquired within the season.

In the Osówka, in the season of 1985, there were three high intensity periods in the smolt migration. The first, 3-day-long with 12.6-% abundance of the smolts, the second, 3-day-long with 33.4-% abundance, and the third, 11-day-long with 43.2-% abundance. These mentioned above, three high intensity periods combined, constituted 89.2% of the smolts acquired within the season.

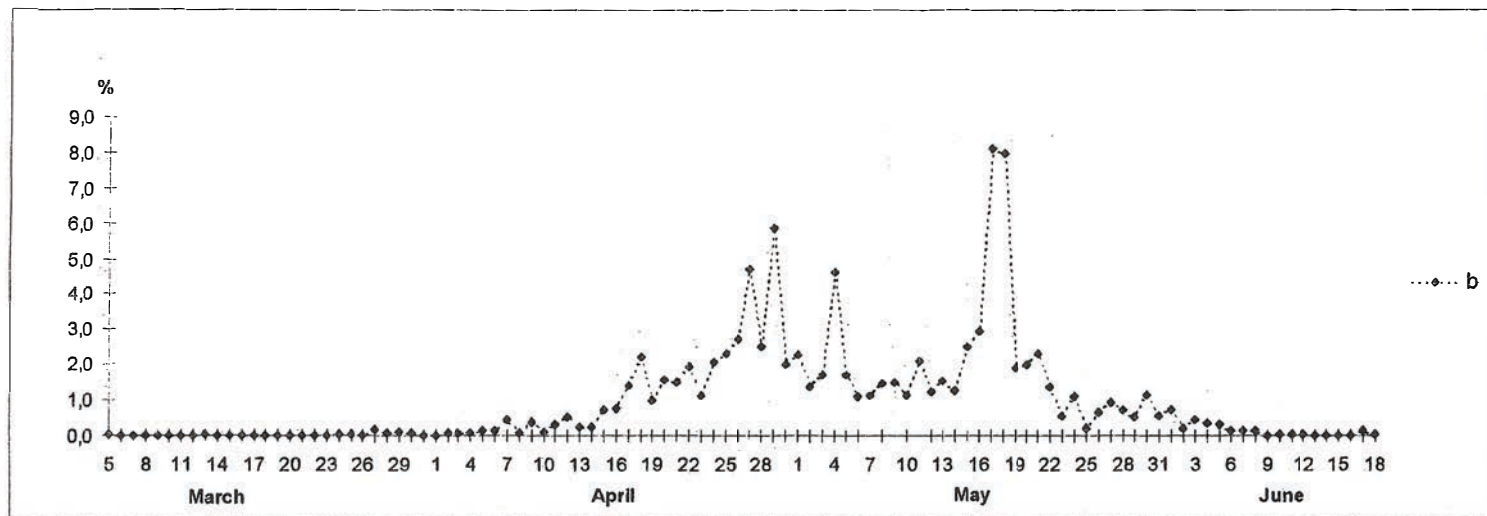


Fig. 3. Daily (24 h) relative abundance values ("b" in %) of the migrating trout smolts for all seasons combined (n=5593)



In the Osówka, in the season of 1988, there were also three high intensity periods in the seaward movement. The first, 1-day-long with 5.8-% abundance, the second, 7-day-long with 18.8-% abundance, and the third, 4-day-long with 64.7-% abundance. These mentioned above, three high intensity periods combined, constituted 89.3% of the smolts acquired within the season.

Within the eight analyzed seasons, a single high intensity period occurred once in the Gowienica in 1982, two high intensity periods occurred four times: in the Mołstowa in 1989, in the Gowienica in 1980, 1981, and 1984, and three high intensity periods occurred three times: in the Gowienica in 1983, in the Osówka in 1985 and 1988.

The high intensity periods covered periods from 1 to 31 days, in most cases few or anywhere from 10 to 20, and 11 in average ( $\bar{x} = 10.9$  days).

It has been presently revealed that the smolts caught within the periods of the high intensity migrations, constitute a large portion of the total number of the fish descending during a season. Smolts, being a part of a single high intensity period constituted 61.4% of the fish migrating within a season. Smolts composing dual high intensity periods constitute anywhere from 72.8% to 100% of the fish migrating within such season. Smolts, however, involved in triple high intensity periods constitute anywhere from 86.6% to 89.3% of the fish migrating within a season.

Portions of the smolts included in the successive high intensity periods of migrations increase, as a general rule. For instance the portions of the migrating smolts acquired during the triple high intensity periods in the Gowienica in 1983 were as follows: 24.1%, 26.1%, and 36.4%. In the Osówka in 1988 they were: 5.8%, 18.8%, and 64.7%. The portions during dual high intensity periods in the Mołstowa in 1879 were: 41.6% and 58.4%, while in the Gowienica in 1980 they were: 33.7 and 50.1%. In certain cases the portions of the migrating smolts were larger during the first high intensity period than they were at the second. The Gowienica in 1981 can serve as an example with 63.8% during the first, and 25.4% during the second high intensity period.

