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Fish biology

ON SOME PROBLEMS IN BIOLOGY OF MINNOW, *PHOXINUS PHOXINUS (L.) (CYPRINIDAE)* IN THE RIVER SKAWA

NIEKTÓRE ZAGADNIENIA Z BIOLOGII STRZEBLI POTOKOWEJ *PHOXINUS PHOXINUS (L.) (CYPRINIDAE)* Z RZEKI SKAWY

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A preliminary biological characteristics of *Phoxinus phoxinus* (L.) in the river Skawa is given. Age of the individuals examined was determined from opercular bones; the age was found to range from 1+ to 6+ yr. Growth rate was back calculated. Filamentous algae and insect larvae turned out to be the main food items of the species within the period of study.

Introduction

The minnow, *Phoxinus phoxinus* (L.) is a fish species widely distributed in waters of the moderate European and Asian climatic zones. The species inhabits piedmontane and lowland rivers of a fast current and clean water. The species has been recorded from all larger rivers of Poland (Rembiszewski and Rolik , 1975), the trout country up to stream springs being, however, its main centre of distribution.

In small swift rivers and streams *Ph. phoxinus* occurs at times very abundantly, thus significantly influencing populations of co-occurring species. These effects are manifest in two different ways. On the one hand, the species can be a food source for predatory fish

(Zacharčenko, 1973; Soin et al., 1981), and on the other, on account of its abundance in salmonid spawning grounds, it can seriously limit reproduction of those fish. Volkova and Kožov (1966), and also Bazikalova and Vilisova (1959), Tygarina et al. (1965), and Helland (1973–1974)(after Soin et al., 1981) found the mature minnow stomachs to contain eggs and larvae of *Thymallus thymallus, Coregonus autumnalis migratorius,* and *Salmo trutta.*

The interest in the species discussed has been kindled also by a possibility of rearing it and making valuable observations on fish behaviour.

Tack (1941) and Frost (1943) described in detail the biology and ecology of *Ph. phoxinus.* Relevant information concerning Polish waters is scant (Starmach, 1963), dealing mostly with the minnow morphology (Kulamowicz and Jażdżewski, 1970; Kulamowicz and Korkuć, 1971, Heese, 1981).

The work presented addresses some problems (age, growth rate, food, and reproduction) of the minnow biology.

MATERIALS AND METHODS

Materials for the study were collected within 6–15 July 1979, during a field trip undertaken by the Students' Ichthyological Society sponsored by the Institute of Ichthyology, Academy of Agriculture, Szczecin. Samples were taken at three sites

