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ECOLOGY OF YOUNG (0^+) HUCHEN, *Hucho hucho* (L.) (*Salmonidae*), PLANTED IN TWO MOUNTAIN STREAMS

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A B S T R A C T. Dispersion of underyearlings in mountain streams depends on their size - the smallest individuals occupy the shallowest microhabitats, moving into deeper parts with increasing size. Gradual migration of young huchen to lower sections of streams, in spite of food abundance, depends probably on some abiotic (mainly water temperature) and biotic factors i.e. initial fish density, the resulting territorial behaviour and other social interactions.

Key words: SALMONIDS, HUCHEN, STOCKING, HABITAT, MOVEMENT, FOOD, GROWTH

1. INTRODUCTION

In order to obtain the huchen stocking material, besides farming in stocking centres, also natural biogeneity of streams is used for fingerling keeping in Poland. As demonstrated in earlier studies (Witkowski et al. 1994), young huchen in the first year of their life do not compete for food with autochthonous species. The fingerlings obtained there are caught or migrate down to the main river. This is a way of keeping material that is not affected by culture process in fish farms.

The aim of this study was to trace the ecology of the underyearlings of huchen, planted in mountain streams: its habitat requirements, distribution patterns, movements in time and space depending on the season and size attained, growth rate, and feeding dynamics and seasonality.

2. STUDY AREA AND METHODS

The experiment was carried out in two small mountain streams: Zimne (tributary to the Poprad River) and Jaworzynka (Dunajec River tributary) (S Poland). The stre-

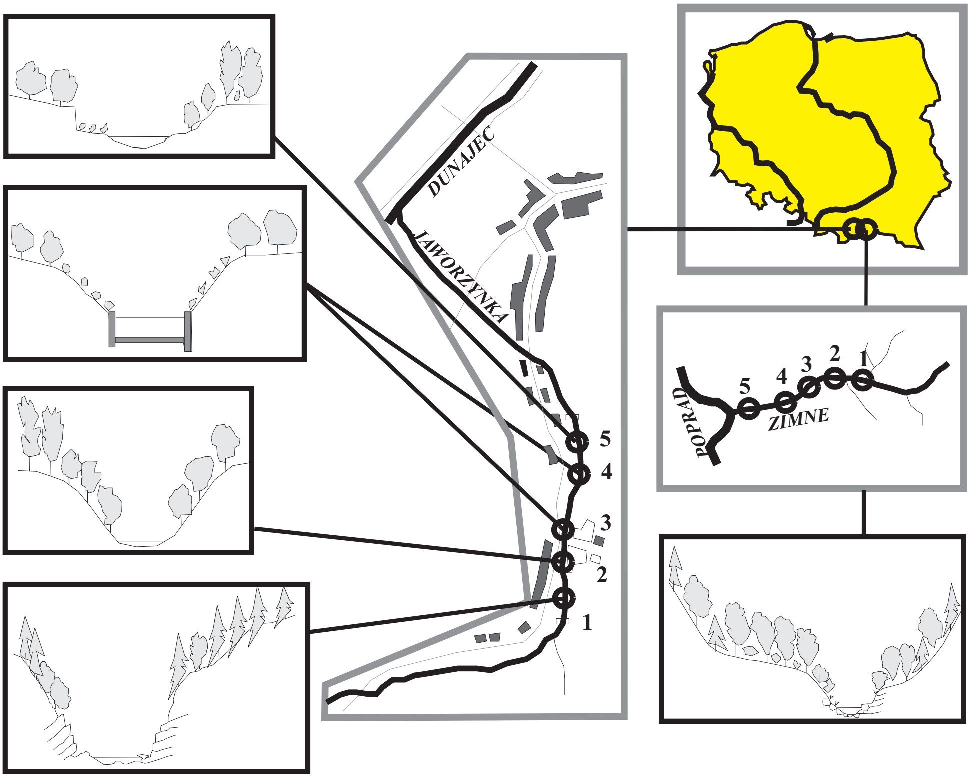

Fig.1. Study area

TABLE 1

Basic information about the Jaworzynka and Zimne streams

Parameters	Jaworzynka Stream	Zimne Stream
Length (km)	12.2	3.5
Slope (‰)	53.6	114.2
Drainage area (km2)	16.7	4.1
Forest (% of area)	80	100
pH	8.4 - 8.5	8.4 - 8.5
BOD_5 (mg O2l^{-1})	1.0 - 6.0	1.6
O_2 (saturity)	mg O2l^{-1})	9.3 - 12.1
PO_4 (mgl^{-1})	0.04	0.01
NNH_4 (mgl^{-1})	0.00-0.085	0.06 - 0.1
NNO_3 (mgl^{-1})	1.61 - 3.53	1.28 - 3.19
Native ichthyofauna:		
Salmo trutta m. fario	0.56 indiv. m^{-2}; 4.3 g m^{-2}	0.12 indiv. m^{-2}; 32.7 g m^{-2}
Cottus poecilopus	0.05 indiv. m^{-2}; 1.2 g m^{-2}	
Phoxinus phoxinus	0.001 indiv. m^{-2}; 0.02 g m^{-2}	

ams differ in the character of catchment area, slope, water thermal conditions and composition of the autochthonous ichthyofauna (Figs 1-2, Tab.1).

