Arch. Ryb. Pol.	Archives of Polish Fisheries	Vol. 5	Fasc. 2	279 - 290	1997

DAILY FEEDING CYCLE TENCH, *Tinca tinca* (L.), IN LARVAL AND FRY STAGES IN THE CONDITIONS OF POND CULTURE. AN ATTEMPT TO DETERMINE DAILY FOOD RATION

Julian Pyka

The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn

A B S T R A C T. The paper presents variability in food composition and daily feeding rhythm of tench larvae and fry. Daily food ration has been estimated for the larvae of average individual weight of 44.3 mg and average daily water temperature of 24.6°C. It amounted to from 6.3 to 6.9 % of average body weight, depending on the formula used (Thorpe 1977 or Eliott and Persson 1978). Daily food ration of tench fry of average individual weight 648.1 mg, calculated with the method of Thorpe (1977), was 1.1 % of body weight at water temperature 8.2 °C.

Key words: POND, TENCH, LARVAE, FRY, FOOD, DAILY FEEDING RHYTHM, DAILY RATION

INTRODUCTION

Fish tolerance to the definite environmental conditions is usually the smallest in the phase of early postembryonal development, which is also a critical period in fish life. This is why breeding practices and ichthyological studies should concentrate on this period with the highest intensity. Food is the major factor determining proper development and high survival of fish in early stages of development - its quality, quantity and availability.

In the studies on fish feeding it is important to know what are quantitative requirements for food of a given species in a definite period of time. Bajkov was one of the first scientists who attempted to determine the amount of food ingested by fish during one day. His experiments were later used in other studies and helped to work out models used to calculate daily food rations for fish of different age. According to the recent opinions, the most reliable models are the modified formulas of Thorpe (1977) and Elliott and Persson (1978). From among many works dealing with the quantity of food ingested by fish, of special interest are also those by Elliott (1972) and Persson (1982).

The objective of this study was to determine variability of food composition and quantity in tench larvae and fry in a daily cycle, and an attempt to determine daily food ration in conditions of pond culture.

MATERIAL AND METHODS

Samples of tench larvae and fry were collected on 25/26 June 1995 (larvae) and 9/10 October 1995 (fry). The fish originated from culture operations in a carp pond of 4 ha, 0.8 m deep (average depth), located in the hatchery and stocking centre Montowo of the Fishery Enterprise Grzmięca (Brodnica Lake District). The fish were caught with a scoop net every 2 hours (larvae) and every 3 hours (fry), throughout the day. Water temperature was measured at the same time.

The fish were immediately preserved in 4% formaldehyde solution. In the laboratory, the fish were dried with a blotting paper, body length was measured up to 0.5 mm (larvae) or 1mm (fry), and weight determined up to 0.5 and 1 mg respectively. Food tracts were removed under a binocular using preparatory needles. Systematic position of the food organisms was determined usually to species. Then the food organisms were counted and measured, and their weight was reconstructed from the formula: $W = aLb$, where: W - weight of the organism in mg, L - length of the organism in mm, a and b - regression factors. The latter were taken from Lebiedieva and Kozlova (1969) and Edmondson (1971) for planktonic crustaceans. Individual weight of insects was determined basing on my own unpublished data.

Food composition was determined with the usual methods: numerical (share in numbers and frequency of occurrence) and weight (share in weight and index of ingesting particular food components) From the daily collection of tench larvae, totally 180 food tracts were analysed, on the average 15 tracts from each sample, while as regards fry sample, there were 80 food tracts i.e. 10 from each sample on the average.

Tench feeding in the first year of fish life was characterised in a daily cycle, and daily food ration was given for 25-day-old larvae of average individual weight 44.3 mg (23.2-87.0 mg), and body length 13.6 mm (12.5-17.0 mm), and for 100-day-old fry of average individual weight 648.1 mg (286-1435 mg), and body length 30.9 mm (24-40 mm).

To estimate the significance of particular food components, the following domination patterns were adopted: eudominant - a component the share of which (either in the numbers of food organisms or in food weight) exceeded 50 %; dominant - a

component representing 10.1 - 50 %; subdominant - 5.1 - 10 %; rare component - 1.1 - 5 %; and sporadic component - less than 1 %.