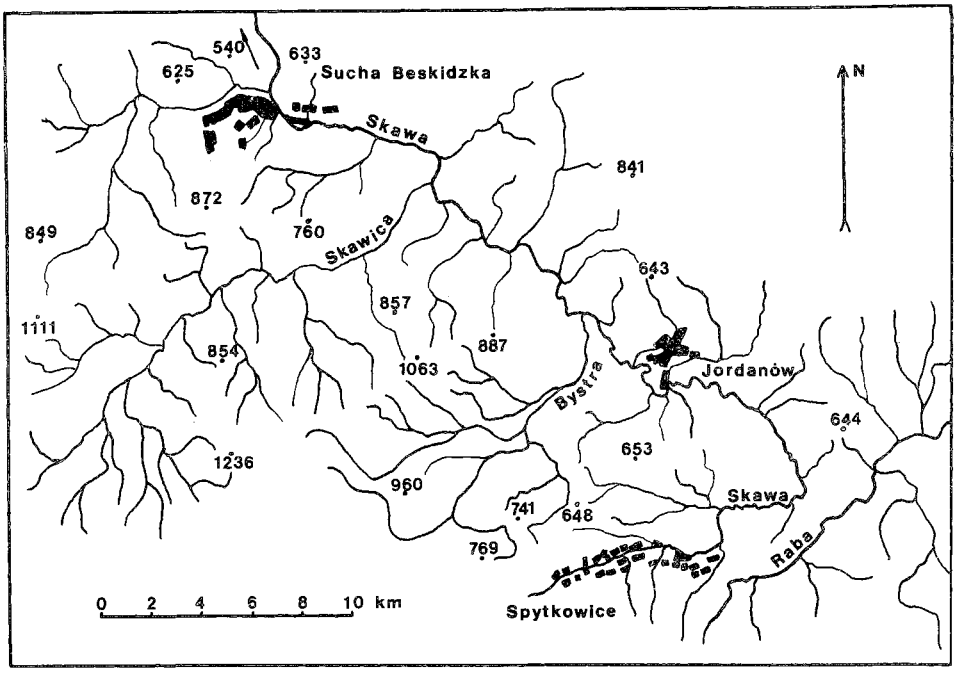

Fig. 1. The river Skawa catchment area

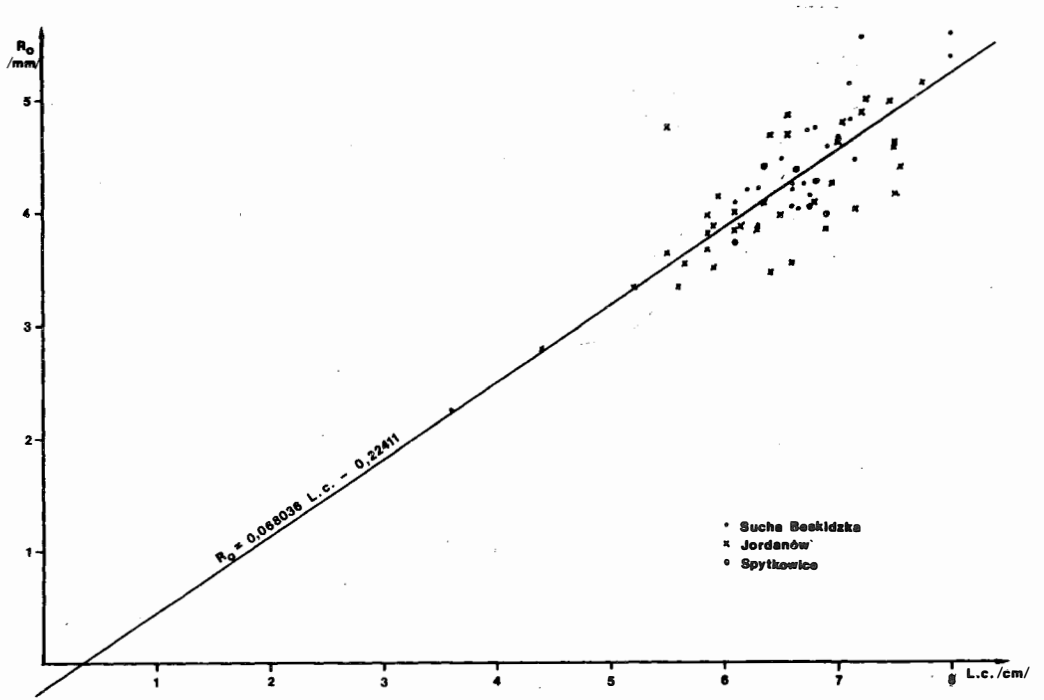

Fig. 2. Body length (l.c.) – operculum radius (R_o) relationship in the River Skawa minnow (*Phoxinus phoxinus*)

(Spytkowice, Jordanów, and Sucha Beskidzka) along the river Skawa (Fig. 1). Out of a total of 69 individuals caught, 62 were subject to detailed examination. The materials were formalin-preserved immediately after capture. The collections were made with dip nets (5 mm mesh size, 2.5 x 1.5 m rectangular frame).

Following Berg (1949), the individuals caught were identified as the nominative subspecies *Ph.phoxinus phoxinus* (L.) (Heese, 1981).

The total (l.t.) and body (l.c.) lengths were measured to 0.5 mm with a calliper. Whole and gutted fishes were weighed to 0.01 g on a laboratory scales. Female gonads were weighed (with the same accuracy) to determine the gonad maturity coefficient, i.e., gonad weight as per cent of total female weight.

The fish age was determined from opercular bones. The age was back-read from bones under a Zeiss measuring microscope. Owing to the linear relationship between the body length and operculum radius (R_0) (Fig. 2), the growth rate was calculated with the Dahl-Lea method with the Rosa Lee correction. The total body weight (W) – body length (l.c.) relationship was calculated with the least squares method. Food composition was determined by calculating numerical and weight contribution, frequency, partial coefficient of filling, and relative importance index of each item. Guts of 56 individuals (31 caught at Jordanów and 25 at Sucha Beskidzka) were examined.

RESULTS

Age and growth rate

The age of the fish examined, as determined from the operculum, was found to range from 1+ to 6+ yr, the body length (l.c.) and total length (l.t.) ranging within 36–80 mm and 41.0–93.5 mm, respectively. The Skawa minnow growth rate analysis is presented in Table 1.

The results show female and male growth rates to differ considerably (Fig. 3), the difference amounting to 2–3 mm. The growth rate difference, evident from the first year of life, was maintained throughout the whole period of study.

No significant between-sites differences in growth rate were found (Table 1). A faster growth rate found at Sucha beskidzka can be associated with a higher proportion of females in that sample, the females growing generally faster than males.

The fastest growth, both in males and females, occurred during the first three years of life.

