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# MORPHOLOGY OF TENCH, *Tinca tinca* (L.), IN THE FIRST YEAR OF POSTEMBRYONAL DEVELOPMENT

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A B S T R A C T. Description is presented of the morphologic development of tench in the first year of life at the background of thermal conditions and food resources in the environment. Three groups of tench larvae and fry were studied; they originated from a three-batch spawning and were reared in separate enclosures in an earthen pond. A strict relationship was found between the rate of morphologic development and the thermal conditions, both during larval and fry stage. Morphologic development of tench fry was clearly affected by the type of food; this effect was less noticeable in the case of larvae. A definite stage of morphologic development sttained by the fish was related to body size irrespective of the fish age.

Key words: TENCH, MORPHOLOGY, FOOD, TEMPERATURE, PONDS

## INTRODUCTION

Tench spawns a few times in the same year (Cheban 1975, Dragin 1939, Epler et al. 1981, Evert 1974, Horoszewicz et al. 1981, Kokurewicz 1981, Papadopol and Weinberg 1971, Pyka 1986, Zubenko 1975). Due to this consecutive stages of the reproduction, embryonal development and early stages of postembryonal development take place in different periods and usually in different environmental conditions. This may lead to the differentiation of tench progeny as regards the rate of individual development.

There are not many papers on tench development in the first year of life. Some data have been presented by Anvand (1965), Kennedy and Fitzmaurice (1970), Rosa (1958) and Starmach (1951), but they are general information only.

The aim of the studies was to analyse the morphologic transformations taking place in early stages of tench development with attention given to thermal and food conditions in the environment. Their results reflect phenotypic character of particular groups, but also consitute some input into the works related to tench breeding and selection, and such works have not been carried out in Poland on a broader scale.

It seems that tench may play an important role in the fishery management due to such important characters as low requirements as to the environment quality, figh resistance to diseases, penetration and utilization of the zones inaccessible to other fish, considerable plasticity of the feeding behaviour and high market value. Hence, culture of this fish should be enhanced. Still insufficiently known biology of this fish justifies new studies.

## MATERIALS AND METHODS

The work has been based on the materials used in the studies on tench biology in the first year of its life (Pyka 1986). It comprises an analysis of the development of three tench groups, since larvae hatching till the end of the first growing season. The fish were reared in separate enclosures in an earthen pond. The first group was 7 days older than the second, and 25 days older than the third group.

Fish samples were collected depending on the degree of the fish development every 1-3 days (non-feeding larvae), and every 7 days (feeding larvae and fry). Thermal conditions and food resources were analysed in each enclosure; the analyses comprised: water temperature, qualitative composition and biomass of the zooplankton and bottom fauna.

Observations on the structural changes in the protopterygium, ray formation in the fins, and development of the scales were made in a field laboratory using both alive fish and fish preserved in alcohol and stained with the methods used for the cyprinids (Balon 1956).

Body length of tench larvae was measured using a measuring microscope, with an accuracy up to 0.1 mm. Individual weight was established weighing each fish on an analytical balance, with an accuracy of 0.1 mg. Body length of the fry was measured using a milimetre scale up to 0.5 mm, and individual weight was established up to 1 mg using an analytical balance.

Two developmental periods were distinguished in each group: the larval one, since larvae hatching till the begining of scale formation, and the fry one, since the appearance of the first scales till the end of the first year of life.

Two phases were distinguished in the larval period: the phase of early postembryonal larvae, lasting since the hatching till the moment when the larvae began to feed in an active way, and the phase of late postembryonal larvae, viz. since larvae passing to exogenous food till the appearance of the first scales.

As regards the latter phase, two stages were still distinguished: a **protopterygiolarval** stage (unformed larvae) - since the begining of active feeding till an advanced stage of protopterygium differentiation, and a **pterygiolarval** stage (formed larvae) - since the moment of fin appearance till complete disappearance of the protopterygium and the begining of scale formation.

The classification criteria consisted of the major anatomic changes viz.: reduction of the protopterygium and fin formation, changes in the body shape and pigmentation, changes in the location of the mouth apparatus, development of the scale cover and of the food tract during endogenic feeding of the larvae, resorption of the yolk sac.