Daily food ration of tench larvae was estimated using two methods: 1) from the equation Ct = (St - Soe-Rt)Rt/1 - eRt (Elliott and Persson 1978), and 2) from the equation C = S2 - S1 + A (Thorpe 1977), where:

C - the amount of food consumed during t hours (between consecutive samplings, t2-t1),

So, St, S1, S2 - relative content of the food tract at the beginning (So, S1) and the end (St, S2) of a time interval (these values were estimated from samples collected every two hours (t = 2 hours) for the larvae, and every 3 hours (t = 3 hours) for fry, in average water temperature 24.6° and 8.2°C respectively,

e - base of a natural logarithm,

R - constant of food digestion rate (exponential rate of tract evacuation),

A - food evacuation during time t2-t1 (equivalent of the mass excreted from the food tract of average relative content equal to 0.5 (S1+S2)-Sr, where: Sr - relative theoretical food weight which should be in the food tract at the end of a time interval, expressed by the equation: Sr = 0.5(S1+S2)e-k2(t2-t1), where: - k2 - constant digestion rate equivalent to R in the first formula). Food consumption in the time interval (t2-t1) can be expressed with the equation: C = 0.5 (3S2-S1-2Sr). Daily food ration will be the sum of values C (Ct in the first formula), calculated for the successive time intervals- weight of ingested and digested food.

Size of the daily food ration of tench fry was estimated using the equation of Thorpe (1977).

RESULTS

Food of tench larvae contained the following taxa of invertebrate fauna: *Rotatoria: Keratella cochlearis; Cladocera: Bosmina longirostris*, *Chydorus sphaericus*, *Daphnia longispina; Copepoda: Eucyclops serrulatus* and insect larvae: *Chironomidae* and *Ephemeroptera* (*Cloen dipterum).*

Copepoda constituted major bulk of tench larvae food. Their only representative, *Eucyclops serrulatus*, was usually an eudominant, both in the numbers of food organisms and in their weight, representing respectively 51-94 % of the numbers and 56-96 % of the food weight, or a dominant - 43-42 % and 19-43 % respectively (fig. 1, 2).

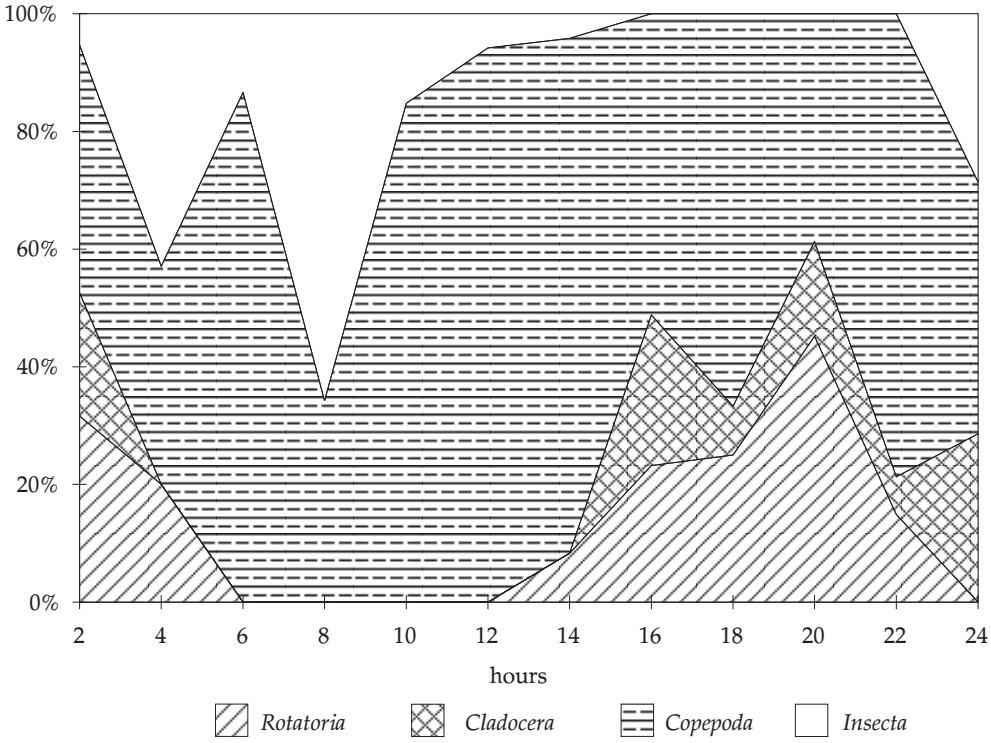

Fig. 1. Variations in the composition of tench larvae food in daily cycle, expressed in % of the numbers of food organisms.