Weight growth rate

The weight (W) – body length (l.c.) relationship (Fig. 4) is described by the formula

$$W = 0.0158052\ l.c.^{3.0862}$$

Table 1

The river Skawa minnow (*Phoxinus phoxinus*) growth rate

Age group	Increments in consecutive years of life (*longitudo corporis*, cm)						No. of individuals
	1	2	3	4	5	6	
I	3.2						1
II	2.1	3.9					1
III	2.8	4.2	5.3				11
IV	2.8	3.9	5.1	5.9			24
V	2.9	4.0	5.2	6.1	6.7		17
VI	2.7	3.9	5.0	5.8	6.5	7.0	8
mean	2.8	4.0	5.2	5.9	6.6	7.0	62
mean annual increment	2.8	1.2	1.2	0.7	0.7	0.4	62
mean ♀♀	2.9	4.1	5.3	6.0	6.7	7.0	40
mean ♂♂	2.6	3.9	5.0	5.8	6.4	6.8	21
mean at Spytkowice	2.8	4.3	5.5	6.1			6
mean at Jordanów	2.8	4.0	5.1	5.9	6.5	7.0	31
mean at Sucha Beskidzka	2.8	4.1	5.3	6.1	6.8	7.0	25
mean weight increment (g)	0.4	1.1	2.6	3.8	5.3	6.4	62

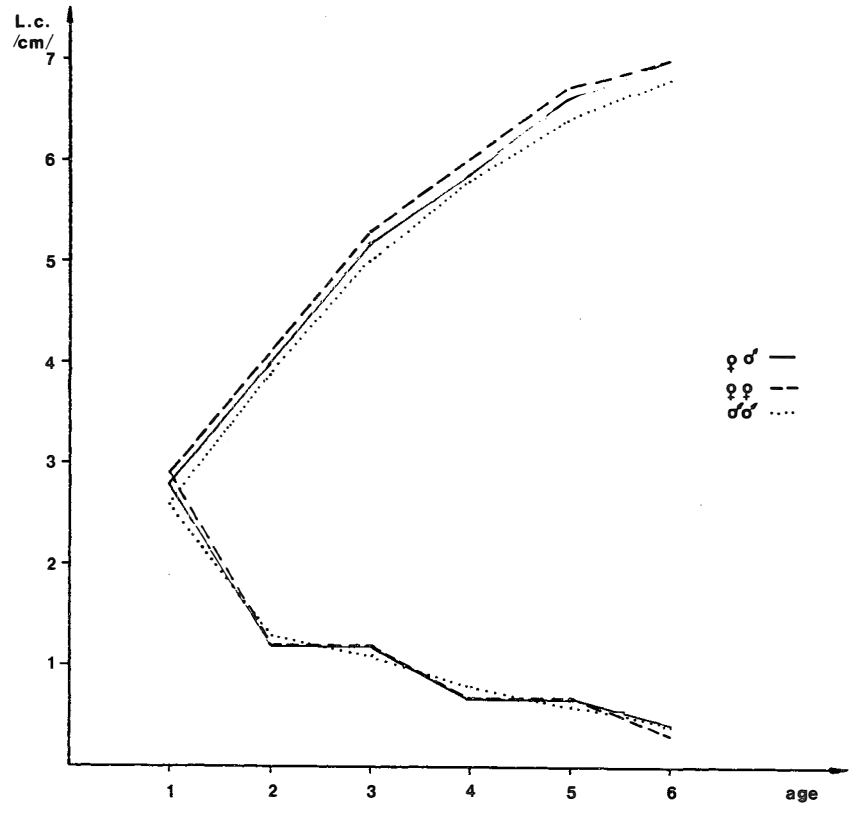

Fig. 3. The Skawa *Ph. phoxinus* growth rate and mean annual increments

Based on the formula, the weight growth rate of the Skawa *Ph.phoxinus* was calculated (Fig. 5). Owing to the lack of discernible between-sexes differences in the weight growth (Fig. 4), the rate was analysed for the pooled samples. Over the first two years, the weight increased rather slowly, the increments becoming larger and similar in all age groups from the second year onwards.

Food composition

The food of the fishes studied was found to consist of 7 items: filamentous algae; *Ephemeroptera; Trichoptera; Coleoptera*; chironomid larvae; oligochaetes; and adult terrestrial insects. The food composition (Table 2) was analysed at 2 sites: Jordanów and Sucha Beskidzka. The food in both samples was dominated by two items (Fig. 6): filamentous algae and larval mayflies (*Ephemeroptera*). The importance of those items is additionally confirmed by their high frequencies and partial coefficients of filling.

