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# FEEDING OF THE TENCH, *Tinca tinca* (L.), LARVAE AND FRY UNDER POND REARING CONDITIONS

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A B S T R A C T. Food composition of three generations of larvae and fry of tench from three times repeated spawning was analyzed. Feeding intensity and food selectivity were assessed against thermal and trophic conditions of the environment. It was concluded that tench larvae fed mostly on cladocerans, while fry preferred copepods and *Diptera* larvae.

Key words: TENCH, LARVA, FRY, FOOD, POND.

## INTRODUCTION

The ovaries of tench females before spawning contain oocytes at various maturity stages (Brylińska et al. 1979, Kazanskij 1949, Monić 1953). Thus, spawning is extended over a period, and under natural conditions, groups of different sized juveniles may occur. It is not clear if all groups feed on the same organisms, or use various food niches, and utilize food resources more extensively. Knowledge of feeding habits and preferences of young tench in first year of life is essential for stocking material production and successful stocking. The aim of the present study was an analysis of food preferences of larvae and fry of tench from three times repeated spawning.

## MATERIAL AND METHODS

In the present study a part of material collected for the survey of juvenile tench biology (Pyka 1986) was used. Larvae and fry from three times repeated spawning were studied. Juveniles were classified into age groups: $0_1^+$, $0_2^+$, and $0_3^+$. All phases of spawning and rearing took place in enclosures of an earthen pond, independently supplied with water as if they were separate ponds. Area of each enclosure was equal to 100 $m^2$, and maximum, minimum and average depth was 1.2 m, 0.2 m, and 0.8 m, respectively.

## ENVIRONMENT STUDIES

Daily changes of water temperature were monitored throughout the experimental season, at 8.00 a. m., 12.00, 6.00 p. m., and 11.00 p. m., at the depth 0.5 m. Zooplankton was sampled from 10 sites (always the same) of each pond, using Patalas sampler of 1 $dm^3$. Samples were treated with 4% formaldehyde and concentrated to the volume of 50 $cm^3$. After through mixing, 1-5 $cm^3$ subsamples were subjected to microscopic analyzes. Zooplankton were identified, counted and measured. Number and biomass of individuals were calculated for 1 $dm^3$. When tench attained late larval and fry stage, bottom fauna was sampled, using pipe sampler of 20 $cm^2$ surface, from 5 sites of each pond. Samples were rinsed with water and sieved, benthic organisms being collected and preserved with 4% formaldehyde. Animals were identified and counted using a hand-glass or a microscope. Number and biomass were calculated per 1 $m^2$ of the bottom.

## FOOD SAMPLES

Fish were harvested from the moment of appearance of first larvae at the spawning grounds, until the end of growing season. Two development stages were distinguished: larvae and fry. Fish from hatching until the end of fin formation were classified as larvae, and from the beginning of scale appearance (body length 15.5-17 mm) until the end of first year of life - as fry. In Figs. 3-5 both periods are separeted with the vertical line. Fish were harvested always at noon and immediately preserved with 4% formaldehyde. Measurements and gut analyzes were done several months later. Body length of the larvae were measured with 0.1 mm accuracy, using microscope micrometer. Fish were weighed after dessication on blotting paper, with 0.1 mg accuracy.

Fry were measured with 0.5 mm accuracy, and weighed with 1 mg accuracy. Alimentary tracts were isolated and their contents were analyzed using a microscope (magnification 75-120). Food items were identified (usually to species) and measured. Biomass of individuals was calculated from body length, using tables (Morduchaj-Boltovskoj 1954, Patalas 1954, Starmach 1955). Total number of 527 alimentary tracts were isolated, from 362 larvae and 165 fry individuals, of all the age groups of tench (Tab. 1). Fraction of empty guts was 16% (58 individuals) and 20% (34 individuals) of larvae and fry, respectively. Thus, contents of 435 alimentary tracts, from 304 larvae and 131 fry individuals were analyzed. Composition of tench diet was asses-