A small crustacean *Eucyclops serrulatus* was present in all samples reaching high indices of occurrence: from 50-66 % (in night samples) to 80-100 % in other periods of a daily cycle.

Small *Chironomidae* larvae also played a significant role in the feeding of tench larvae. They represented a dominant position in the numbers and weight of food organisms, 15-42 % and 10-43 % respectively, or were eudominants, representing 65 % and 69-96 % respectively (fig. 1,2). Insect larvae attained the highest frequency of occurrence (50-100 %) in morning hours, and the lowest (0-66 %) at night. They were usually absent in the food of tench larvae in afternoon hours.

Cladocera played an inferior role in tench larvae food. They were present in only 6 samples collected in the afternoon and at night, most frequently as dominants (16-28 %), rarely subdominants (6-8 %) of the numbers of food organisms. Their position in food weight was usually eudominant (54-56 %), sporadically dominant (26 %), sub-

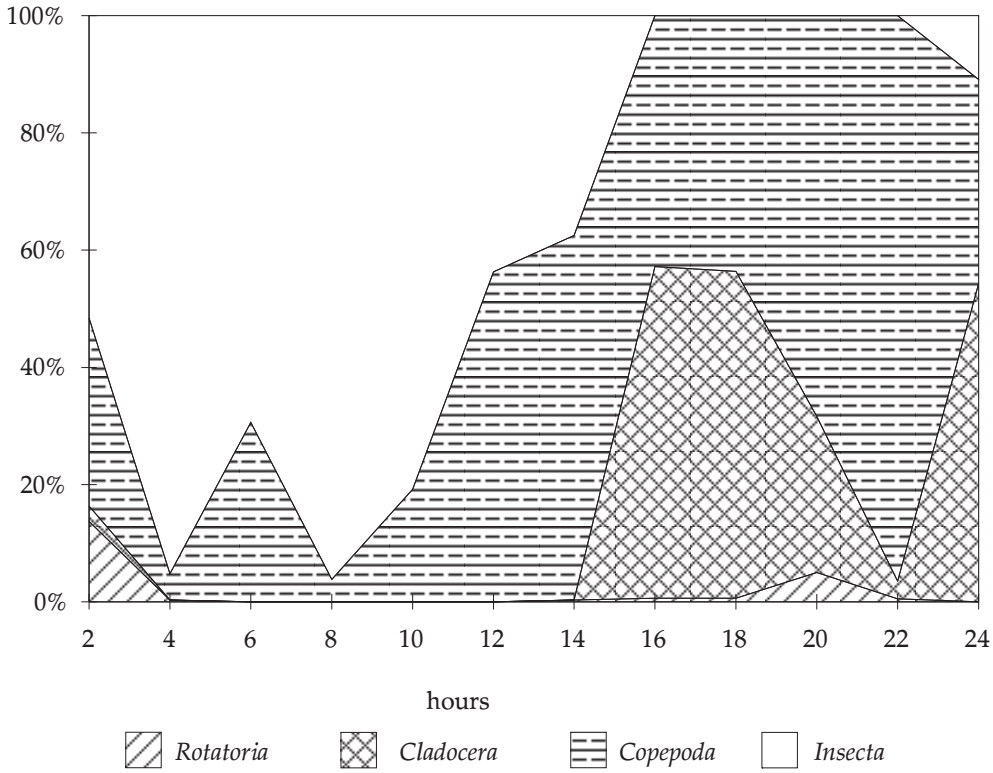

Fig. 2. Variations in the composition of tench larvae food in daily cycle, expressed in % of the weight of food

dominant (7 %), or they were rare components (3 %) (fig. 2). *Cladocera* attained the lowest frequencies (from among all food components). They ranged from 0 to 66 % in a daily cycle.

