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Pisciculture

THE USE OF LAKE ZOOPLANKTON AS FEED FOR CARP (*CYPRINUS CARPIO* L.) FRY IN POND CULTURE

ZASTOSOWANIE ZOOPLANKTONU JEZIORNEGO DO KARMIENIA NARYBKU KARPIA (*CYPRINUS CARPIO* L.) W HODOWLI STAWOWEJ

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Carp fry reared in ponds beginning from the larval stage was fed on live zooplankton which has been captured in river near the place of its outflow from the lake. The best out of the obtained results was rearing of 1830 kg/ha of young fish during 62 days (from June 4 to August 4) with average weight of 2.64 g. Average survival rate amounted 47%. Density of 140 fry individuals per square meter is considered as optimal.

INTRODUCTION

Poland has possibilities to develop the carp culture in the typical fish farms as well as in artificially preheated waters. Moreover, stocking of the natural waters with fry of this species, especially polluted ones is recommended. Carp is adapted to life in the over-fertilized and polluted environments. Growing in such waters it accumulates biogens in its body, and finally they are removed from water together with caught fishes. The shortage of fry creates difficulties in development of stocking and culturing of this species. It was shown in earlier works that mentioned shortage could be reduced by use of lake zooplankton as feed for fry rearing (B. Szlauer – 1976a, b; 1977 a), and solution of

mass catch of zooplankton in lake outflow was presented (B. Szlauer – 1977 b). The aim of this work was an attempt to culture the carp fry in small ponds with use of live lake zooplankton as a feed. As an example of experiments based on analogous assumptions, the succesful attempt of mass rearing of carp fry in preheated water with feeding on lake zooplankton could be pointed out (E. Seidlitz and U. Seidlitz, 1972).

METHODS

The zooplankton required for carp fry feeding was captured by means of nets placed in the river Płonia about 100 meters below its outflow from the lake Płoń. Length of the used cylindrical nets constructed out of nylon gauze 0.28 mm mesh size, reached 4–5 meters (Fig. 1). Inlet of the net was kept in open position by the rigid frame. Rear of the net was always placed beyond the water surface. During catch (Fig. 1A) zooplankton was

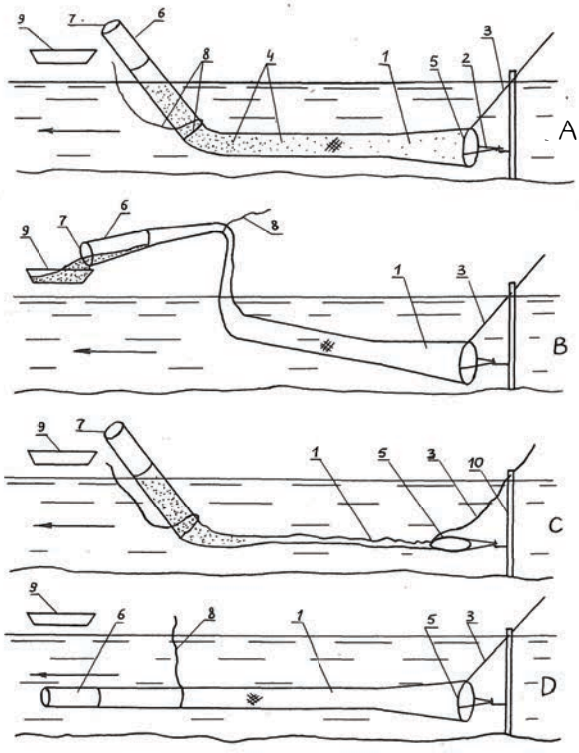

Fig. 1. The net used for plankton catch in an ebb flowing out from a lake. A – stage of catching operation, B – stage of pouring off of captured plankton, C – stage of the net flushing (way I), D – stage of the net flushing (way II) 1 – net; 2 – fastening line; 3 – line serving for the net opening and closing; 4 – filtering section of the net made out of fabric 0.2 mm mesh size; 5 – inlet frame; 6 – passage tube made out of thick fabric; 7 – outlet of the net; 8 – lifting line; 9 – vessel for the captured plankton; 10 – pile

concentrating in the terminal part of net. The way of harvesting collected zooplankton from the net is shown on Fig. 1B. The catching net required often flushing. It has been made by two means which are shown on Fig. 1C and 1D. Two or three such nets were used simultaneously. For better results were obtained by more frequent harvesting of the captured zooplankton from the net, the nets were emptied at possibly short time intervals.

Freshly caught, concentrated zooplankton was transferred to barrel containing about 40 l of water, and allowed to stay there for 15 minutes. Over this time dead animals, impurities, and part of phytoplankton have fallen on the bottom. Supernatant water was carefully poured off, leaving the sediment on the bottom of barrel. By this mean live animals swimming in a water layer were separated, and were released into the ponds with surrounding water through the net 1 mm mesh size. This filtration prevented introduction of leeches, bugs and mature carp lice (*Argulus*) to the ponds. Because sediment which was left on the barrel bottom still contained a lot of live animals, it was resuspended in a new portion of water, and after sedimentation live specimens intended for fish feeding were decanted. Unfortunately, together with the live zooplankton large amounts of planktonic algae were introduced to the ponds.

Accordingly to assumptions the raised fry was intended to feed in excess, so that zooplankton could be visible in the every sample of water taken from ponds. As a matter of fact, this condition was fulfilled only at the beginning of the culture because later the rate of fry feeding was unsatisfactory.

The quantitative samples of zooplankton were taken from the river from February to August, 1977 and 1978. The number of animals and their weight were determined for these samples. On the basis of these data, and flow rate of water in the river, the wet weight of zooplankton carried out by river Płonia from lake Płoń was estimated.

At 1978, from June to August, quantitative samples of zooplankton were taken simultaneously from culture ponds and river Płonia for estimation of nutritional conditions existing in ponds, as well as for determination of nutritional selectivity of carp fry. Contents of the alimentary canals of fry were also determined for five individuals from the sample.

Carp fry culture was conducted in the provisional ponds, lined (for sealing) with foil of horticultural type, and with ridges formed by the pushed down soil. Foil only made the pond bottom. At 1977 only three ponds were operation (No. I–III). Next ponds were buildt at 1978, and marked by numbers IV–XII. Dimensions of the ponds, and their arrangement shows Fig. 2. The ponds were flooded with water from the river to the depth of 50–80 cm shortly before release of the fish larvae. Emptying of the ponds was done in August during harvest of the fry. Water losses caused by evaporation and draining were complemented in the meantime. Sporadically, part of water was replaced to improve environmental conditions.

Temperature, oxygen content, and water reaction were registered in the ponds and river. Over the days June 20 – June 22, 1978 these parameters were measured at the different times of day.