The above division into stages is a simplified one, but it is generally based on the theory of fish development presented by Vasniecov (1953).

Morphologic transfromations taking place in stages, phases and periods of the fish life have been illustrated with figures related to the first group (stages a-h), while morphologic changes of tench in this group have been related to body size and fish age and compared to the order groups (second and third one).

## RESULTS

### DESCRIPTION OF THE DEVELOPMENT OF MORPHOLOGIC FEATURES

Tench larvae commenced the phase of early postembryonal development immediately after hathing. The larvae in particular groups differed with respect to body size. The biggest individuals, of average body length 4.3 mm, belonged to the group originating from the first egg batch, while the smallest ones, 3.9 mm in length, originated from the third batch (Tab. 1).

**TABLE 1**

Length of tench larvae in particular groups just after hatching (mm)

| Date | Group | n | Lc | $Lc_1$ - $Lc_n$ |
|---|---|---|---|---|
| 3.VI | I | 26 | 4.3 | 3.6 - 4.8 |
| 10.VI | II | 30 | 4.0 | 3.5 - 4.6 |
| 28.VI | III | 29 | 3.9 | 3.5 - 4.5 |

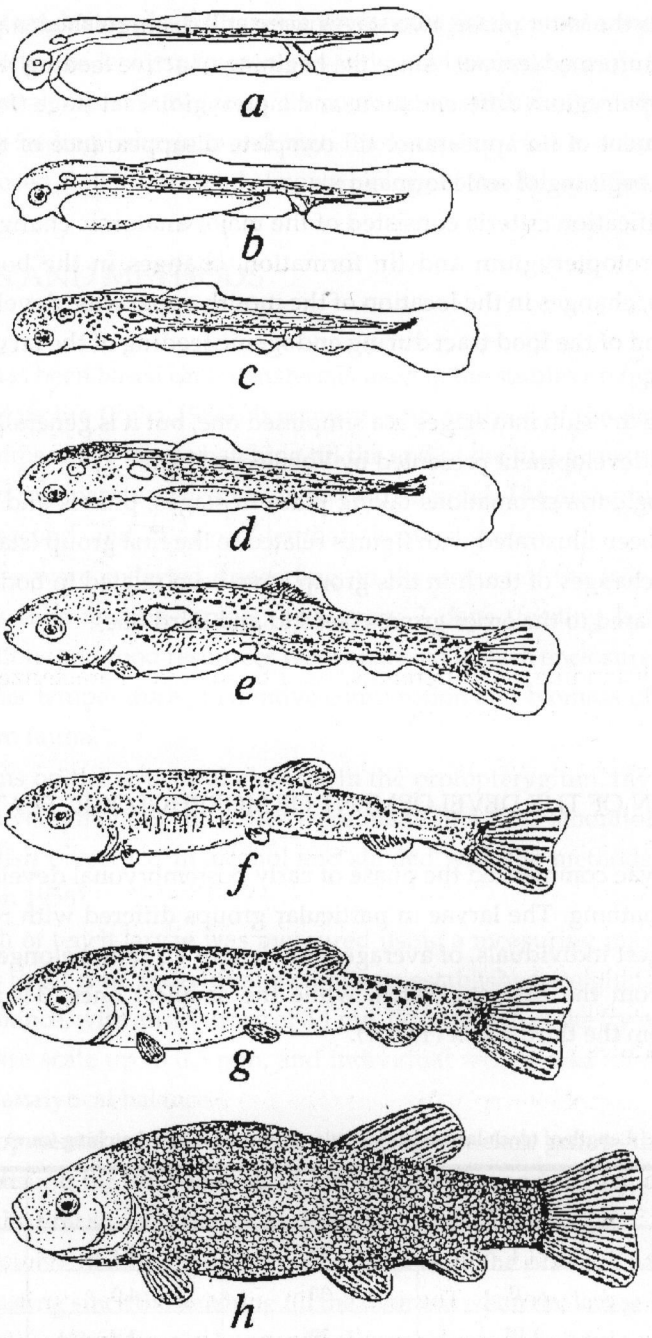


Fig. 1. Morphologic development of tench in the first year of life - stages a - h

