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STUDIES ON THE LARVAE AND FRY FEEDING OF THE TWO *COREGONIDAE* SPECIES DURING ITS FIRST YEAR OF GROWTH IN ILLUMINATED CAGES

STUDIA NAD ODŻYWIANIEM SIĘ LARW I NARYBKU DWU GATUNKÓW RYB GŁĄBIELOWATYCH (*COREGONIDAE*) PODCZAS PIERWSZEGO ROKU PODCHOWU W SADZACH OŚWIETLONYCH

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Feeding character of the 0+ age *Coregonidae,* in cages, depends on the quantitative and qualitative composition of organisms during spring and autumn plactonic growth peaks. Planctonic growth peak in spring supports energetic needs of fish larvae and with light applied to concentrate plankton, enables to get a large amount of stocking material. An autumn one seems to be insufficient for covering the *Coregonidae* fry energetic needs. The character of *Coregonus lavaretus* L. and *Coregonus peled* Gmel. larvae and fry feeding is discussed, including differences in natural environment as well as changes during succesive seasons of growth.

INTRODUCTION

In Poland, surveys on the *Coregonidae* growth in the illuminated lake cages have carried out since 1973 (*Bryliński* et al., 1975, Radziej et al., 1978). It brought into general use an original method of stocking material production, based on feeding fish with zooplankton, allured, into cages, by the light. Growth effectiveness depends, however, to a great extend, on a type of the lake and seasonal changes of zooplankton biomass(Bryliński et al.,1979; Mamcarz and Szczerbowski, 1984). On the basis of the up to date surveys it was stated, that small eutrophic basins with high and stabilized nutritional resources are to be chosen for production, in cages, purpose (Radziej et al., 1978). It does not exclude the possibility of fish rearing in the less nutritious lakes. However, it requires both, recognition of its nutritional basis and nutritional needs of fishes in cages, and rearing adjustment to these conditions. As yet this subjest has been recognised only slightly.

The presented work gives analysis of the feeding pattern of *Coregonus lavaretus* L. and *Coregonus peled* Gmel. larvae and fry in illuminated cages placed in the lake of an average nutritional conditions.

EXPERIMENTAL AREA

The Leginskie Lake (228.3 ha) is a vendace basin in Northern Poland (gathering ground of Łyna and Pregoła) with maximal depth of 37.2 m. According to Olszewski and Więcławska (1965) this is the lake between meso- and eutrophy type. The whole summer there is a thermal stratification with cold (6 to 9°C) and stable hypolymnion. The water temperature, within epilimnion, exceeds 14°C in May and drops below this temperature in September. An oxygen content, in surface layer, does not drop below 6 mg/dm^3, with over oxygenation up to 120–130%, noted ussually in summer. The characteristic feature is only slight changes of chemical composition of the water. Annually, there are 16 species of rotifers, 4 species of copepods and 13 species of cladocerans in zooplankton. *Rotatoria* state for 65 to 75% of zooplankton, while *Copepoda* 17 to 27% and *Cladocera*3 to 15% (Mamcarz, 1982). Dominants among rotifers are *Keratella, Asplanchna* and *Polyarthra spp.* Within the copepods group, juvenile forms are most numerous, with *Eudiaptomus graciloides* dominating among the adult individuals. The most common cladocerans are *Daphnia cucullata* and *Bosmina spp.*

MATERIAL AND METHODS

To determine changes within a nutritional ground of the lake, samples of zooplankton were collected outside the cages in a day- and a night- time. In 1977, samples from inside the cages were also collected in a day time. The plankton samples were collected by the 5 dm^3 Ruttner's sampler, every 1 m below the surface down to the cage submersion level (5 m). When caught, organisms were seeved through a planktonic net and classified. Zooplankton biomass was estimated according to the below given equations:

for Copepodes $W = 55\ L^{2.73}$

for Daphnidae $W = 52\ L^{3.012}$,

Where:

W– is weight in μg and L–length in mm (Hillbricht-Ilkowska and Patalas, 1967). Biomass of rotifers as well as other rarely noted species was estimated according to the weight standards.

The Coregonidae rearing methods, growth rate and survival of both tested species and the environmental conditions were presented, in details, in previous works (Mamcarz and Szczerbowski, 1984; Szczerbowski and Mamcarz, 1984).

To test a composition of food, samples were collected, in succesive rearing years (from May to December 1977–1979), from cages of initial concentration of larvae per 1 m^3 equal to 12 500, 3750 and 6250, respectively (*Coregonus peled* Gmel), and 5832 of *C. lavaretus* L. larvae/m^3 (in 1977). Two to three times a month 10 to 20 individuals were being fished from to cages, at random, as to test contents of its alimentary tracts. Fishes were kept in 4% formalin; its total length measured, with the 1 mm accuracy, and weight determined (larvae with 1 mg and fry with 1 g accuracy). Next alimentary tract of each individual was carefully analysed for its content. A total number of organisms of each category was estimated as an average number of preys per fish. Share of each category was estimated quantitatively and energetically.

An average energetical value of food (E in mcal) was estimated according to the method of van Densen (1985). For each planktonic organism a relation between the body length and energy (LE), according to Vijverberg and Frank (1976) was applied. For *Daphnia cucullata* and for *Bosmina longirostris*, the above given relation estimated by the authors, respectively, for *Daphnia hyalina* and Bosmina coregoni, *was applied. For sporadically noted representatives of* Diaphanosoma species the relation LE for *Daphnia* was used. Energetic value of *Eudiaptomus graciloides* was calculated due to LE relation for *Eurytemora affinis*. Nauplia and rotifers were not measured. Its energetical values were taken from van Densen (1985).

Electivity index in fishes for various zooplankton taxa were calculated according to the Ivlev equation (1977):

$$I = \frac{r_i - p_i}{r_i - p_i}$$

where:

r_i – share of i – category of prey in the alimentary tract, in percent,

p_i – share of i – category of prey in the lake, in percent.

Analysis were conducted on 630 larvae and fry of *Coregonus peled* Gmel. and 233 individuals of *Coregonus lavaretus* L.

RESULTS

Changes in zooplankton biomass in the lake and cages.

