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# FEEDING INTENSITY OF SILVER CARP (*HYPOPHTHALMICHTHYS MOLITRIX* VAL.) FROM THE PAPROTECKIE LAKE IN THE ANNUAL CYCLE

ABSTRACT: The amounts of food consumed by silver carp introduced to eutrophic Paproteckie Lake were investigated. The period of food passage, diurnal and periodical food rations, fish increments and feeding coefficients were determined. Annual food consumption was estimated as 8.8 kg, 90% of which was in the three warmest months in the year. Weight increase of fish approximated the average one for the region. Feeding coefficient was about 19, fluctuating between 7.9 and 24.6.

KEY WORDS: Lake, fish, silver carp, passage period, food consumption, feeding coefficient.

Contents



## 1. INTRODUCTION

The silver carp is a species with which great hopes are connected in the Polish fish industry. The filtrating apparatus of silver carp which filtrates from water food particles of a size 25 μm allows for feeding with fine live and dead food particles suspended in water. Water bodies have great resources of this kind of food matter practically inaccessible for our native species of fishes. Although the mechanisms controlling the biological and ecological processes in a water body fully stocked with silver carp are very complex, it can be said that when finally catching big individuals additional production is obtained and food substances bound in fish tissues are obtained. Under Polish climatic conditions natural reproduction does not take place and the silver carp's influence on environment is mainly in the form of food sampling, excretion and body growth. Fragmentary results of these factors can be found in the available literature. They, however, concern fish cultivated in ponds or living under different climatic conditions. With regard to the increasing tendency to introduce the silver carp to our natural lakes studies have been initiated to obtain data on the amount of food consumed and the body growth of silver carp introduced to the eutrophic Paproteckie Lake.

## 2. MATERIAL AND METHOD

The Paproteckie Lake is a small eutrophic lake of the Masurian Lakeland. The water surface area is 27.8 ha, maximal depth 7.2 m and mean depth 3.5 m. The lake is elongated with a shallow and muddy southern part and a much deeper northern part. Vascular vegetation overgrows the littoral zone narrowly with some intervals. Water transparency expressed as the visibility of Secchi disc is low and does not exceed 1 m in the summer. Before the introduction of silver carp the following fish dominated in the lake: bream, roach, pike-perch and eel.

On April 9 and 10, 1976, the lake was stocked with silver carp: 1555 kg $\cdot$ $ha^{-1}$ of fish of the same age supplied by the Fisheries Experimental Station at Żabieniec. The fish stock had on average 34.5 cm in length, 667 g of weight and were 3+ old. There were no losses in transport.

Material for studies on increments of silver carp, passage period and food coefficients was collected between April 10, 1976 and March 25, 1977 (Table I). The increase in length and body weight and the increase in weight of silver carp during the year of investigations were calculated on the basis of mean lengths and body weights from the period of fish stocking and after periodical test catches. Material for studies of contents of alimentary tracts and the passage period was collected six times during the year. Fish catches were made always at noon assuming that the index of fullness at noon approximates the mean diurnal one. This was assumed on the basis of analysis of alimentary tracts of silver carp caught at different hours on May 4, 1976 and by comparing the indices of fullness.

Table I. Collected and analysed materials

| Date of sampling | Number of fish analysed | | | |
|---|---|---|---|---|
| | increases of length and body weight | diurnal pattern of feeding | passage period | weight of intestine contents |
| Apr. 10, 1976 | 24 | – | – | – |
| May 4, 1976 | 16 | 16 | 7 | 5 |
| June 24, 1976 | 6 | – | 19 | 5 |
| Aug. 14, 1976 | 34 | – | 4 | 5 |
| Sept. 28, 1976 | 27 | – | 9 | 5 |
| Nov. 16, 1976 | 10 | – | 5 | 5 |
| Mar. 25, 1977 | 11 | – | 6 | 5 |
| Total | 128 | 16 | 50 | 30 |

The fish were caught with the seine net. Immediately after catches the silver carp was divided into two groups. From the first group alimentary tracts were taken out and fixed in order to determine the weight and composition of food contents (J. Ciborowska-Leszczyńska – unpublished data). The second group was placed in polyester tanks with flow water filtrated through bolting-cloth No 25. Filtration of water made the feeding by fish impossible during the experiment. From the tanks the faeces were constantly removed. Temperature of water in tanks was the same as in the lake at the depth of 2 m. Every time and now some fish were taken from the tanks in order to check the degree of emptiness of alimentary tracts. The gradually increasing emptiness of alimentary tracts was estimated much easier by observing the faeces excreted by fish. The passage period was assumed as the number of hours from the moment of catching the fish to the moment when all fish caught at the same time had empty alimentary tracts. Diurnal food rations were calculated using the equation of Bajkov (1935):

$$D = A\,\frac{24}{n}$$

$D$ – diurnal ration (g), $A$ – mean weight of contents of alimentary tracts (g), $n$ – passage period (hours).