Tench larvae at the begining of the phase of early postembryonal development. viz. in stage "a" (Fig. 1) possessed a uniform slightly arched protopterygium running along the back to the end of the caudal part, and along the ventral part, reaching the anus. Ventral part of the protopterygium was divided into two sections: post- and preanal. Single melanophores were present along the longer axis of a pear-shaped yolk sac, close to the upper edge of the body and the protopterygium. The head, directed downwards, adhered to the frontal, swollen part of the yolk sac. Metamerization was noticed in the fish body. Larvae from the three groups (originating from consecutive egg. batches) aged 4, 8 and 5 days respectively, did not differ as to their morphology.

As soon as the yolk sac content decreased to less than 40% of body weight, and the larvae attained 4.6-5.1 mm, the rate of individual development increased. Changes were observed as to head location, and the developing mouth moved to the end position. Pigment accumulated over the body and the protopterygium began to differentiate - stage "b" (Fig. 1). Tench larvae aged respectively 5, 8 and 6 days resorbed the yolk sac content viz. they reached the end of an early postembryonal phase. Notwithstanding age differences, all of them were characterized by the same degree of mophologic development.

Resporbtion of the yolk sac (viz. duration of the early postebrional phase) was decisively affected by water temperature. In the first group of the larvae rate of resorbtion was the highest. Average daily temperature in this group was the highest; it amounted to 21.4°C, and the most frequent temperatures also exceeded 20°C. Also the average daily indices of the fish growth in length, taken as the measures of individual development, were the highest in the first group. In the second and third group, in which rate of yolk sac resorbtion was slower and so was the fish growth, water temperatures were much lower (Tab. 2).

The stage of protopterygial larvae of the late phase of postembryonal development began since the moment when the larvae commenced active feeding. The protopterygiumm was significantly transformed - stage "c" (Fig. 1). These parts of the protopterygium which receive the mesenchematic cells of the future skeleton and muscles began to be noticeable (later on they remain as the fins, while the rest of the protopterygium disappears). The caudal fin, most advanced in its development, began to be of a rounded shape, hypuralia began to form and buds of the lepidotrichia appeared (the picture shows only undifferentiated mesenchymatic cells). Also pecto-

**TABLE 2**

Average body length, daily length increments, and water temperature in the phase of early postembryonal development of tench larvae from particular groups

| Group | Phase duration | Age (days) | N | Lc (mm) | Increment Lc (%) | Average daily water temp. for the phase °C | Temp. range °C | Most frequently noted °C |
|---|---|---|---|---|---|---|---|---|
| I | 3.VI-9.VI | 6 | 19 | 5.2 | 16.7 | 21.4 | 18.0-25.0 | 20.0-25.0 |
| II | 10.VI-19.VI | 9 | 18 | 5.2 | 11.1 | 15.5 | 12.5-19.5 | 12.5-15.0 |
| III | 28.VI-5.VIII | 7 | 32 | 5.1 | 14.3 | 19.5 | 18.0-21.5 | 18.0-19.0 |