All high intensity periods of the smolt migrations exhibited peaks in migration intensity. In the calculation combining all the results, there had been three peaks. The first, 3-day-long, with dual summit and 13.2-% abundance of the acquired smolts, occurred within 27–29 April. The second 1-day-long with 4.7-% abundance, occurred on 4 May. The third, 2-day-long peak with 16.2-% abundance, took place within 17–18 May. Therefore the abundance of the smolts in the third peak was the highest compared to the preceding two (Fig. 3). On the other hand, in the eight analyzed seasons, being considered separately, there were anywhere from one to three peaks and the respective number of high intensity periods. The peaks lasted from 1 to 7 days. One-day-long peak occurred five times, 2-day-long—four

times, 3-day-long—three times, 4-day-long—two times, 5-day-long—three times, and 7-day-long occurred only one time. Most often the peaks lasted 3 days ( $\bar{x} = 2.9$  days).

The smolts composing the peak days constituted also large portions of the fish migrating within the seasons. The single peak in 1982 in the Gowienica, constituted 37.0% of the smolts migrating during that season. Two peaks in the season of 1979 in the Mołstowa constituted 51.4%, two in the season of 1980 in the Gowienica—50.1%, two in the season of 1981 in the Gowienica—50.1%, and two peaks in the season of 1984 in the Gowienica constituted 42.1% of the smolts migrating during the season. Three peaks in the season of 1983 in the Gowienica constituted 39.9%, three in the season of 1985 in the Osówka—53.2%, and three in the season of 1988 in the Osówka constituted 67.2% of the smolts migrating during the season.

The daily catches yielded interesting information on the respective rivers and the respective seasons. The number of smolts caught on a single day ranged from 0 to 427. The most abundant catch of 427 individuals took place on 18 May 1979 in the Mołstowa River and it constituted 13.4% of the fish acquired during the season. Relatively most abundant catch of 54.9% of the season's yield occurred on 4 May 1988 in the Osówka and it comprised 151 smolts. High portions of the daily catches occurred also in the remaining seasons, which is shown in the following list:

Osówka	4 May 1985	31 individuals	27.9%
Gowienica	12 April 1981	14 ind.	12.7%
Gowienica	17 May 1983	43 ind.	12.1%
Gowienica	11 May 1982	25 ind.	11.4%
Gowienica	18 April 1980	94 ind.	10.3%
Gowienica	3 May 1984	34 ind.	8.3%

There had been pauses during the smolt migration downstream. The number of pauses, in the seasons analyzed, ranged from 1 to 14 ( $\bar{x} = 8.3$ ). The duration of the pauses was anywhere from 1 to 19 days, mostly from 1 to 3 days, rarely reaching 7, and very rarely 13, and only in one case it equaled 19 days.

The length of the pauses in the respective seasons of migration ranged from 4 to 55 days, while the number of days of active migration was within 23–56. Sometimes the number of pause days exceeded the number of actual active migration days, although there were seasons of the reverse proportion. For example in the season of 1988 in the Osówka, within 78-day-long season, the smolts were pausing for a total of 55 days, and were actively migrating for a total of 23 days. On the other hand, in the season of 1979 in the Mołstowa, within 51-day-long migration season, the smolts were pausing for as few as 4 days. Statistically, however, based on the combined data from the all seasons, there were fewer pause days (27 days) than there were days of active migration (39 days), Table 1.

Riverine water temperatures during the migrations of the brown trout smolts

As it has been mentioned earlier, on the end of the winter, on 5 and 13 March 1988, in the Osówka River, the first two smolts of the season were acquired. The first one was caught in the water temperature of  $2.0^{\circ}\text{C}$  and the second in the temperature of  $1.5^{\circ}\text{C}$ . It seems that such early migrating smolts, not having counterparts in the remaining seasons, can be disregarded in the forthcoming discussion on thermal changes during the migration. The widest range of the water temperatures, during the eight seasons of the smolt migration was  $4.4\text{--}19.0^{\circ}\text{C}$ , while the average values ranged from  $5.7$  to  $17.5^{\circ}\text{C}$  (Tab. 2). The values of extreme temperatures listed above are not synonymous with the temperatures at which the smolts commence and cease their migration. Those temperatures are slightly different, because the extreme temperatures do not necessarily occur at the beginning and at the end of a season, and they may as well occur at a given time within a season (Figs. 2A, 4). That is why the trout smolts were commencing their spring migrations in the temperatures ranging from  $5.8$  to  $11.0^{\circ}\text{C}$  ( $7.4^{\circ}\text{C}$  in average). The smolts ceased to migrate within the water temperature range of  $13.0\text{--}18.3^{\circ}\text{C}$  ( $15.4^{\circ}\text{C}$  in average).

The sum of the daily water temperatures allows to calculate the average water temperature for the respective seasons, rivers, as well as for the whole survey. The average water temperatures for the eight seasons ranged from  $9.6$  to  $12.7^{\circ}\text{C}$ , while the average temperature for the Mołstowa was  $10.8^{\circ}\text{C}$ , for the Gowienica— $11.1^{\circ}\text{C}$  and the Osówka— $11.0^{\circ}\text{C}$ . The average water temperature for all seasons combined was  $11.0^{\circ}\text{C}$  (Tab. 2).