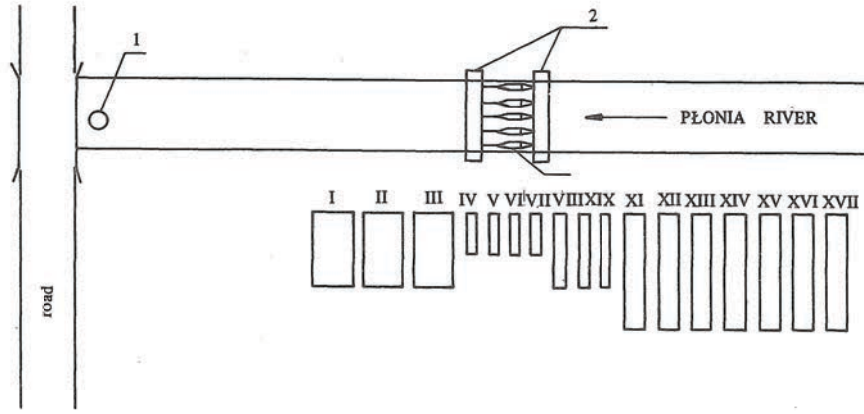

Fig. 2. Lay-out the ponds for carp fry rearing in Lubiatów. 1 – plankton catch station; 2 – plattorms; 3 – trout cages; I–XVII – ponds for carp fry rearing.
Dimensions in meters: I – 4.5X8.0; II and III – 3.6X8.0; IV and VII – 1.5X4.0; VIII–X – 0.9X8.0; XI–XVII – 2.0X12.0.

The fish larvae coming from artificial spawning and incubation were used for stocking of the ponds. At June 4, 1977, four days old fish larvae were released into ponds I and II, while pond III was stocked with fish larvae harvested from the natural spawning ground. The fry was harvested at August 8, 1977. At May 28, 1978, the ponds were stocked with several days old fish larvae coming from the Gosławice fish farm. Pond I was inhabited most lightly – 266 fry pieces per square meter, while the ponds IV, V, and VI were heavily stocked i.e. 1530 individuals per sq. meter. Those three ponds were intended to serve as provisional storing place for fish larvae. Ponds VIII–X and XV–XVII were not used for carp rearing. The fry was harvested at August, 16, 1978.

The following factors measuring culture effects were assumed: rate of fish survival, increment, and production of the fry calculated as the difference between the total weight of harvested, and released fish. This production was next calculated over 1 hectare of pond area.

RESULTS

The estimation of river Płonia plankton resources over 1977–1978 is given in Tables I and II. From May to August 1977, i.e. over the period of fry rearing the river removed from the lake 249.5–723.9 kg (average 510 kg) of zooplankton daily (wet weight). The adult and growing up copepods were predominating in a plankton mass, exceeding cladocerans, rotifers, and nauplii. Slightly different sequence was noted at July. The following species had predominating validity in the zooplankton biomass: *Daphnia*

Table 1

Wet weight of zooplankton removed by the river Płonia from the lake Płoń (kilograms per day) – year 1977

Species \ Month	II	III	IV	V	VI	VII	VIII
Daphnia	0	1.5	2.5	170.5	88.3	0	124.7
Bosmina	7.6	6.4	10.6	75.2	59.2	8.0	13.4
Chydorus	0.2	1.1	1.4	12.5	2.6	12.7	28.1
Other *Cladocera*	0	0	0	1.5	1.7	0	0
Eudiaptomus	46.1	85.7	127.5	153.2	114.9	8.2	7.2
Mescocyclops	0	0	0	186.3	237.4	119.2	190.8
Cyclops	690.0	800.5	669.7	0	0	0	0
Naupli	169.6	234.9	281.5	18.0	12.3	10.5	19.5
Rotatoria	8.8	23.2	19.8	106.7	43.8	90.9	124.7
Total *Cladocera*	7.8	9.0	14.5	259.7	151.8	20.7	166.2
Total *Copepoda*	736.1	886.2	797.2	339.5	352.3	127.4	198.0
Nauplii	169.6	234.9	281.5	18.0	12.3	10.5	19.5
Total *Rotatoria*	8.8	23.2	19.8	106.7	43.8	90.9	124.7
Totaly	922.3	1153.3	1113.0	723.9	560.2	249.5	508.4

Table 2

Wet weight of zooplankton removed by the river Płonia from the lake Płoń
(kilograms per day) – year 1978

Species \ Date	14 III	15 IV	15 V	28 V	6 VI	15 VI	1 VII	2 VIII	15 VIII
Daphnia	0.1	0	0.2	15.5	268.9	18.4	0.2	15.0	10.2
Bosmina	0.6	0.2	0.2	0	100.5	16.5	20.8	0.5	2.3
Chydorus sphaericus	1.3	9.1	8.0	0	67.4	0.1	0	8.3	30.4
Other *cladocerans*	0	0	0	0	0	1.6	0.3	0	1.3
Eudiaptomus	10.5	30.0	10.4	11.3	399.6	14.5	0	56.8	17.6
Cyclopoida	35.2	103.8	11.4	28.2	54.9	13,4	3.0	13.9	19.4
Total *Cladocera*	2.0	9.3	8.4	15.5	436.8	36.6	21.3	23.8	44.2
Total *Copepoda*	45.7	133.8	21.8	39.5	454.5	27.9	3.0	70.7	37.0
Nauplii	11.1	30.1	11.8	2.3	20.4	2.9	3.6	2.4	5.1
Total *Rotatoria*	0.3	0.8	0.2	0.4	6.7	2.6	4.8	16.1	10.6
Totally	59.1	174.0	42.2	57.7	918.4	70.0	32.7	113.0	96.9

Table 3

The comparison of qualitative composition and quantity of zooplankton in the river Płonia (A) and in the culture ponds with carp fry (B). Number of individuals per 1 liter

Date 1978	6 VI		15 VI		1 VII		2 VIII		15 VIII		Mean	
Species	A	B	A	B	A	B	A	B	A	B	A	B
Daphnia	264.0	0.8	9.9	0.9	0.8	1.6	2.4	0	4.5	1.3	56.3	0.9
Bosmina	315.0	7.3	50.4	2.7	78.0	84.2	0.8	3.6	12.0	1.3	91.5	19.8
Chydorus	182.0	3.9	0.6	0.3	0	1.6	12.0	1.2	37.0	1.2	46.3	1.6
Other *Cladocera*	0	0	1.5	0	0.4	0.4	0	0	0	0	0.4	0.1
Eudiaptomus	512.0	4.1	1.8	4.2	0	0.8	8.0	0.7	2.0	0.6	14.8	2.1
Cyclopoida	132.0	5.9	33.9	9.0	6.0	10.8	32.0	4.4	29.5	10.0	45.5	8.0
Nauplii	91.2	56.6	19.5	44.4	24.8	36.2	37.6	26.2	78.5	46.1	50.3	41.9
Rotatoria	169.6	1311.0	666.0	1747.5	120.4	7216.0	407.6	2330.6	269.5	2867.1	302.5	3094.4
Totaly *Crustacea* (excluding *Nauplii*)	1405.0	22.0	98.1	17.1	85.2	99.4	55.2	9.9	85.0	14.4	258.8	32.5

cucullata, D. longispina, Bosmina coregoni crassicornis, Eudiaptomus gracilis, E. graciloides, Cyclops vicinus, C. kolensis, and *Mesocyclops leuckarti* (Table 1). In 1978, over the same months (May–August), grown up, and adult crustaceans predominated with respect to biomass over minor forms – nauplii and rotifers (Table 2). The more important species were the same as in 1977. River Płonia removed 32.6–918.4 kg (average 190 kg) of zooplankton daily.