**TABLE 1**

Study material

| Age group | Development stage | Date | N | $N_0$ | Average body length l.c.(mm) | Average body mass (mg) | Age group | Development stage | Date | N | $N_0$ | Average body length l.c.(mm) | Average body mass (mg) | Age group | Development stage | Date | N | $N_0$ | Average body length l.c.(mm) | Average body mass (mg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $0_1^+$ | larvae | 8.06 | 19 | - | 5.1 | 1.2 | $0_2^+$ | larvae | 18.06 | 18 | - | 4.6 | 0.9 | $0_3^+$ | larvae | 4.07 | 32 | - | 5.0 | 0.8 |
| | | $9.06^x$ | 19 | 18 | 5.2 | 1.2 | | | $19.06^x$ | 22 | 18 | 5.3 | 1.0 | | | $5.07^x$ | 24 | 17 | 5.1 | 0.8 |
| | | 13.06 | 14 | 1 | 5.6 | 1.8 | | | 23.06 | 9 | 1 | 5.4 | 1.6 | | | 9.07 | 10 | - | 5.3 | 1.0 |
| | | 19.06 | 14 | - | 6.0 | 2.1 | | | 1.07 | 12 | - | 7.7 | 4.2 | | | 13.07 | 12 | - | 6.5 | 1.6 |
| | | 27.06 | 19 | - | 7.5 | 4.2 | | | 9.07 | 5 | - | 8.1 | 4.4 | | | 18.06 | 10 | - | 8.3 | 3.4 |
| | | 5.07 | 8 | - | 8.4 | 6.4 | | | 13.07 | 6 | - | 10.0 | 15.0 | | | 25.07 | 14 | - | 8.6 | 5.0 |
| | | 13.07 | 20 | - | 10.5 | 19.0 | | | 18.07 | 9 | 2 | 11.5 | 23.0 | | | 1.08 | 11 | - | 12.5 | 30.0 |
| | | 18.07 | 19 | - | 12.0 | 22.0 | | | 25.07 | 11 | 1 | 15.0 | 68.0 | | | 8.08 | 13 | - | 15.0 | 71.0 |
| | | 25.07 | 12 | - | 13.5 | 46.0 | | | | | | | | | | | | | | |
| | | Total | 144 | 19 | - | - | | | Total | 92 | 22 | - | - | | | Total | 126 | 17 | - | - |
| | fry | 1.08 | 7 | - | 19.0 | 164 | | fry | 1.08 | 8 | - | 17.0 | 89 | | fry | 15.08 | 8 | - | 16.0 | 81 |
| | | 8.08 | 8 | 1 | 22.5 | 249 | | | 8.08 | 14 | - | 18.0 | 134 | | | 22.08 | 12 | 2 | 17.5 | 123 |
| | | 15.08 | 6 | 1 | 27.5 | 432 | | | 15.08 | 10 | - | 20.5 | 159 | | | 31.08 | 15 | - | 19.5 | 158 |
| | | 22.08 | 7 | 6 | 28.5 | 637 | | | 22.08 | 12 | 2 | 22.0 | 216 | | | 14.09 | 11 | 2 | 20.5 | 186 |
| | | 31.08 | 8 | 6 | 29.0 | 640 | | | 31.08 | 16 | 2 | 23.0 | 284 | | | | | | | |
| | | 14.09 | 8 | 6 | 30.0 | 750 | | | 14.09 | 15 | 6 | 24.0 | 300 | | | | | | | |
| | | Total | 44 | 20 | - | - | | | Total | 75 | 10 | - | - | | | Total | 46 | 4 | - | - |

*x - beginning of exogenous feeding*

*$N_0$ - number of empty alimentary tracts*

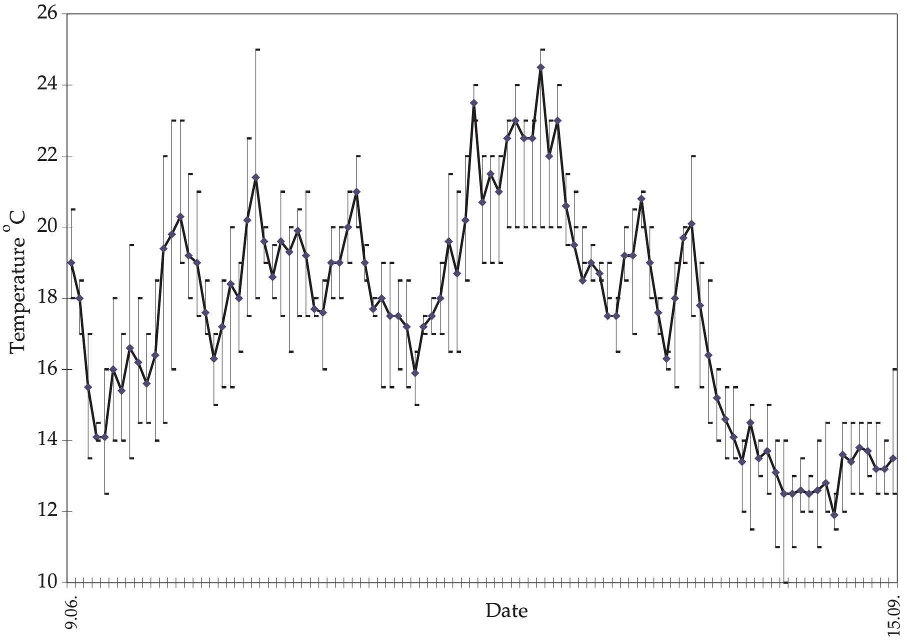


Fig. 1. Daily average, minimum and maximum water temperatures during experimental season.

sed, calculating number and biomass of each group of animals. Feeding intensity was estimated throughout the growing season, using Ivlev (1955) selectivity index:

$$E_i = \frac{r_i - p_i}{r_i + p_i}$$

where:

Ei - food selectivity index for food type „i"

ri - the proportion of food type „i" in the fish's ration (%),

pi - the proportion of food type „i" in the environment (%).

# RESULTS

## FOOD BASE OF FISH IN THE PONDS

Zooplankton of the ponds consisted of total number of 29 genera and species of rotifers (*Rotatoria*), cladocerans (*Cladocera*) and copepods (*Copepoda*). Seasonal dynamics of zooplankton density is shown in Fig. 2.