During the whole year, excluding the spring growth peak, zooplankton biomass in the lake was lower than 2 g/m^3, (Fig. 1). In May and June the highest concentration of planktonic organisms was noted, with its biomass reaching 7 to 16 g/m^3. *Daphnia cucullata* and *Bosmina longirostris* dominated in zooplankton that time (over 80% of the biomass). There was an increase, in the planktonic organisms biomass, noted outside the cages during the night-time, up to 16–18 g/m^3. The increase caused mainly by a selective attraction of *Cladocera*, by the light. During summer stagnation there was a rapid decline in biomass noted, caused by a reduction of cladoceran number in

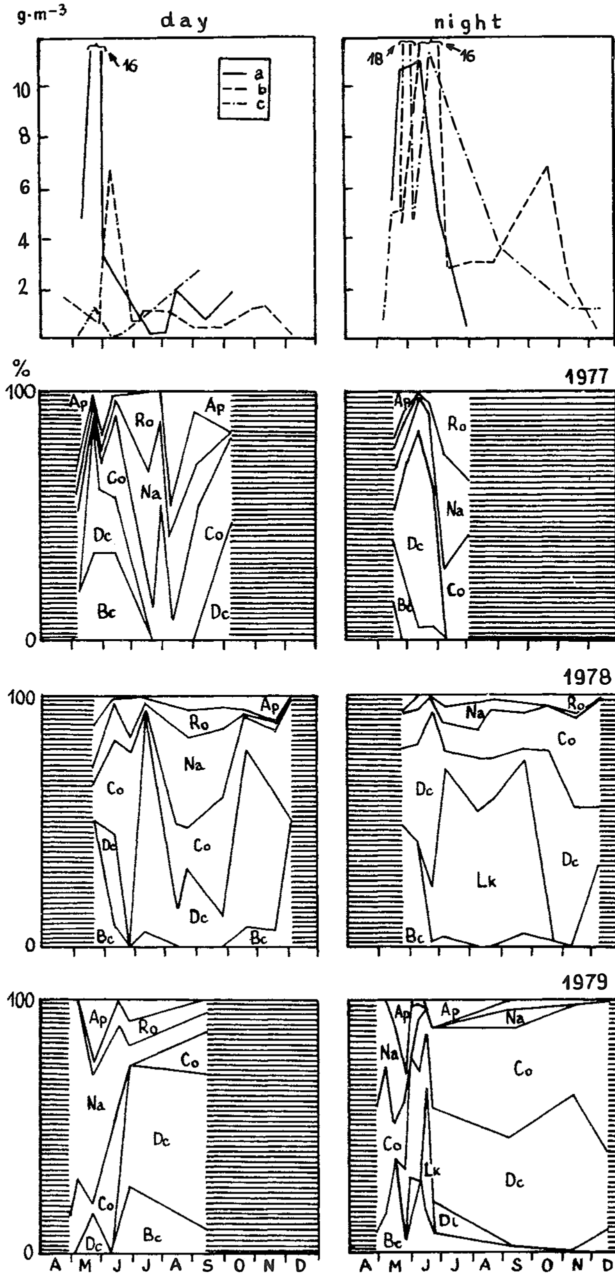


Fig. 1. Biomass and zooplankton composition, in percentage, outside the cages, at the day and the night time, in 1977 to 1979. From the bottom to the top sequence:
Bc = *Bosmina coregoni,* Lk = *Leptodora kindti,* Dc = *Daphnia cucculata,* Dl = *Daphnia longispina,* Co = *Copepoda,* Na = *nauplia,* Ap = *Asplanchna priodonta,* Ro = *other rotifers.*
Years: a = 1977, b = 1978, c = 1979

Table 1

Prey (in numbers per fish) of *Coregonus lavaretus* larvae and fry in day (D) and night (N) from illuminated cages located in Lake Leginskie in 1977

Notations: Ro = rotifers, Na = nauplia, Co = copepodites, Me = Mesocyclops adults, Eu = *Eudiaptomus* adults, Bo = *Bosmina sp.*, Da = *Daphnia sp.*, Ld = *Leptodora kindti*

Date		Fish length (mm)	Number of fishes		Food organisms							
			exa-mined	with food	Ro	Na	Co	Me	Eu	Bo	Da	Lk
May, 15	D	21.0–22.9	15	15	–	0.1	46.8	1.7	0.1	6.3	1.5	–
	N	18.0–23.9	15	15	–	0.1	66.7	2.8	–	50.1	3.0	–
May, 25	D	20.0–23.9	9	5	–	–	2.6	0.4	0.2	1.6	3.4	–
	N	21.0–31.9	12	12	–	–	10.4	1.3	–	31.7	13.9	–
June, 2	D	28.0–33.9	14	14	–	0.1	4.5	0.6	–	44.8	20.1	–
	N	25.0–34.9	15	15	1.2	0.7	12.2	14.2	3.0	124.3	45.9	0.1
June, 15	D	32.0–46.9	19	19	–	0.1	2.5	3.6	6.6	3.4	100.4	0.1
	N	31.0–43.9	9	9	–	–	13.4	7.5	0.5	3.2	175.0	–
June, 29	D	34.0–48.9	22	22	–	0.04	7.7	10.9	6.9	2.8	38.4	–
	N	31.0–47.9	21	21	–	2.9	8.3	8.9	2.2	7.3	64.9	1.7
July, 5	D	32.0–53.9	20	2	–	0.5	–	0.5	–	1.0	–	–
	N	33.0–49.9	18	17	1.1	1.9	4.7	2.2	0.2	1.1	34.2	–
July, 18	D	38.0–57.9	23	–	–	–	–	–	–	–	–	–
July, 26	D	46.0–53.9	10	9	–	0.9	5.7	5.8	3.0	1.8	1.5	0.2
	N	44.0–56.9	11	10	–	1.8	4.9	0.5	0.9	0.3	10.1	–