The zooplankton delivered to the ponds was there eaten up by the fry. Results of the fish pressure upon zooplankton are shown in Table 3 where composition of zooplankton from the ponds is displayed on the background of river Płonia zooplankton i.e. of zooplankton delivered to the ponds. Compared to river plankton, the plankton from ponds was entirely different with respect to number of adult and growing up crustaceans which was lower on the average about eight times. Average concentration of these animals amounted in river 258.8 specimens per liter, while on the other hand only 32.5 specimens per liter in the ponds. Especially, the number of cladocerans of *Daphnia* and *Chydorus spp.* was markedly reduced. Situation of rotifers and nauplii appeared quite differently. There were ten times more rotifers in the ponds than in the river plankton. On the other hand, the number of nauplii was almost the same in the ponds (41.9 specimens per 1.), and in the river (50.3 specimens per 1.). Distinctly lower concentration of nauplii in the ponds was observed only at the outset of culture at June 6 (Table 3).

It should be emphasized that lessening of crustacean number was already ascertained at June 6, i.e. after nine days of stay of the fish larvae in ponds. The other interesting phenomenon was increase of the rotifer number in the ponds as the culture was continued. Their concentration reached the peak at July 1 (7216 specimens per 1.).

The alimentary canal contents of the plankton fed fry presents Table 4 and 5. The composition of the Płonia river zooplankton which served as feed is also shown in these tables. It proceeds from Table 4 concerning 1977' culture that mainly copepodits of *Cyclopoida, Chydorus*, and *Bosmina* made up the feed of carp larvae at the 10th day of life. In the later period, i.e. up to the end of June it did not change. The fish larvae almost did not eat rotifers or ate minimal quantities of them, at the beginning period of life. During the first month of culture, because of the small demand for feed the fish larvae seeked food in the conditions of its excess. For this reason the composition of feed of fish larvae reflected their alimentary selectivity. Attention should be paid to the considerable importance of Cladocerans – *Chydorus* and *Bosmina* in the feed of fry, although they occuppied later quantitative positions in the river plankton. The intensity of feeding of this still very young fry was striking because at June 27, the average number of *Cyclopoida* kopepodits per one alimentary canal amounted up to 1153 specimens. So young fishes often ate up copepods of *Eudiaptomus sp.* which is considered as difficult to catch animal because of its ability to make long and rapid jumps. In the later period of culture (July and beginning of August), the crustaceans – *Cyclopoida, Bosmina,* and *Chydorus* continued to dominate in the feed of mentioned fry, but on the other hand, the rotifers occured always alongside of them in relatively high numbers. This created somewhat paradoxal situation i.e. grown up fry included the smallest forms of plankton – rotifers, to its diet.

Table 4

The feed of carp fry fed on the river Płonia zooplankton. Average numbers of specimens per one alimentary canal are reported*. Year 1977.

Date	Taxon No. of pond	*Rotatoria*	*Bosmina*	*Chydorus*	*Daphnia*	*Cyclopoida*	*Eudiaptomus*	*Insect larvae*	Contribution of more important animals in the river Płonia zooplankton. In kilograms of animals removed by the river from the lake per day
10 VI	I	0.2	4.6	4.6	0.8	8.0	0.6	0.0	*Cyclopoida* – 237 *Eudiaptomus* – 115 *Daphnia* – 88 *Bosmina* – 59 *Rotatoria* – 44 *Nauplii* – 18 *Chydorus* – 12
	II	–	–	–	–	–	–	–	
14 VI	I	0.0	4.6	13.0	4.0	7.2	0.4	0.0	
	II	–	–	–	–	–	–	–	
17 VI	I	0.6	15.2	13.2	0.4	17.8	5.0	0.0	
	II	0.2	23.6	8.6	1.0	44.6	6.6	0.0	
27 VI	I	58.4	68.4	0.0	28.6	1153.0	164.0	0.0	
	II	1.2	182.8	0.0	4.0	155.4	95.8	0.0	
1 VII	I	3.7	525.0	0.0	0.0	33.0	4.0	0.3	*Cyclopoida* – 119 *Rotatotia* – 91 *Chydorus* – 13 *Nauplii* – 10 *Bosmina* – 8 *Eudiaptomus* – 8
	II	60.8	95.6	0.0	2.6	37.8	7.2	0.0	
9 VII	I	5.6	10.8	0.0	0.0	37.2	0.0	1.6	
	II	2.8	2.8	0.2	0.0	2.4	0.0	0.0	
16 VII	I	7.8	576.3	20.0	0.0	156.3	5.0	1.3	
	II	7.8	3.0	4.8	0.0	59.0	4.2	0.2	
25 VII	I	7.5	358.8	37.5	12.0	413.8	47.5	1.3	
	II	20.4	2.6	0.8	0.2	12.2	4.0	0.4	
29 VII	I	8.3	98.3	225.0	16.7	1608.0	6.7	1.7	
	II	1046.0	5.0	8.0	1.8	26.8	0.8	6.4	
4 VIII	I	32.0	110.0	258.7	9.3	100.7	0.0	0.0	*Cyclopoida* – 191 *Daphnia* – 125 *Rotatoria* – 125 *Chydorus* – 28 *Napulii* – 19 *Bosmina* – 13 *Eudiaptomus* – 7
	II	32.0	0.0	12.0	0.0	4.0	0.0	0.0	

* Calculations based on the investigations of 5 individuals.