Both these streams were stocked (1 June 1994) with huchen fry obtained at the Fishery Farm of the Polish Angling Association in Łopuszna, just before resorption of yolk sac. Twenty thousand fry were released in each stream: in the Zimne Stream to an area of 2 653 m^2 (section between localities 2 and 3), which resulted in a density of 7.5 individuals per m^2; in the Jaworzynka Stream to an area of 5 838.7 m^2 (between loaclities 1-4), resulting in a density of 3.4 individuals per m^2. Prior to stocking, most autochthonous species were removed from each stream by electrofishing.

Within the first two months control catches and observations of habitats occupied by the huchen fry were made every fortnight, and later monthly, till the huchen fry

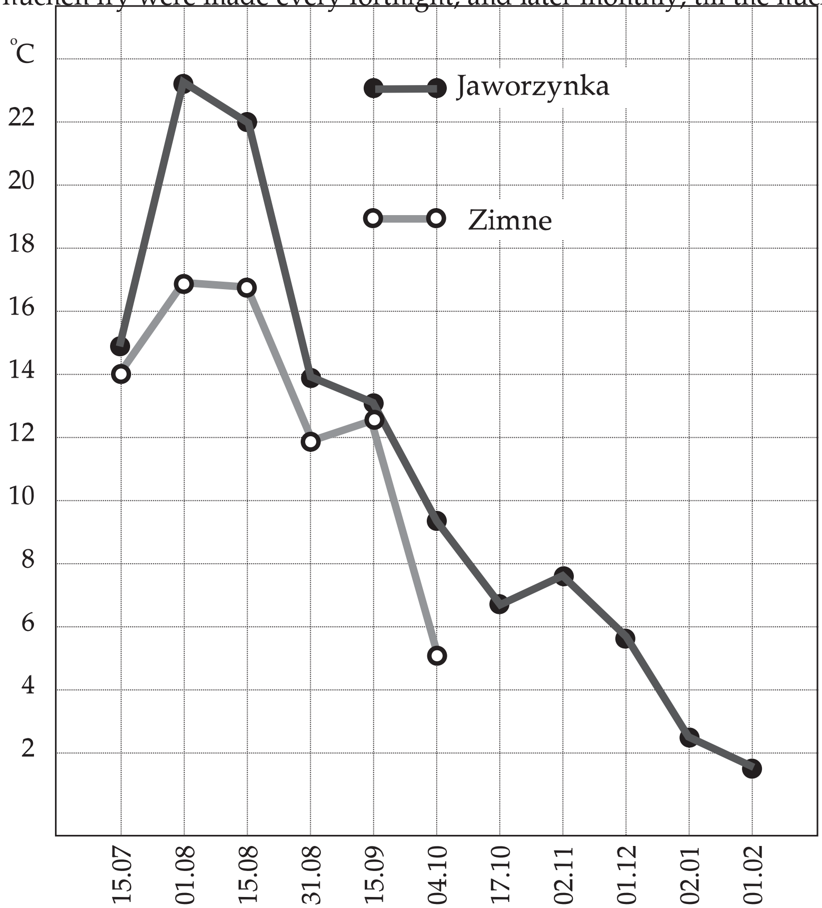

Fig.2. Water temperature in the streams Jaworzynka and Zimne

migrated to the main rivers, Dunajec and Poprad (Jaworzynka: from 15 July 1994 till 16 May 1995; Zimne from 15 July 1994 till 1 October 1994). Single catches were made at five 100 m sections (in places where the fry was released and below them), using backpack electrofishing equipment. At the same time, characteristics of the fry habitat were noted (substratum, degree of shading, depth), and water tempearture was measured. This made it possible to determine the density of fry at various periods, and its habitat preferences in particular sections of the streams. Of each sample, about 10 individuals were preserved in 4% formalin for further studies on growth rate and food. The fish were measured with 0.01 cm accuracy and weighted with 0.01 g accuracy.

Only organisms found in the oesophagus and stomach were considered in food analysis. When the organisms were much damaged, their mass was deduced from the dependence between the metric characters and the mass of an organism. To establish the food spectrum, the indices of biomass (B) and abundance (N) of each kind of prey were used, expressed as %. Feeding intensity was estimated based on stomach index (SI), expressed as SI = B/W, where B - total mass of prey items in mg, W - fish mass in g. Growth charactersitics of the huchen in the first season of quick growth was determind based on Bertalanffy's equation: $Tl_{\_} = Tl_t (1-e^{-K(t-to)})$. In the model it was assumed that at the moment of releasing the fry in the streams their mean length was 16 mm; at that length larvae have partly resorbed yolk sac (Witkowski, Kokurewicz 1981). The dependence between the fish mass (W) and total length (Tl) was calculated according to an equation $W = aTl^b$, after converting it to linear form log W = log a + b log Tl.