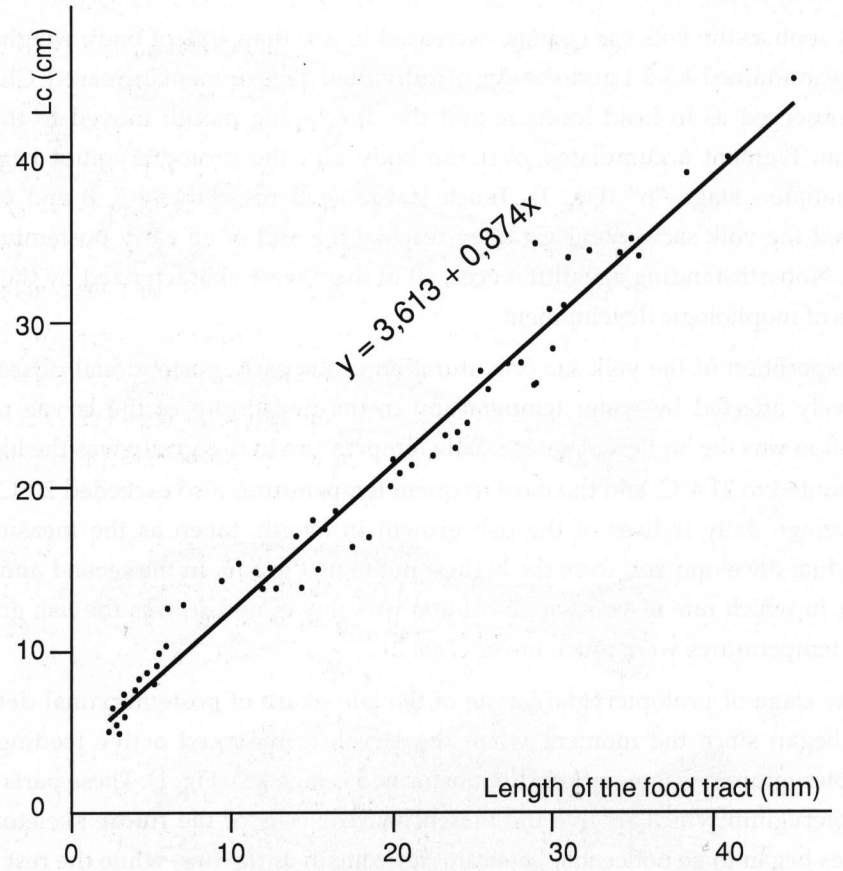


Fig. 2. Dependence between length of the food tract and body length in the first year of life

ral fins began to be noticeable. The food tract of the feeding larvae was in form of a straight tube and constituted about 1/2 of the body length (Fig. 2). Diameter of the anterior part was 0.1-0.2 mm, of the middle part 0.1-0.3 mm, and of the end part 0.1-0.2 mm. This degree of morphologic development was attained by the larvae of average body length 5.2 mm aged 6 days - the first group, 9 days - the second group, and 7 days - the third group.

As the protopterygiolarval stage proceeded, other features of an adult fish began to appear - stage "d" (Fig. 1). Fin nuclei appeared in the protopterygium: dorsal, anal and ventral. In place of the future dorsal and anal fins tissues formed from the myomers began to grow in, but in place of the ventral fin only nonstructural bud was noticeable.

The pectoral fin, in form of a fold with the first nucleus of its base skeleton, got a rounded shape. Further development of the lepidotrichia took place in the caudal fin; they grew noticeably towards end sections of the spinal chord. The pigment still gathered intensively - mostly in the dorsal part of the body, less so over the ventral one. This degree of the development was attained by the 13-day larvae from all groups, at average body length in the respective groups being 5.7 mm, 5.4 mm and 5.3 mm.

More rapid morphologic development of the larvae from the first group in the protopterygiolarval stage might have been connected with shorter phase of the early postembryonal development and, thus, with earlier formation of the new morphologic features and physiological changes which increased food accessibility for the fish and its utilization.

In the second stage of the phase of late postembryonal (pterygiolarval) development the characteristic changes of the fish morphology comprised further development of the fins - stage "e" (Fig. 1). The dorsal fin differentiated and delicate basal rays (interspinalia) became noticeable, as well as lepidotrichia. The protopterygium, laying prior and behind the dorsal fin, became almost totally reduced.

Further development of the lepidotrichia took place in the caudal fin; they almost reached the outer edge of the fin. Rays became visible also in the pectoral fin, but they did not attain their final shape yet. The pigment was still being accumulated - mostly at the base of the caudal part and along the abdomen. This stage of development was attained by the larvae from the first group at average body length of 7.5 mm, aged 24 days. In the other groups the larvae at this stage were a little younger - 21 and 22 days - and slightly bigger (8.0 and 8.5 mm).

Tench larvae from the first group, of average body length 8.0 mm (aged 26 days), and from the other two groups, of average length 8.5 and 8.6 mm respectively (aged 23 days), had already well developed rays in the dorsal and caudal fins - stage "f" (Fig. 1). Caudal fin became shaped like in the adult fish, with a characteristic indent. It had bifurcated rays, each forming 5-6 thin bands at the fin circumference. Rays in the dorsal fin also branched, but those in the anal, ventral and pectoral fins were still in the form of dorsal ray nuclei.