This equation was used by many authors, including some modifications, for different species of fish (Fortunatova 1961, Darnell and Meierotto 1962, Savina 1965, Omarov 1970, Backiel 1971, Nagięć 1973, Białokoz and Krzywosz 1978, Białokoz, Krzywosz and Zachwieja 1978).

To this equation coefficient 1.5 was introduced which was calculated on the basis of an experiment by the method resembling the one used by Omarov (1970) and Noble (1973). Namely, experimental silver carp divided into 3 groups with 5 individuals in each were kept in tanks with water abundant in phytoplankton (initial food). After three days of adaptation, during which the feeding was normal, crushed pellet "Evos No 2" was introduced into the first tank. To the second tank concentrated phytoplankton from another water body, differing in colour and shape, was introduced. The third group of fish in filtrated water was the control group. For all three groups the passage period of initial food was measured. Fish from the first group did not show preference to "Evos", their alimentary tracts were filled unevenly with new food, and although the digested "Evos" was distinctly different in colour and consistency from initial food (easier observations) no difference was observed in the passage period in the intestines of fish from group one and the control. In fish of the second group, fed with plankton with changed composition, the passage rate was much higher in the intestine much faster removing the initial food. The division between initial and final food was not at first visible, especially at the end of the experiment, but under the microscope it was very easy to distinguish these two kinds of food tkanks to mass contribution in the final food of shells of Dinophyceae of the genus *Ceratium*. At a temperature about 23°C, at which the experiment was conducted, the fish not fed for the second time (control group) emptied their alimentary tracts in 9 hours, whereas the fish fed for the second time with changed phytoplankton (second group) excreted the digested food after 6 hours. The quotient of emptiness of alimentary tracts was 1.5. And this ratio was assumed as a constant one during the entire year of experiment. Thus the cited above equation of Bajkov (1935) after modification was as follows:

$$D = 1.5\,\frac{24 . A}{n}$$

Diurnal rations for each group of fish caught at six different periods of the year were calculated. Then the food ration consumed by fish was estimated for the time between fish stocking and taking the samples. Also feeding coefficients for these periods were determined.

## 3. RESULTS

### 3.1. INCREASE IN LENGTH AND WEIGHT OF BODY

Good rate of increase in weight and length of fish was observed only late in spring and in the summer (Table II). Till the end of September mean increase of body length of fish (l.c.) was 5.6 cm and the mean weight increase by 474 g. The mid-November sample differed only slightly from the September sample, whereas the one from March 1977 should not be considered as representative. It was not abundant and the mean body length of fish in that sample was smaller than in the sample from previous periods.

In other eutrophic Masurian lakes stocked with similar fish material the mean seasonal increments fluctuated between 432 and 495 g. Thus, it can be said that increments of silver carp in the Paproteckie Lake are typical of eutrophic lakes in the region.

### 3.2. PASSAGE PERIOD

The passage period fluctuated from 10 hours at 22.6°C to 108 hours at 4.0°C (Table III). The higher the water temperature the shorter the passage period. The diagram showing the dependence of passage period upen temperature has a hyperbolic shape (Fig. 1). Some deviations from this dependence, most visible at 4°C, are undoubtedly due to varying degree of intestine fullness. Alimentary tracts containing more food (sample of March 25, 1977) are emptied slowlier than less full ones (sample of November 16, 1976) despite the identical temperature of surroundings. It should be pointed out that uncritical assumption of the time of intestine emptying as the basis for diurnal calculations would contain a serious error. Silver carp, similarly as other planktonivorous fish, only under exceptional conditions stops feeding till the alimentary tracts are emptied. In months of intense feeding this is an almost constant process. The just consumed food accelerates mechanically and perhaps physiologically the passage of food contents in the intestine. Own investigations as described in the chapter "Material and method" have proved that the passage period in constantly feeding fish is about 30% shorter than in fish which stopped feeding and is from 7 hours at 22.6°C to 72 hours at 4.0°C.