Table 5

The feed of carp fry fed on the river Płonia zooplankton. Average numbers of specimens per one alimentary canal are reported*. Year 1978

Date, average fish weight and length	Taxon / No of pond	*Rotatoria*	*Bosmina*	*Chydorus*	*Daphnia*	*Cyclopoida*	*Eudiaptomus*	*Insect larvae*	Contribution of more important animals in the river Płonia zooplankton. Specimens per 1 liter
6 VI 21.2 mg 1.18 cm	I	0	2.2	4.8	1.0	4.4	17.6	0	*Eudiaptomus* – 512.0
	III	0.2	16.6	17.2	5.4	8.4	1.4	0.2	*Bosmina* – 315.0
	VI	0.4	6.2	13.0	1.2	4.6	0	0	*Dapnia* – 264.0
	XI	1.2	5.2	10.8	2.6	0.2	3.6	0	*Chydorus* – 182.0
	XIII	0.8	4.4	5.8	1.0	1.0	0.4	0	*Rotatoria* – 169.6
	mean	0.5	6.9	10.3	2.2	3.7	4.6	0.04	
15 VI 39.0 mg 1.37 cm	I	0	120.6	2.8	45.8	73.0	14.0	0.4	*Rotatoria* – 666.0
	III	0.6	153.0	8.6	72.2	65.4	22.8	0.2	*Bosmina* – 50.4
	VI	0.2	113.2	0.4	30.6	4.8	6.6	0	
	XI	0.4	91.8	3.8	22.8	9.0	1.0	0.2	
	XIII	0	57.0	2.4	24.4	22.8	0	0.2	
	mean	0.2	107.1	3.6	39.2	33.0	8.9	0.2	
22 VI 40.6 mg 1.47 cm	I	1.0	56.4	23.8	10.8	24.0	2.2	0.4	*Cyclopoida* – 33.9
	III	116.0	26.6	12.2	10.0	21.4	1.0	1.4	
	VI	120.4	68.4	13.8	8.4	1.0	0.2	0.8	*Nauplii* – 19.5
	XI	1.8	74.8	18.6	15.6	25.4	0.6	0.2	
	XIII	11.6	19.0	19.6	3.8	35.2	0.2	1.4	*Daphnia* – 9.9
	mean	50.2	49.0	17.6	9.7	21.4	0.8	0.8	
1 VII 79.2 mg 1.67 cm	I	0.4	454.4	0.6	3.0	48.2	34.8	0.2	
	III	2.6	144.2	0.4	2.2	64.4	1.4	2.0	*Rotatoria* – 120.4
	VI	18.6	89.6	1.0	3.4	130.2	8.6	0.2	
	XI	0.6	110.2	1.0	4.2	73.0	1.2	0	*Bosmina* – 78.0
	XIII	0.6	94.4	1.2	4.4	41.0	1.4	3.0	
	mean	4.6	178.6	0.8	3.4	71.4	9.5	1.1	
14 VII 116.4 mg 1.84 cm	I	2.0	15.4	0.2	1.2	16.0	18.8	1.8	*Nauplii* – 24.8
	III	8.4	1.6	0	0	1.8	0.2	0.2	
	VI	0.8	0.2	0	0	0.6	0.4	0	*Cyclopoida* – 6.0
	XI	25.6	0.4	0	0	2.0	0	0.2	
	XIII	16.4	0.2	0	0	0	0	0.4	*Daphnia* – 0.8
	mean	10.6	3.6	0.04	0.2	4.1	3.9	0.5	
2 VIII 194.6 mg 2.33 cm	I	144.4	8.6	7.6	1.6	32.6	10.2	4.0	*Rotatoria* – 407.6
	III	221.2	12.4	12.8	1.2	15.0	6.0	5.8	*Nauplii* – 37.6
	VI	18.6	4.6	7.6	4.6	110.2	29.4	6.0	*Cyclopoida* – 32.0
	XI	8.4	6.0	14.6	3.0	62.8	20.4	1.8	*Chydorus* – 12.0
	XIII	330.0	2.8	11.6	1.8	64.0	7.2	0.4	*Eudiaptomus* – 8.0
	mean	144.5	6.9	10.8	2.4	56.9	14.6	3.6	
15 VIII 420.0 mg 2.81 cm	I	137.0	76.0	101.0	29.0	162.0	3.0	53.0	*Rotatoria* – 269.5
	III	71.0	66.0	203.0	22.0	377.0	1.0	1.0	*Nauplii* – 78.5
	VI	8.2	206.8	424.0	65.4	455.0	6.0	1.0	*Chydorus* – 37.0
	XI	5.8	15.0	212.0	19.6	210.0	1.0	0	*Cyclopoida* – 29.5
	XIII	1.0	22.2	188.8	30.6	296.0	2.4	0.6	*Bosmina* – 12.0
	mean	44.6	77.2	225.7	33.3	300.0	2.7	11.1	

For the duration of culture at 1978, it was ascertained that about 10 days old fry ate mainly cladocerans *Chydorus* and *Bosmina*, and in pond I also copepods of *Eudiaptomus sp.* (Table 5). It was noted that over this period *Bosmina* and *Chydorus* were not dominating quantitatively in the Płonia river zooplankton (Table 5). The cladocerans – *Bosmina* and *Daphnia* continued to dominate in the feed after the next decade (June 15) though their number (especially *Daphnia*) was very low in the delivered plankton. On the initial days of life of fish larvae, the rotifers were almost not included in the feed. The fishes began to eat up the rotifers on the later period of culture – from the end of June to the half of August.

Alimentary canal fillings of the fry reared in 1978 was very low. Average numbers of plankton animals per one alimentary canal in a few cases exceeded 500 specimens even among grown up fry at August.

The nauplii always occuring numerously in the brought in plankton have not been found in the fry feed. The fishes might not have eaten these larvae, or the nauplii were damaged in the alimentary canals to the extent making identification impossible.

For the almost entire duration of culture, the fry have eaten up larvae of *Tendipedidae* which developed in the culture ponds.

Table 6 gives up description of thermic conditions, oxygen content, and reaction of water in the ponds. On the basis of these, and other observations it could be stated that at 1978, only over 30 initial days of culture duration, the temperature at the daytime was higher than 20°C, reaching even 26°C. In the later period, from the end of June to August 16, temperature of pond waters reached only 18°C at the daytime. This cool period, lasting about 50 days did not promoted the feeding intensity, and growth of the warm liking carp fry. Temperatures of pond waters during warm days were higher in comparison to river e.g. at May 28, 1978, this temperature difference amounted 5°C. The great diurnal temperature variations were also ascertained e.g. at June 20–21, 1978 – 18.5°C was noted at 4:00 A.M. while at 2:00 P.M. – 23°C was registered.

The great variations of the oxygen content were noted – from 4.0 to 15.4 mg 0_2 per liter. Periodic oversaturation and deficits of oxygen occured in the pond waters (Table 6). Daily variations of the oxygen content were also noted (Table 7). During daily maximum, by the days from June 20 to 22, at 3:00 P.M., oxygen content in ponds reached almost 15 mg per liter, while in the extremal cases at 4:00 and 5:00 A.M. it dropped to 4.5 and 5.1 mg 0_2 per liter, respectively.

