Effect of live and dry food on rearing of tench (Tinca tinca L.) larvae under controlled conditions

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Abstract

In the current paper we present a method of rearing tench (Tinca tinca L.) larvae under controlled conditions, fed on dry food (Gemma and Perla) and Artemia nauplii or decapsulated cysts of Artemia. Tench larvae were obtained after artificial spawning by aid of Ovopel stimulation. Two experiments were conducted during which fish were divided into 4 groups (in duplicate) and placed in 30 dm³ glass fish tanks set up in a recirculating system. The fish were fed ad libitum and reared for 25 days. Larvae were fed exclusively (experiment 1) or after 10 days (experiment 2) of receiving Artemia nauplii with two types of compound feeds and decapsulated cysts of Artemia. The best growth rate was observed in the control group fed on Artemia nauplii and in the group offered decapsulated cysts in both experiments. The highest survival rate, over 96%, occurred in the control group. A twofold worse survival rate was obtained in the group fed exclusively on dry food. Applied transition schedule had significant effect on survival rate among treatments, however it did not influence the percentage of body deformations occurring in groups receiving compound feed only. The results obtained indicate the necessity of applying gradual transition from live food to compound feed and the improvement of feeding schedules in common tench culture.

Introduction

Commercial production of cyprinid fish species is one of the major branches of European freshwater aquaculture. However, intensive methods of its production, except common carp, are very uncommon. The most commonly applied method of intensification is semi-intensive earthen pond-based management with application of natural or semi-natural propagation (Gela et al., 2006; Kujawa et al., 2009). Therefore, in recent years many scientific research programs have been dedicated to intensification of production. It concerns especially controlled reproduction (Kucharzyk et al., 2008, Kujawa et al. 2010), sperm cryopreservation (Babiak et al., 1998; Cejko et al., 2010), gamete management (Linhart et al., 2006), incubation conditions and initial rearing of larvae under controlled conditions (i.e. Kucharzyk et al., 1997; 1998; Kujawa et al., 2009; Wolnicki et al., 2003; Wolnicki et al., 2006; Mamcarz et al., 2006).

The initial rearing of larvae is one of the bottlenecks in production of freshwater fishes. For that purpose, most commonly used techniques are: specially prepared and naturally fertilized ponds (Milestone et al., 2006; Śliwiński, 2009), net cages (Huang et al., 2006) or recirculating aquaculture systems (i.e. Wol nicki et al., 2003; Wolnicki et al., 2006; Wolnicki et al., 2009). Fast developing cultures in closed systems are becoming increasingly widely used due to the possibility of full control of environmental and sanitary conditions (Blancheton, 2000) and economic effectiveness of production (Turkowski et al. 2008). In controlled rearing of fish larvae many different parameters have great impact on the production outcome where the kind of food is one of the main bottlenecks (Kucharzyk et al., 1998; Wolnicki, 2005). In general, it is strongly linked to the biological characteristic of each species and its physiological ability to digest particular kind of food (Dąbrowski, 1984). Therefore, data improving this part of knowledge are valuable for potential researchers as well as producers, especially, when economical advantages are considered (Turkowski et al. 2008, Hakuc’-Bla’owska et al. 2009).

Common tench Tinca tinca (L.) is one of the fish species recently declared as one of the most perspective species for diversification of freshwater aquaculture (Wang et al., 2006; Gela et al., 2006). In addition, researches have been undertaken on rearing tench larvae under controlled conditions (Quiros and Alvarinó, 2000; Wolnicki et al., 2003). Initially, lack of suitable food for very small young larvae was a serious problem in the early rearing of fish larvae. Advances in using Artemia as the first live foods for the larvae (Fleig et al., 2001; Wolnicki et al., 2003, Celada et al., 2007b) as well as improved new types of artificial, commercially available fish feeds make it possible to overcome this obstacle (Wolnicki and Gorný, 1995; Wolnicki and Myszkowski, 1998; Quiros et al., 2003; Wolnicki et al., 2006).