O k o n i e w s k a and K r ü g e r (1979), when examining the food passage in the intestine, have observed, using the isotope method, that for silver carp weighing 200–500 g the passage period at 22–25°C fluctuates between 5 hours and 32 minutes to 10 hours and 11 minutes (on the average 6 hours and 22 minutes). O m a r o v (1970), using the method of food labelling, has calculated the passage period in two years old silver carps weighing 320–370 g. At 23°C in June the passage rate was 4 hours. Considering that the passage period is usually longer for heavier fish the results obtained in this paper approximate the data of other authors. Unfortunately, there are no literature data for winter months and comparisons cannot be made with the passage period in the autumn-winter season.

Table II. Increase of length and body weight of silver carp in the Paproteckie Lake

| Parameters | Stocking | Catches | | | | | |
|---|---|---|---|---|---|---|---|
| | Apr. 10, 1976 | May 4, 1976 | June 24, 1976 | Aug. 14, 1976 | Sept. 28, 1976 | Nov. 16, 1976 | Mar. 25, 1977 |
| Number of individuals | 24 | 16 | 6 | 34 | 27 | 10 | 11 |
| The mean and the range of body length (l. c.) (cm) | 34.5 (25.5–39.0) | 34.4 (29.5–42.0) | 36.7 (33.0–40.0) | 38.8 (32.0–42.5) | 40.1 (37.0–42.5) | 39.9 (35.5–43.0) | 38.3 (35.0–41.0) |
| The mean and the range of body weight (g) | 667 (204–933) | 700 (388–1485) | 875 (653–1300) | 1049 (529–1493) | 1141 (985–1383) | 1155 (818–1575) | 1023 (747–1350) |

Table III. Consumption of food and feeding coefficients of silver carp in the Paproteckie Lake

| Date of sampling | Water temperature at a depth of 2 m (°C) | Index of fullness (‰) | Average weight of food calculated from indices of fullness (g) | Passage period (hours) | Diurnal food ration | | Food ration consumed for the period between stocking and sampling (g) | Increase of body weight for the period between stocking and sampling (g) | Feeding coefficient for the period between stocking and sampling |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | weight (g) | ‰ of fish body weight | | | |
| May 4, 1976 | 9.5 | 17.37 | 12.16 | 34 | 12.87 | 18.39 | 260.52 | 33 | 7.89 |
| June 24, 1976 | 22.6 | 32.54 | 28.47 | 10 | 102.49 | 117.13 | 3157.39 | 208 | 15.18 |
| Aug. 14, 1976 | 19.6 | 25.54 | 26.79 | 16 | 60.28 | 57.46 | 7329.13 | 382 | 19.19 |
| Sept. 28, 1976 | 14.8 | 0.02 | 0.02 | 26 | 0.03 | 0.03 | 8716.23 | 474 | 18.39 |
| Nov. 16, 1976 | 4.0 | 0.11 | 0.13 | 61 | 0.08 | 0.07 | 8718.90 | 488 | 17.87 |
| Mar. 25, 1977 | 4.0 | 2.28 | 2.33 | 108 | 0.78 | 0.76 | 8774.02 | 356 | 24.65 |

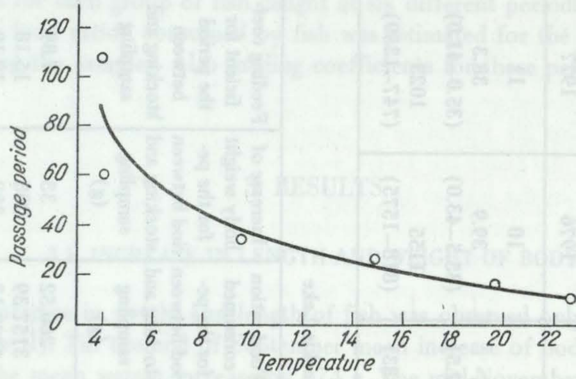


Fig. 1. Dependence of the passage period (in hours) upon the temperature (in °C)