Small cosmopolitan and morphologically differentiated forms of *Keratella cochlearis* from the group *Rotatoria* were of little significance in the feeding of tench larvae, similarly as *Cladocera*. Only as regards their percentage in the numbers of food organisms, they were classified as dominants (14-45 %) (fig. 1). These forms were a sporadic component of food weight (0.3-0.6 %), sometimes rare (4-5 %) (fig. 2). *Keratella cochlearis* were present in tench food most of all in afternoon and night hours, but in a daily cycle their percentage was from 0 to 100 %.

DAILY RHYTHM OF FOOD CONSUMPTION BY TENCH LARVAE

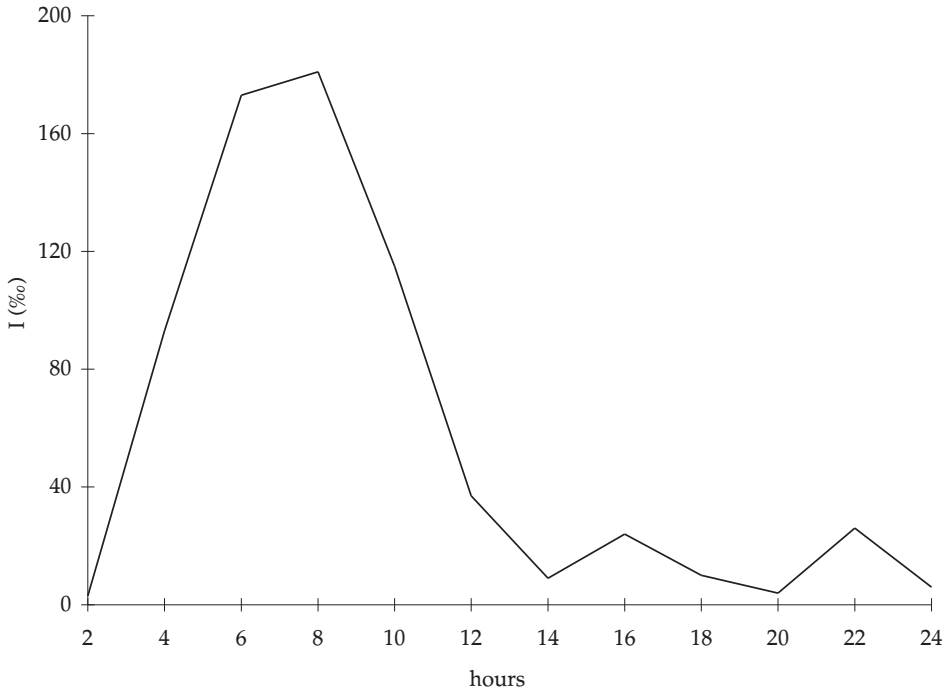

Fig. 3. Intensity in feeding by tench larvae in daily cycle, expressed as average consumption index (1 - ‰)

Consumption index (I) which reflects intensity of feeding of tench larvae in a daily cycle was the highest in morning hours, decreasing noticeably in the afternoon and at night. A curve illustrating intensity of feeding by tench larvae is characterised by one peak (fig. 3). From 22.00 to 3.00 hours the fish did not ingest any food. Almost 50 % of the food tracts collected during this time were empty. Feeding activity increased noticeably from sunrise to 8.00 hours.

DAILY FOOD RATION

The constant of evacuation rate (R in the equation 1, k2 in the equation 2) for tench larvae feeding mostly on zooplankton, less on insect larvae, was about 0.230 at average daily water temperature of 24.6°C, and food evacuation time of 4 hours. For 25-day-old tench larvae of average individual weight 44.3 g, the daily food ration calculated with the method of Thorpe was 6.3 %, and with the method of Elliott and Persson 6.9 % of average body weight.