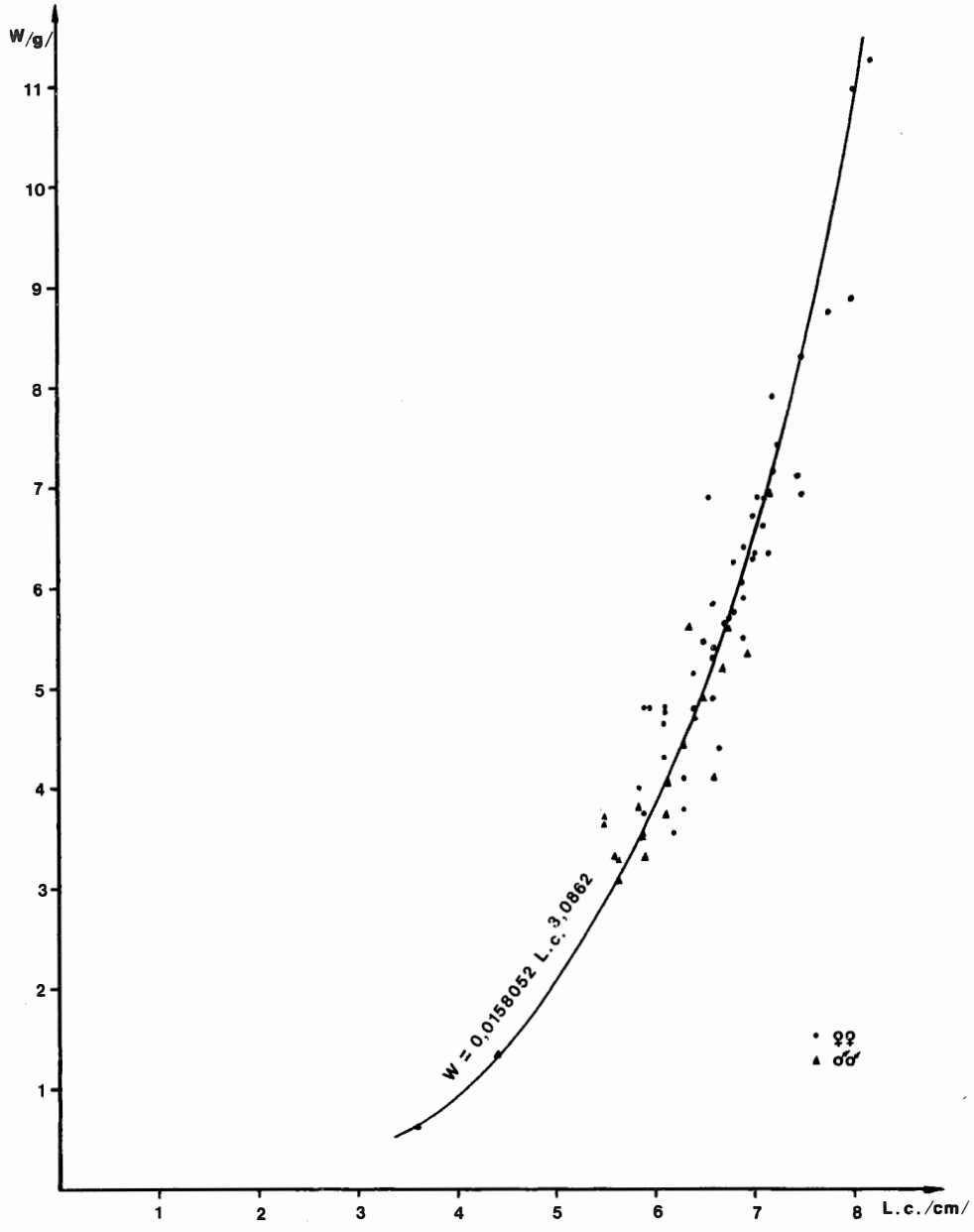

Fig. 4. Body length (L.c.) – total weight (W) relationship in the river Skawa minnow

Additionally, the Sucha Beskidzka sample shows the larval *Trichoptera* to be an important diet component. On the other hand, the Jordanów fishes showed a higher proportion of chironomid larvae and adult terrestrial insects in their food.