Water reaction had values in the limits of pH from 7.2 to 8.8. The cultures maintained over 62 days in 1977, gave a number of interesting results. In the pond I with the area of 36 sq meters, there were raised 2500 pieces of fry with total weight of 6.6 kg. Counting it over one hectare of pond gives about 690 000 pieces of fry with total weight of 1830 kg. This biomass is almost equivalent with production from one hectare obtained after 62 days. In the pond II with area of 29 sq.m. there were harvested 8330 pcs. of fry with total weight of 3.5 kg which after counting over one hectare is equivalent to 2 870 000 pcs. of fry and production of 1200 kg.

Table 6

Physical and chemical characteristics of water in the fry ponds. Doubly underlined numbers – cases of oxygen supersaturation; singly underlined numbers – oxygen deficits

Properties of water	Temperature (°C)						pH						O_2 mg per liter					
No. of ponds	I	III	VI	XI	XIII	river	I	III	VI	XI	XIII	river	I	III	VI	XI	XIII	river
28 V 78	25.0	25.0	25.0	25.0	25.0	21.0	–	–	–	–	–	–	9.6	9.6	9.6	9.6	9.6	9.9
6 VI	25.0	25.0	26.0	25.5	25.0	–	7.5	7.5	7.6	8.0	7.9	–	11.0	8.3	9.8	9.4	9.0	–
15 VI	19.5	20.3	20.9	20.6	20.9	19.0	7.2	7.2	7.4	7.4	7.2	7.1	8.0	8.6	11.2	15.4	12.2	14.7
1 VII	17.0	17.0	17.5	17.4	17.4	18.2	7.7	7.9	8.0	8.2	8.1	7.5	6.7	8.6	9.1	8.0	8.0	7.4
14 VII	17.3	17.1	17.6	18.1	17.9	17.8	7.3	7.3	7.3	7.2	7.2	7.1	5.6	6.1	4.0	5.9	6.4	7.2
16 VIII	18.0	17.0	–	17.5	17.5	17.0	7.8	8.8	–	7.7	7.6	7.8	12.8	12.5	–	9.0	8.6	11.8

Table 7

Daily variations of the oxygen content (mg O_2 per liter) in the water of fry ponds
June 20 - 22, 1978

Hour / No. of pond	3:00 P.M.	5 A.M.	10 A.M.	3:00 P.M.	4:00 A.M.
1	12.9	7.0	7.4	12.2	9.0
3	12.3	4.5	–	11.0	7.8
6	11.5	8.6	7.3	11.5	7.2
11	–	5.1	6.7	10.7	8.2
13	11.8	8.5	8.2	9.6	7.5
river	9.6	8.6	8.5	9.9	6.9

More detailed data concerning the fry reared in pond I are given in Table 8. In the final day of experiments (August 4, 1977), the fishes reared there reached average length 5.4 cm, and average weight of 2.64 g. The biggest individuals exceeded 5.0 g. So that was the carp fry consistent with the approved standards. The fry reared in pond II where its initial concentration was much higher than in pond I, gave smaller crop (Table 9). At August 4, the fishes had average length and weight – 2.8 cm, and 0.42 g, respectively. The heaviest individuals reached just 0.8 g.

In the pond III stocked with fish larvae from spawning ground, only a few individuals there were caught, but on the other hand mass occurence of bugs belonging to *Notonecta glauca* was ascertained there.

The culture lasting 80 days, maintained over summer season of 1978, gave the results shown in Table 10. In all ponds with total area of 214 sq.m. there were reared 43 752 pcs. of fry which made 47% of total number of released individuals. Average survival of the fishes varied from 4% in pond II to 89% in pond XIV. The result of 112% survival noted in pond III has been regarded as the result of error. Taking into account that for the average estimation the data concerning 11 ponds were taken, this result did not aggravate the averages too much. Total weight of the fry harvested from all ponds amounted 19.988 kg. Average length (l_t) of the fry amounted 30 mm in the range from 14 to 54 mm. However, such a broad range included the entire group of fishes. Considerably narrower range of lengths was noted among individuals coming from the particular ponds. Large differentiation of the average lengths was ascertained for the individuals coming from the different ponds – from 22.8 mm in pond VI to 48.9 mm in pond II. Average individual weight of the fry amounted 0.62 g, while the range of weight for entire crop was 0.07 to 2.9 g. Average weights of fishes from different ponds also varied in a considerable extent – from 0.26 g in pond VI to 2.34 g in pond II. More detailed data about the rate of fry growth shows Table 10.

Table 8

An increase of body weight and total length (l_t) of carp fry reared from June 4 to August 4, 1977 fed with the river Płonia zooplankton

Pond I

Date	Number of culture days	Average length (l_t) (cm)	Range of lengths in the sample (cm)	Average weight (grams)	Range of weights in the sample (grams)
4.VI.77	0	0.5	–	0.001	–
10.VI.77	7	0.75	0.7–0.8	0.0024	0.0007–0.0028
14.VI.77	12	1.1	0.9–1.3	0.0154	0.0057–0.0263
17.VI.77	15	1.4	1.1–1.6	0.0320	0.0042–0.0490
27.VI.77	25	2.4	2.1–3.0	0.24	0.1066–0.4240
1.VII.77	29	2.4	2.1–2.6	0.20	0.1660–0.2460
9.VII.77	37	3.5	2.7–3.8	0.64	0.3043–0.8610
16.VII.77	44	4.1	3.7–4.7	1.30	0.9330–1.7310
25.VII.77	53	4.5	4.2–5.1	1.53	1.3345–2.2874
29.VII.77	57	4.6	4.4–4.8	1.78	1.5902–2.1588
4.VIII.77	63	5.4	4.9–6.9	2.64	1.9127–5.247

Table 9

An increase of body weight and total length (l_t) of carp fry reared from June 4 to August 4, 1977 fed with the river Płonia zooplankton

Pond II

Date	Number of culture days	Average length (l_t) (cm)	Range of lengths in the sample (cm)	Average weight (grams)	Range of weights in the sample (grams)
4.VI.77	0	0.5	–	0.001	–
10.VI.77	7	0.75	0.7–0.8	0.002	0.0007–0.0028
14.VI.77	12	1.1	0.9–1.3	0.015	0.0057–0.0263
17.VI.77	15	1.5	1.3–1.8	0.034	0.0034–0.085
27.VI.77	25	1.5	1.3–2.0	0.05	0.023–0.119
1.VII.77	29	1.7	1.4–1.9	0.06	0.029–0.081
9.VII.77	37	1.9	1.6–2.3	0.12	0.053–0.143
16.VII.77	44	2.6	2.1–3.0	0.32	0.124–0.486
25.VII.77	53	2.4	2.1–3.0	0.26	0.135–0.454
29.VII.77	57	2.8	2.3–3.5	0.40	0.207–0.710
4.VIII.77	63	2.8	2.1–3.5	0.42	0.140–0.810