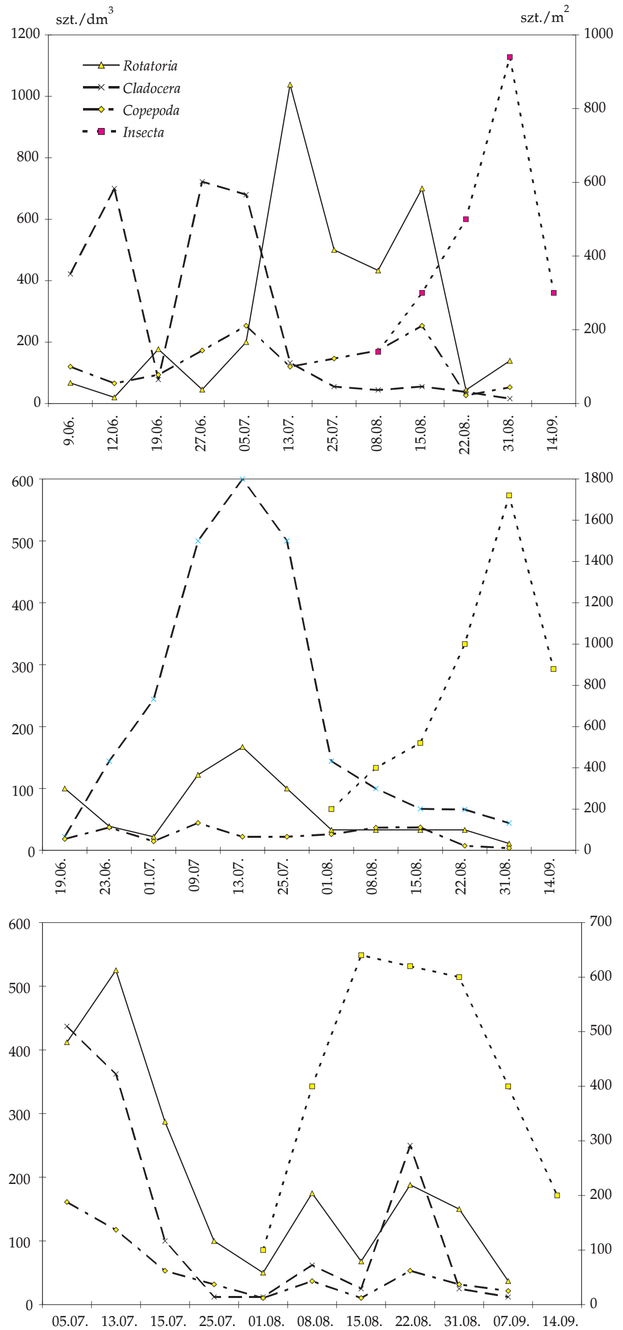


Fig. 2. Dynamics of zooplankton (ind./m$^3$) and insect larvae (ind./m$^2$) densities in the experimental ponds. 1-3: pond number, a - *Rotatoria*, b - *Cladocera*, c - *Copepoda*, d - *Insecta*.

Rotifers were most numerous and represented by cosmopolitic *Asplanchna, Hexarthra, Keratella, Polyarthra* and *Synchaeta*, and typical for pond environment *Brachionus, Colurella* and *Mytilina*. Rotifers were most numerous in summer, with maximum densities in July. Density of rotifers in summer considerably differed among the ponds. Number fluctuations, indicating high lability of populations (Patalas 1963) were observed in the pond with first group of tench juveniles. Highest share of rotifers occured almost in the same periods as maximum densities of *Cladocera* and *Copepoda*.

Among cladocerans *Bosminidae* predominated, with only one species *Bosmina longirostris*, together with *Daphnidae* (*Daphnia longispina, Ceriodaphnia pulchella, Simocephalus sp.*). Moreover, small numbers of *Chydoridae* (*Alona quadrangularis*, *Alonella nana* and *Chydorus sphaericus*) were observed in the ponds. Densities of cladocerans considerably fluctuated in summer. Dynamics differed among the ponds, especially changes of numbers of *Bosminidae* and *Chydoridae*. Lowest share of *Cladocerans* and different pattern of seasonal dynamics was observed in the pond with third age group of tench juveniles. In that pond number of cladocerans changed very fast, within a very wide range.

Among copepods, juveniles predominated in all the ponds (mainly *Cyclopidae copepodites*). During entire experimental season, copepods were least numerous group of zooplankton. In spring and summer their number did not considerably varied (except pond 3). At the end of summer and in fall density of copepods gradually dropped.

### OTHER INVERTEBRATES

Besides zooplankton, also larvae of insects were an important item of tench food, especially at the fry stage. Dynamics of this group of invertebrates is shown in Fig. 2. In all the analyzed samples *Diptera* predominated, among which *Chironomus plumosus* and *Ceratopogon sp.* were most numerous. *Oligochaeta* were also present in the ponds, although never found in fish alimentary tracts.

## RESULTS OF ALIMENTARY TRACT ANALYZES

### DIET COMPOSITION

Exogenous feeding of tench larvae started after 6-9 days post hatch, at body length 5.1-5.3 mm, when the fish completely or almost completely absorbed yolk. Youngest larvae fed mostly on planktonic rotifers and crustaceans. In gut contents of fish of $0_1^+$ and $0_2^+$ age groups only small cladocerans were found (*Ceriodaphnia pulchella*, *Chydorus sphaericus*). The youngest age group $0_3^+$ fed mostly on *Brachionus* (98% of total number and biomass of food items), with small addition of most abundant crustacean - *Bosmina longirostris* (Fig. 3). Food diversity increased with the age of fish. Gut contents contained mainly *Daphnidae*, *Chydoridae* and *Bosminidae*. Share of *Cyclopidae* increased with fish activity, while share of rotifers decreased (Fig. 3).