During the periods of spring migrations of the smolts, the temperatures grow as a rule, while in all migration seasons rapid or slow decreases or increases of the daily temperatures are observed. The decreased temperature, although for a short time, may drop below the limit under which the smolts commence their migration. For instance, in the season of 1985 in the Osówka, smolts begun their migration on 6 April in relatively high water temperature of  $11.0^{\circ}\text{C}$ , while on 28 April the temperature dropped down to  $4.4^{\circ}\text{C}$ .

The data gathered presently, indicate that there is a distinct influence of the water temperature on the quantities of the migrating trout smolts. In the season of 1979 in the Mołstowa, within 26 and 27 April, the temperature rise from  $8.2$  to  $9.3^{\circ}\text{C}$  increased the daily abundance of the trout smolts from  $4.1$  to  $7.9\%$ . Following that, the temperature drop on 28 April from  $9.3$  to  $6.4^{\circ}\text{C}$  decreased the daily smolt abundance down to  $3.7\%$ . Subsequent temperature rise on 29 April to  $7.0^{\circ}\text{C}$  increased again the daily abundance of smolts up to  $9.3\%$ . Consecutive temperature drop within next few days triggered again the decrease in the daily abundance of the migrating smolts. Again, the temperature rise within 14–18 May from  $10$  to  $15^{\circ}\text{C}$  resulted in a peak of smolt daily abundance, amounting  $13.5\%$  on 18 May. On 19 May, the water temperature dropped from  $15.0^{\circ}\text{C}$  to  $12.4^{\circ}\text{C}$  what limited the abundance of the migrating smolts to  $3.2\%$ . The influence of the daily increase or decrease of the water temperature on the re-

spective increase or decrease of the quantities of the migrating smolts is evident also in the remaining rivers and the seasons surveyed. Such dependence was particularly well visible in the season of 1980 in the Gowienica within 13–19 April (Fig. 2B) and in the Osówka in the season of 1985 within 20–24 April (Fig. 2G).

As it has been already mentioned, there can be anywhere from 1 to 3 high intensity periods and peaks in the intensity of smolt migration within the individual seasons. The number of the high intensity periods and the peaks is quite clearly dependent on the fluctuating course of the temperature changes in the rivers.

In 1982 in the Gowienica, there was only one high intensity period with a peak of the migration of the trout smolts. The high intensity period occurred in the water temperatures of 8.4–17.1°C and the peak of migration intensity—within 11.0–12.0°C.

In 1979 in the Mołstowa and in 1980, 1981, and 1984 in the Gowienica there were two high intensity periods with the peaks. The first high intensity period took place in the water temperatures of 5.8–11.4°C and the second in the temperature of 7.2–16.0°C. The first peak of the intensive migration occurred in the water temperatures of 6.4–11.4°C and the second in the temperatures of 8.2–15.0°C.

There were three high intensity periods with peaks in the Gowienica in 1983 and 1985 and in the Osówka in 1988. The first high intensity period took place in the water temperatures of 7.0–10.9°C, the second under the water temperatures of 5.0–12.7°C, and the third—in the temperatures of 10.7–17.6°C. The first peak of the intensity occurred in the water temperatures of 7.0–10.0°C, the second in the temperatures of 5.4–12.7°C, and the third, in the temperatures of 13.0–16.0°C.

#### Trout smolts migrations in relation to the moon phases

The beginning of the spring migration of the trout smolts in the Mołstowa in the season of 1979 and in the Gowienica in the seasons of 1981 and 1983 occurred during last quarter of the moon. In the Gowienica in the seasons of 1980 and 1982 it occurred at new moon, in the Gowienica in the season of 1984—at the first quarter, while in the Osówka in the seasons of 1985 and 1988—during fool moon. The beginning of the migration of the trout smolts occurred in the above-mentioned rivers and seasons in all four moon phases. Most often, however, the migrations commenced within last quarter (3 times), then within fool moon and new moon (2 times each), and least frequently within first quarter of the moon (1 time) (Figs. 2A–H).