3. RESULTS

3.1. HABITAT

The huchen fry in both streams, during the first three months after release, selected the shallowest (as a rule shore) places, 5-10 cm deep, characterised by a slow water current. At that time the fish selected also the best illuminated places, clearly avoiding shaded sections. With increasing size, the young huchen moved gradually to deeper water (Fig.3). In the Jaworzynka Stream individuals above 100 mm Tl gathered mostly in the current, initially somewhat farther from and then just below natural steps. This was associated with the largest depth in these parts of the stream. From

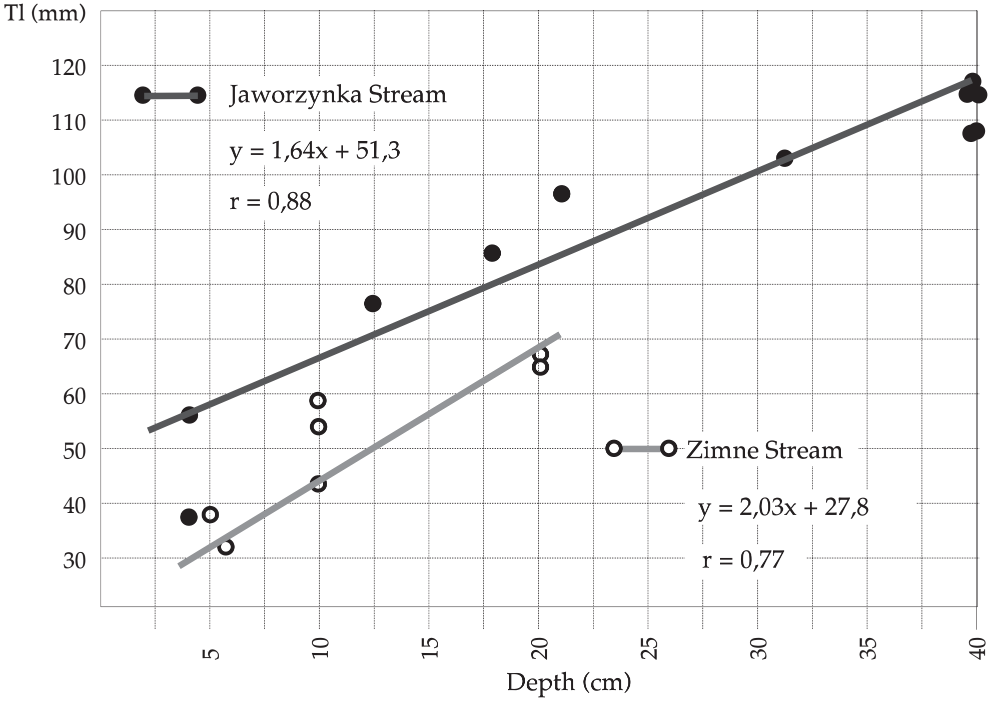

Fig.3. Dependence between size of huchen fry and water depth

that moment onward they evenly occupied both insolated and shaded sections. In the Zimne Stream, no such behaviour was observed, as fish migrated to the main river before reaching 80 mm average Tl.

3.2. DOWNSTREAM MOVEMENT

Cyclic control catches (each 14 and 30 days) during all the experimental period indicated a successive movement of the young huchen to increasingly deeper parts of the two streams (Fig.4). Their movement was distinctly quicker down the Zimne Stream, where they were absent from the first two (highest situated) localities one month after release. At that time their highest density (0.49 indiv./m^2) was observed at locality 5. In subsequent periods (September-October) they were found only in this locality, and their number kept increasing. In the Jaworzynka Stream, a similar tendency was noted, the rate of downstream migration (expressed as density) being distinctly slower. One month after release, few individuals (0.12 indiv./m^2) were recorded at the second locality. At that time, the highest density was observed in the sections