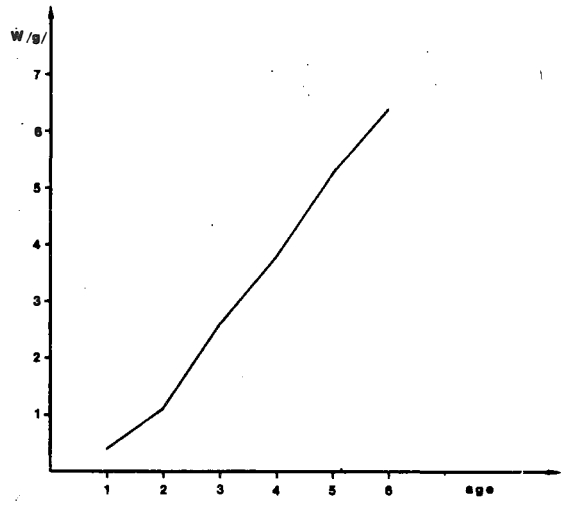

Fig. 5. Weight growth rate in the river Skawa *Ph. phoxinus*

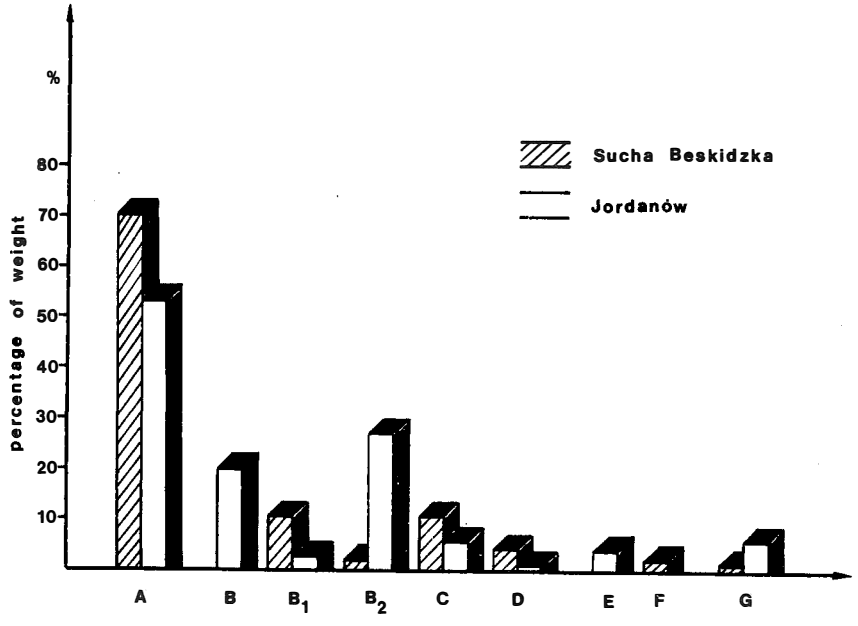

Fig. 6. Weight contributions of food items to the river Skawa minnow diet (for explanation of symbols A to G, see Table 2).

Table 2

The minnow food composition at Sucha Beskidzka and Jordanów

Site	Sucha Beskidzka								
Food item	A	B		C	D	E	F	G	Total
		B_1	B_2						
Percentage of abundance	–	27.9	27.9	7.0	11.6	11.6	4.7	9.3	100 %
Frequency	90	35	10	5	5	15	10	15	185 %
Percentage of weight	70	10.6	1.9	10.2	4.3	0.02	1.9	1.08	100 %
Partial coefficient of filling ($^0/_{000}$)	26.7	4.0	0.7	3.9	1.7	0.008	0.7	0.4	38.11$^0/_{000}$
Relative importance index	–	1347.5	298	86	79.5	174.3	66	156	–
Site	Jordanów								
Food item	A	B	B_1	B_2	C	D	E	G	Total
Percentage of abundance	–	2.6	0.6	15	6.2	0.6	71	4.0	100%
Frequency	52	20	4	24	36	8	36	36	216%
Percentage of weight	53	2.5	1.2	27	5.7	1	3.8	5.8	100%
Partial coefficient of filling ($^0/_{000}$)	8.2	0.4	0.2	4.2	0.9	0.1	0.6	0.8	15.4$^0/_{000}$
Relative importance index	–	102	7.2	1008	428.4	12.8	2692.8	352.8	–

A = filamentous algae
B = *Ephemeroptera*
B_1 = *Oligoneuriella rhenana*
B_2 = *Caenis macrura*
C = *Trichoptera*
D = *Coleoptera*
E = *Chironomidae*
F = *Oligochaeta*
G = unidentified

Moreover, the sum of total coefficients of filling was much higher in the Sucha Beskidzka sample (38.11‰) than in the Jordanów one (15.4‰).

The Spytkowice fishes were found to contain larval *Ephemeroptera* and *Coleoptera* in their stomachs.

Sexual dimorphism and gonad maturity coefficient

The basic sex-differentiating external traits in *Ph.phoxinus* are the pectoral and ventral fins, larger and stouter in males. These traits almost always allow to determine sex in the minnow older than 3 years, before the fish is dissected. Additionally, the spawning fish show nuptial (pearly) tubercles on their foreheads, the trait again being stronger in males. Singular pearly tubercles may appear also on the sides of the body.

The spawning coloration is different in both sexes as well, the males bearing more intensive colours: the dorsal side is occasionally almost black, and the pectoral and ventral fins, particularly in their basal part, are bright red. The males show a red coloration on the throat and on the ventral side, while spawning females show sometimes a red coloration on the basal part of the pectoral, ventral and anal fins.

The females examined showed considerable differences in their appearance, which prompted the author to try to correlate various external features shown by the individuals studied with their gonad maturity stage (Table 3). As seen from the description, external characteristics and the presence of intestinal fat are closely related to the gonad maturity stage. A large part of the Jordanów (upstream) individuals were classified in the second and third groups, the first group predominating in the Sucha Beskidzka sample (Fig. 7).

Most Sucha Beskidzka females showed their gonads to be partly spent, i.e., with no mature eggs. The egg diameter distribution (Fig. 8) in a partly spent gonad of a Sucha Beskidzka female is bimodal, trimodal distributions being obtained for the Jordanów and Spytkowice samples. Moreover, on the Jordanów female graph, the eggs to be laid (1.3–1.7 mm diameter) are clearly marked.