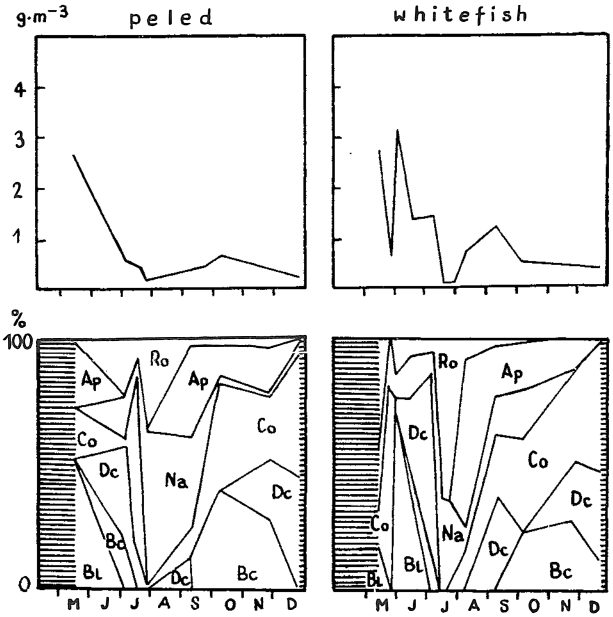


Fig. 2. Biomas and zooplankton composition, in percentage in cages with *Coregonus lavaretus* L. and *Coregonus peled* Gmel. day time samples, in 1977. Sequence and strips of components as on Fig.1

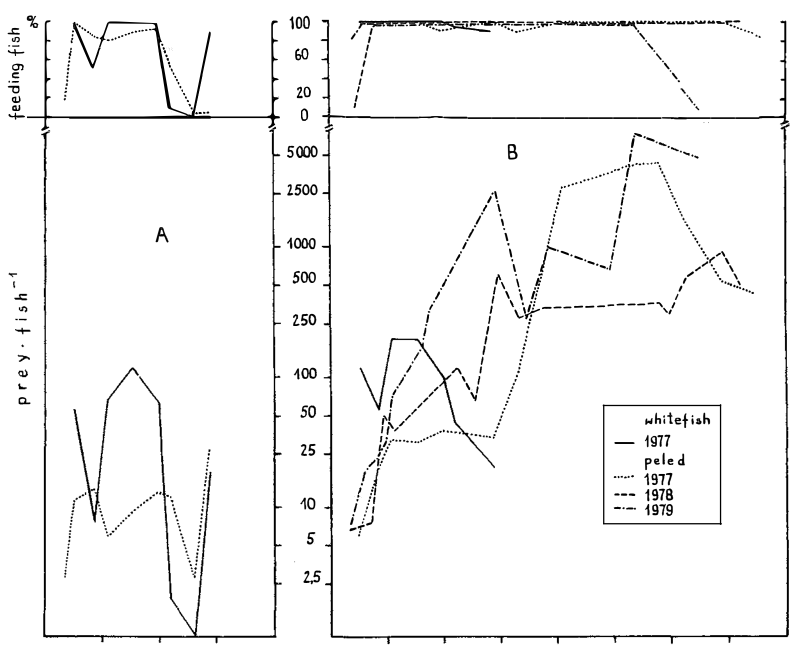


Fig. 3. An average number of prey in the alimentary tract of *Coregonus lavaretus* L. and *Coregonus* peled Gmel. during the day time (A) and the night time (B) and percent of preying fishes (upper part of figure)

zooplankton. Main components of plankton that time were rotifers and juvenile Copepodes (nauplia), which created an exceptionally unconvinient nutritional situation for fish in cages. Since August a steady increase in *Cladocera* number in fish prey was noted. As for *Eudiaptomus graciloides,* dominated among the *Copepoda* species, two growth peaks were noted (in may and in autumn). *Asplanchna priodonta,* dominant among rotifers, reached over 2 g/m^3 in biomass, in May.

During the day time zooplankton biomass in cages do not differ essentially from the one in the lake (Fig. 2). In the night time a visible increase in number of prey, in cages, was observed, despite an intensive preying of fish (Szczerbowski and Mamcarz, 1984).

Food of *Coregonus lavaretus L.* in cages.

There was a fast increase in number of organisms in the *Coregonus lavaretus* L. larvae alimentary tracts in May and June 1977, when the maximum multiplication of zooplankton was observed (Table 1). Number of prey grew up from 50 individuals per fish during the day time preying in the middle of May, to 100 individuals per fish in the middle of June (Fig. 3). During that time the larvae size increased, in average, from 21.3 to 38.6 mm. In May, the main component of the *Coregonus lavaretus* L. larvae food were copepods, replaced fast by cladocerans such as *Bosmina coregoni* and *Daphnia cucullata* (Fig. 4). Since the end of June, when *Cladocera* disappeared from zooplankton, *Coregonus lavaretus* L. stopped on feeding during the day time. In some still preying individuals, however, separate grown up *Copepoda* and its nauplia were present.

In the night time number of planktonic organisms within the alimentary tracts of *Coregonus lavaretus* L. was almost twice that high as in the day time (Fig. 3). Increase in number of the two dominating, both quantitatively and energetically, cladocerans, in fish food, was even greater (Fig. 4). By the end of June some juvenile individuals of *Leptodora kindti* were isolated from the fish food. The fish did not stop feeding in the night time during the drastic drop of *Cladocera* number in zooplankton, however there was a visible decrease in number of organisms in its alimentary tracts down to 15–25 individuals per fish (Fig. 3). There were only few fishes with totally empty alimentary tracts. A maximal energetic value of food taken by *Coregonus lavaretus* L. was alike during the day and the night time and equal to ~ 1 cal per individual (Fig. 5). Essential differences were noted in July, when energetic value of food, in the night, was about 0.1 cal/individual, while in the day time there was no food in the fish alimentary tracts.

Feeding of *Coregonus peled* Gmel. in cages.