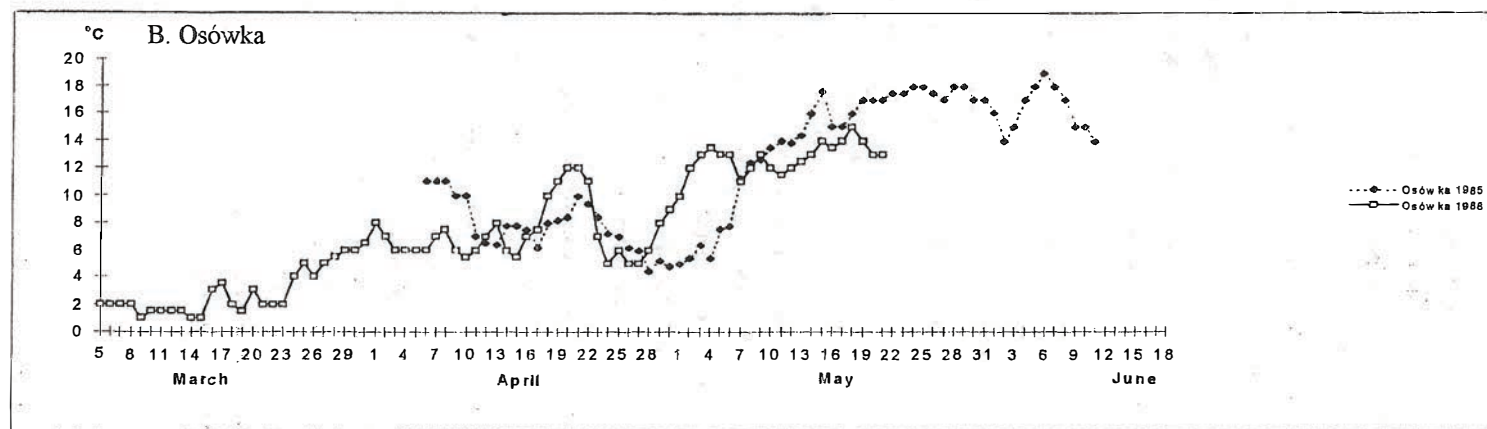
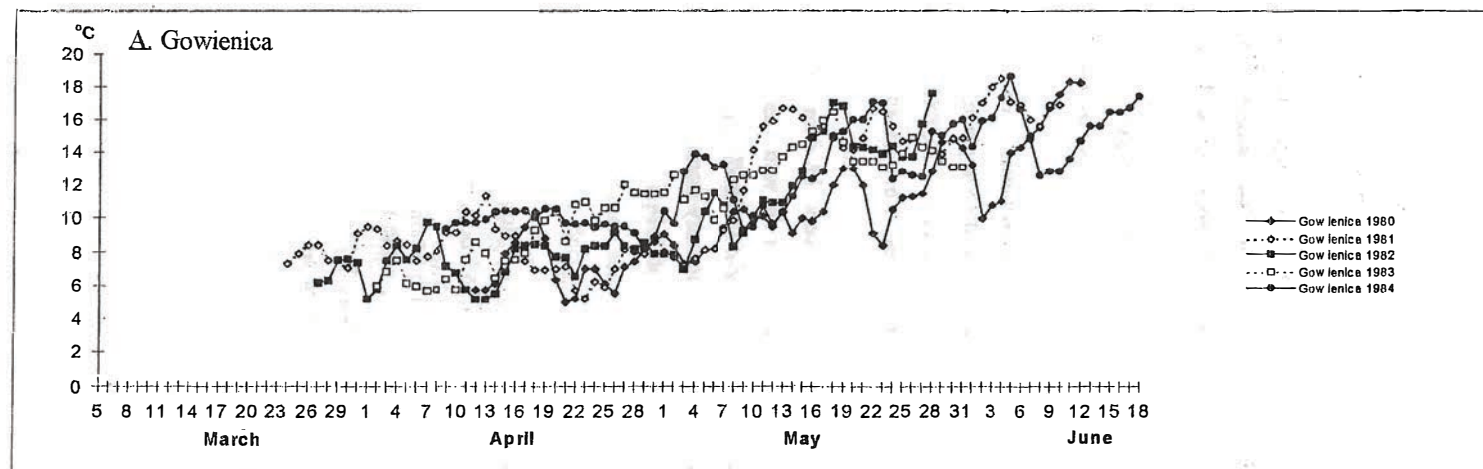


Fig. 4. Temperature values of the waters of the Gowienica and Osówka rivers in the respective seasons of the trout smolt survey



Similarly, the migrations of the trout smolts in the analyzed rivers and seasons terminated at all moon phases. In the Mołstowa in the season of 1979 it ended at the fool moon, in the Gowienica in the seasons of 1983 and 1984, and in Osówka in the season of 1985—at last quarter, in the Gowienica in the season of 1980—at new moon, while in the Gowienica in the season of 1981, 1982 and in the Osówka in the season of 1988—during first quarter of the moon. Most often the end of the migration occurred within first and last quarter (3 times, less frequently at fool moon and new moon (1 time) (Figs. 2A–H).

The percentage portions of the acquired smolts in the individual moon phases appeared to be an interesting feature. In the Osówka in the season of 1985 and 1988, smolts migrating during fool moon constituted the largest share. Also large portion of the smolts migrating within fool moon occurred in the Gowienica in the season of 1982. On the other hand in the Mołstowa in the seasons of 1979 and in the Gowienica in the seasons of 1980, 1981 and 1984, the portions of the smolts migrating within fool moon were small or very small. Portions of the smolts migrating at first and last quarter and new moon as well, were variable in the studied seasons, exhibiting a wide range of values. Sometimes, the dominant were the portions of the smolts migrating at last quarter (Mołstowa—1979 season and Gowienica—1982 season), sometimes at new moon (Gowienica—1980 and 1984 seasons), or at first quarter (Gowienica – 1981 and 1983 seasons) (Fig. 5).