DISCUSSION

It is a general practice to determine the age of cyprinids from scales. However, it is very difficult to interpret the Skawa minnow annual rings (Plates 1 and 2) and the outcome of such an analysis is dubious. By comparison, opercular bones provided a better clue to age back readings and were regarded as fulfilling the requirements of the technique (Plates 3 and 4). Additionally, the readings were checked against otoliths (*sagitta* and *asterias*) and vertebrae obtained from 6 individuals of different age and alizarin-stained. Both otoliths and vertebrae were less legible, particularly in older fish (more than 4 years of age) than the operculum, although the age back reading from the latter was thus confirmed.

Table 3

The minnow gonad maturity index as related to female external appearance and presence of intestinal fat

Gonad maturity index (%)		Symptoms	Percentage of females	
Range	Mean		Sucha Beskidzka	Jordanów
2.7 – 13.5	5.5	1. no pearly tubercles (or poorly visible as white spots on head) 2. large amount of fat on intestine 3. normal body coloration	66.7	33.3
11.5 – 16.7	14.2	1. few pearly tubercles on forehead 2. englarged dark spots along sides of body 3. tubercles shaped as sharp cones 4. no intestinal fat	22.2	38.9
14.2 – 25.5	18.2	1. numerous pearly tubercles 2. few tubercles may occur on sides of body 3. frequently dark coloration of body 4. widened anus 5. pectoral, ventral, and anal fins slightly reddened at their bases 6. no intestinal fat	11.1	27.8

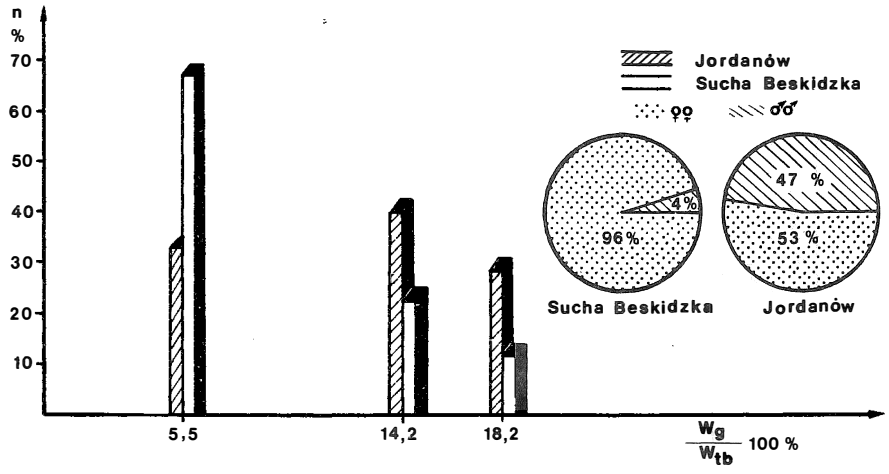

Fig. 7. Percentages of females at Jordanów and Sucha Beskidzka as related to gonad maturity index and sex ratios (circle diagrams) at these sites (Wg = gonad weight; W_{tb} = total body weight)

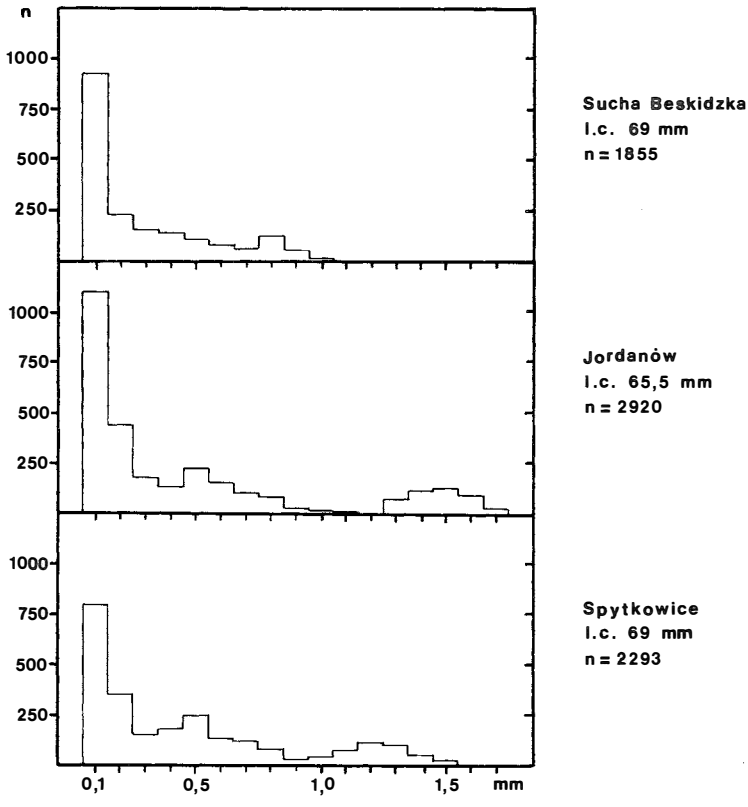

Fig. 8. Egg diameter distributions in gonads of females caught at Spytkowice, Jordanów, and Sucha Beskidzka