Feeding of *Coregonus peled* Gmel., in illuminated cages, was somewhat different than the one of *Coregonus lavaretus* L. Until the middle of May larvae were not preying, utilizing reserves of yolk sack. Since then, a fast increase in number of organisms in its alimentary tracts was observed, however, to a manifold lower level, than the one noted for *Coregonus lavaretus* L. (Table 2,3,4). During the day time preying number of prey taken increased from about 2,5 individuals/fish, in the middle of May, up to

15 individuals/fish at the end of May; being doubled during the night time preying (Fig. 3). The larvae size increased from 11 up to 14.8 mm. The day time rations were dominated, at the beginning, by *Rotatoria* (mainly *Keratella* and *Kellicottia* species), replaced, by the end of month by cladocerans *Bosmina coregoni* and *Daphnia cucullata* (Fig. 6). Share of *Rotatoria* during the night time preying, reached its minimum, being

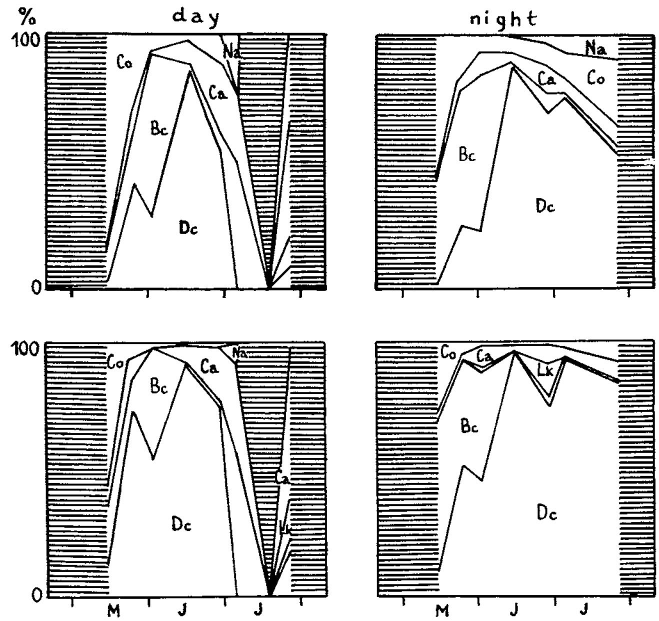


Fig. 4. Quantitative (above) and energetic (beneath) composition of zooplankton within the *Coregonus lavaretus* L. food during spring season 1977. From the bottom to the top: Dc = *Daphnia cucullata*, Bc = *Bosmina coregoni*, Lk = *Leptodora kindti*, Ca = Copepoda adults Co kopepodits, Na = *nauplia*

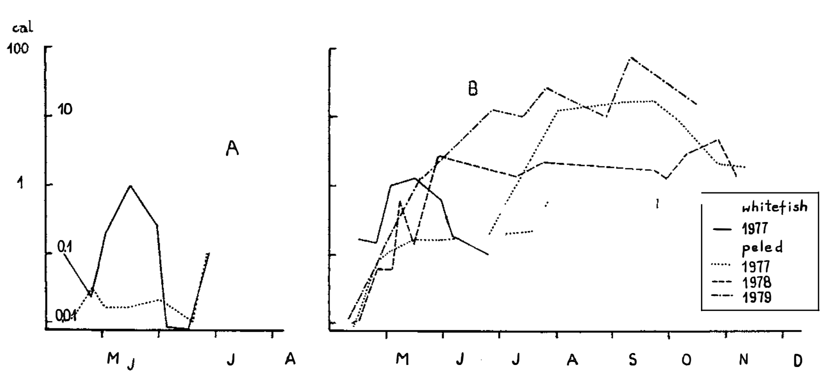


Fig. 5. Energy (cal) of an average amount of prey consumed by the *Coregonus lavaretus* L. and *Coregonus peled* Gmel. in the day time (A) and the night time (B), illuminated cages, during the first year of life

Table 2

Prey (in numbers per fish) of *Coregonus peled* larvae and fry in day (D) and night (N) from illuminated cages located in Lake Leginskie in 1977
Notations as in Table 1

Date		Fish length (mm)	Number of fishes		Food organisms							
			examined	with food	Ro	Na	Co	Me	Eu	Bo	Da	Lk
May, 10	D	10.0–12.9	7	1	–	–	–	–	–	3.0	–	–
May, 15	D	11.0–14.9	17	17	8.7	0.1	0.6	–	–	2.0	0.2	–
	N	11.0–13.9	15	15	2.1	–	0.1	–	–	4.2	–	–
May, 25	D	13.0–17.9	13	11	0.2	0.7	1.1	0.4	–	10.8	1.4	–
	N	12.0–17.9	18	18	1.4	–	0.6	–	–	15.0	3.6	0.05
June, 2	D	16.0–20.9	15	12	1.4	–	0.6	–	–	2.7	1.7	–
	N	15.0–21.9	15	15	0.8	0.1	1.1	0.1	0.1	23.9	8.1	–
June, 15	D	23.0–29.9	10	9	0.1	–	5.7	1.0	–	0.3	1.9	–
	N	19.0–26.9	17	17	–	0.2	2.6	0.3	0.2	0.8	29.0	0.05
June, 29	D	24.0–39.9	20	19	–	1.3	8.3	1.9	–	0.1	2.0	–
	N	20.0–36.9	20	18	–	0.5	8.4	2.4	0.7	1.6	26.6	–
July, 5	D	28.0–42.9	18	10	–	2.4	6.4	1.4	0.1	0.9	1.5	–
July, 18	D	35.0–52.9	17	1	–	–	–	3.0	–	–	–	–
July, 26	D	37.0–51.9	16	1	–	8.0	13.0	–	–	1.0	5.0	1.0
	N	37.0–47.9	14	14	–	2.8	16.9	1.0	5.8	0.6	5.6	3.3
August, 9	N	50.0–60.9	10	9	–	0.3	–	–	1.8	12.4	106.2	1.3
September, 2	N	54.0–74.9	9	9	–	10.0	147.8	326.7	1091.1	74.4	1038.9	0.5
October, 5	N	56.0–95.9	5	5	–	–	149.0	704.0	152.0	172.0	3000.0	–
October, 22	N	82.0–108.9	10	10	–	–	–	740.0	275.0	1361.0	2095.8	–
November, 5	N	91.0–113.9	10	10	–	–	–	245.0	81.0	361.0	1058.0	–
November, 26	N	100.0–127.9	10	10	–	–	–	116.1	56.7	84.0	294.1	–
December, 10	N	97.0–123.9	9	8	–	–	–	81.2	17.9	90.2	283.4	–