### 3.3. DIURNAL AND PERIODICAL FOOD RATIONS AND FEEDING COEFFICIENTS

Mean food weight of fish used for determining the contents of their alimentary tracts ranged from 0.02 g at the end of September to 29.52 g in August. Indices of fullness fluctuated from 0.02‰ of fish body weight at the end of September to 32.54‰ in June (J. Ciborowska-Leszczyńska – unpublished data). Indices of fullness were used to calculate mean food weight for all fish caught at particular seasons of the year and it fluctuated from 0.02 g at the end of September to 28.47 g in June (Table III). Diurnal food rations broadly fluctuated. In May the food ration was 12.87 g which was 18.39‰ of fish weight. In June at high temperatures of water the diurnal ration was the highest and attained 102.49 g (117.13‰ of body weight). In August at slightly lower temperature the fish consumed daily 60.28 g of food (57.46‰ of body weight). In the following months, when the temperature of water dropped below 15°C, the fish hardly showed any consumption. At the time single cases of death of silver carp were noticed, although no invasion diseases were recorded. In the winter months the fish began to feed again although indices of fullness and diurnal rations were low. Diurnal food rations of silver carp as recorded by other authors differ considerably. S a v i n a (1965), when examining the feeding of silver carp at 16–24°C, has obtained diurnal rations being 0.2–11.1‰ of fish weight. O m a r o v (1970) has determined the diurnal food ration of silver carp weighing 320–370 g as 58 g (172‰ of body weight). O m a r o v (1970) has carried out his investigations at water temperature 23°C. According to M o s k u l (1977) two years old silver carp, weighing 44.6–47.14 g, at water temperature 18–30°C have had the mean diurnal food ration equal to 209‰ of body weight.

These food rations, except the results of S a v i n a (1965), are slightly higher than those calculated in the present paper. This is undoubtedly due to faster metabolism in smaller fishes, usually kept at higher temperatures. Still the diurnal rations obtained in S a v i n a 's (1965) experiments seem to be too low as the author used a different method with conditions for fish very much different from natural conditions.

A comparison of diagrams showing the variability of water temperature, indices of fullness and diurnal food rations (Fig. 2) allows to say that all factors mentioned are connected to a considerable extent. Increase of water temperature causes higher feeding intensity of fish which is expresed by the index of fullness and the diurnal food ration. The feeding intensity rapidly decreases with the autumn temperature drop.

Estimations of food rations consumed at particular seasons of the year have to be based on an assumption that the calculated diurnal rations are constant for longer periods of time. It has been assumed that a period with constant diurnal food ration is the second half of the period of time since taking the previous sample with the first half of the period of time till taking the next sample. From the day of stocking the lake with fish to the day of taking the last sample (349 days) the fish consumed 8774 g of food (Table III). Extrapolation of calculations for the whole annual cycle (365 days) gave annual food consumption 8786 g. During the three warmest months the fish consumed over 90% of the annual ration. Comparing the food rations consumed by fish with the water temperature diagram (Table III, Fig. 2) it can be said that intense feeding of silver carp took place only at temperatures above 17°C. This is undoubtedly a proof that this species has a warmwater character.

Feeding coefficients in Table III calculated on the basis of estimated food rations and increments of body weight range from 7.89 to 24.65. The extreme values are with an error and especially with an error in measurements of fish body weight increments. This is due to the difficulty in obtaining a sufficiently representative fish sample which would reflect the real individual weight increments of fish in the lake. It seems that feeding coefficients for months in which fish samples have been more numerous (Table I) are more reliable. And so since the fish stocking (April 10, 1976) till August 14, 1976 the fish consumed 7329 g of food gaining in that time the weight of 382 g at a feeding coefficient equal to 19.19. Till September 28, 1976 the fish consumed 8716 g of food increasing their weight by 474 g at a feeding coefficient 18.39. The feeding coefficient calculated by M o s k u l (1977) for the silver carp fry was 18.8 and thus did not really differ from the coefficient for the silver carp from the Paproteckie Lake.