Alimentary tracts of first age group of larvae *Daphnidae* were most abundant: *Ceriodaphnia pulchella*, *Daphnia longispina* and *Scapholeberis mucronata*. Their numbers in gut contents depended on sampling date and fish age. Share of these organisms (in number and biomass of food items) exceeded 50%. Among *Chydoridae* mainly *Chydorus sphaericus* and *Alonella nana* were found in alimentary tracts (10.1-50% of number and 5.1-10% of total biomass of food items). Eventually their share decreased down to 1-1.5% (rare items) or below 1% (sporadically found items). *Bosmina longirostris* was regularly found in fish gut contents. It was a dominating or subdominating species in number of tench food items, but it's biomass situated *Bosmina* among subdominants or rare components. *Cyclopidae* were captured periodically. They occured in gut contents quite numerously, as subdominants. Fish usually captured juvenile stages of copepods: nauplii and copepodites. Rotifers were least abundant in alimentary tract contents, sporadically occuring as food component of early and late larval stages.

Food of second age group of tench larvae consisted mainly of *Daphnidae*, too. *Ceriodaphnia pulchella*, *Scapholeberis mucronata*, *Daphnia longirostris* and less numerous *Daphnia pulex* were found in all the samples. They predominated in all the gut contents, except samples taken on July 9 and July 25. *Chydoridae* (*Alonella nana* and *Chydorus sphaericus*) occured irregularly but were found in fish food in high numbers (usually dominated in number and subdominated in biomass). Unlike in first age group, *Bosmina longirostris* was rarely found in gut contents. It appeared irregularly in various numbers, sometimes as dominant, and sometimes scarce.

*Cyclopidae* (mainly adult stages) were found only in two samples of late larvae, as dominants (together with *Daphnidae*) in number and biomass of food items. Rotifers were absent in gut contents of this age group of fish.

Food composition of third age group of tench juveniles considerably differed from the other groups. *Daphnidae* (the same species as mentioned above) and *Bosmina longirostris* were most abundant food components of fish. They were found in almost all the samples, usually as dominants in number and biomass of food items. *Chydoridae* appeared in small numbers, only in first two samples. Share of *Cyclopidae* increa-

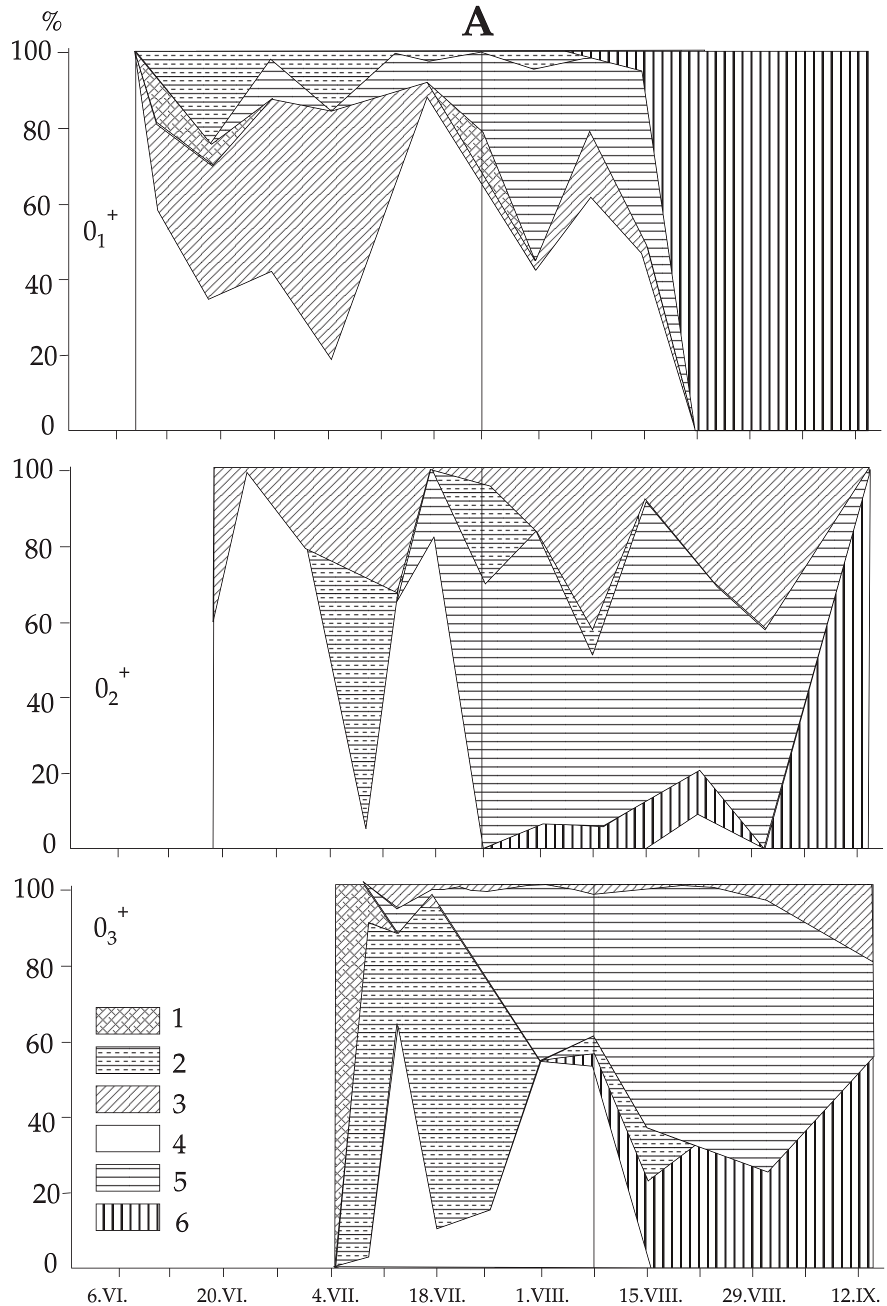


Fig. 3a. Number (A) of food items in various age groups of tench larvae and fry. 1 - *Rotatoria*, 2 - *Bosmina*, 3 - *Chydoridae*, 4 - *Daphnidae*, 5 - *Cyclopidae*, 6 - *Insecta*.