The present study aimed at determining the potential effects of rearing tench larvae fed exclusively, or after 10 days of receiving Artemia nauplii, with two types of commercial artificial feeds (Perla and Gemma, which were reported to be useful in tench intensive rearing, however never compared with each other) as compared to the ones receiving Artemia nauplii as well as their decapsulated cysts.

Materials and methods

Broodstock and freshly hatched larvae management

Common tench spawners were caught from the Sasek Wielki lake (north-eastern Poland). After capture, the fish were transported to the hatchery of the Department of Lake and River Fisheries, University of Warmia and Mazury, Olsztyn, Poland where they were divided into males and females, which were then placed in separate tanks (Kujawa et al., 1999). In order to obtain gametes, double hormonal injection (Ovopel) was applied according to the method described by Kucharzyk et al. (2007). Ovulation occurred fourteen hours after the second injection. Eggs were put into to dry plastic vessel, fertilized and then unsticked using modified Woynarovich solution and tannin bath (Kujawa et al., 2009). Incubation of eggs was carried out in Weiss’ jars, in water at the temperature of 21°C for 3 days. Freshly hatched larvae [mean total length
(TL)=5.02±0.09 mm, mean body weight (BW)=0.45±0.05 mg were placed in the transition tank (total capacity 150 dm³) where they were kept at 23°C for 4 days. Three days after hatching, the larvae could swim actively and their posterior chamber of the swim bladder was filled with air. Five days post hatch (DPH), the yolk sack had been resorbed. Next, proper acclimation to the temperature of 25°C was provided. After all initial preparations the larvae were stocked for experiments. Until that moment the fish were not fed.

**Experimental rearing conditions**

The study was divided into two separate experiments during which the same rearing conditions were maintained. Each rearing was conducted for 25 days in the closed water system. During rearing 10% of water in the whole system was replaced daily. Total ammonia concentration in each experiment and during the whole period of rearing did not exceed 0.1 mg dm⁻³ and nitrites 0.05 mg dm⁻³ (water analysis was done using a Slandi LF205 photometer, Michałowice, Poland). The larvae were reared in glass tanks (aquaria) of 30 dm³ supplied with filtered and oxygenated water. The system was equipped with devices that allowed maintaining constant water temperature (25°C±0.5°C) and the photoperiod (12L:12D). Each tank possessed its own independent aerating stone and gentle aeration was provided which allowed keeping the dissolved oxygen concentration at over 85%. The top water inlet (to each tank separately at water flow 2 dm³ min⁻¹) caused small water motion, which additionally helped in even distribution of all the food given throughout the whole tank. The stocking density was 70 ind. dm⁻³.

Every day in the morning, prior to the first feeding, all aquaria were cleaned to remove food remains, faeces and dead larvae. The number of dead larvae was recorded. Every five days, 25 randomly chosen fishes from each aquarium were measured. The measurements consisted of checking the TL and wet BW (±0.1 mg). Before the measurements, the fish were anesthetized in the Etomidat solution (0.5%) (Propiscin, IRS, Olsztyn, Poland). The larvae were acclimated in the Etomidat solution (0.5%) (Propiscin, IRS, Olsztyn, Poland). At first, 0.6 cm² dm⁻³ of the preparation was used, but the rate was gradually diminished to 0.2 cm² dm⁻³ on day 25. The larvae were measured (±0.01 mm) on the base of the digitized image (DP-Soft software) captured with the optical microscope (Olympus, Tokio, Japan). After the measurements, the fish were returned to the same tanks they had been captured from. At the end of each experiment 200 randomly captured fish from each group were photographed and the percentage of body deformities was determined.

**Experiment #1 – initial food**

During this experiment, the larvae were divided into four groups. In each group different food was offered. The control group (group AN0) received live Artemia nauplii (Artemia sp., Great Salt Lake origin, 85%). The second group (group DC0) was fed by decapsulated cysts of Artemia (Great Salt Lake origin, Artemia International, Fairview, TX, USA). Two other groups received different commercial feeds: Perla larva (Skretting; 62% protein, 11% fat, 0.8% fiber, 10% ash, 1.1% phosphorus) (group PF0) and Gemma 300 (Skretting; 55% protein, 15% fat, 5% fiber, 13.5% ash, 2% phosphorus) (group GF0). The larvae were fed ad libitum four times a day with a 3-hour interval. The first feeding was provided an hour after switching on the light. The experiment was conducted in two replicates.