More light on the smolt migration in the respective moon phases is being shed by the portions based on the materials concerning the individual rivers (Fig. 5). In the Mołstowa the majority of smolts migrated to the sea within last quarter (46.4%), new moon (40.2%), and much less within fool moon (6.8%) and at first quarter (6.6%). On the other hand, in the Gowienica the majority of the smolts undertook the migration at new moon (34.7%), at last quarter (30.3%) and much less at first quarter (19.8%), and at fool moon (15.2%). On the other hand, in the Osówka the majority of the smolts undertook their migration during fool moon (57.0%), much less at last quarter (18.1%), new moon (16.6%), and first quarter (8.3%). It is evident from the data listed above, that the major migration of the smolts in the Mołstowa and the Gowienica occurred at last quarter and the new moon, while in the Osówka within fool moon. The portions of the migrating smolts in the Mołstowa and the Gowienica within first quarter and fool moon are much smaller. Also the portions of the migrating smolts in the Osówka at the remaining moon phases: last quarter, new moon, and first quarter are small.

The details concerning the peaks in the intensity of the smolt migrations in relation to the moon phases in the eight seasons surveyed, turn out to be very interesting. Out of a total number of 18 migration intensity peaks, 6 occurred at new moon, 5 at last quarter, 3 at first quarter, 2 at fool moon, and 2 at a phase between fool moon and last quarter. Summing up, the migration intensity peaks occurred mostly within new moon and last and first quarter, less frequently within fool moon.

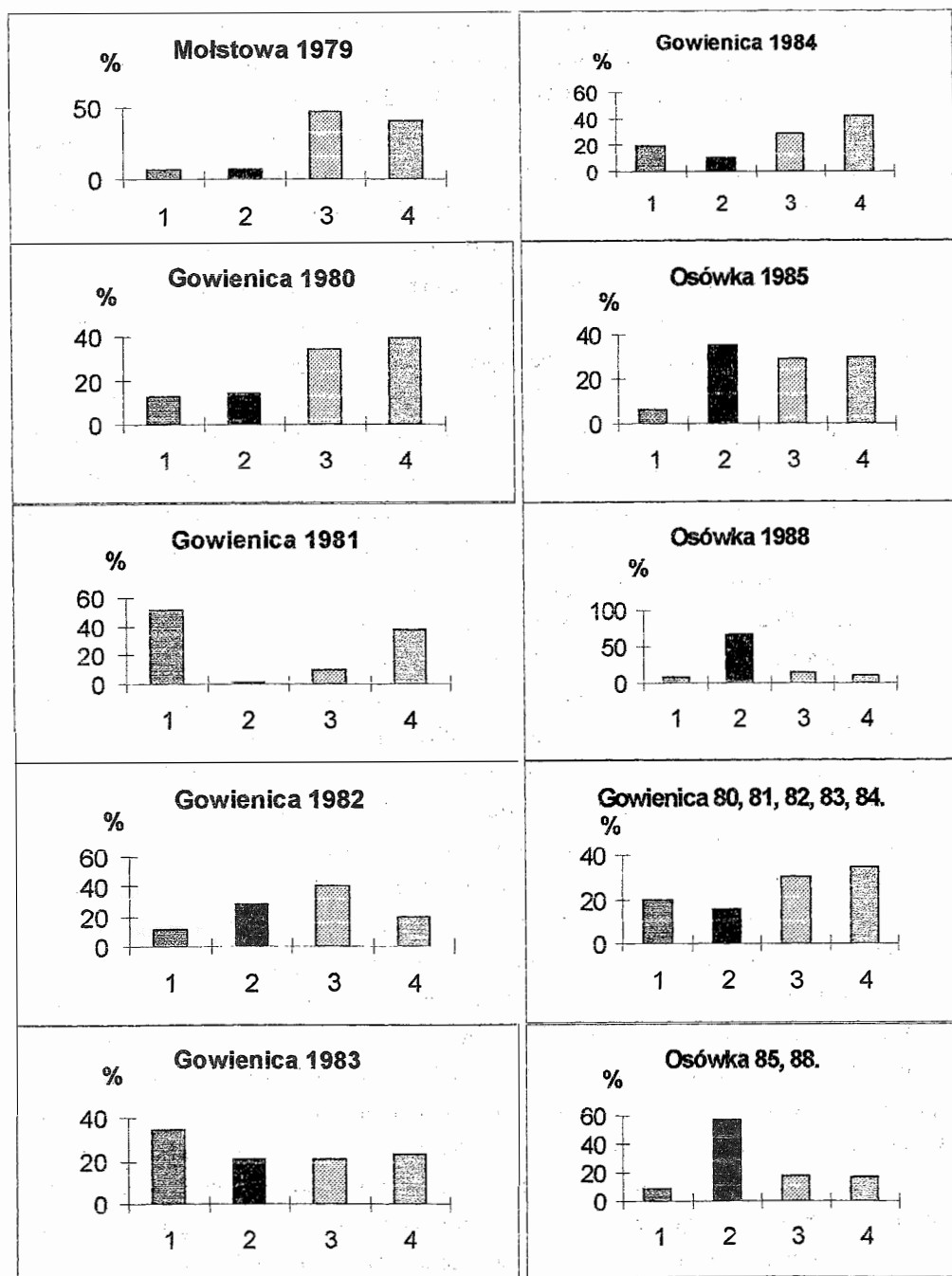


Fig. 5. Relative abundance values (in %) of the migrating smolts in the Mołstowa, Gowienica and Osówka rivers within the respective moon phases