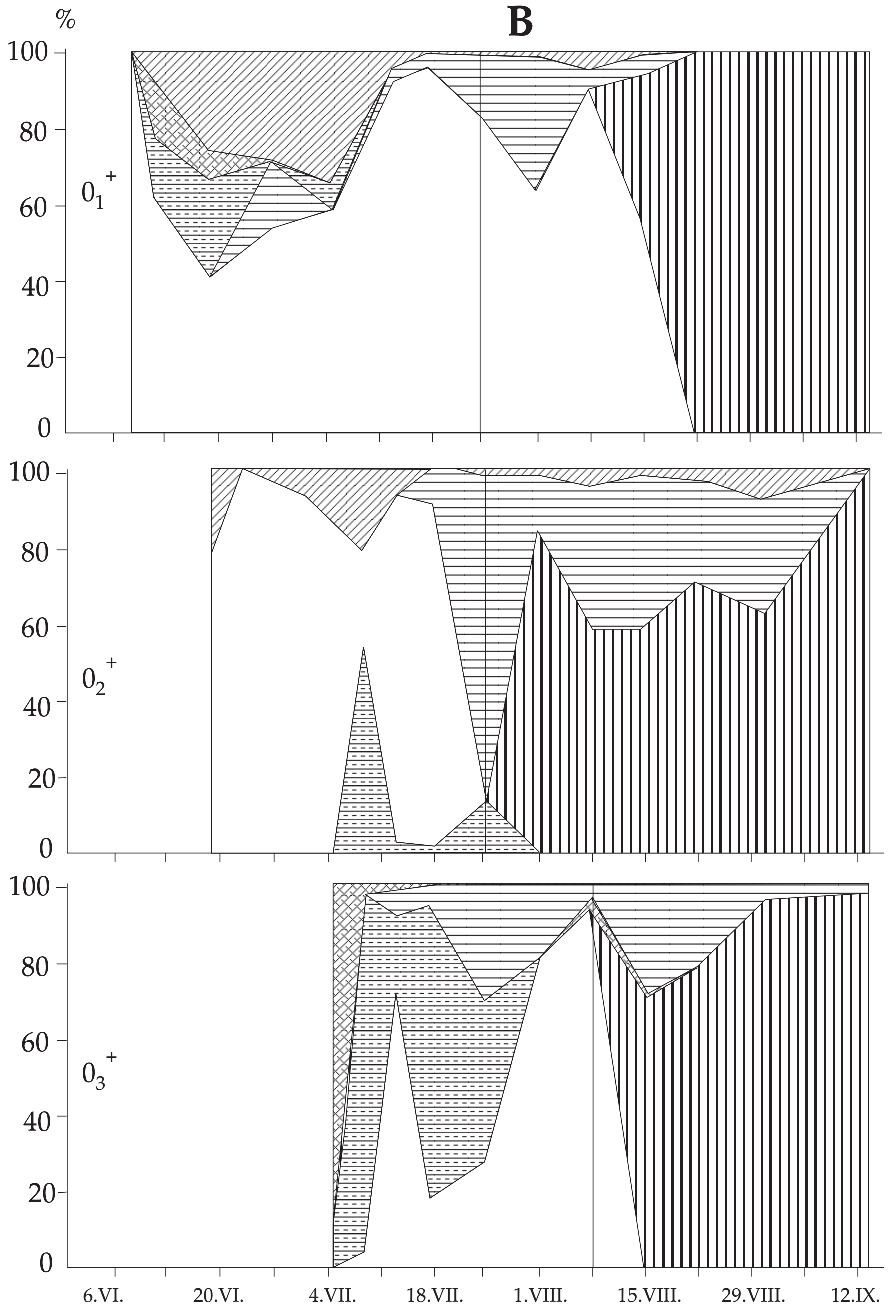


Fig. 3b. Biomass (B) of food items in various age groups of tench larvae and fry. 1 - *Rotatoria*, 2 - *Bosmina*, 3 - *Chydoridae*, 4 - *Daphnidae*, 5 - *Cyclopidae*, 6 - *Insecta*.

sed with fish age. They were rare in gut contents of young larvae and predominated in food of late larval stages. Rotifers occured only in first two samples, as dominants in number and subdominants or rare in food biomass. Share of small crustaceans (*Bosmina longirostris*, *Chydoridae*) considerably decreased in diet of tench fry of all age groups, comparing with larvae. Also *Daphnidae*, with exception of food of early stages of first age group, did not play important role in diet of tench fry. Fry fed most readily on *Diptera* larvae, which predominated in food biomass, and on adult *Cyclopidae*, dominants in number of food items.