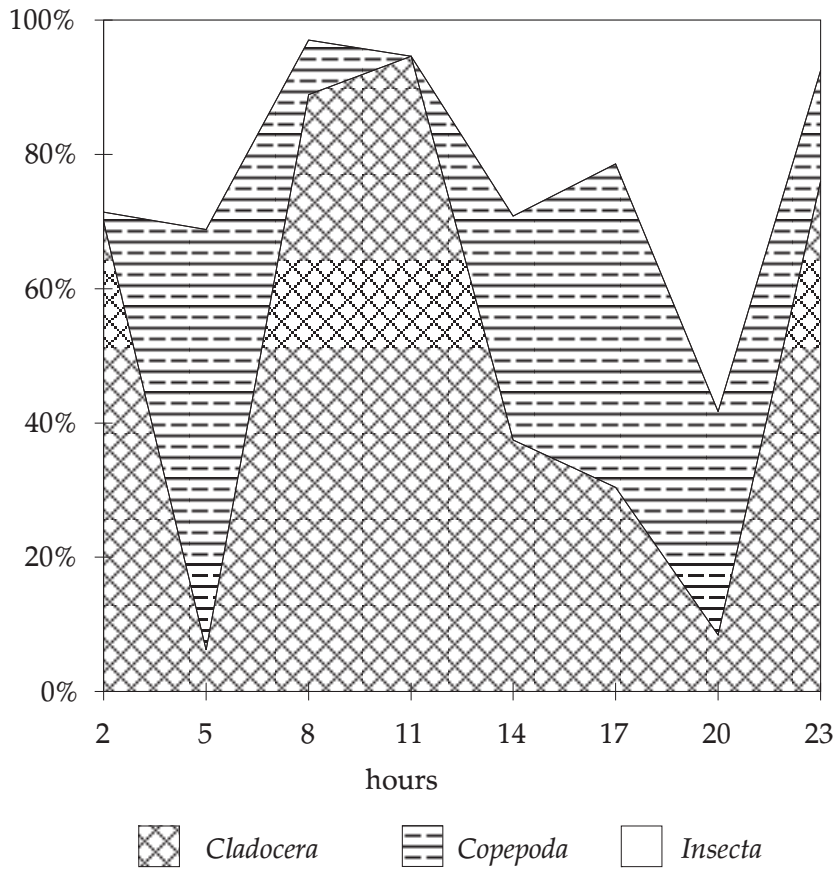

Fig. 4. Variations in the composition of tench fry food in daily cycle, expressed in % of the numbers of food organisms

FOOD COMPOSITION OF TENCH FRY AND ITS VARIATIONS IN A DAILY CYCLE

Food of tench fry contained the following taxa of invertebrate fauna: *Cladocera: Alonella nana*, *Chydorus sphaericus*, *Daphnia longispina; Copepoda: Eucyclops serrulatus*, and insect larvae: *Ceratopogonidae*, *Chironomidae*, *Ephemeroptera (Cloen dipterum)*, *Odonata*.

Major part of tench fry food was represented by insect larvae, *Chironomidae* and *Ceratopogonidae* most of all. As regards numbers of food organisms, the latter were usually dominants in a daily cycle (21-31 %), less frequently eudominants (58 %), or subdominants (5-7 %) and rare components (fig. 4). Insect larvae were a decisive eu-

dominant (88-99 %) in food weight (fig. 5). They were present in all samples, attaining the highest indices of the frequency of occurrence (50-100 %) from among all food items.

Planktonic crustaceans from the groups *Cladocera* and *Copepoda* were important food components only as regards numbers of the organisms consumed; they were eudominants (62-94 %) or dominants (16-48 %), less frequently subdominants (6-8 5) (fig. 4), but they were of no significance in food weight representing sporadic (0.01-0.9%) or rare (1.5 - 3 %) components (fig. 5). Frequency of occurrence ranged from 0 to 100 %.