Plate 1. A minnow (*Phoxinus phoxinus*) scale (x 110). Age 4+; l.t. 74.5 mm; l.c. 65.5. mm

Plate 2. A minnow scale (x 110) Age 6+; l.t. 90 mm; l.c. 77.5 mm

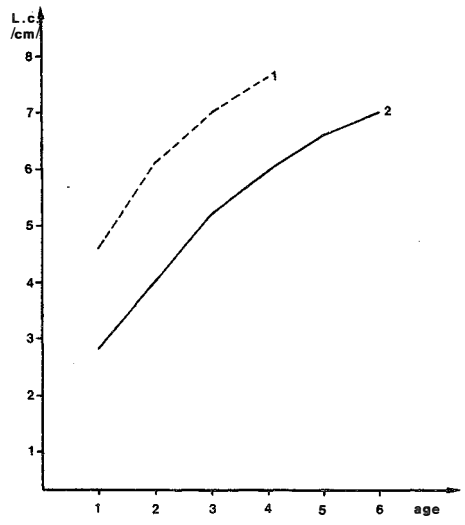

Fig. 9. *Ph. phoxinus* growth rates in the Mszanka (1) (Starmach, 1963) and Skawa (2)

Quite considerable differences are seen when the Skawa minnow growth rate is compared to that obtained for the species in the stream of Mszanka, a tributary of the river Raba (Starmach, 1963) (Fig. 9). This difference may have resulted, i.a., from differing age readings and methods used, the Mszanka individuals age being determined from scales and the growth rate – from direct measuremtnts. The growht rate comparisons with data from other areas of the *Ph. phoxinus* range are very difficult as the techniques used by various workers differ, the growth rate in other studies being based either on the total (l.t.) or on furcal (caudal, l.caud.) lengths and direct measurements.

Sex-dependent growth differentiation (Fig. 3) was described by Frost (1943) and Starmach (1963), their results being similar to those in the present project. On the other hand, in the West German streams (Tack, 1941) the fish of both sexes grew similarly during the first two years of life, differences in growth being more pronounced in older fish.

The main food components of minnows under study were algae, followed by larval mayflies and *Trichoptera*. Similar results are reported by Levanidov (1959) who added detritus to the diet composition. Lower weight contribution and frequency of filamentous algae in the Jordanów sample is probably related to the river fertility decreasing upstream. On the other hand, the Jordanów sample showed a larger contribution of chironomid larvae and terrestrial insects. Particularly the latter seem to be related to the abundant riparian vegetation occurring on the river banks upstream. The insects that inhabit trees and shrubs growing on the river banks more frequently fall into the water than is the case at sites with banks lacking this type of vegetation, e.g., Sucha Beskidzka.

Plate 3. A minnow operculum (x 16). Age 4+; l.t. 74.5 mm; l.c. 65.5 mm

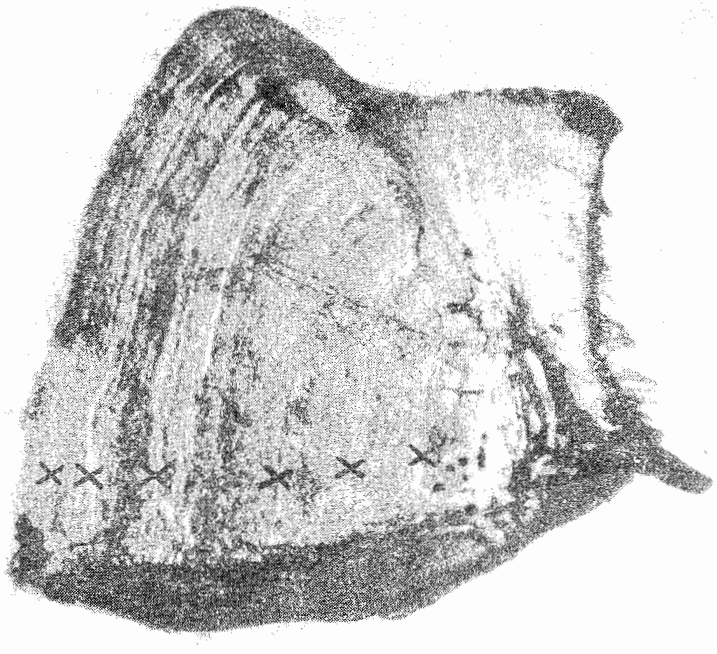

Plate 4. A minnow operculum (x 16). Age 6+; l.t. 90 mm; l.c. 77.5 mm

The minnow spawns, according to various authors, from May through July (Gąsowska, 1962; Wootton and Mills, 1979; Soin et al., 1981). During the spawning period, eggs are laid in 3 portions (Wootton and Mills, 1979; Soin et al., 1981). In Rumania, Papadopol and Weinberger (1975) reported 4 to 5 portions of eggs being laid by the minnow at about 15-day intervales.