Table 10

Results of carp fry rearing with feeding on the lake Płoń zooplankton in 1978

No. of pond	Stocking at the moment of culture beginning			In the moment of harvest after 80 days culture, August 16, 1978									
	Number of ind. in the pond	Total weight (grams)	Number of ind. per 1 sq. m.	Number of ind. in the pond	Total weight (grams)	Percentage of survival	Average length of ind. (mm)	Range of lengths (mm)	Average ind. weight (grams)	Range of ind. weights (grams)	Daily increase of ind. weight (grams)	Number of ind. per 1 hectare	Production kilograms per 1 hectare
I	9600	19	266	6482	3176	68	31.1	22–51	0.49	0.22–1.47	0.006	1800556	877
II	8560	17	295	389	910	4	48.9	38–54	2.34	1.43–2.90	0.029	135069	310
III	8560	17	295	9578	3544	112	27.6	19–41	0.37	0.11–1.09	0.005	3325694	1225
IV	9200	18	1530	3262	886	36	30.1	19–45	0.55	0.10–1.35	0.007	5436667	1447
V	9200	18	1530	1388	500	15	25.4	16–41	0.36	0.07–1.10	0.004	2313333	803
VI	9200	18	1530	1584	396	17	22.8	14–40	0.26	0.07–1.00	0.003	2640000	630
VII	5500	11	920	2096	707	39	24.1	16–44	0.29	0.12–1.47	0.004	3493333	1160
XI	7860	15	327	4028	1853	51	29.2	18–46	0.49	0.11–1.24	0.006	1678333	766
XII	8400	16	350	4556	3600	54	34.7	25–47	0.79	0.34–1.64	0.010	1898333	1493
XIII	9800	20	408	2896	1419	30	29.8	18–46	0.49	0.11–1.25	0.006	1206667	583
XIV	8400	16	350	7493	2997	89	26.7	17–47	0.40	0.08–1.40	0.005	3122083	1242
Mean	8570	16	709	3977	1817	47	30.0		0.62		0.008	2459097	958

In each pond a few really big specimens were met – with lengths from 6.0 to 12.0 cm, and weights from 5 to 35 g. Because of the great divergences from the mean values, the dimensions of these individuals were not taken into consideration when averages were calculated.

To make possible comparisons of culture results in the particular ponds, the number of harvested fishes and production were counted over 1 hectare of pond area. Two last columns of Table 10 present such re-counted data. It proceeds out of them that the highest number of fishes per 1 hectare was reared in the pond IV (5.4 milions), while the smallest number came from pond II (135 000). Effect of culture interpreted as the weight of the harvested fishes per 1 hectare was greatest in pond XII (1493 kg), and least in pond II (310 kg).

Over the period of culture duration at 1978, there were observed symptoms of cannibalism. Weak and small fishes were attacked by the other individuals which have sponged on them eating up eyeballs, fins, and even biting up the pieces of muscle tissue. The reared fry was annoyed by carp lice (*Argulus foliaceus*). In spite of filtration of the zooplankton furnished as feed the *Argulus* penetrated into ponds. At the very beginning they were met sporadically. As the culture developed, the number of parasites increased as a result of multiplication and introduction of new individuals with the plankton. The attempts to fight this parasite by means of "Foschlor" have not given any result.

Other negative phenomenon occuring during fry rearing was mass development of filamentous algae (*Spirogyra*) occupying bottom of the ponds in a thick layer. An excess of these algae made difficult harvest of fry when ponds were emptied.

The frogs living in the ponds fed on young fishes causing severe losses of the fry. Refuge of the fishes during heavy down-pour, (night – August 8, 1978) causing overflow of waters through causeways, was rather unexpected reason of the fry losses.

DISCUSSION

The zooplankton mass described in the results of this work which is removed by the river from lake Płoń determines the largeness of easy available nutritional resources which could be utilized for rearing of the carp fry. Assuming that fry would have been reared from the larval stage to the stage of July fry with 3.0 g weight, and considering nutritional coefficient as equal 5, the presumable production of such fry has been estimated. It appeared that mass of zooplankton taken off from May to August would have been sufficient for rearing about 4 milions pieces of the July fry at 1977, and about 1.36 milions of such fry at 1978. It proceeds from this evaluation that in the same spring period Płonia river carried away on the average 510 kg of zooplankton per day in 1977, and only 190 kg in 1978. The mass of the zooplankton removed at 1978 was smaller in comparison to 1977 and 1971, as well (B. Szlauer 1976 b). The fluctuations of this kind should be also expected in the future. They are quite normal, resulting from the distinctness of weather conditions in particular year. Mentioned quantities illustrate

potential possibilities. Permanent exploitation of the whole zooplankton flowing our from the lake is not easy to accomplish, because among others, it is difficult to capture it entirely from the river.

On the other hand, it should be taken into consideration that zooplankton removed from the lake by river is only part of zooplankton existing in the lake Płoń. Accordingly to B. Szlauer (unpublished data) zooplankton biomass of the lake Płoń reaches in the summer months 10 g per cubic meter. Assuming the average biomass content as 5 g per cubic meter it was calculated that 200 kg of zooplankton exists on each hectare of the lake area which makes about 140 tons for the whole lake. This basic source of food could be always included into exploitation when actual demand will arise.

As a feed for the fry rearing we would like to propose the zooplankton from the lake outflow before all. The considerable flow rate of river water speaks for it because it makes possible settling of nets for the mass catch of zooplankton. The method of the zooplankton catch in the outflow is exceptionally simple. The catching net does not require pulling out of the water, and servicing of its is limited to emptying and washing of its terminal part. Single man may work on the whole set of simultaneously catching nets. It is more difficult to exploit lake Płoń. In this case we recommend the device consisting of the overboard boat motor with appropriately attached plankton net (Szlauer et. al. 1978). This device may be installed on the lake shore or may serve for catching of zooplankton from boat (floating version).

The value of the live zooplankton as a feed for carp larvae is a matter requiring explanation. The zooplankton is natural food of carp in its initial period of life, and tentative feeding of fish larvae with artificial feed did not give positive results up to date. Ostroumova et al. (1979) carried off extensive experiments with application of granulates with different compositions of constituents. They proved that during five initial days of life fish larvae do not take artificial feed, eating only zooplankton. They propose feeding of fish larvae with zooplankton exclusively, up to the fifth day of life, and application of zooplankton and dried feed in equal proportions over the next 15–20 days. An exclusive use of fodder is possible when carp attains 150 mg. Similar conclusions were drawn by Littak et. al. (1979). Their experiments have shown that giving of supplementary fodder to carp larvae is purposeful from the 10th day of culture, and fodder quantities should not exceed 15 percent of the total weight of reared young fishes. They did not obtain satisfactory growth rate od fry although zooplankton was used as supplement of folder (about 37% of food rations). The results of studies quoted as an example prove distinctly for the use of live zooplankton for feeding of fish larvae.