DAILY RHYTHM OF TENCH FRY FEEDING

Consumption indices which reflect feeding intensity of tench larvae in a daily cycle were the highest in morning hours, the lowest at night. The curve characterising

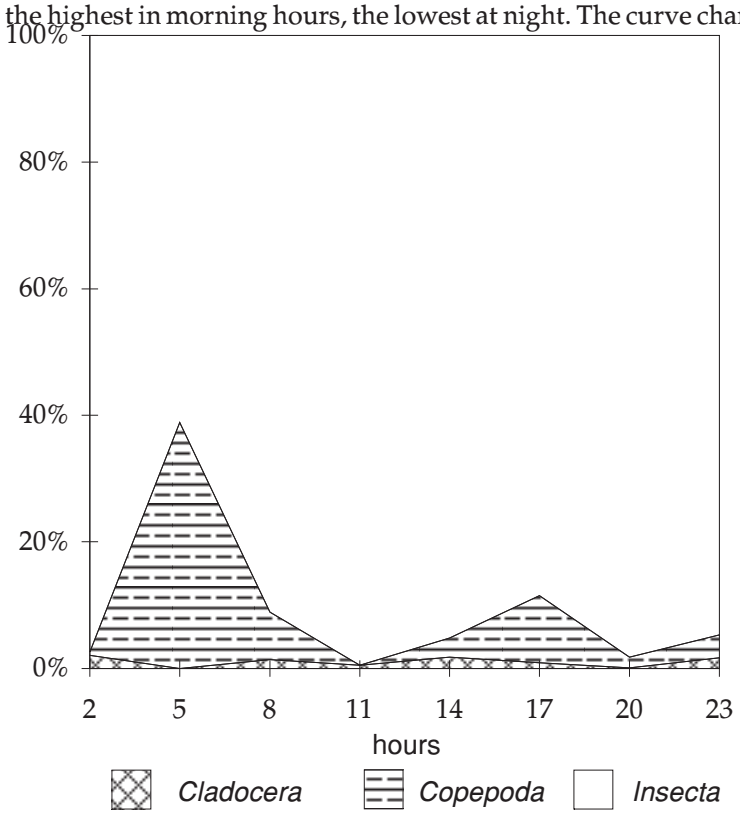

Fig. 5. Variations in the composition of tench fry food in daily cycle, expressed in % of the weight of food

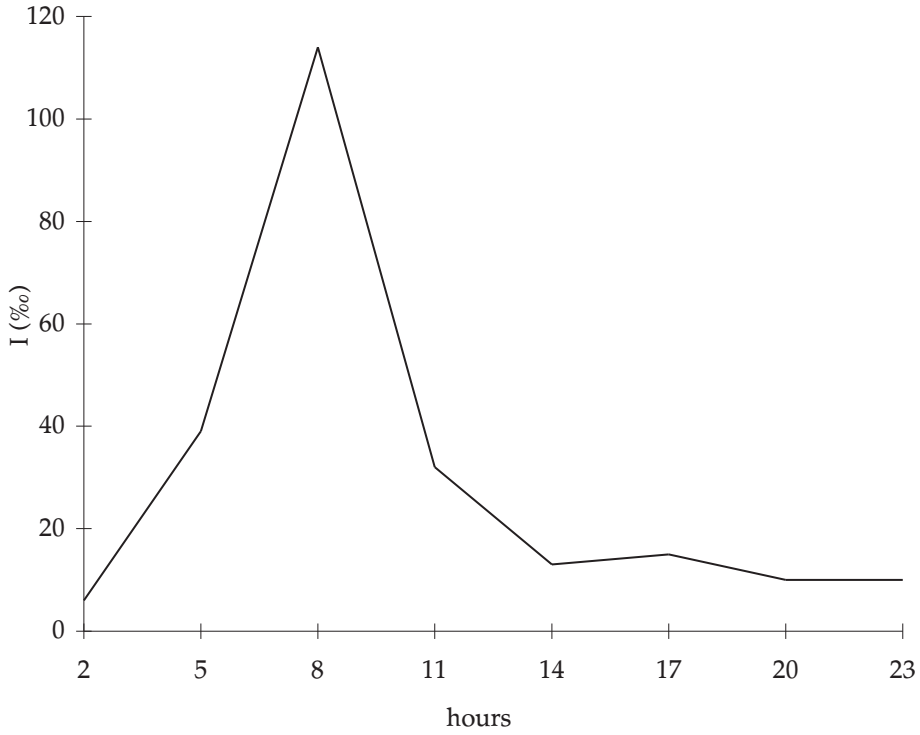

Fig. 6. Intensity of feeding by tench fry in daily cycle, expressed as average consumption index (I - ‰)

intensity of feeding of tench fry in a daily cycle had one peak (fig. 6) similarly as the curve for larvae. The highest feeding intensity was observed in morning hours. The fish did not feed at night (20.00-2.00 hours).