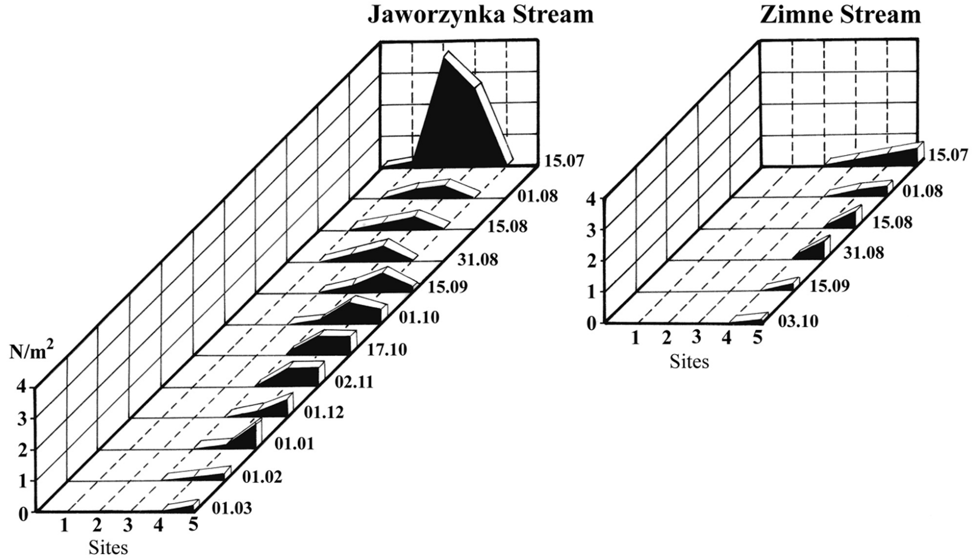

Fig.4. Density (N/m^2) of huchen fry at particular localities in consecutive periods in the streams Jaworzynka and Zimne

comprising localities 3 and 4, of 3.55 and 2.40 indiv./m^2, respectively. At later periods, the fry density at the upper three localities decreased gradually. At locality 5 (not stocked) the first huchen appeared as late as the second half of September. From October till January their density remained at a similar level (0.55-0.69 indiv./m^2). From that moment, a more intense migration downstream started in this section, and the last individuals were noted there at the beginning of March. In May, single individuals were caught only in the mouth section.

3.3. FEEDING

In both streams the young huchen fed most intensely in July and August, and the feeding intensity decreased till October. In winter, in the Jaworzynka Stream it was ten times lower than in the summer, and increased again in May, when the huchen entered the second season of quick growth (Tab.2).

In both streams the main food for the young huchen were *Ephemeroptera* (mainly Baetis sp.), *Trichoptera*, *Chironomidae* and *Gammaridae*. The remaining aquatic organisms (*Plecoptera*, *Simuliidae*) were consumed in smaller quantities and only in some months. The proportion of terrestrial organisms was small. In the Zimne Stream these

TABLE 2

Characteristics of the studied fish and their stomach index (n - number of fish, Tl - total length in mm, W - mass in mg, SI - stomach index, SD - standard deviation).

Period	n	Tl	SD	W	SD	SI	SD
Zimny Stream							
15.07.1994	13	31,9	2,7	0,32	0,06	22,1	14,3
01.08.1994	10	43,8	2,6	0,69	0,17	37,2	44,0
16.08.1994	12	53,3	4,1	1,37	0,29	10,3	7,5
31.08.1994	11	58,0	5,3	1,89	0,43	17,3	9,3
15.09.1994	9	66,4	5,4	2,72	0,63	11,6	6,9
01.10.1994	12	67,1	8,0	2,82	0,87	9,1	6,0
Jaworzynka Stream							
15.07.1994	10	37,8	1,7	0,42	0,07	20,1	11,9
01.08.1994	10	57,3	5,3	1,57	0,32	11,1	6,3
16.08.1994	10	76,8	2,2	4,13	0,27	17,1	7,0
31.08.1994	10	85,9	2,8	5,46	0,25	6,4	6,4
15.09.1994	11	97,9	4,8				
03.10.1994	10	103,4	4,8	9,9	1,5	6,1	4,6
17.10.1994	11	109,8	6,7	11,2	1,8	6,0	4,9
02.11.1994	10	109,8	5,8	11,7	2,0	4,7	2,6
01.12.1994	10	115,0	6,8	13,0	2,0	3,4	4,4
02.01.1995	11	115,1	6,5	13,9	2,2	3,4	2,0
01.02.1995	12	115,4	7,2	13,4	2,0	2,5	1,9
01.03.1995	13	115,5	9,0	12,4	3,0	5,3	3,7
16.05.1995	5	125,6	4,1	19,1	2,1	16,5	7,2

were only *Oligochaeta*, in the Jaworzynka Stream also *Diptera* and *Coleoptera*. Mutual proportions of particular groups of prey differed clearly between the two streams. In the Zimne Stream a very large role in the huchen food, especially in case of larger individuals, was played by *Gammaridae*, while in the Jaworzynka Stream *Ephemeropetra* and *Chironomidae* were of greater significance (Figs 5-8).