On the basis of zooplankton composition in fry ponds, as well as contents of alimentary canals of fry, it could be concluded that young fishes demonstrated distinctive nutritional selectivity in relation to planktonic crustaceans. The fry was feeding on species out of genus *Bosmina, Chydorus, Daphnia, Cyclops,* and even *Eudiaptomus*. It was eating up the mature and growing up forms of these crustaceans, but on the other hand the nauplii were not eaten. The rotifers were obviously omitted by the fry. These animals were introduced to the ponds everyday but they were not eaten up, so number of

rotifers and nauplii was increasing. Moreover, number of these animals increased as a result of reproduction, especially intensive was multiplication of the rotifer species most rarely occuring in the river.

The clear tendency toward feeding of fish larvae on planktonic crustaceans, including species reaching length of 1 mm (*Daphnia cucullata, Eudiaptomus, Cyclops*) was already shown by the ten days old carp. This finding being after all consistent with research data of some authors (Grygierek, 1973; Trzoch-Szulkiewicz, 1970) controverts popular opinions predicating that small rotifers serve as initial feed of carp larvae. Feeding on rotifers was found to be more intensive in the later period of culture. Existence of this paradoxal situation, when grown up young fishes change their feed to smaller forms (rotifers) could be explained only by shortage of food in ponds, and resulting from this fish starvation. For this reason the rotifers are recognized as the obligatory feed of reared fishes.

Not looking deeper into problem of nutritional inclinations of juvenile carp, it may be thought from the results that carp larvae, and next carp fry are able to utilize almost all animals from the lake Płoń plankton. The possibility of eating up the largest planktonic forms by the youngest stages of carp, as well as possibility of eating up the tiny rotifers by the several centimeters long fry should be taken into account.

Physical and chemical conditions prevailing in the ponds with cultured fry could be defined as highly variable, and dependent on weather and the time of a day. It concerns especially temperature and oxygen content of water. Large variations of water temperature happening in a short time intervals resulted from the small thermic inertion of the slight mass of pond water.

Large variations of the oxygen content (4 to 15.4 mg 0_2 per liter) resulted from the overfertilization and overcrowding of ponds by living organisms. Filamentous algae were developing in masses, concentration of fishes was high, and microflora was developing on the plankton debris. As a result, assimilating algae caused oversaturation of water with oxygen during sunny weather, while over cloudy days, and at nights, it has came to oxygen deficits which resulted from respiration processes.

The results of fry culture fed on the basis of the lake zooplankton may be evaluated from several points of view – number of grown up pieces of fry, individual weight etc. From the standpoint of usefulness for continuation of culture the good-looking appearance of fry and its production should be the measure for estimation of the culture effects. Applying these criterions, the production of 1830 kg of fry i.e. 690 000 pcs. with average individual weight 2.64 g, counted over 1 hectare of pond I in 1977, was recognized as the best result of culture. Second place is occupied by pond XII where after 80 days in 1978, 1493 kg of fishes (1.89 milions of pcs. of fry with average weight 0.79 g) counted over 1 hectare of pond were obtained. Third result was obtained in pond II where production amounted only 310 kg of fry per 1 hectare mainly due to fish escape. Large number of small fry lighter than 0.5 g has been grown in the other ponds. This kind of fry has also value for continuation of culture or as stocking material.

Results of culture obtained in 1978 were considerably worse in comparison to which were obtained in pond I at 1977. Unsatisfactory feeding at 1978 was identified the main reason. A number of observations bears evidence about it i.e. incomplete of alimentary canals at 1978, cannibalism, composition of plankton in the ponds. additional evidence bearing witness to unsatisfactory feeding was the case of pond Probably due to partial escape of the fry in the moment of harvest it contained number of fishes – 130 specimens per sq. meter. The same portions of plankton has made available here to the fishes like in the other ponds which created better conditions. As a consequence, good-looking fry characterized by average weight 2.34 g and relatively even size – from 1.43 to 2.9 g, has been grown here.

Accordingly to Grygierek (1973) investigations, production of fry from fish larvae without fertilization amounted 96–246 kg per hectare with mortality rate from 58 to 89 per cent. These results are comparable with our data, emphasizing distinctly the positive results obtained by the use of zooplankton as feed.

Coming to an end of our deliberations about effects of fry culture we would like to point out the result that may be taken as a basis to foresee culture effects in large ponds with use of live zooplankton as a feed. That is production in pond I at 1977 i.e. 1830 kg per hectare which corresponds to 690 000 pcs. of fry with mean individual weight 2.64 g after 2-months culture without additional use of fodder. Such effects could be expected in the relatively primitive ponds without water flow. The remaining results have been recognized as too low – effects of 1978, culture mainly due to unsatisfactory feeding, and on the other hand 1977, culture effects as resulting from overcrowding of the pond II.

Commonly known rules of fish culture, as well as results of experiments indicate that appropriate stocking of ponds is among others required to get good culture effects. In our opinion ponds serving for carp fry rearing with use of zooplankton as a feed should be stocked with larvae in concentration of 140 pcs, per sq. meter of pond. It was calculated assuming 47% survival rate, and the same final culture results as obtained at 1977 in pond I. This calculation concerns provisional ponds without water flow. The ponds with flow of water could have been stocked more intensively.

The usefulness of June fry coming from the ponds near Płonia river for further rearing was checked by its use as stocking material in the experimental ponds. The positive results concerning survival and growth rate of this fry in comunal sewage waters of Nowogard city are reported in L. and B. Szlauer (1978) paper. Positive effects were also obtained when rearing of this fry was continued in sewage waters of Chemical Company "Police". Out of the small fry with average weight 0.225 g during 100 days, culture (July 4 to October 13, 1978) there were obtained fishes with average weight 48.3 g (range 5–240 g).

Fish cultures carried out over two years have shown that the sole disease symptom observed among fry fed with zooplankton was annoying of fishes by *Argulus foliaceus*. It has shaken opinions expressed by sceptics about possibilities of fish disease transmission by live zooplankton used as feed which is not justified from biological standpoint.

Argulus undoubtedly causes considerable losses in fish culture but in spite of it the fish survival is high and amounts almost 50%. The parasite could not be destroyed by use of "Foschlor"* – it was more resistant to the action of this compound than cultured fry. In our opinion the solution is to accept its presence in the ponds and to use appropriately higher initial stock to compensate the losses.