Pigmentation noticeably spread over the body sides. All fish possessed a two-chamber swimming bladder, and the food tract was in the form of a straight tube. As the larvae grew and approached the end of the pterygiolarval stage, morphologic changes slowed down. Larvae in particular groups which attained average length of 10.5, 10.0 and 12.5 mm respectively (aged 40, 33 and 38 days) had finally formed caudal, dorsal and anal fins. 21-25 rays were present in the caudal fin, 8-10 in the dorsal and 7-8 in the anal. Food tract represented more than a half of body length (Fig. 2). Diameter of its anterior part was 0.7-1.2 mm, of the middle part 0.4-0.6 mm. The food tract began to form loops (in the larva 11.5 mm long).

Pterygiolarval stage in the case of group 3 took place when water temperatures were noticeably higher and favoured larvae development. These larvae were decisively bigger. Rate of larvae development must have been directly related to water temperatures since the composition of the consumed food was similar in all groups (Pyka 1988).

**TABLE 3**

Average body length of tench and daily increments attained in the protopterygiolarval and pterygiolarval stage of late postembryonal development phase

| Group | | Stage duration | Age (days) | Lc (mm) | Increment Lc (%) | Average daily water temp. for the stage °C | Temp. range °C | Most frequently noted °C |
|---|---|---|---|---|---|---|---|---|
| I | a | 9.VI-16.VI | 13 | 5.7 | 1.3 | 16.5 | 12.5-20.5 | 14.0-18.0 |
| | b | 16.VI-25.VI | 54 | 15.5 | 1.6 | 18.0 | 13.5-23.0 | 15.0-18.0 |
| II | a | 19.VI-23.VI | 13 | 5.4 | 0.9 | 19.0 | 14.0-23.0 | 18.0-23.0 |
| | b | 23.VI-25.VI | 45 | 15.5 | 2.9 | 18.0 | 15.0-22.0 | 17.0-18.0 |
| III | a | 5.VII-11.VII | 13 | 5.3 | 0.6 | 18.0 | 16.0-22.0 | 16.0-18.0 |
| | b | 11.VII-8.VII | 41 | 15.0 | 3.3 | 20.0 | 15.0-24.0 | 21.0-22.0 |

*a - protopterygiolarval stage, b - pterygiolarval stage*

Decisive effect of temperature on the development of tench larvae (a warm-water fish) was also reflected in daily increments of body length in the third group, both in the protopterygiolarval and pterygiolarval stage (Tab. 3). In the second stage these larvae attained almost 5 times higher indices than in the first, this being due to higher temperatures. Considerable variations of zooplankton and insect larvae concentrations in the pond with the third group of the fish (Fig. 3) (also in the other ponds) seemed to have no effect on the rate of individual development of the larvae, as the food resources were nevertheless high. The same relationship was noted also for the fish from the first and the second group.

Larval stage ended when the fish attained average body length of 15.0-15.5 mm. In the second and the third group these were the fish aged 41 and 45 days. As regards the first group, the same size was attained much later, at the age of 54 days. The fish which left the larval stage and entered the fry stage had all fins well developed. The ventral and anal fins attained their final form and possessed 8-10 and 14-15 rays respectively.

Formation of the scale cover is a characteristic feature marking the begining of the fry stage. Single nuclei of scales - stage "g" (Foig. 1) - were noted when the fish attained 15.5-16.0 mm (Tab. 4). The first scales appeared below the lateral line, behind the dorsal fin, towards the base of the caudal fin. They were in form of oval plates, of similar shape as melanophores, and contrarily to other cyprinids (Balon 1956) were strongly stained with alizarine. The whole scale cover - stage "h" (Fig. 1) - was observed in the fish 21.0-25.5 mm long; age of the fish in this stage was less differentiated: from 67 to 70 days (in all groups).