3.4. GROWTH

The period of quick growth of the young huchen did not exceed 100 days from the release. In the Zimne Stream decrease in the growth rate took place as early as September, in the Jaworzynka Stream, with warmer water, it was observed as late as October. In the winter, from December till March, the huchen did not grow at all (mean

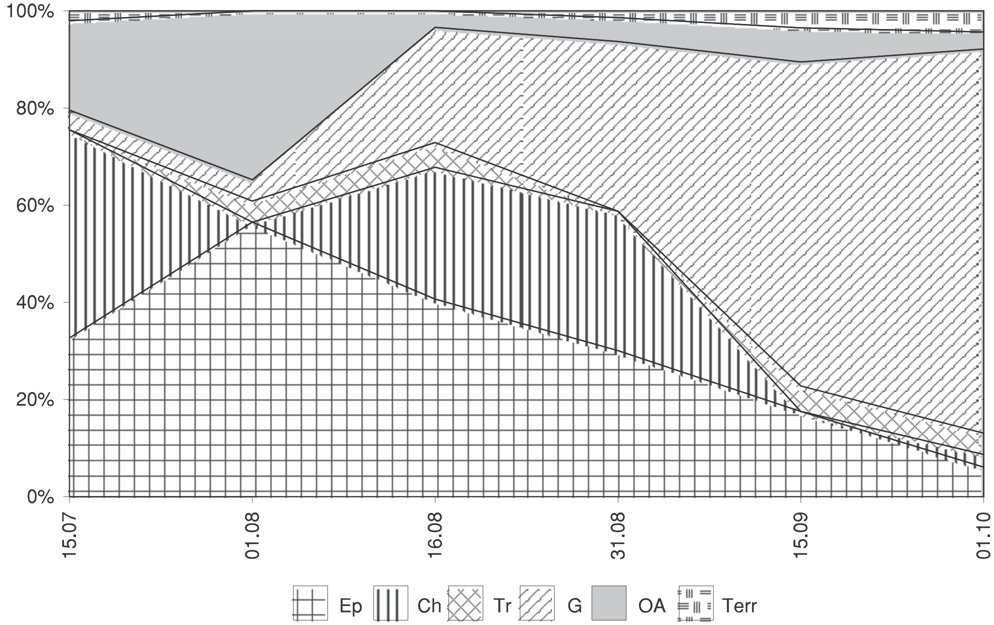

Fig.5. Number of prey items in the food of huchen fry from the Zimne Stream. Ep - *Ehemeroptera*, Ch - *Chironomidae*, Tr - *Trichoptera*, G - *Gammaridae*, OA - other aquatic prey, Terr - terriestrial prey

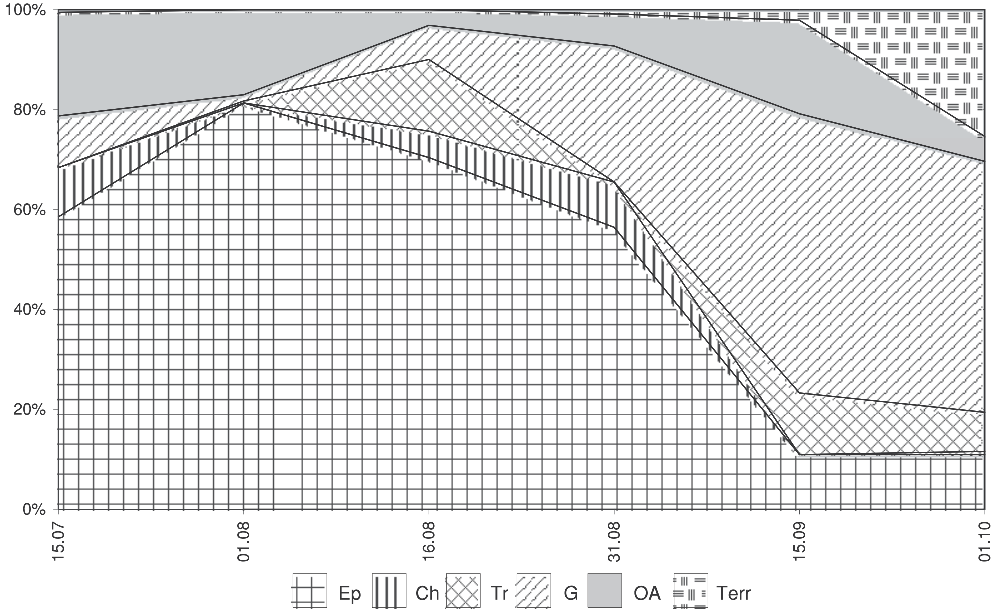

Fig.6. Prey mass in the food of huchen fry from the Zimne Stream. For lettering see fig.5