Alimentary tracts of age group $0_1^+$ contained mainly large *Daphnidae: Daphnia pulex*, *D. longispina*, *Simocephalus sp.*, and smaller ones: *Ceriodaphnia pulchella* and *Scapholeberis mucronata*. *Daphnidae* were dominants in number and biomass of food of earliest stages of tench fry. Share of adult *Cyclopidae* was lower, they dominated in number, but subdominated in biomass. Early stages of tench fry captured also small numbers of *Bosmina longirostris* and *Chydoridae*, but share of these plankters decreased with fish age, and in gut contents of late fry they were absent. Late tench fry switched from *Crustacea* to *Diptera* (*Chironomus plumosus*, *Cloëon dipterum*, *Ceratopogon sp.*). With the exception of one sample (at the end of planktonic phase in fish development), insects were exclusive component of tench fry diet.

Fry of $0_2^+$ group fed on *Chydoridae* (*Alonella nana*, *Alona sp.*), on adult *Cyclopidae*, and on *Diptera* larvae (*Ceratopogon sp.*, *Cloëon dipterum*). *Daphnidae* and *Bosmina longirostris* were scarce in gut contents. *Chydoridae* predominated in number of food items but their share in food biomass was very low. Adult stages of *Cyclopidae* were most numerous in $0_2^+$ fry food but in the biomass larvae of insects predominated (except first sample).

Age group $0_3^+$ fed mostly on adult *Cyclopidae* and larvae of *Diptera* (*Ceratopogon sp., Chironomus plumosus, Cloëon dipterum and Chaoborus sp.*). Share of *Cyclopidae* gradually decreased and fish switched to to insects. Share of insects in tench fry diet increased, and they predominated in biomass of all the samples, except first one.

Small cladocerans (*Bosmina longirostris* and *Chydoridae*) were rarely found in alimentary tracts and, as in previous age group, were negligible as food item. *Daphnidae* (*Ceriodaphnia pulchella*, *Daphnia longispina*, *D. pulex and Scapholeberis mucronata*) predominated only in first sample of fry gut contents.

## FOOD SELECTIVITY

Food of tench larvae and fry was closely related to the composition of invertebrate community of the ponds, and to the lesser extent - to the availability of prey to fish. One of the most important availability factors is prey motility. Studies of Szlauer (1965) revealed that adult copepods have highest escape ability, while cladocerans and rotifers have the least. Body shape, presence of thick carapace or long carapace processes may also affect capture of plankters by fish. Ivlev's index of food selectivity show feeding preferences of tench larvae and fry (Fig. 4). Values above zero indicate selectivity, and below zero - avoidance of certain food items. Pattern of electivity revealed that all age groups of tench larvae most redily captured cladocerans. Fish preferred slow moving, vegetation-bound *Daphnidae* and *Chydoridae*. Rotifers were strongly avoided. It should be mentioned that in all the ponds *Keratella* predominated, rotifers protected by thick lorica are poorly digestible by fish. Also *Bosmina longirostris*, abundant in the pond plankton communities, was avoided by tench juveniles. It might have resulted from spatial separation: *Bosmina longirostris* was observed mainly in open water, and tench larvae tended to gather among water vegetation.

Copepods were poorly available because of high escape ability and avoided by tench larvae. They were positively selected, however, by tench fry, and took place of small cladocerans (mainly *Daphnidae*) in diet of this group of fish. Large *Diptera* larvae that appeared and dominated in alimentary tract contents of fry were, according to Ivlev index values, avoided. It indicates that this group of invertebrates was not extensively exploited by the fish.

## FEEDING INTENSITY

Feeding intensity is usually assessed using filling indices calculated as the ratio of food biomas and body mass of fish, expressed as parts per ten thousand. Sometimes the index is calculated from idividual biomass of food organisms, according to the table of standard weights, and called consumption index (Fortunatova 1964). Its values are higher than values of filling index, since the level of food digestion is not taken into consideration. In the present paper consumption index was applied, based on individual biomass of invertebrates.

Pattern of total and partial averages of consumption index (Fig. 5) shows that feeding intensity was highest during larval period, when fish consumed easily available crustaceans. In fry period feeding intensity considerably decreased. Undoubtedly, it was a result of metabolic rate slow down, related to the age of fish. Noteworthy is, however, sharp reduction of feeding intensity in early fry stages. It might have resulted from the change of thermal and trophic conditions of the environment over the expe-