DAILY FOOD RATION

Daily food ration of tench fry which fed mostly on insect larvae, less on zooplankton, was 0.090 at water temperature of 8.2°C and evacuation time of 6 hours. Fry aged 100 days, of average individual weight 648.1 g, consumed daily ration equal to 1.1 % of average body weight when calculated using the formula by Thorpe.

DISCUSSION

Studies on the composition of tench food in early stages of postembryonal development revealed a decisive domination of planktonic crustaceans during larval

growth, and of insect larvae during fry stage (Evert 1974, Kennedy and Fitzmaurice 1970, Pokorny 1974, Pyka 1996, Smisek 1963). These preferences are in tench determined by food availability in terms of its quality and quantity, as well as by the size of organisms present in a water body. Food composition of juvenile tench is also affected by the lack of feeding specialisation in this species and considerable plasticity of its feeding behaviour (Pyka 1996).

Increasing food consumption indices at daytime, and their decrease at night are usually characteristic of predators, which need light for active feeding. Similar feeding rhythm was , however, observed by Sozinow (1978) and Zusser (cit. by Sozinow 1978) in some non-predatory fish (peled, white aspe). My studies showed that tench larvae and fry exhibit similar feeding activity in pond conditions. Food absence at night is followed by a phase of intensive feeding in early morning hours.

Level of daily consumption is strictly related to water temperature which determines metabolism rate, but also depends on fish age, type of ingested food, and food evacuation rate. The latter is expressed by exponential equations (Brett and Higgs 1970, Elliott 1970, Tyler 1970, Persson 1979 and 1981), the approximation being fairly good in the case of fish possessing stomach. In the case of stomachless non-predatory fish (roach, tench), there are some discrepancies. For example, in the case of roach feeding at 26°C, exponential index of digestion rate determined by Kitchel (cit. after Persson 1982) was 0.240, while at lower temperature (24°C) it was estimated by Persson (1982) at 0.500. My studies showed that rate of food digestion was about 0.230 for tench larvae at 24.6°C, and 0.090 for tench fry at 8.2°C. These values seem to be fairly accurate compared to the literature data.

Two methods were used to calculate daily for rations of tench larvae: of Thorpe (1977), and of Elliott and Persson (1978), taking into consideration the index of food digestion rate of 0.230. The results were very similar. It seems, however, that the model of Elliott and Persson is of no use in the case of low temperatures (as in the experiment with tench larvae). This was shown in earlier studies (unpubl. data). Daily food consumption by tench fry estimated with this method was highly overestimated. It should be, however, noted that the use of consumption indices to estimate quantitative relations in fish food, the value of which is calculated from reconstructed unit weights of the given food component, may also somewhat bias the obtained daily ration (overestimation), as these indices do not take into account the degree of food digestion.

CONCLUSIONS

1. Food of 25-day-old tench larvae of average individual weight 44.3 mg, and average body length 13.6 mm, was dominated in the daily cycle by *Copepoda*: small forms *Eucyclops serrulatus*.
2. Food of 100-day-old tench fry of average individual weight 648.1 mg, and average body length 30.9 mm, was dominated in the daily cycle by insect larvae, *Chironomidae* and *Ceratopogonidae* most of all.
3. Intensidy of feeding by tench larvae and fry was the highest in morning hours, the lowest at night.
4. Daily food ration of tench larvae was 6.3 % of average body weight when estimated using the method of Thorpe, and 6.9 % using the method of Elliott and Persson. Daily food ration of tench fry was 1.1 % of average body weight when estimated with the method of Thorpe.

REFERENCES

Brett J.R., Higgs D.A. 1970 - Effect of temperature on the rate of gastric digestion in figerling sockeye salmon (*Oncorhynchus nerka*) - J, Fish. Res. Bd. Can.(27): 1767 - 1797.