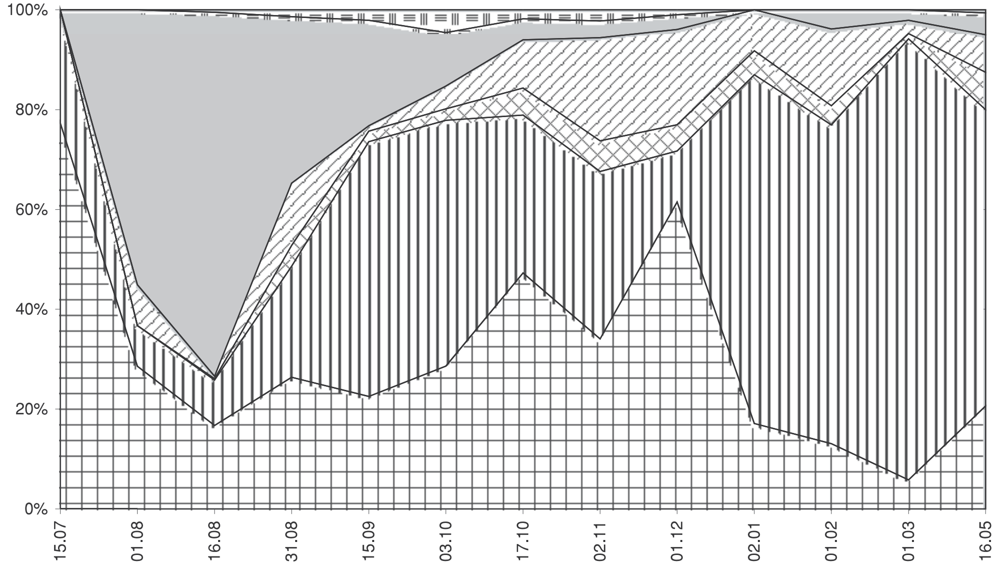

Fig.7. Number of prey items in the food of huchen fry from the Jaworzynka Stream. For lettering see fig.5

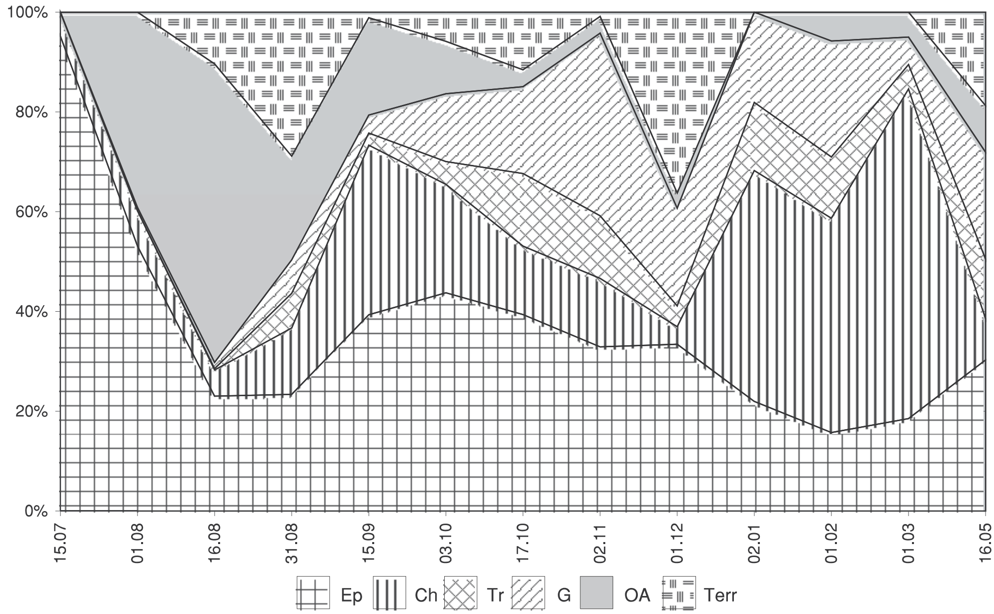

Fig.8. Prey mass in the food of huchen fry from the Jaworzynka Stream. For lettering see fig.5