**Experiment #2 – food transition**

In this experiment four feeding regimes were tested. Larvae from all groups were fed for 10 days with freshly hatched Artemia nauplii. After this period Artemia nauplii were offered in the control group (AN10) only. Other three groups received dry feeds according to the experiment 1. These groups were marked as DC10, PF10 and GF10 for groups fed by decapsulated cysts, Perla and Gemma feeds respectively. Food was offered ad libitum four times a day with a 3-hour interval. The first feeding was provided an hour after switching on the light. The experiment was conducted in two replications.

**Data analysis and statistics**

The results obtained allowed computation of the specific growth rate (SGR, 100 (% day⁻¹)) according to the formula ((ln WT−ln W₁)/(T−t))−¹, where WT and W₁ represent the mass of fish at the beginning (day 0) and the end (day 21) of rearing and T−t represent the number of days between measurements. Daily increments in total length (ITL, mm day⁻¹) were computed according to the formula: (TLₙ−TL₀)/n, where TL₀ and TLₙ were the final and initial mean total length (mm) of the fish, and “n” was the duration of rearing (days).

The statistical analysis of the data was carried out using the STATISTICA for Windows ver.8.0 PL software package (StatSoft). All the values are expressed as percentages or arc-sine transformed prior to statistical analysis. Differences between groups were analyzed by means of the analysis of variance (ANOVA) and Tukey’s post hoc test (α=0.05).

**Results**

**Experiment #1**

After 25 days of rearing, the best length and body growth rates for tench larvae occurred in the control group fed exclusively Artemia nauplii. Fish in this group reached the average body length of over 20 mm and body weight of around 90 mg (Figure 1a and 1b). The fish from both groups receiving artificial feeds (GF0 and PF0) reached the length between 10 and 15 mm and body weight of 20-25 mg. At the end of the rearing period, the differences in body weight and length between the larvae from all the experimental groups were statistically significant (at P<0.05). A similar tendency appeared regarding the values of all the rearing parameters (SGR and ITL) (Table 1). In general, a relatively low mortality rate was recorded in all the experimental groups, never exceeding 8%. However, when the compound feeds were given the mortality was nearly twice as high as in the groups AN0 and DC0. The differences in mortality between the groups fed on natural food versus the ones receiving compound feeds were statistically significant (at P<0.05). Besides, both GF0 and PF0 groups had the highest percentages of individuals with developmental anomalies (from 4.5% to 10.5%), whereas the percentage

**Table 1. Final characteristic of common tench larvae obtained after 25-days of rearing where different kind of food was offered exclusively. Data are expressed as mean (±SD).**

| Parameter                      | AN₀ | DC₀ | PF₀ | GF₀ | AN₀ | DC₀ | PF₀ | GF₀ |
|-------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Total length, mm              | 21.68±0.34a | 16.87±0.31b | 10.78±0.42c | 13.78±0.45c |
| Wet body weight, mg           | 87.90±2.64a | 68.99±1.37b | 20.36±3.56c | 25.32±3.07c |
| Survival, %                   | 96.22±2c | 95.85±1c | 92.02b | 92.94b |
| SGR (100 % day⁻¹)             | 21.10±0.17a | 20.13±0.11b | 15.19±1.00b | 16.09±0.69b |
| ITL, mm day⁻¹                 | 0.67±0.02a | 0.47±0.02b | 0.25±0.02c | 0.35±0.02c |
| Deformations, % [n=200]       | 0.5a | 0.5a | 10.5a | 4.5a |

AN, Artemia nauplii; DC, decapsulated Artemia cysts; PF, Perla feed; GF, Gemma feed; SGR, specific growth rate; ITL, increments in total length; "a"-"c"means in rows marked with different superscripts are statistically different (P<0.05).
Experiment #2