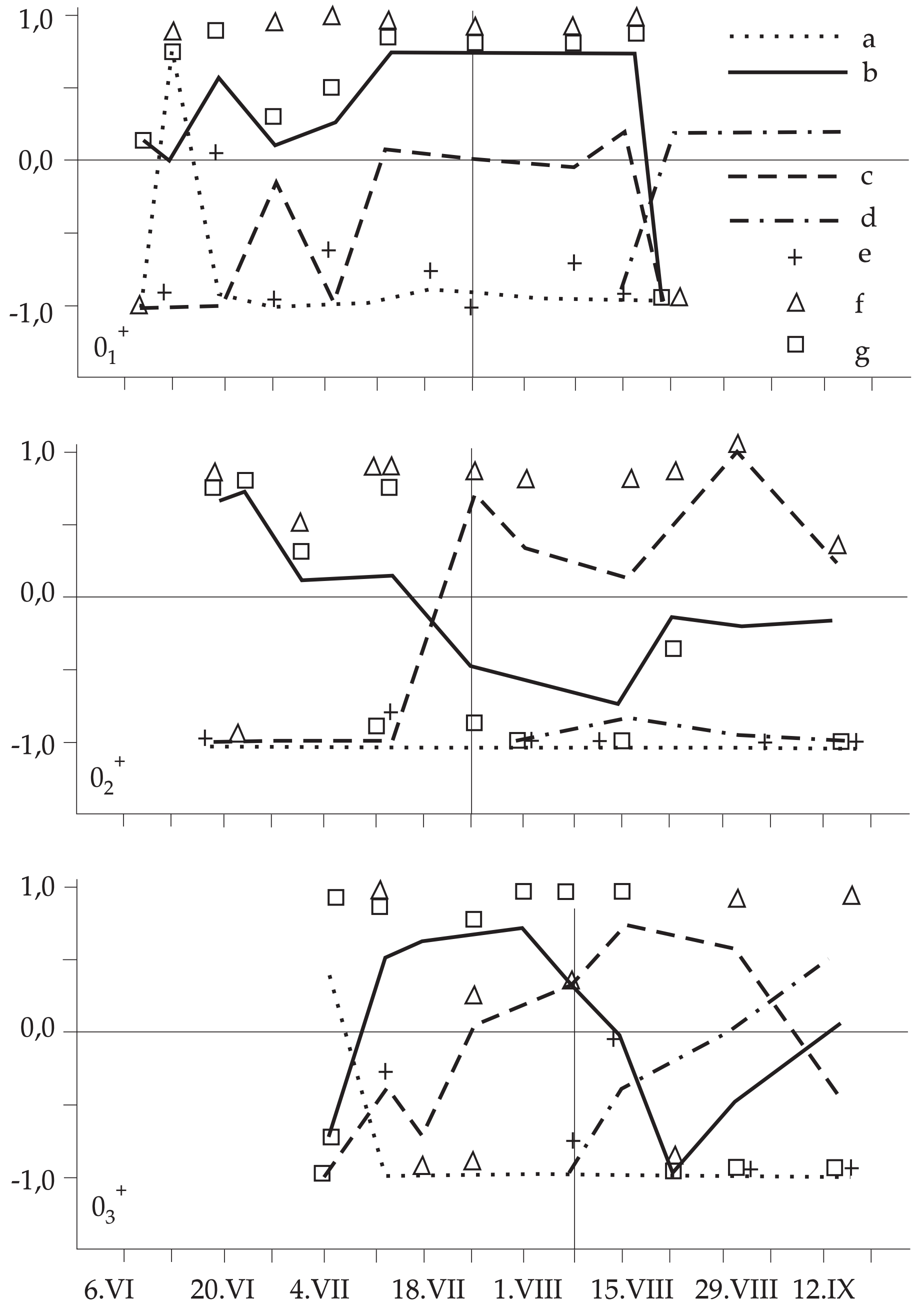


Fig. 4. Dynamics of food selectivity index (Ei) in various age groups of tench larvae and fry.
a-d: see - Fig. 2., e - *Bosmina*, f - *Chydoridae*, g - *Daphnidae*.