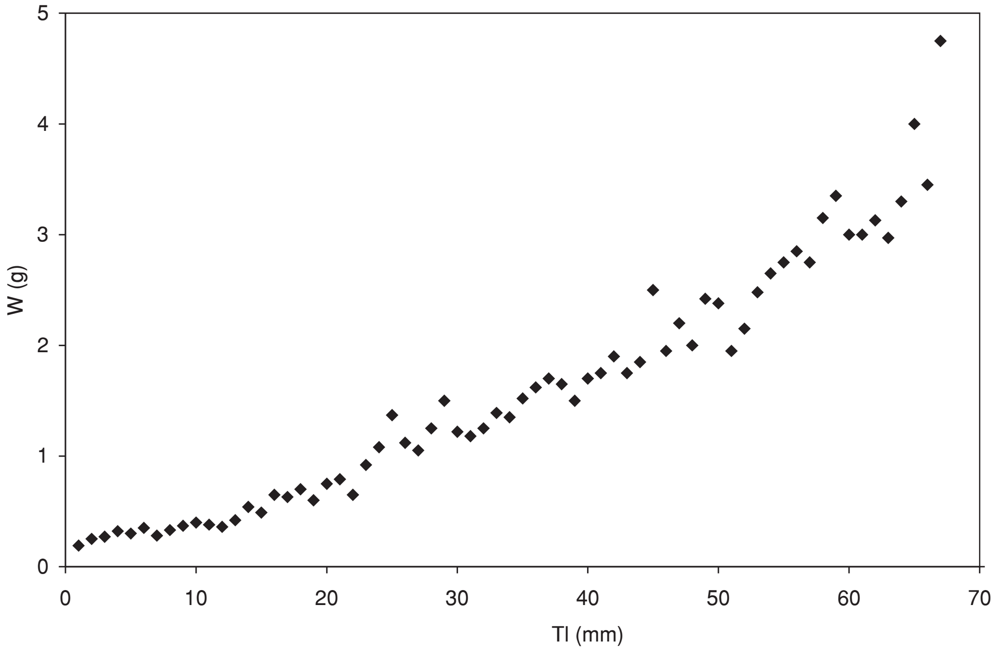

Fig.9. Dependence between the body mass and length in huchen fry from the Zimne Stream: n = 67; r=0.98; log W= -4.8784 + 2.90 log Tl

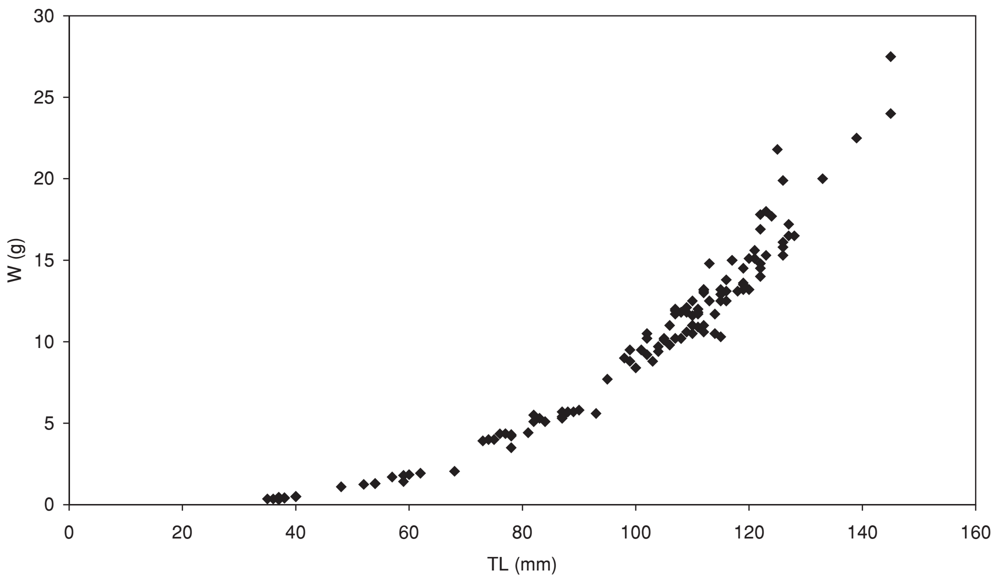

Fig.10. Dependence between the body mass and length in huchen fry from the Jaworzynka Stream: n = 126; r=0.99; log W=-5.1773 + 3.05 log Tl

length at that period oscillated around 115 mm).

Asymptotic length of the first growth season in the Zimne Stream was 76.5 mm, and in the Jaworzynka Stream it was almost twice larger and amounted to 128.3 mm (Tab.3). The fish mass very strictly correlated with their total length in both streams (Figs 9-10), though in the Jaworzynka Stream in winter the fish, not increasing their body size, decreased their mean mass (Tab.2). In spite of this, b parameter of the equation describing the mass-length dependence was higher in the huchen from the Jaworzynka Stream, indicating a better condition of the fry in that stream.

4. DISCUSSION

Spatial and temporal distribution, microhabitat selection, downstream movement and feeding strategies of the youngest stages of salmonid fishes (underyearlings, yearlings) in spawning streams constitute a complex problem which is not easy to solve (Egglishaw, Shackley 1982, Elliot 1986).

Contrary to diadromous salmonids (*Salmo salar, S. trutta*), the huchen, *Hucho hucho*, is a more thermophilous species (Holčik et al. 1988). It inhabits mid sections of large mountain rivers and spawns practically only in the main river, rarely entering small, most often distinctly warmer tributaries (Witkowski 1988). The experiment carried out in two mountain streams clearly departs from the conditions that are prevalent in typical spawning grounds and habitats characteristic of the youngest stages of the species (Bastl, Kirka 1959).

During all the period spent in the streams, the distribution of young huchen depended on water depth. The highest densities in the initial periods were noted in the shore shallowest parts, characterized by slow water flow. With increasing size, the fish occupied increasingly deeper places of higher water velocity. A similar behaviour was observed in fry of the Atlantic salmon and sea trout (Allen 1951, Elliot 1966, Egglishaw, Shackley 1982, Elson 1967, Harcup et al. 1984, Keenleyside 1962, Kennedy, Strange 1982, Schuck 1943, Solomon 1982, Symons, Heland 1978). The gradual change of habitat by huchen, from the shallowest to increasingly deeper, with the decreasing density within the locality, may be also associated with avoidance of potential predation and increasing territorial behaviour (Egglishaw, Shackley 1980, 1985).