Table 3

Prey (in number per fish) of *Coregonus peled* larvae and fry in night from illuminated cages located in Lake Leginskie in 1978
Notations as in Table 1; By = *Bythotrephes sp.*

Date	Fish length (mm)	Number of fishes										
		exa-mined	with food	Ro	Na	Co	Me	Eu	Bo	Da	Lk	By
May, 10	10.0–11.9	15	2	–	–	3.5	–	–	3.5	–	–	–
May, 15	10.0–12.9	12	11	0.2	0.6	4.2	–	–	0.1	0.1	–	–
May, 25	15.0–18.9	20	20	2.2	–	0.6	–	–	19.9	1.4	–	–
June, 3	23.0–26.9	10	10	0.5	7.0	19.5	–	–	13.0	0.3	–	–
June, 7	27.0–31.9	10	10	–	1.2	23.3	2.9	4.2	26.0	63.9	0.5	–
June, 16	26.0–35.9	12	12	0.5	3.1	39.6	1.1	–	9.7	15.6	–	–
June, 28	33.0–42.9	15	15	–	0.7	53.1	–	26.9	38.1	515.0	–	–
August, 9	37.0–53.9	10	10	–	1.6	80.8	28.3	69.4	2.3	94.9	11.3	–
August, 23	43.0–58.9	11	11	–	–	58.6	11.4	95.3	0.9	79.6	30.4	75.2
October, 23	65.0–86.9	7	7	–	–	–	137.1	21.3	35.0	196.6	–	0.7
October, 28	70.0–88.9	10	10	–	–	–	106.0	14.9	45.2	149.4	–	–
November, 8	73.0–96.9	10	10	–	–	–	121.0	114.0	36.0	336.0	–	0.5
November, 26	89.0–105.9	10	10	–	–	–	262.0	125.0	19.0	513.0	–	–
December, 5	90.0–107.9	10	10	–	–	–	445.5	8.0	14.5	39.0	0.5	–

Table 4

Prey (in numbers per fish) of *Coregonus peled* larvae and fry in night illuminated cages located in Lake Leginskie in 1979
located in Lake Leginskie in 1979

Date	Fish length (mm)	Number of fish		Food organisms									
		exa-mined	with food	Ro	Na	Co	Me	Eu	Bo	Da	Lk	By	Ve
May, 11	10.0–12.9	6	5	0.4	5.6	1.8	–	–	–	0.2	–	–	
May, 17	12.0–14.9	10	10	0.1	14.1	5.0	–	–	–	0.1	–	–	
May, 29	19.0–24.9	10	10	0.9	0.7	6.2	5.4	3.1	3.0	13.6	–	–	
June, 3	23.0–25.9	10	10	–	0.3	8.2	0.8	–	40.4	29.6	0.2	–	
June, 18	23.0–35.9	10	10	–	0.4	14.9	17.6	32.6	7.0	100.8	8.1	–	
June, 22	32.0–44.9	10	10	–	–	5.3	7.0	211.7	50.9	69.8	1.1	–	
June, 27	53.0–65.9	10	10	–	0.3	1.5	3.6	1.0	1.4	89.4	–	–	2443
August, 13	67.0–92.9	10	10	–	1.1	–	39.9	4.1	4.7	67.9	160.9	0.1	
September, 27	118.0–140.9	10	10	–	–	30.5	356.9	9.6	63.6	117.0	102.0	57.6	
October, 10	129.0–174.9	7	7	–	–	194.3	1485.7	46.4	3035.7	2002.8	740.0	196.4	
November, 13	132.0–168.9	6	1	–	–	–	882.4	52.0	306.0	3606.0	–	2.0	

replaced by the juvenile forms of *Copepoda.* Due to changes in zooplankton composition, changes in relations between the *Coregonus peled* Gmel. food components, in successive years, were noted. (Fig. 6 and 7). Energetic value of *Coregonus peled* Gmel. food, taken in May, in the day time did not exceed 0.05 cal level, increasing up to about 0.1 cal/individual in the night time (Fig. 5).

In the successive years of *Coregonus peled* Gmel. rearing its character of feeding, during the summer stagnation in the lake, was changing. During the day time number of prey ranged from 5 to 10 individuals/fish, droping down to 2.5 individuals/fish in July (Fig. 3). Energetic value of that food was lower than 0.05 cal/individual (Fig. 3) with Copepoda copepodits playing the main role in that food (Fig. 6).

A night time preying character of *Coregonus peled* Gmel. was influenced greatly by relations between the planktonic organisms, under the cladocerans deficit. In 1977, almost throughout the whole summer stagnation, number of prey taken by *Coregonus peled* Gmel. was stabilized at the level of about 25 individuals/fish (Fig. 3). Main components were *Daphnia cucullata* and copepodits of Copepods (Fig. 6). Next year, a dynamic increase in number of prey from about 50 (at the end of May) up to about 500 individuals at the end of July) per alimentary tract of *Coregonus peled* Gmel. was