## DISCUSSION

The migrations of the Atlantic salmon and trout smolts in the lower Parsęta River in the season of 1914, occurred within 19 March–6 May (Eichelbaum 1916). In the upper Parsęta in three successive seasons: 1984–1986 smolts of the trout migrated within 3 April–18 May (Dębowski et al. 1992). In the lower Rega in four seasons: 1965, 1966, 1967, and 1974—within 29 March–9 June (Chełkowski 1978), in the Osówka in two seasons 1986, 1987—within 7 April–7 June (Chełkowski 1990), and in the same river in the season of 1989—within 18 March–4 May (Chełkowski 1993). The migrations of the studied trout smolts in the Mołstowa in the season of 1979, took place within the period of 19 April–8 June, in the Gowienica in the five seasons: 1980–1984—within 24 March–18 June, in the Osówka in two seasons: 1985, 1988—within 5 March–11 June. From the analysis of the listed above surveys, covering 19 seasons, it is evident that the smolts of the trout in the Pomeranian rivers migrate to the sea, in broader sense, within 5 March–18 June, but most commonly in spring within 24 March–18 June. Involvement of the migrating smolts in the latter period, as evident from the present results, reaches 99.96%. The majority of the smolts migrates to the sea, according to Chełkowski (1993), within four decades: second decade of April–second decade of May. The main period of the smolt migration in the Mołstowa, Gowienica, and the Osówka covers 52 days, within 15 April–5 June. In the above period slightly more than 96% of migrating smolts occurred.

The beginning of the smolt migration in the winter occurred only in 3 seasons: on 19 March in the lower Parsęta in the season of 1914, on 18 March in the Osówka in the season of 1989, and on 5 March also in the Osówka in 1988. Obviously the beginning of the smolt migration in the remaining 16 seasons surveyed, occurred in spring. In this number on 24 March in the Gowienica in the season of 1981, on 27 March also in the Gowienica in the season of 1982. In 13 further seasons it occurred in April, and only in one case in May in the Rega River, in the season of 1965. The end of the trout smolt migration in the Pomeranian rivers, occurred in 10 seasons in May and in 9 seasons in June.

In the analyzed eight seasons of the downstream trout smolt migration in the Mołstowa, Gowienica, and the Osówka rivers, there were pauses in the migration. Similarly, one- or several-day-long pauses in the smolt migration occurred in the upper Parsęta in three successive seasons of the downstream migration: 1984–1986 (Dębowski et al. 1992).

Interesting conclusions may result from comparing the high intensity periods and the peaks in the migration intensity in three Pomeranian rivers: the Gowienica, 1984 season, the Osówka, 1985 season, with the similar data on smolts of the trout from the upper Parsęta of the same seasons after Dąbrowski et al. (1992). It comes out that the beginning of the smolt migration in the season of 1984 occurred almost at the same time in the Gowienica (9 April)

and in the Parsęta (11 April). The end of the migrations occurred in the Parsęta on 13 May and in the Gowienica much later—on 18 June. In the Gowienica, in the season of 1984, there were two high intensity periods of the trout smolt migration. The first was within 18–26 April and the second within 28 April–8 May. Similarly in the Parsęta in the same season there were two high intensity periods within quite similar dates. The first was within 20–29 April and the second within 30 April–7 May. Also the peaks of the downstream migration intensity in the Gowienica and the Parsęta in the same season fell in the similar dates. In the Gowienica, the first peak of the trout smolt migrations occurred within 19–23 April, while the second—within 3–5 May. In the Parsęta, however, the first peak of the downstream migration of the trout smolts occurred within 25–27 April, the second—within 3–4 May.

In the season of 1985 the smolts of trout commenced their migration in the Osówka on 6 April, while in the Parsęta they did that on 4 April which was two days earlier. End of the migrations in the Parsęta occurred on 18 May, while in the Osówka much later—on 11 June. There were three high intensity periods in the Osówka within: 21–23 April, 3–5 and 9–19 May, while in the Parsęta there was one within 7–15 May. There were three peaks in the intensity of the seaward migrations in the Osówka: 21 April, 4 May, and 11–12 May. In the Parsęta, however, there were two peaks on 8 May and 13 May. The greatest abundance of the smolts of trout migrating downstream occurred in the second high intensity period in the Osówka and in the first one in the Parsęta. The high intensity periods of these migrations occurred in similar dates: 4 and 8 May.

In the rivers of the south-west Norway the smolts of the brown trout migrate downstream, according to Bohlin et al. (1993), mostly within the period of 26 April–17 May, which is the time of the high intensity downstream migration of the trout smolts in the Pomeranian rivers.

Migration seasons of the trout smolts in the coastal rivers of Normandy (France) are substantially longer, covering periods from end of February till June or even September (Euzend et al. 1991).

In the English river Piddl (Dorset) smolts of the trout migrate to the sea in spring as well, in similar few-day-long high intensity periods, surmounted with peaks and separated by pauses (Solomon 1978).