Other negative phenomenons observed in pond cultures are of such nature that they could be tempered. The excess of filamentous algae may be "raked-off" or their growth could be limited by rising the level of pond water up to about 1 meter. It proceeds from our observations that combination of this depth with the "outburst" of planktonic algae reduces amounts of light permeating on to bottom to the level which does not permit for development of the lying on the bottom *Spirogyra*.

The ponds should be preserved against frogs by net fencing. They should be also equipped with net preserved overflows, making possible draining away the excess of waters after showers.

Presented method up carp fry rearing may be developed into culture of commercial meaning. That could be made by building of appropriate center in the region of river outflow from a lake. Considering weather variations, this kind of enterprise should be equipped with preheated workshop similar to the horticultural glassworks with ponds for rearing of fish larvae. Moreover, the center should contain open air ponds type of the first nursery ponds. All culture vessels should contain devices maintaining regular water flow, and making possible entire evacuation of water. To get selfsupport the center has to be equipped with facilities for artificial spawning and fish eggs incubation. The size of a center would have been dependent on the planned production of fish fry. The initial concentration of fish larvae in ponds amounting 140 individuals per sq.m., and production of July fry of magnitude 1800 kg may be assumed for the necessary calculations. Feeding of fry would have been relied upon supply of plankton captured by means of nets fastened in an outflow or in a lake. Moreover, the plankton could have been supplied with water flowing out through the ponds. Supplementary feeding of fry with use of traditional fodder is also foreseen in the final stage of culture.

After harvesting of the June fry the ponds could have been filled again with water, and used for rearing of some quantity of the autumn fry.

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* Phosphororganic insecticide (25% Trichlorphon).

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Translated: dr Edward Ceronik

ZASTOSOWANIE ZOOPLANKTONU JEZIORNEGO DO KARMIENIA NARYBKU KARPIA (*CYPRINUS CARPIO* L.) W HODOWLI STAWOWEJ

Streszczenie

W latach 1977–78 hodowano karpia od wylęgu do narybku lipcowego w kilkunastu nieprzepływowych stawach zbudowanych tuż przy wypływie rzeki z jeziora Płoń. Narybek był karmiony żywym zooplanktonem odławianym w rzece przy pomocy specjalnych sieci. Najlepszym z uzyskanych wyników było wyhodowanie 1830 kg narybku karpia w przeliczeniu na 1 ha stawu, o średnim ciężarze 2,64 g, po 62 dniach hodowli (4 VI–4 VIII 77 r.). Stopień przeżycia narybku wyniósł średnio 47%. Za najwłaściwszą gęstość obsady nieprzepływowych stawów uznano 140 szt. wylęgu na 1 m^2.

Narybek karmiony zooplanktonem jeziornym zjadał głównie dorosłe skorupiaki z rodzaju *Bosmina, Chydorus, Daphnia* a nawet *Eudiaptomus.* Wyraźnie pomijał natomiast wrotki i naupliusy. Taką wybiórczość pokarmową stwierdzono już u dziesięciodniowego wylęgu karpia. Zjadanie wrotków w większych ilościach stwierdzono dopiero u podrośniętego narybku, w sytuacji gdy

zabrakło w stawach skorupiaków i ryby zaczęły głodować. Intensywność żerowania narybku była wysoka. Liczba *Cyclopoida*, przypadająca na jeden przewód pokarmowy narybku, w wieku 30 dni, dochodziła do 1153.

Przyjmując współczynnik pokarmowy równy 5, wyliczono, że zooplankton wynoszony z jeziora Płoń przez rzekę, w okresie od maja do sierpnia, wystarczyłby do wyhodowania 4 mln narybku lipcowego w roku 1977 i około 1 360 000 takiego narybku w roku 1978. Są to potencjalne możliwości.

Warunki fizyczne i chemiczne, panujące w stawach z hodowanym narybkiem odznaczały się małą stabilnością. Wahania tlenu wynosiły od 4,0 do 15,4 mg O_2/1. Zanotowano też duże wahania temperatury i natlenienia w skali dobowej.

Zjawiskiem negatywnym w prowadzonych hodowlach było nękanie narybku przez splewkę (*Argulus foliaceus*). Masowy rozwój nitkowatego glonu (*Spirogyra*) w stawach utrudniał odłów narybku podczas spuszczania stawów.

Uzyskane wyniki wskazują na możliwość rozszerzenia opisanego sposobu hodowli narybku karpia do skali gospodarstwa. Taki obiekt mógłby być zbudowany w rejonie wypływania rzeki z jeziora Płoń.

Б. и Л. Шлауэр

ИСПОЛЬЗОВАНИЕ ОЗЕРНОГО ЗООПЛАНКТОНА В КАЧЕСТВЕ КОРМА МОЛОДИ КАРПА (CYPRINUS CARPIO L.) ВЫРАЩИВАЕМОЙ В ПРУДАХ

Резюме

В 1977-1978 годах выращивали карпа от вылупления до 2-х месячного возраста в нескольких непроточных прудах построеных рядом с выходом реки из озера Плонь. Молодь кормили зоопланктоном который отлавливали в реке с помощью специальных сетей. Самим лучшим результатом можно считать получение 1830 кг карпа со средним весом 2,64 гр после 62 дневного выращивания (4 VI -4 VIII 77 г.). Выход молоди составил в среднем 47%. Считают, что оптимальной плотностью посадки непроточных прудов является 140 шт. личинок на 1 $м^2$. Молодь кормленная озерным зоопланктоном потребляла в основном ракообразные следующих родов: Bosmina, Chydarus, Daphnia и даже Eudiatomus. Молодь отчетливо отрицала коловраток и науплюсов. Такую кормовую избирательность обнаружили уже у десятидневных личинок. Потребление коловраток в большом количестве обнаружили лишь у подросшей молоди когда в прудах нехватало ракообразных и рыбы начинали голодать. Интенсивность потребления корма мальками была очень высокой. Число Cyclopoida находящихся в одном пищеварительном тракте 30 дневного малька доходило до 1153 шт. Принимая кормовой коэффициент равным пяти подсчитали, что количество зоопланктона выносимого рекой из озера Плонь в период с мая по август хватило бы для выращивания 4 млн 2-х месячных мальков в 1977 г. и 1,36 млн такой же молоди в 1978 году. Это потенциальные возможности. Физические и химические условия в исследованных прудах характеризовались малой стабильностью. Содержание кислорода колебалось от 4 до 15,4 мг O_2/л. Отметили

большие колебания температуры и содержания кислорода в течение суток. Отрицательным явлением при выращивании было поражение молоди Argulus foliaceus. Массовое размножение нитчатых водорослей (Spirogyra) в прудах затрудняло отлов молоди во время спуска прудов. Полученные результаты указывают на возможность применения описанного метода разведения молоди карпа в промышленных масштабах. Промышленный рыбоводный комплекс можно построить в районе выхода реки из озера Плонь.

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