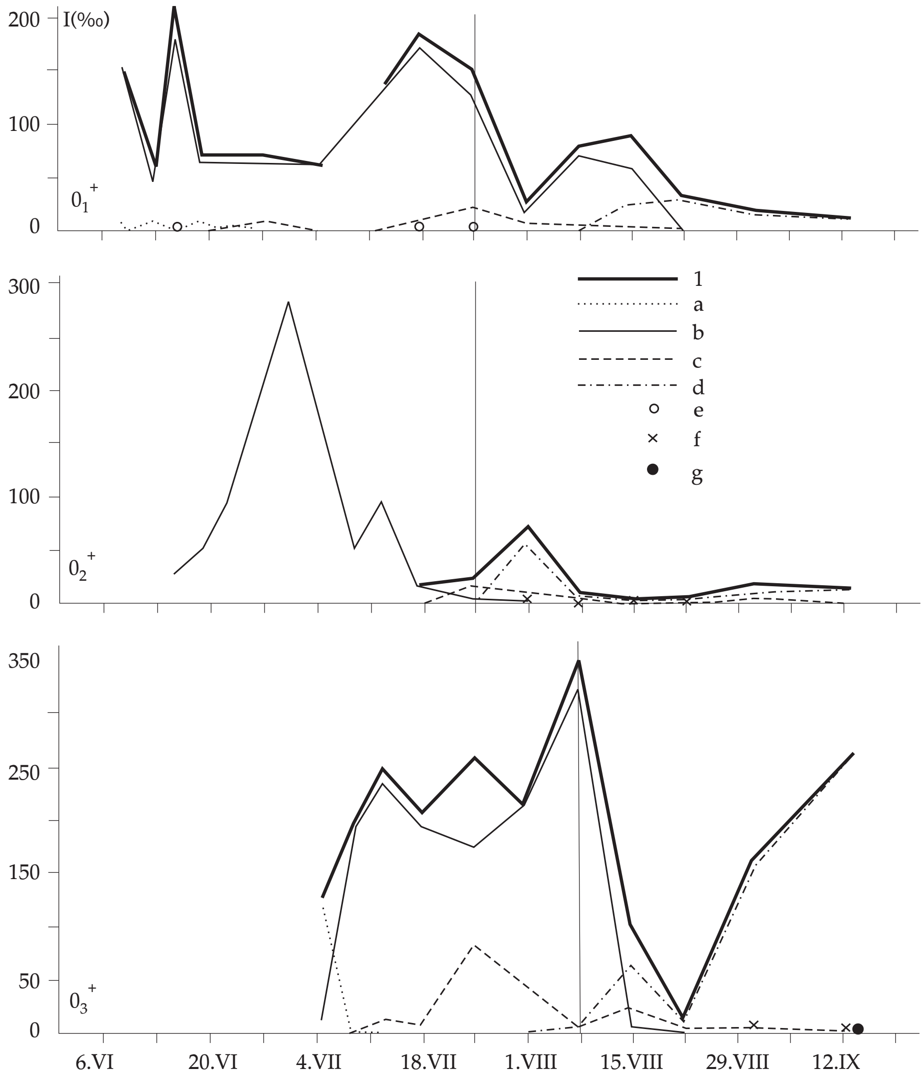


Fig. 5. Dynamics of total and partial consumption index (I 1/10000) of various food items in age groups of tench larvae and fry. 1 - total index, partial indices: a-d: see - Fig. 2., and under 1/10000: e - *Rotatoria*, f - *Cladocera*, g - *Copepoda*.

rimental period. Feeding intensity of all age groups of tench (Fig. 5) viewed against zooplankton and benthos dynamics in the ponds (Fig. 2), and the pattern of average daily water temperatures (Fig. 1) revealed that only during larval period of tench development environment conditions were favourable for intense feeding (highest zooplankton concentration and temperatures). Low consumption index values in early fry of all age groups must have resulted from considerable decrease of zooplankton density. Temperatures during that period did not much differ from the values measured during larval development. Feeding intensity of first and second age group of late fry stage was, however, affected by temperature fluctuations. Despite an improvement of trophic conditions (increase of insect larvae density), gradual drop of consumption index was observed. On the other hand, it seemed that temperature did not adversely affect third age group of fry, in which some increase of feeding intensity occured.

## RECAPITULATION

Presented results indicate that all the age groups of tench larvae fed mainly on cladocerans. Most readily captured species belonged to vegetation-bound *Daphnidae*: *Ceriodaphnia pulchella*, *Daphnia longispina*, *Scapholeberis mucronata*, and *Chydoridae: Chydorus sphaericus* and *Alonella nana*. *Bosmina longirostris* were less abundant in larval diet. During growth, fish switched from cladocerans to large copepods and *Diptera* larvae: *Ceratopogon sp.*, *Chironomus plumosus*, *Cloëon dipterum*, and *Chaoborus sp.*

Tench fry most readily captured *Copepoda*: adult *Cyclopidae* and *Diptera* larvae, organisms of higher energetic value, comparing to the *Cladocera* (Galinat 1960). Data of other authors (Kennedy, Fitzmaurice 1970, Lesczyński 1963, Pyka 1986, Rosa 1958, Vavilkin 1960) on feeding of tench juveniles revealed that young stages of this fish fed mainly on vegetation-bound *Daphnidae*, *Chydoridae* and *Copepoda*, as well as on *Insecta* larvae, mainly *Chironomidae* and *Ephemeroptera*. Share of these invertebrates in tench diet vary seasonally and with fish growth, it may also vary among water bodies. Abundance of crustaceans in tench larvae diet suggests that at that stage of development fish feed mainly in vegetated areas of reservoirs. Composition of tench fry food shows that older fish are able to use more diverse food niches, and search their food not among vegetation, but also in open water and in the bottom.

No considerable diferences of diet composition among age groups of tench were observed. Food of juvenile tench was closely related to the composition of invertebrate communities of the ponds, and to the availability of food items to particular development stages. The results show no food specialization within tench age groups, and indicate high trophic flexibility, which is an important adaptative characteristic of the species. Certain authors (Galinat 1960) observed weak feeding preferences in tench also in second year of life.

## CONCLUSIONS

1. Tench larvae in the ponds fed mainly on planktonic crustaceans, among which *Daphnidae* and *Chydoridae* predominated. Tench fry selected *Copepoda* (adult *Cyclopidae*) and *Diptera* larvae.
2. Diet composition of tench juveniles was closely related to the composition of invertebrate community of the ponds and to the prey availability.
3. Prey density and, to the lesser extent, water temperature affected feeding intensity of tench fry.

*Trans. by Małgorzata Witeska*

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## STRESZCZENIE

ODŻYWIANIE SIĘ LARW I NARYBKU LINA *Tinca tinca* L. W WARUNKACH CHOWU STAWOWEGO

W pracy scharakteryzowano pokarm trzech pokoleń (podgrup wiekowych) larw i narybku lina, pochodzących z rozrodu trójporcyjnego. Na tle zasobności stawów w faunę bezkręgową omówiono zależności pokarmowe, analizując zmiany składu jakościowego i ilościowego, wybiórczość oraz intensywność żerowania młodocianych stadiów lina w pierwszym roku życia. Stwierdzono, że w okresie larwalnym zasadniczym pokarmem były *Cladocera*, w okresie narybkowym *Copepoda* i larwy *Diptera*. Wyakazano barak specjalizacji pokarmowej w podgrupach wiekowych larw i narybku oraz istnienie plastyczności pokarmowej. Głównym czynnikiem regulującym poziom spożycia był jakościowy skład fauny pokarmowej stawów.

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