Change of food after 10 days of rearing on Artemia as the sole food did not influence the obtained results of common tench larvae rearing positively (Table 2). However, application of this procedure had great impact on survival rate and no statistical differences between treatments (P>0.05) were confirmed. The best results regarding ITL among groups fed on compound diets were obtained in GF10 (0.44) as opposed to group PF10 (0.37). No statistical differences were noted between those groups regarding SGR parameter (16.30 and 17.33 for PF10 and GF10, respectively), but it was significantly lower than in groups AN10 and DC10. Growth of the larvae (TL and BW) were presented in Figure 2a and 2b. Despite better growth recorded in this experiment as compared to experiment 1, the larvae of common tench grew much slower than in the control and DC10 groups.

Discussion

Acceleration of the growth rate in finfish aquaculture is possible by modification of thermal conditions (Peñaz et al., 1989; Wolnicki and Korwin-Kossakowski, 1993), or feeding or stocking density (Quiros and Alvariño, 2000; Wolnicki et al., 2003; Celada et al., 2007a). The best growth rate of tench larvae (about 0.5 mm day\(^{-1}\) ITL) was obtained at 28°C with the use of live food for 12-13 h per day (Wolnicki and Korwin-Kossakowski, 1993; Wolnicki et al., 2003). However, this may affect the economic effectiveness of production because Artemia is rather expensive kind of food and using it permanently is labour-intensive. It seems that new possibilities for improved larviculture of tench can appear with the use of new types of commercial artificial starter feeds available in the market. Application of dry starters at as early stage as possible may also positively affect growth rate and economic effectiveness of production (Turkowski et al., 2008).

The growth rate in the present study was very satisfactory as compared to those obtained by other authors (i.e. Wolnicki and Korwin-Kossakowski, 1993; Celada et al., 2007b; Celada et al., 2008), especially in groups fed exclusively by live food. However, the growth rate of larvae of this species is very slow as compared to other cyprinids (i.e. Wolnicki, 2005; Wolnicki et al., 2009), which were able to reach c.a. 25 mm TL during 21 days of rearing.

Table 2. Final characteristic of common tench larvae obtained after 25-days of rearing where transition of food was applied after first 10 days of feeding by Artemia nauplii as a sole food. Data are expressed as mean (±SD).

| Parameter | Group | AN10 | DC10 | PF10 | GF10 |
|-----------|-------|------|------|------|------|
| Total length, mm |      | 21.68±0.34\(^a\) | 17.89±0.32\(^b\) | 14.24±0.38\(^d\) | 16.02±0.41\(^c\) |
| Wet body weight, mg |    | 87.90±2.64\(^a\) | 77.46±1.98\(^b\) | 6.64±3.07\(^d\) | 34.43±2.98\(^b\) |
| Survival, % |      | 96.22\(^a\) | 96.01\(^a\) | 95.79\(^a\) | 96.08\(^a\) |
| SGR (100[% day\(^{-1}\)) |   | 21.10±0.17\(^a\) | 20.59±0.14\(^b\) | 16.30±0.65\(^b\) | 17.33±0.49\(^b\) |
| ITL, mm day\(^{-1}\) |    | 0.67±0.02\(^a\) | 0.51±0.02\(^b\) | 0.37±0.02\(^d\) | 0.44±0.02\(^c\) |
| Deformations, % [n=200] |     | 0.5\(^a\) | 0.5\(^a\) | 7.6\(^b\) | 3.4\(^b\) |

\(^a\) AN, Artemia nauplii; DC, decapsulated Artemia cysts; PF, Perla feed; GF, Gemma feed; SGR, specific growth rate; ITL, increments in total length; *\(^a\) means in rows marked with different superscripts are statistically different (P<0.05).
days of rearing at the same temperature level. Analyses of ITL and SGR confirm this tendency. The highest parameters obtained were: ITL=0.67 (mm day⁻¹) and SGR=21.10 (100 [% day⁻¹]), where for example Wolnicki (1996) during rearing of vimba bream Vimba vimba (L.) recorded ITL=0.70 mm day⁻¹, while ITL=0.79 mm day⁻¹ was reported for asp Aspius aspius (Wolnicki and Myszkowski, 1999).