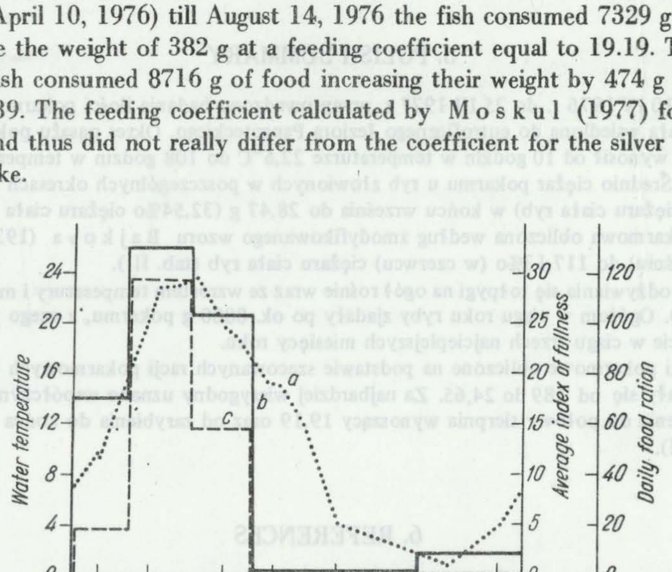


Fig. 2. Variability of water temperature in °C (a), indices of fullness in ‰ of body weight (b) and of diurnal food rations in ‰ of body weight (c) in the annual cycle

Predatory fish and also fish feeding on zooplankton and insects have usually much lower feeding coefficients (B a c k i e l 1971, N a g i ę ć 1973, B i a ł o k o z and K r z y w o s z 1978, B i a ł o k o z, K r z y w o s z and Z a c h w i e j a 1978). The silver carp feeding in the Paproteckie Lake mainly with detritus and also with phyto- and zooplankton (J. Ciborowska-Leszczyńska – unpublished data) has to consume at least 20 kg of food to show a weight increase of 1 kg. This can be explained by the low energetic value of food consumed and the high energy expenditure due to active way of life.

## 4. SUMMARY

Between April 10, 1976 and March 25, 1977 the amounts of food consumed by silver carp introduced to the Paprotockie Lake were estimated. The passage period depended on temperature and was from 10 hours at 22.6°C to 108 hours at 4.0°C (Table III, Fig. 1). On the average the food weight in fish caught in particular seasons of the year ranged from 0.02 g (0.02‰ of fish body weight) at the end of September to 28.47 g (32.54‰ of fish body weight) in June. The diurnal food ration calculated according to the modified equation of Bajkov (1935) was between 0.03‰ (in September) and 117.13‰ (in June) of fish body weight (Table III).

The feeding intensity of silver carp generally increases with the temperature rise and decreases with its drop (Fig. 2). Altogether during the year the fish consumed about 8800 g of food each, of which over 90% was consumed during the three warmest months of the year.

Feeding coefficients calculated on the basis of estimated food rations and body weight of fish increase fluctuated between 7.89 and 24.65. The coefficients obtained for the period between the fish stocking and mid-August (19.19) and between the fish stocking and the end of September (18.39) were considered as most reliable (Table III).

## 5. POLISH SUMMARY

W okresie od 10 IV 1976 r. do 25 III 1977 r. przeprowadzono badania ilości pokarmu spożywanego przez tołpygę białą wsiedloną do eutroficznego Jeziora Paproteckiego. Okres pasażu pokarmu zależny był od temperatury i wynosił od 10 godzin w temperaturze 22,6°C do 108 godzin w temperaturze 4,0°C (tab. III, rys. 1). Średnio ciężar pokarmu u ryb złowionych w poszczególnych okresach roku wahał się od 0,02 g (0,02‰ ciężaru ciała ryb) w końcu września do 28,47 g (32,54‰ ciężaru ciała ryb) w czerwcu. Dobowa racja pokarmowa obliczona według zmodyfikowanego wzoru Bajkova (1935) wynosiła od 0,03‰ (we wrześniu) do 117,13‰ (w czerwcu) ciężaru ciała ryb (tab. III).

Intensywność odżywiania się tołpygi na ogół rośnie wraz ze wzrostem temperatury i maleje wraz z jej spadkiem (rys. 2). Ogółem w ciągu roku ryby zjadały po ok. 8800 g pokarmu, z czego ponad 90% przypadało na spożycie w ciągu trzech najcieplejszych miesięcy roku.

Współczynniki pokarmowe obliczone na podstawie szacowanych racji pokarmowych i przyrostu ciężaru ciała ryb wahały się od 7,89 do 24,65. Za najbardziej wiarygodny uznano współczynnik uzyskany dla okresu od zarybienia do połowy sierpnia wynoszący 19,19 oraz od zarybienia do końca września wynoszący 18,39 (tab. III).

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