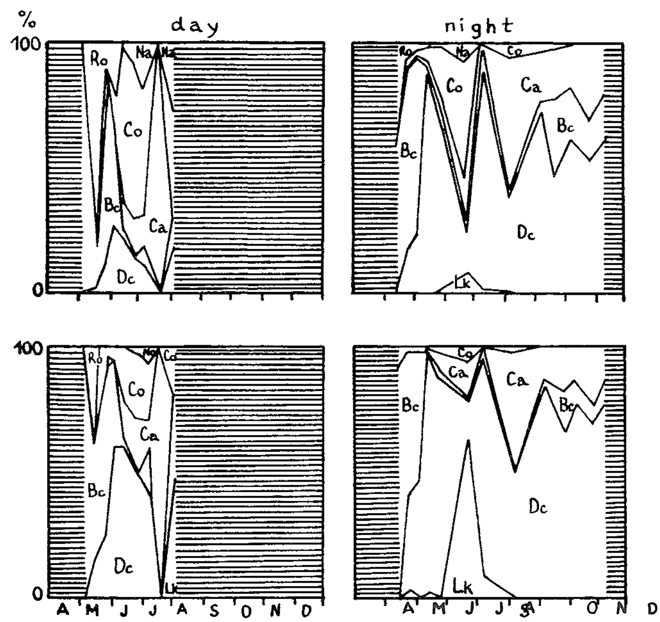
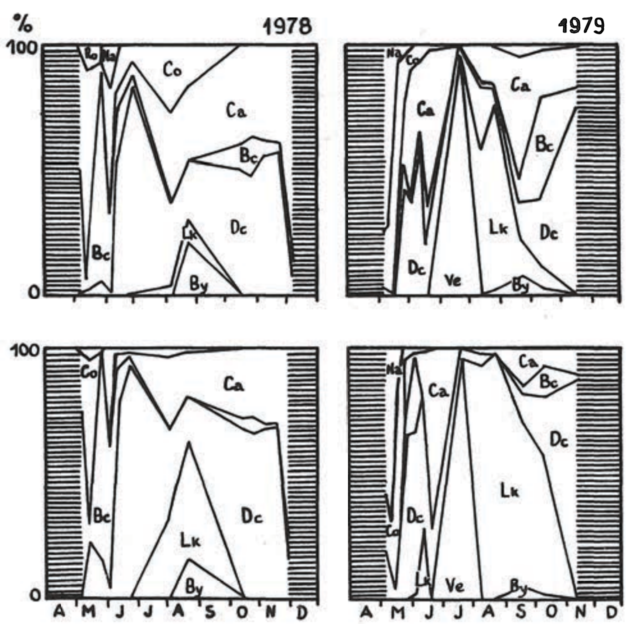


Fig. 6. Quantitative (above) and energetic (beneath) composition of zooplankton within the *Coregonus peled* Gmel. food in 1977. From the bottom to the top: Lk = *Leptodora kindti* Dc = *Daphnia cucullata*, Bc = *Bosmina coregoni*, Ca = *Copepoda adults*, Co = *kopepodits*, Na = *nauplia*, Ro = *rotifers*.

observed. The food was enriched by a quantitative and energetic share of *Copepoda* (mainly copepodits and adults individuals of *Eudiaptomus graciloides*/and *Leptodora kindti* (Fig. 7). By the end of July, 1979, number of prey caught reached its maximum level of about 2500 individuals per fish. That time *Coregonus peled* Gmel. was feeding mostly on *Dreissena polymorpha* veligers- attached to an experimental platform- and on *Leptodora kindti* (Table 4). In effect an energetic value of food taken by the fish, during successive experimental years, was quite variable. At the end of July it ranged from 0,2 to 10 cal/individual (Fig. 5). Those differences influenced the fish growth, which, during the time of experimental rearing, reached 41.8; 49.9 and 60.7 mm in, respectively, 1977; 1978 and 1979.

Differences in the quantitative and qualitative composition of the *Coregonus peled* Gmel. food were visible also in autumn seasons 1977--1979. Number of planktonic organisms taken ranged from 250 (in 1977) to over 5000 individuals (in 1979) per fish (Fig. 3). Energetic value ranged, respectively, from 1 to about 100 cal per individual (Fig. 5). Prevailing part of food, both quantitatively and energetically, were cladocerans, such as: *Daphnia cucullata, Leptodora kindti, Bosmina coregoni* and *Bythotrephes longimanus* (Fig. 6 and 7). Essential were also copepods – *Eudiaptomus graciloides.*



Quantitative (above) and energetic (beneath) composition of zooplankton within the *Coregonus peled* Gmel. food, in 1978 and 1979. From the bottom to the top: By = *Bythotrephes longimanus,* Lk = *Leptodora kindti,* Ve = veligers of *Dreissena polymorpha,* Dc = *Daphnia cucullata,* Bc = *Bosmina coregoni*, Ca = Copepoda adults, Co = kopepodits, Na = nauplia, Ro = rotifers.

Table 5

Electivity index in *Coregonus lavaretus* L. and *Coregonus peled* Gmel. for the main zooplankton taxa during day (D) and night (N) feeding in cages (May – July 1977)

Notations: Ro = Rotatoria, Na = nauplia, Co = copepodits, Cy = Cyclopidae, Dia = Diaptomidae, Bo = Bosminidae, Da = Daphnidae, Lk = Leptodora kindti

	Month		Ro	Na	Co	Cy	Dia	Do	Da	Lk
C. lavaretus	May	D	–1.0	–0.94	+0.86	+0.38	–0.80	+0.43	–0.24	0.0
		N	–1.0	–0.99	+0.89	+0.23	–1.0	+0.84	+0.26	0.0
	June	D	–1.0	–0.97	+0.01	+0.26	+0.78	+0.60	+0.94	–0.50
		N	–0.98	–0.79	+0.12	–0.21	–0.44	+0.88	+0.13	+1.0
	July	D	–1.0	–0.31	+0.93	+0.99	+0.90	+1.0	+1.0	+1.0
		N	–0.95	–0.31	+0.84	+0.70	+0.70	+1.0	+1.0	0.0
C. peled	May	D	–0.27	–0.43	+0.02	0.0	–1.0	+0.80	–0.14	0.0
		N	–0.71	–1.0	+0.04	+1.0	+1.0	+0.89	+0.47	+1.0
	June	D	–0.89	–0.15	+0.78	+0.46	–1.0	+0.38	+0.80	–1.0
		N	–0.87	–0.83	+0.36	–0.57	–0.56	+0.84	+0.18	+1.0
	July	D	–1.0	+0.35	+0.96	+0.96	–0.19	+1.0	+1.0	+1.0
		N	–1.0	–0.12	+0.95	+0.55	+0.97	+1.0	+1.0	+1.0

Electivity

Electivity coefficient values, calculated for May, are erroneous to some extend, because size of larvae snout, influencing its feeding possibilities at the preliminary stage of growth, was not taken into consideration. In the following months, when larvae could catch all kind of prey and when the r_i and p_i values were high, the electivity coefficient was more reliable.