However, i.e. crucian carp, Carassius carassius (L.), was found to be the species achieving the growth rate (SGR=20.06 100 [% day⁻¹]) quite similar to that of the common tench larvae in the present study. The levels of the ITL in the control groups were similar to those reported by Wolnicki et al. (2003) and the SGR was much better than reported by Celada et al. (2008) and similar to that reported by Quiros and Alvarino (2000).

The survival rates were usually very low in other cyprinid larvae when dry feeds were applied solely (Wolnicki, 2005). The larvae during these experiments were characterized by high survival rate as compared to the data presented by other authors (Quiros and Alvarino, 2000; Wolnicki and Górný, 1995; Wolnicki et al., 2003; Celada et al., 2007b; 2008). Even in groups fed permanently by compound feed the survival was satisfactory (over 90%), which is in opposition to the data reported by Wolnicki and Górný (1995) where the mortality rate of over 40% was recorded. Therefore, compound feeds used in the present study seemed to be very sufficient for common tench larvae. However, in the present study the statistically better survival rates were observed in groups fed exclusively on live food and on decapsulated cysts of Artemia. This later kind of food seemed to be very promising as an alternative kind of food for common tench larvae what was already proved for chub Leuciscus cephalus (L.) (Shiri Harzevili et al., 2003) and ide Leuciscus idus (L.) larvae (Shiri Harzevili et al., 2004). In view of the results obtained it could be suggested that the transition applied did not influence the rearing parameters such as ITL and SGR between GF and PF groups in experiments. However, in the GF group better results were obtained. It indicates that Gemma is more sufficient in common tench larvae feeding than Perla.

The larvae of cyprinids very often need not only high nutritive value but also exogenous digestive enzymes necessary for effective digestion at the start of exogenous feeding (Dabrowski, 1984). In case of cyprinids larvae, too short periods of feeding with natural food lead to essential decrease in survival as well as growth rates (Wolnicki, 2005). In the majority of cases, 10 days is enough to prevent the negative effect of compound food offering (Wolnicki, 2005; Wolnicki et al., 2009). In the present study this period influenced positively the survival rate but it turned out not enough to prevent the slowest growth and deformities rate. Celada et al. (2008) reared tench larvae with the use of Gemma feed but after 28 days of initial rearing with the use of live food and no deformities were recorded. In the present study feeding with Gemma resulted with higher deformation rate as compared to the control group even after 10-day transition schedule.

It was previously reported, that commercial feeds (Perla) affected high (over 96%) body deformities in tench juveniles (Wolnicki et al., 2006). This kind of food affected the highest deformation rate among treatments. A result in the present study indicates that body deformations could be affected by the initial feeding regime. It is probably the effect of too fast transition from natural to compound feed. Thus, it should be recommended that initial rearing of common tench larvae should be reared with live food for the much longer period than applied in this study. Despite very good rearing outcome reflected in growth and survival rate.

Conclusions

The results obtained in this study indicate the need of more intensive activity in researches accelerating problematic slow growth rate of these species. It should be focused mainly on the type of food offered because stocking densities have low impact on the initial rearing effects (Celada et al., 2007b). Additionally, it is clear that high deformation rate during permanent feeding with commercially available compound starter feeds is the bottleneck in common tench aquaculture. This concern in particular the production where marketable fish would be produced and the deformation could significantly influence on market price. This should be taken into consideration, because this phenomenon is clearly exposed not only during rearing of juveniles (Wolnicki et al., 2006) but during larval rearing as well, as demonstrated in the present study.