Atlantic salmon smolts grown in the Swedish river Ricklean, emptying to the north Baltic Sea (Gulf of Bothnia), migrate to the sea within the period of 1 June–18 July (Österdahl 1964, 1969), which is much later compared to the migrations of the trout smolts in the Pomeranian rivers.

Atlantic salmon smolts grown in the Orkla River in the central Norway, emptying to the Atlantic, according to Hvidsten et al. (1955), migrated to the sea within 22 April–5 June,

what matches the high intensity periods of the brown trout smolts migration in the presently analyzed rivers.

The widest range of the water temperature during the trout smolts migrations in the presently analyzed rivers was within 1.5–19.0°C. In the upper Parsęta (after Dębowski et al. 1992) they were within 2.0–15.0°C. The ranges of the temperature fluctuation during the trout smolts migrations were similar in the upper Parsęta and in the presently analyzed rivers.

Riverine water temperatures, rising above 10°C, and occurring in spring according to McClaove (after Grau 1981), stimulate migrations of the Atlantic salmon smolts. Such conclusion, as evident from the present studies, concerns also the migrations of the trout smolts in the Pomeranian rivers.

As it is evident from the present results and from the results of Dębowski et al. (1992), temperature rise—increases, while temperature drop—decreases or completely halts migration of the trout smolts.

According to Larsson et al. (1979) the most suitable temperatures for stocking Swedish rivers, emptying to the Baltic Sea with raised in confinement, tagged Atlantic salmon smolts were within the range of 7–14°C. The major migrations of the brown trout smolts in the Pomeranian rivers occur in such temperatures.

Grau (1981) believes that the lunar cycle can be the important indicator of the migration commencement. The above-mentioned author, however, failed to specify which particular moon phase he meant. It is impossible too draw such conclusion from the presently analyzed data, because the trout smolts migrations in the Mołstowa, Gowienica and the Osówka begin, last, and terminate within all four moon phases. Similarly, Hvidsten et al. (1995) did not show any impact of the moon phases on the migration of the Atlantic salmon smolts.

## CONCLUSIONS

The migrations of the trout smolts grown in the Mołstowa, Gowienica and the Osówka lasted, in general terms, up to 106 days between 5 March and 18 June. Practically, this range should be narrowed down to 66 days within 24 March–18 June with the majority of the smolts migrating within 52 days, between 15 April and 5 June.

The main period of the migration, occurring within 15 April and 5 June, yielded 96.15% of the acquired trout smolts. The initial period of the migrations, within 24 March–14 April and the closing period within 6–18 June gave a combined yield of 3.81%. Calendar winter fraction (5–23 March) of the migrating season yielded 0.04% of the smolts.

The spring migrations of the trout smolts started in the average riverine water temperature of 7.4°C and ended in the temperature of 15.4°C. The widest range of the water temperatures during the spring migrations of the smolts was 4.4–19.0°C, while the average temperature during the smolt migration was 11.0°C.



There had been pauses in the course of the trout smolt migrations, as well as two, rarely three or one high intensity periods, occurring at all four moon phases. The most frequently however, the smolts migrated during new moon, then at first and last quarter, while rarely within fool moon.