Downstream movement, estimated based on fish density in each particular locality at different periods, progressed at a different rate in each stream. In the Zimne Stream it was distinctly quicker than in the Jaworzynka Stream. The fish from the former stream migrated to the main river earlier. As mentioned above, the species prefers warmer waters compared to other salmonids. The first Stream, because of its character (Tab.1, Fig.2), is distinctly colder than the Jaworzynka stream. Quicker downstream migration of the fry in the Zimne Stream could also result from the absence of proper habitats, i.e. deeper pools, or from some factors associated with water depth (Fig.1). Some authors (Le Cren 1965, Northcote 1978, Taylor, Taylor 1977) report that downstream moving in anadromous salmonids is associated with food resources in a stream and depends on food competition. Elliot (1986) noted that fry and parr of sea trout caught (in stop-nets) downstream were smaller and had a worse condition than those remaining in the upper sections, and the stomachs of dead specimens were most often empty. This is confirmed also by the data of Egglishaw and Shackley (1980); according to these authors fry of Atlantic salmon do not disperse as long as there is a sufficient abundance of small invertebrates. The analysis of feeding of young huchen indicates that food deficiency is not the factor that stimulates their downstream migration. In the Zimne Stream the huchen moved downstream, at the same time feeding more intensely than in the Jaworzynka stream (in October the average in the Zimne Stream was 11.6, and in the Jaworzynka Stream 6.1). Compared with the huchen from the Łopuszanka Stream (Witkowski et al. 1994), the fish in the two streams practically did not use allochthonous food, which indirectly testifies to sufficient food resources.

The quicker downstream movement in the Zimne Stream could be also influenced by the higher initial fry density (Egglishaw, Shackley 1980, 1985). At the moment of release, the density was 7.5 indiv./m^2, while in the Jaworzynka Stream it amounted to 3.4 indiv./m^2 only. In this case the role of predation, or competition with other species, both for space and food, can be excluded since both streams had been almost completely cleared of fish prior to the experiment. Thus, in the case of huchen planted in these two streams, social interactions, territorial behaviour, as well as some abiotic factors (mainly temperature) probably play a significant part in determining the speed of the downstream movement. This is indirectly supported by the fact that, despite the sufficient food resources, the fish grew slowly, in both streams and the young huchen in the Zimne Stream were characterized by a much slower growth rate. Even in the Jaworzynka Stream, where the fish grew at a higher rate, the total length attained in the first season of growth was much smaller than that reached at a corresponding time by the huchen in the Dunajec River (Witkowski et al. 1985). This indicates that in both streams growth conditions for this species are worse than in the Dunajec River.

The presented results do not allow an unambiguous estimation of the efficiency of stocking cold mounatin streams with huchen fry. The yearlings attain there much smaller size than in the main river, and quickly migrate downstream. Perhaps, however, the conditions created there by decreased density of authochthonous fish species and abundant food resources contribute to a high survival rate of the fry. The problem requires further studies, and only then will the estimation of the efficiency of this method of stocking mountain streams be possible.

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6. STRESZCZENIE

EKOLOGIA NARYBKU (0^+) GŁOWACICY, *Hucho hucho* (L.) (*Salmonidae*), WPROWADZONEGO DO DWÓCH POTOKÓW GÓRSKICH

Dwa potoki – Zimne i Jaworzynka (dopływ Popradu i Dunajca) – o górskim charakterze, po wcześniejszym odłowieniu autochtonicznej ichtiofauny, obsadzono wylęgiem głowacicy w stadium resorbcji woreczka żółtkowego. Początkowe zagęszczenie wynosiło odpowiednio: 7.5 i 3.4 sztuk m^{-2}. W jednakowych odstępach czasowych (w początkowym okresie co dwa tygodnie, a później co miesiąc) na pięciu stanowiskach przy użyciu agregatu bateryjnego kontrolowano liczebność narybku.

Stwierdzono, że w okresie pierwszych trzech miesięcy narybek wybierał najpłytsze i najbardziej nasłonecznione miejsca. W miarę osiągania coraz większych rozmiarów przesuwał się w głębsze partie potoków. Tempo wzrostu oraz szybkość przemieszczania się narybku w dół w obu potokach była różna. W potoku Zimne młode głowacice rosły wolniej niż w Jaworzynce i szybciej też wyemigrowały. Nie było to uzależnione od zasobów pokarmowych (ilości i jakości pokarmu), lecz prawdopodobnie od oddziaływania niektórych czynników abiotycznych (mniejsza liczba habitatów, niższa temperatura wody, większy spadek) oraz biotycznych (wyższe zagęszczenie, interakcje socjalne, behawior terytorialny).

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