There were 90-115 scales along the lateral line (l.l.), while in the vertical row - above (s) and below (i) the lateral line (to the highest place of the fish back and the lowest of the fish abdomen) there were 28-34 and 18-23 scales respectively. Hence the scale formula was: l.l. (s/i) (90-115) (28-34) / (18-23).

**TABLE 4**

Tench body size and age at the moment of scale formation

| Group | Age (days) | Lc (mm) | Lt (mm) | W (mg) |
|---|---|---|---|---|
| I | 54 | 15.5-16.0 | 18.5-19.5 | 72.0-76.0 |
| II | 45 | 16.0 | 19.0 | 80.0 |
| III | 41 | 16.0 | 19.0 | 85.0 |

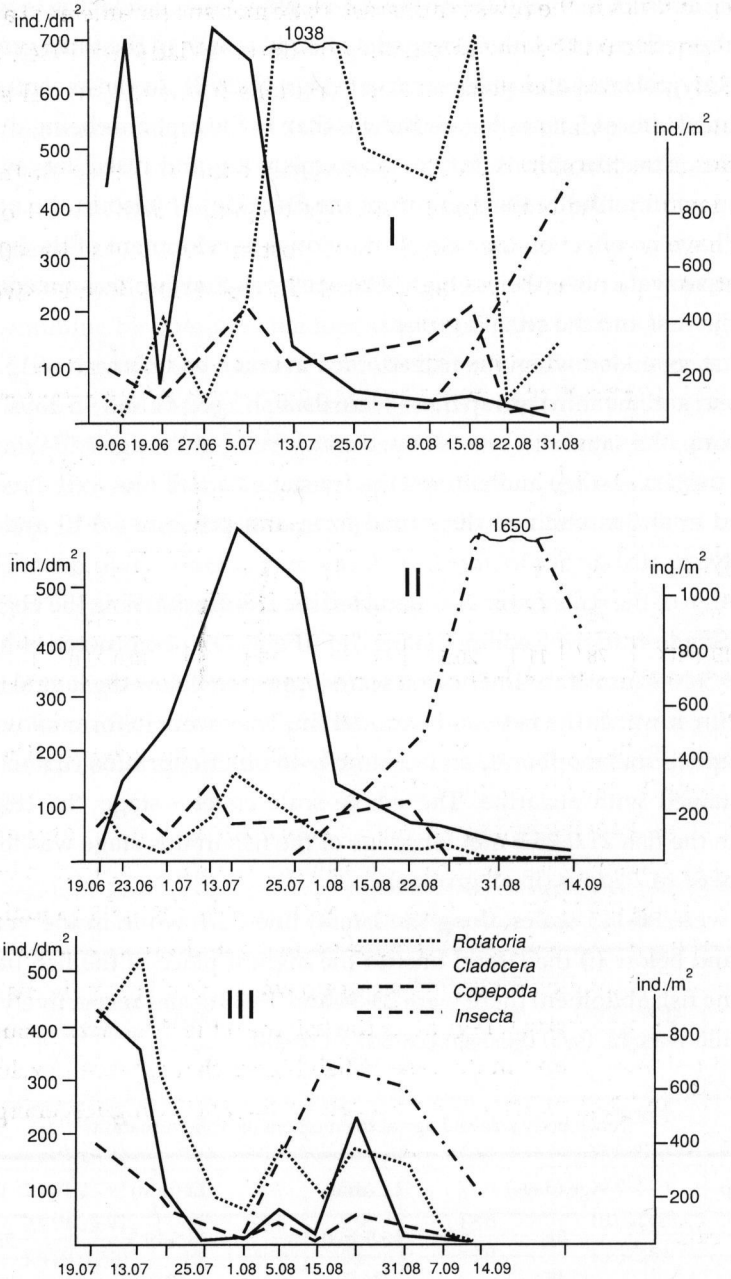


Fig. 3. Dynamics of the zooplankton and insect larvae numbers in the ponds with particular groups of tench fry

Number of scales in the rows is a characteristic meristic parameter of a species; its variability depends on the environmental conditions (Vladykov 1934). Studies by Mottley (1931) revealed that temperature variations in the embryonal stage could determine number of scales.