Edmondson W.T. 1971 - Methods for processing samples and developing data : 127-169 - In: A manual on methods for assessment of secondary productivity in fresh waters (Ed.) Edmondson W.T., Winberg G.G.

Elliott J.M. 1972 - Rates of gastric evacuation in brown trout, Salmo trutta L. - Freshwat. Bio. (2): 1 - 8.

Elliott J.M., Persson L. 1978 - The estimation of daily rates of food consumption fer fish - J. Anim. Ecol. (47): 977 - 991.

Evert H. 1974 - Egrebiusse bei der Erbrutung der Schleie und Aufzucht der larven bis zum Alter von 30 lagen. Z. Binnenfischerei DDR, Berlin, 21 (1): 365 - 368.

Kennedy M., Fitzmaurice P. 1970 - The biology of the tench *Tinca tinca* (L.) in Irish warers. Brog. of the Royal Irish Academy, v.69 sect.B, (3): 31 - 82.

Lebiedieva L.I., Kozlova E.I. 1969 - Razmiernoviesova charaktieristika zivych i fiksirovanych formalinom presnovodnych Cladocera - Gidrobiol. Ż. 5 (2): 73 - 69.

Persson L. 1979 - The effects of temperature and different food organisms on the rate of gastric evacuation in perch (*Perca fluviatilis*) - Freshwat. Biol. (9): 99 - 104.

Persson L. 1981 - The effects of temperature and meal size in the rate of gastric evacuation in perch (*Perca fluviatilis*) fed on fish larve - Freshwat. Biol. (11); 131 - 138.

Persson L. 1982 - Rate of food evacuation in roach (*Rutilus rutilus*) in relation to temperature, and the application of evacuation rate estimates for studies on the rate of food consumption - Freshat. Biol. (3): 203 - 210.

Pokorny J., 1974 - Niedocenena ryba. Vyter lina a odchov pludku. Cs. Rybarstvi, c. (12): 268 - 270.

Pyka J. 1996 - Feeding of the tench, *Tinca tinca* (L.), larvae and fry under pond rearing conditions - Arch. Ryb. Pol. 4 (1): 69 - 84.

Smisec J. 1963 - Rust pludku lina obecneho a jeho potrava. Cs. Rybarstvi (7): 100.

Sozinov J.A. 1978 - Sutocnyj ritm pitanija i racion dvuchletkov peljadi v ozere Cebac'e - Izv. GosNI0RCh (136): 110 - 117.

Thorpe J.E. 1977 - Daily ration of adult perch, *Perca fluviatillis* L. during summer in Loch Leven, Scotland. J.Fish. Biol. (11): 55 - 68.

Tyler A.V. 1970 - Rates of gastric emptying in young cod. J.Fish Res. Board Can.(27): 1177 - 1189.

STRESZCZENIE

DOBOWY CYKL ODŻYWIANIA SIĘ LINA *Tinca tinca* (L.) W STADIACH LARWALNYM I NARYBKOWYM, W WARUNKACH CHOWU STAWOWEGO. PRÓBA OKREŚLENIA DOBOWEJ RACJI POKARMOWEJ

W pracy omówiono odżywianie się larw i narybku lina w stawie, charakteryzując zmienność składu pokarmu w cyklu dobowym. Udział poszczególnych komponentów w pokarmie ryb przedstawiono w ujęciu liczbowym i wagowym. Podano ich wskaźniki częstości występowania. Prześledzono przebieg intensywności żerowania ryb w różnych porach doby. Oszacowano wielkość dobowego spożycia, które dla larw o średniej masie jednostkowej 44,3 mg, w średniej dobowej temperaturze wody 24,6^{o} C wyniosło, zależnie od metody liczenia (Thorpe 1977; Elliott, Persson 1978), od 6,3% do 6,9% ich średniej masy ciała. Wielkość dobowej racji pokarmowej dla narybku lina o średniej masie jednostkowej 648,1 mg, w średniej dobowej temperaturze wody 8,2^{o} C, obliczone metodą Thorpe'go, wyniosło 1,1% ich średniej masy ciała.

ADRES AUTORA:

Dr Julian Pyka
Instytut Rybactwa Śródlądowego
10-719 Olsztyn-Kortowo
ul. Oczapowskiego 10