References

Babiak, I., Glogowski, J., Kujawa, R., Kucharczyk, D., Mamcarz, A., 1998. Cryopreservation of sperm from asp Aspius aspius. Prog. Fish Cult. 60:146-148. Blancheton, J.P., 2000. Developments in recirculation systems for Mediterranean fish species. Aquacult. Eng. 22:17-31. Cejko, B.L., Kowalski, R.K., Kucharczyk, D., Targorska, K., Krejzzeff, S., Żarski, D., Glogowski, J., 2010. Influence of the length of time after hormonal stimulation on selected parameters of milk of ide Leuciscus idus L. Aquac. Res. 41:804-813. Celada, J.D., Aguilera, A., Carral, J.M., Saez-Royuela, M., Melendre, P., 2008. Rearing tench (Tinca tinca L.) larvae on live feed (Artemia) and on two transition schedules from live to dry diets. J. Appl. Ichthyol. 24:595-600. Celada, J.D., Aguilera, A., Carral, J.M., Saez-Royuela, M., Melendre, P.M., Perez, J.R., 2007a. Effects of stocking density on survival and growth of juvenile tench (Tinca tinca L.). Aquacult. Int. 15:461-465. Celada, J.D., Carral, J.M., Rodriguez, S., Saez-Royuela, M., Aguilera, A., Melendre, P., Martin, J., 2007b. Tench (Tinca tinca L.) larvae rearing under controlled conditions. density and basic supply of Artemia nauplii as the sole food. Aquacult. Int. 15:489-495. Dabrowski, K., 1984. The feeding of fish larvae, present “state of the art” and perspectives. Reprod. Nutr. Dev. 24:807-833. Fleig, R., Gottschalk, T., Hubenova, T., 2001. Raising larvae of the tench (Tinca tinca L.). Bulg. J. Agr. Sci. 7:479-488. Gela, D., Flajshans, M., Kocour, M., Rodina, M., Linhart, O., 2006. Tench (Tinca tinca) broodstock management in breeding station under conditions of pond culture. a review. Aquacult. Int. 14:195-203. Haku, J., Kucharczyk, M., Kujawa, R., Mamcarz, A., 2009. Comparison of economic effectiveness of applying different hormonal agents in asp Aspius aspius (L.) and ide Leuciscus idus (L.). Pol. J. Nat. Sci. 24:224-234. Huang, C.C., Tang, H.J., Liu, J.Y., 2006. Dynamical analysis of net cage structures for marine aquaculture. Numerical simulation and model testing. Aquacult. Eng. 35:258-270. Kucharczyk, D., Kujawa, R., Mamcarz, A., Targorska, K., Krejzzeff, S., Wyszomirska, E., 2007. Artificial spawning of common tench (Tinca tinca L.) collected from wild populations. Pol. J. Nat. Sci. 22:37-45. Kucharczyk, D., Łuczyński, M., Kujawa, R., Czerkies, P., 1997. Effect of temperature on embryonic and larval development of bream (Abramis brama L.). Aquat. Sci. 59:214-224. Kucharczyk, D., Łuczyński, M., Kujawa, R,
Kamiński, R., Ulikkiowski, D., Brzuzan, P., 1998. Influences of temperature and food on early development of bream (Abramis brama L.). Arch. Hydrobiol. 141:243-256.

Kucharczyk, D., Targońska, K., Hliwa, P., Gomułka, P., Kwiatkowski, M., Krejszeff, S., Perkowski, J., 2008. Reproductive parameters of common carp (Cyprinus carpio L.) spawning during natural season and out-of-season spawning. Reprod. Biol. 8:285-289.

Kujawa, R., Kucharzyk, D., Mamcarz, A., 1999. A model system for keeping spawners of wild and domestic fish before artificial spawning. Aquacult. Eng. 20:85-89.

Kujawa, R., Kucharzyk, D., Mamcarz, A., 2009. The effect of tannin concentration and egg unstickling time on the hatching success of tench (Tinca tinca L.) larvae. Rev. Fish Biol. Fisher. 20:339-343.

Kujawa, R., Kucharzyk, D., Mamcarz, A., Zarski, D., Targórska, K., 2010. Artificial spawning of common tench (Tinca tinca Linnaeus, 1758), obtained from wild and domestic stocks. Aquacult. Int. (In press).

Linhart, O., Rodina, M., Kocour, M., Gela, D., 2006. Insemination, fertilization and gamete management in tench, Tinca tinca L. Aquacult. Int. 14:61-73.