Both tested *Coregonidae* species showed positive electivity towards cladocerans and *Cyclopidae* in the day and the night time as well (Table 5). Together with the fish size growth an increase of the electivity coefficient value, up to maximum (+1,0), was observed. Electivity towards *Diaptomidae* was variable and changed from positive to negative due to a seasonal dynamic of copepods and its reaction to light. Practically, throughout the whole rearing period, in cages, fishes showed negative electivity towards rotifers and nauplia of copepods (Table 5 and 6). A character of the electivity changes towards individual zooplankton groups was very simillar for both reared Coregonidae species.

DISCUSSION

Results of many surveys done by other authors indicate, that insufficient number and quality of food, available for the *Coregonidae* larvae causes its high mortality due to starvation. A critical period in the larvae life, when changing a source of energy from interior one to food from an environment, creates the survival possibilities for individuals, living under various nutritional conditions (Jezierska et al. 1978, 1979; Grudniewski, 1980). During ontogenesis, there are fast developmental changes in: morphological and anatomic features, alimentary tract, swimming abilities and larvae behaviour (Stroband and Dąbrowski, 1979; Mähr et al. 1983; Dąbrowski, 1986; Mamcarz, 1988). Together with an increase of energetic needs, there is a rapid increase in larvae' demand for food. According to Geisler (1953) a minimal daily nutrition dosis for the vendace hatch was equal to about 40, 80 and 150 nauplia in the first, second and third week of age, respectively. According to Braum (1967), during the first three days, at the temperature 11°C, a 10-hours food ration of *Coregonus wartmanni* increases from 13 to 44 individuals of zooplankton. Einsele, cited by Kriegsmana (1970), publishes, that the *Coregonus lavaretus* L. larvae feeding demands increases from about 500 organisms, per individual of 20 mm in length, up to 1000 organisms for fish of 30 mm in length. Studies of Hoagman (1974) suggest the feeding minimum for *Coregonus clupeaformis* to be 10 to 20 planktonic organisms per day, at the water temperature 14.4°C. According to Dąbrowski's (1976) calculations, *Coregonus lavaretus* L. larvae consumes daily, during its first 16 days of life, 80 to 97 organisms of zooplankton, at the temperature 13.5°C. All the above cited results, obtained at various laboratories for various fish species and nutrition, approach life conditions and larvae feeding strategy in nature. . Some data on feeding of *Coregonidae* larvae in natural

Table 6

Electivity index in *Coregonus peled* Gmel. for the main zooplankton taxa during night feeding in cages (1978–1979)
Notations as in Table 5

Month	Ro	Na	Co	Cy	Dia	Bo	Da	Lk
1978:								
May	−0.80	−0.71	+0.36	−1.0	−1.0	+0.85	+0.04	0.0
June	−1.0	−0.80	+0.09	−0.38	+0.32	+0.24	+0.50	−0.88
August	−1.0	−0.96	+0.67	+0.93	+0.86	+1.0	+0.88	+0.87
September	−1.0	−1.0	−1.0	0.0	−1.0	−1.0	−1.0	−1.0
October	−1.0	−1.0	−1.0	+0.93	−0.21	+0.81	+0.92	0.0
November	−1.0	−1.0	−1.0	+1.0	+0.04	+1.0	+0.48	0.0
December	−1.0	−1.0	−1.0	+1.0	−0.68	−0.49	−0.04	+1.0
1979:								
May	−0.94	+0.10	+0.69	+0.74	+0.76	+0.56	+0.91	0.0
June	−1.0	−0.99	−0.14	−0.87	+0.80	+0.62	+0.50	−1.0
September	−1.0	−1.0	−0.28	+0.97	−0.44	+0.95	+0.71	+1.0
November	−1.0	0.0	−1.0	+0.49	−0.93	+1.0	+0.23	0.0
December	0.0	−1.0	−1.0	−1.0	−1.0	−1.0	−1.0	0.0

environment (Lindström, 1962; Salojärvi, 1979; Dąbrowski et al. 1984; Huusko et al. 1988) proves a number of planktonic organisms taken by one fish is very variable and ussually lower than the one calculated experimentally. It is influenced, in between, by uneven distribution of zooplankton (Salojärvi, 1979; Ponton and Müller, 1987), light conditions (Hoagman, 1974) and other factors. Even a slight changes in zooplankton concentration result in a high variability in larvae survival (Taylor and Freedberg, 1984). Under such conditions a feeding selectivity reflects not only larvae needs but also its possibilities (Hoagman, 1973; Hartmann, 1986; Niesslbeck and Klein, 1988).

Larvae rearing, in the illuminated cages, where, attracted by the light, zooplankton is concentrated, creates a very convenient feeding situation for larvae. Practically all planktonic organisms are directing towards the light source, giving huge concentrations during its maximum growth season. It is essential for an increase in larvae survival, due to minimalization its energetic loses, when seeking for food in the critical period of life. A feeding strategy of *Coregonidae*, reared in cages, also changes. Under natural conditions a character oflarvae feeding changes a lot due to availibility of planktonic organisms (*Lindström, 1970; Naesje et al. 1986).* However, nauplia and copepodits of copepods are the basic prey (Flüchter, 1980; Salojärvi, 1979; Dąbrowski et al. 1984; Niesslbeck and Klein,1988). Together with an increase of food concentration, larvae select bigger prey (Rajasilta and Vuorinen, 1983) and grow faster (Korovina et al. 1975). From the very first weeks, there is a strongly underlined pression on greater organisms noted, if only a larvae snout size is big enough. Already in May, number of consumed cladocerans reaches 50 to 100 individuals/fish. Nauplia and copepodits of copepods lose, in cages, its priority in fish feed, and its significance for fish increases when availability of *Cladocera* is limited.