Most probably, the minnow in the river Skawa started spawning in late June or in early July, the spawning being commenced earlier downstream. This presumption is indirectly confirmed by the trimodal egg diameter distribution in gonads of females caught at Spytkowice and Jordanów (Fig. 8). On the other hand, most Sucha Beskidzka females had already laid a portion of eggs, while the Jordanów minnows were either laying their first portion or preparing to do it. The shift of spawning period upstream is presumably related to a lower temperature there.

Soin et al. (1981) report few pearly tubercles, if any, in minnow females, while other authors (e.g., Žukov, 1965) recorded that feature in both males and females. In the river Skawa, the intensity of pearly tubercles occurrence was related to the gonad maturity stage (Table 3). As opposed to males, the pearly tubercles in females appear before a portion of eggs is laid and disappear in part thereafter. It is perhaps a specific adaptation to the portional spawning, when the appearance of abundant pearly tubercles is a signal for males to begin mating.

The sex ratio at Jordanów and Sucha Beskidzka (Fig. 7) allows to suppose that males and females feed separately after a portion of eggs has been laid. The much higher sum of partial coefficients of filling at Sucha Beskidzka than that at Jordanów (Table 2) and a large amount of intestinal fat in the individuals of the lowest gonad maturity index (Table 3) indicate the minnow to feed intensively in between egg laying.

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NIEKTÓRE ZAGADNIENIA Z BIOLOGII STRZEBLI POTOKOWEJ *PHOXINUS PHOXINUS* (L.) *(CYPRINIDAE)* Z RZEKI SKAWY

STRESZCZENIE

Materiał do badań zebrano w rzece Skawie w lipcu 1979 roku. Połowy prowadzono przy pomocy brodnika i podrywki na trzech stanowiskach wzdłuż rzeki, w Spytkowicach (okolice źródeł), Jordanowie i w Suchej Beskidzkiej. (Ryc. 1).

Wiek u badanych ryb, określony na podstawie kości pokrywowej (*operculum*) wieczka skrzelowego, wahał się od 1+ do 6+. Najszybsza szybkość wzrostu (Ryc. 3) przypada na pierwsze trzy lata życia. Samice osiągają większe rozmiary od samców, a różnica w szybkości wzrostu jaka pojawia się już w 1 roku życia utrzymuje się na prawie stałym poziomie przez cały analizowany okres. Wyraźnych różnic w szybkości wzrostu na poszczególnych stanowiskach (Tabela 1) nie stwierdzono. Przyrosty masy zarówno u samic i samców są podobne.

Głównym składnikiem pokarmu badanej strzebli są glony nitkowate, następnie larwy jętek (*Ephemeroptera*) i chruścików (*Trichoptera*) (Tabela 2).

Tarło strzebli potokowej jest porcyjne, przypuszalnie ikra jest składana w trzech porcjach (Ryc. 8). Termin rozpoczęcia tarła w dolnych odcinkach rzeki jest wcześniejszy niż w górnych.

Геесе Т.

НЕКОТОРЫЕ ВОПРОСЫ В ОБЛАСТИ БИОЛОГИИ ОБЫКНОВЕННОГО ГОЛЬЯНА PHOXINUS PHOXINUS (L.)(CYPRINIDAE) ИЗ РЕКИ СКАВА

Р е з ю м е

Материал для исследований был избран из реки Скава в июле 1979 г. Рыболовлю осуществляли с помощью бредней и намёток. Вдоль реки были установлены три станка для рыболовли, а именно; Спытковице (вблизи источников), Ёрданово и Суха Бескидска (рис.1).

Возраст рыбы, составлявший с 1+ до 6+, определяли на основании покровной кости (operculum) жаберной крышечки. В течение первого трёхгодичного периода наблюдалась самая большая скорость роста (рис.3). У самок установлено большие размеры, чем у самцов. Различия в скорости роста, установленные уже в первом году жизни, удерживались на почти постоянном уровне за весь период исследований. Не установлено отчётливых различий в скорости роста между отдельными пунктами рыболовли (таб.1). Весовые приросты у самок и самцов почти не различались.

У исследованного гольяна корм составляли: нитевидные водоросли, затем личинки подёнок (Ephemeroptera) и пыхокрылых (Trichoptera) (таб.2).

Икрометание у обыкновенного гольяна дозированное, по всей вероятности имеются три порции икрометания (рис.8). По нижним участкам реки икрометание наблюдается раньше, чем по верхнем течении реки.

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