## REFERENCES

- Anonymous**, 1949: Szczegółowy podział dorzecza Odry i rzek Przymorza [Detailed classification of the drainage basin of the Odra River and of the rivers of the maritime coastal area]. Pr. IMGW Warszawa: 90–92. (In Polish)
- Anonymous**, 1979–1985, 1988: Rocznik Astronomiczny na rok 1979–1985, 1988 (Astronomical Annals for the year of 1979–1985, 1988). Geod. i Kartogr. Warszawa 34–40 and 43. (In Polish)
- Bohlin T., C. Dellefors, U. Faremo**, 1993: Timing of sea-run brown trout (*Salmo trutta*) smolt migration. Effects of climatic variabion. Can. J. Fish. Aquat. Sci., **50**, 6: 1132–1136.
- Chelkowski Z.**, 1978: Studies on trout (*Salmo trutta* L.) wild smolts of the river Rega. Acta Ichth. Piscat., **8**, 2: 41–58.
- Chelkowski Z.**, 1990: Period of downstream migration of sea trout (*Salmo trutta* L.) smolts grown in Osówka stream and their characteristics. Acta Ichth. Piscat., **20**, 2: 37–51.
- Chelkowski Z.**, 1993: Splywanie smoltów troci wędrownej (*Salmo trutta* m. *trutta* L.) wyrosłych z narybku w potoku Osówka [Descent of migratory sea trout (*Salmo trutta* m. *trutta* L.) smolts grown from fry in stream Osówka]. Zesz. Nauk. AR Szczecin, Ryb. Mor., **20**, 156: 19–28. (In Polish, English summary)
- Chelkowski Z., B. Chelkowska**, 1981: Descent of trout (*Salmo trutta* L.) smolts grown in river Mołstowa catchment area. Acta Ichth. Piscat., **11**, 2: 57–65.
- Chelkowski Z., B. Chelkowska, M. Ciupiński**, 1994: Period of downstream migration of sea trout (*Salmo trutta* L.) smolt grown in Gowienica river. Acta Ichth. Piscat., **24**, 1: 145–152
- Dębowski P., K. Goryczko, W. Wiśniewolski**, 1992: Przeżywalność i wzrost troci (*Salmo trutta* L.) wpuszczonej jako wylęg do górnej Parsęty [Survival and growth of sea trout (*Salmo trutta* L.) released as hatched fish into the upper Parsęta river]. Roczn. Nauk. PZW, Warszawa, **5**: 125–136. (In Polish, English summary)
- Eichelbaum E.**, 1916: Reifegrad und Nahrung der zur Untersuchung eingesandten Lachse und Meerforellen. In: H. Henking, Die Lachsfrage im Ostseegebiet. II Copenhagen. Rapp. Cons. Explor. Mer., 84–91.
- Euzend G., F. Fournel, A. Richard**, 1991: The sea trout, *Salmo trutta* L. in Normandy–Picardy. In: The trout, biology and ecology [Bagliniere, I. L. Maisse, G., (ed.)]. Paris–France INRA: 183–213.
- Grau E. G.**, 1981: Is the lunar cycle a factor timing the onset of salmon migration? Salmon and Trout Migratory Behavior Symposium [E. L. Brannon and E. O. Salo (ed.)]: 184–189. Berkeley California.
- Hvidsten N. A., A. J. Jensen, H. Vivas, Ø. Bakke, T. G. Heggberget**, 1955: Downstream migration of Atlantic Salmon smolts in relation to water flow, water temperature, moon phase and social interaction. Nordic J. Freshw. Res., **70**: 38–48.
- Krzykowski S., T. Heese, C. Przybyszewski**, 1984: Systematyka ryb [Systematics of fishes]. AR Szczecin: 77–78. (In Polish)
- Larsson P. O., C. Eriksson**, 1979: Resultat av märkningsförsök med odlade laxungar, *Salmo salar* L., i relation till vattentemperaturen vid utsättningen [The impact of water temperature at release on the subsequent return rates of hatchery reared Atlantic salmon smolts (*Salmo salar* L.)]. Laxforskningsinstitutet Meddelande, Salmon Research Institute Report, 3. (In Swedish, English summary)

- Österdahl L., 1964: Smolt investigations in the River Riclean. ICES. Salmon and trout committee no. 47.
- Österdahl L., 1969: The smolt run of a small Swedish river. In: Salmon and Trout in streams. [T. G. Northcote, (ed.)]: p. 205–215. H. R. MacMillan lectures in fisheries. Univ. of British Columbia. Vancouver.
- Solomon D. J., 1978: Migration of smolts of Atlantic salmon (*Salmo salar* L.) and sea trout (*Salmo trutta* L.) in a chalkstream. Env. Biol. Fish., 3, 2: 223–229.

Zygmunt CHEŁKOWSKI

PRZEBIEG WĘDRÓWEK SMOLTÓW TROCI WĘDROWNEJ (*SALMO TRUTTA*  
*M. TRUTTA* L.) WYROSŁYCH W RZEKACH POMORZA

STRESZCZENIE

W opracowaniu analizowano przebieg dobowych wędrówek smoltów troci (*Salmo trutta* m. *trutta* L. 1758), wyrosłych w warunkach naturalnych w Mołstowej w sezonie 1979 r., w Gowienicy w 5 sezonach w latach 1980–1984 oraz w Osówce w dwóch sezonach 1985 i 1988 r., na tle temperatury wód rzek i faz księżyca. Badania oparto na 5593 smoltach. Wędrówki smoltów troci w wymienionych rzekach trwały w najszerszym ujęciu 106 dni między 5 marca a 18 czerwca, wiosną 66 dni między 24 marca a 18 czerwca i głównie 52 dni między 15 kwietnia a 5 czerwca. W głównym okresie wędrówek, przypadającym między 15 kwietnia a 5 czerwca, wystąpiło 96,15%, w okresie poprzedzającym i kończącym główne wędrówki, między 24 marca a 14 kwietnia oraz 6 a 18 czerwca wystąpiło 3,81% oraz w okresie zimy, między 5 a 23 marca, wystąpiło 0,04% pozyskanych smoltów. Wiosenne wędrówki smoltów rozpoczynały się przy średniej temperaturze wód rzeki 7,4°C i kończyły się przy średniej temperaturze wody 15,4°C. Ekstremalne temperatury wód w okresie wiosennych wędrówek smoltów wahały się w przedziale 4,4 – 19,0°C, a średnia temperatura wód rzek w okresie wędrówek smoltów wynosiła 11,0°C. Wędrówki smoltów troci odbywały się z przerwami, z dwoma, rzadziej z trzema nasileniami lub jednym nasileniem, we wszystkich czterech fazach księżyca. Najliczniej jednak smolty wędrowały podczas nowiu, następnie pierwszej i ostatniej kwadrze, a rzadziej podczas pełni księżyca.

Received: 15 December 1995

Author's address:

Zygmunt Chelkowski PhD DSc Prof Tit  
Division of Salmonid Fishes Management  
Agricultural University of Szczecin  
ul. Kazimierza Królewicza 4, 71–550 Szczecin, Poland