During the whole rearing time, in cages, a negative electivity of *Coregonus lavaretus* L. and *Coregonus peled* Gmel. towards nauplia was observed. Nutritional meaning of *Rotatoria*, under those conditions, is even less pronounced. Larvae of *Coregonus peled* Gmel., bigger at the moment of hatching, did not accept rotifers from the beginning, however smaller ones consumed rotifers at the first two months in small numbers. Individuals from *Keratella* and *Polyarthra* species were the main prey, although, which is interesting, *Asplanchna* dominated both; quantitatively and in size. Lack of interest in rotifers during rearing of Coregonidae larvae in cages and a natural environment, was noted by the others/Marciak et al. 1976; Marciak, 1979; Salojärvi, 1979; Dąbrowski et al. 1984). A sporadic come back to the same type of feeding resulted from a compulsory situation (Hoagman, 1973; Marciak, 1979; Flüchter, 1982).

A particular role, in the formation of intensive feeding competition, accompanied by an increased fish mortality, in cages, played periods of decreases in copepods number due to its seasonal dynamics (June-July). An increased feeding pression of *Coregonidae* on all bigger zooplanktonic organisms present in the cages, including such atypical as veligers of *Dreissena polymorpha*, was noted then. A reflaction of feeding relations in cages, when some fishes were starving, was increase in size variability and in condition of individuals (Mamcarz, 1984).

Right from the beginning of an autumn homothermy, nauplia were of no nutritional value for *Coregonidae* reared in cages. There was a drop in copepodites share, as well, replaced by a maximum pression on *Cladocera* and adults copepods. During autumn, there was, also, an increase in number of prey taken, exceeding, often, level of 5.000 to 7.000 individuals/fish. The *Coregonus peled* Gmel. fry feeding ration ranged, in the successive years of rearing, from 1 to 100 cal/fish. Even in 1979 rations were below the data possible to be obtained under the natural conditions. According to Tichomirova (1978), a feeding ration of *Coregonus peled* Gmel fry in the Vrevo Lake was 0.288 kcal/individual. Dmitrenko (1978) stated, that to reach the weight 4.2–30.0 g *Coregonus peled* Gmel. needs 33.1–150 kcal/individual, which converted to food, respond to 52–254 g. An energetic maximum for *Coregonus lavaretus* L., determined by Giussani and Bernardi (1977), equal to 2550 cal per individual, was noted at the end of August. According to that, an autumn rearing in cages does not seem to cover the nutritional needs of Coregonidae.

Under the natural conditions several essential changes in type of *Coregonus lavaretus* L. and *Coregonus peled* Gmel. feeding were noted. An increase in amount of food taken is being accompanied by a drop in efectiveness of using it for growth (Gordeeva et al. 1975; 1976, Sterligov et al. 1977). Besides, there is an increased pressure on big *Cladocera organisms* (Grimaldi, 1972; Giussani, 1974), with a feeding spectrum enriched in benthos organisms (Loskutova and Solovov, 1969; Naesje et al. 1986; Novoselov, 1987). It is not possible to be done in cages, that is why fishes are dependent on an autumn developmental peak of *Cladocera*. It dictates the limits to productive possibilities, because under such conditions number of individuals in cages are to be minimal.

SUMMARY

Studies on feeding of larvae and fry 0+ of two *Coregonidae* species (*Coregonus lavaretus* L. and *Coregonus peled* Gmel.) reared in illuminated cages, in lake of an average feeding resources, were carried out. A quantitative and qualitative composition of fish food, taken during the day and a night time, was tested, as well as fish electivity towards various zooplanktonic categories and energetic value of an average feeding ration per fish.

It was stated, that fish feeding characteristic, in cages, is dependent on the organisms composition in the spring and autumn planktonic peaks. The first prey of *Coregonus lavaretus* L. larvae are nauplia and copepodites while for *Coregonus peled* Gmel. rotifers and juvenile copepods. In succesive rearing months an increasing pressure of *Coregonidae* towards big planktonic forms (cladocerans and adult copepods) is noted. Together with the fish growth there is an increase in number of consumed organisms per individual, up to 5.000–7.000 organisms during autumn season. The parallel increase of energetic value of the taken food takes place. Besides essential fluctuations in quality, quantity and energetic value of zooplankton available for fish in cages, in succesive rearing seasons. An autumn planktonic summit does not cover the nutritional needs of fish, that is why rearing continuation up to an autumn is being uneffective.

The differences in the nature of the both fish species feeding were discussed and obtained results were compared to the ones for fish feeding in natural environment.

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STUDIA NAD ODŻYWIANIEM SIĘ LARW I NARYBKU DWU GATUNKÓW RYB GŁĄBIELOWATYCH (COREGONIDAE) PODCZAS PIERWSZEGO ROKU PODCHOWU W SADZACH OŚWIETLONYCH

STRESZCZENIE

Badano odżywianie się larw i narybku 0+ dwu gatunków Coregonidae (Coregonus lavaretus L. i Coregonus peled Gmel.) podczas podchowu w sadzach oświetlonych w warunkach jeziora o przeciętnej zasobności pokarmowej. Określano skład ilościowy i jakościowy pokarmu ryb w czasie dnia i nocy, elektywność w stosunku do różnych kategorii zooplanktonu a także wartość energetyczną średniej racji pokarmowej przypadającej na jedną rybę.

Stwierdzono, że o charakterze odżywiania się ryb w sadzach decyduje skład organizmów w wiosennym i jesiennym szczycie planktonowym. Pierwszym pokarmem larw siei są nauplii i kopepodity, natomiast u pelugi wrotki i młodociane stadia widłonogów. W kolejnych miesiącach podchowu wzrasta zdecydowanie presja Coregonidae na duże formy planktonowe (wioślarki i dorosłe widłonogi), wraz ze wzrostem ryb zwiększa się ilość organizmów konsumowanych w przeliczeniu na jednego osobnika aż do 5–7 tysięcy sztuk w okresie jesiennym. Odpowiednio do tego wzrasta wartość energetyczna zjadanego pokarmu. Wykazano znaczne wahania w jakości, ilości i wartości energetycznej zooplanktonu przypadającego na ryby w sadzach w kolejnych sezonach podchowu. Jesienny szczyt planktonowy nie zabezpiecza już potrzeb pokarmowych ryb, w związku z tym kontynuowanie podchowu do jesieni jest nieefektywne. Omówiono różnice w charakterze odżywiania się obu gatunków a także porównano uzyskane wyniki z informacjami o odżywianiu się ryb w środowisku naturalnym.

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