Food tract of the fish still became longer and increased its diameter in the fry stage. Its relative length at the begining of this stage ranged from 0.8 to 1.1 of the body length, and its average thickness was 0.8 mm (posterior part of the guts 0.8-1.2 mm, middle part 0.7-1.2 mm, end part 0.6-0.9 mm). The food tract formed two loops. In

**TABLE 5**

Average body length of tench and daily increments attained in fry stage

| Group | Rearing duration | Age (days) | n | Lc (mm) | Increment | Average daily water temp. for the phase °C | Temp. range °C | Most frequently noted °C |
|---|---|---|---|---|---|---|---|---|
| I | 25.VII-14.IX | 103 | 20 | 29.0 | 1.1 | 16.2 | 10.0-24.5 | 12.0-19.0 |
| II | 25.VII-14.IX | 96 | 15 | 24.0 | 0.7 | 16.2 | 10.0-24.5 | 12.0-19.0 |
| III | 8.VIII-14.IX | 78 | 11 | 20.5 | 0.6 | 15.4 | 10.0-22.0 | 12.0-15.0 |

older fry, of body length over 20 mm, feeding on insect larvae, length of the food tract was slightly longer than body length (Fig. 2).

Juvenile tench from the first group entered the fry stage with a noticeable growth compensation phenomenon. Due to this, the fish were able to attain much bigger body size than the fish in the other two groups. In view of this, these fish should be given attention in selection procedures. It is possible that rapid growth of these fish was connected with food quality. Fry from this group was in similar conditions as regards the food resources and thermal regime as the fish from the other two groups (Tab. 5, Fig. 3), but it fed mostly, and in the case of fish bigger than 23 mm - exclusively, on insect larvae (Pyka 1988) which represent a natural food of the highest energetic value (Galinat 1960).

## CONCLUSIONS

1. Morphologic development of different tench groups in the first year of life was closely related to thermal conditions in the enviornment.

2. Rate of morphologic development of tench was connected to a varying degree with food quality. In the larval stage this relationship was weak, but it was very strong in the fry stage.
3. Changes of the natural food resources in a pond, at the existing food concentration and fish requirements, had no visible effect on the rate of morphologic changes in tench, both in the larval and the fry stage.
4. Tench fry from the first group was characterized by the most rapid morphologic development. This should be the material used for further breeding and selection procedures.

*Trans. by Maria E. Bnińska*

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## STRESZCZENIE

MORFOLOGIA LINA *Tinca tinca* (L.) W PIERWSZYM ROKU ROZWOJU POSTEMBRIONALNEGO.

W pracy przedstawiono przebieg zmian w budowie morfologicznej lina w pierwszym roku życia w warunkach chowu stawowego. Analizie poddano trzy grupy wczesnych stadiów lina, pochodzące z rozrodu trójporcyjnego, które podchowywano w oddzielnych przegrodach stawu ziemnego. W poszczególnych grupach rozpatrywano dwa okresy rozwojowe: larwalny i narybkowy. W okresie larwalnym wydzielono fazę wczesnego rozwoju postembrionalnego larw i fazę poźnego rozwoju postembrionalnego larw. W drugiej fazie wyodrębniono dwie niższe jednostki: etap protopterygiolarwalny (larwy nieukształtowanej) i etap pterygiolarwalny (larwy ukształtowanej). Podstawą podziału były zmiany ważniejszych cech budowy morfologicznej, charakterystyczne dla okresu - fazy - etapu, obejmujące: redukcję fałdu skórnego i formowanie się płetw, zmiany położenia aparatu gębowego, zmiany kształtu i pigmentacji ciała, rozwój szaty łuskowej. Przeobrażenia w budowie morfologicznej odnoszono do wieku i rozmiarów ciała ryb.

Stwierdzono ścisłą korelację tempa rozwoju morfologicznego lina, zarówno w okresie larwalnym jak i narybkowym, z warunkami termicznymi środowiska, a w okresie narybkowym również z rodzajem zjadanego pokarmu.

Osiągnięcie przez ryby określonego stopnia rozwoju morfologicznego było związane z rozmiarami ciała i niezależne od wieku.

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