Mamcarz, A., Kucharzyk, D., Kujawa, R., 2006. Reciprocal hybrids of tench (Tinca tinca L.) × bream (Abramis brama L.), and tench × carp (Cyprinus carpio L.), and some characteristics of their early development. Aquacult. Int. 14:27-33.

Milstein, A., Valdenberg, A., Harpaz, S., 2006. Fish larvae – zooplankton relationships in microcosm simulations of earthen nursery ponds. I. Freshwater system. Aquacult. Int. 14:231-246.

Peřáz, M., Prokeš, M., Kouřil, J., Hamáčková, J., 1989. Influence of water temperature on the early development and growth of the tench, Tinca tinca. Folia Zool. 38:275-287.

Quiros, M., Alvariño, J.M.R., 2000. Growth and survival of tench larvae fed under different feeding strategies. J. Appl. Ichthyol. 16:32-35.

Quiros, M., Nicodemos, N., Alonso, M., Bartolomé, M., Eciá, J. L., Alvariño, J. M. R., 2003. Survival and changes in growth of juvenile tench (Tinca tinca L.) fed defined diets commonly used to culture non-cyprinid species. J. Appl. Ichthyol. 19:149-151.

Shiri Harzevili, A., De Charleroy, D., Auwerx, J., Vught, I., Van Slycken, J., 2003. Larval rearing of chub, Leuciscus cephalus (L.), using decapsulated Artemia as direct food. J. Appl. Ichthyol. 19:123-125.

Shiri Harzevili, A., Vught, I., Auwerx, J., De Charleroy, D., 2004. Larval rearing of ide (Leuciscus idus (L.)), using decapsulated Artemia. Arch. Pol. Fish. 12:191-195.

Śliwiński, J., 2009. Diet and growth of asp (Aspius aspius (L.)) larvae reared in carp ponds. Rocznik Nauk. PZW 22:163-176.

Turkowski, K., Kucharzyk, D., Kupren, K., Hakuć-Blażowska, A., Targórska, K., Zarski, D., Kwiatkowski, M., 2008. Economic aspects of the experimental rearing of asp, Aspius aspius (L.), ide, Leuciscus idus (L.), and dace, Leuciscus leuciscus (L.), under controlled conditions. Arch. Pol. Fish. 16:397-411.

Wang, J., Min, W., Guan M., Gong, L., Ren J., Huang, Z., Zheng, H., Zhang, J., Liu, H., Han, Y., 2006. Tench farming in China. Present status and future Prospects. Aquacult. Int. 14:205-208.

Wolnicki, J., 1996. Intensive rearing of larval and juvenile vimba, Vimba vimba (L.), fed natural and formulated diets. Pol. Arch. Hydrobiol. 43:447-454.

Wolnicki, J., 2005. Intensywny podchów wczesnych stadiów ryb karpiowatych w warunkach kontrolowanych. Arch. Fish. Pol. 13:5-87.

Wolnicki, J., Górny, W., 1995. Suitability of two commercial dry diets for intensive rearing of larval tench (Tinca tinca L.) under controlled conditions. Aquaculture 129:256-258.

Wolnicki, J., Kamiński, R., Myszkowski, L., 2003. Survival, growth, and condition of tench (Tinca tinca (L.) larvae fed live food for 12, 18 or 24 h a day under controlled conditions. J. Appl. Ichthyol. 19:146-148.

Wolnicki, J., Korwin-Kossakowski, M., 1993. Survival and growth of larval and juvenile tench, Tinca tinca L., fed different diets under controlled conditions. Aquac. Res. 24:707-713.

Wolnicki, J., Myszkowski, L., 1998. Evaluation of four commercial diets for intensive production of tench (Tinca tinca (L.) juveniles under controlled conditions. Pol. Arch. Hydrobiol. 45:453-458.

Wolnicki, J., Myszkowski, L., 1999. Larval rearing of rheophilic cyprinids, Aspius aspius (L.) and Leuciscus cephalus (L.), on live, dry or mixed diet. Eur. Aquacult. Soc. Spec. Pub. 27:258-259.

Wolnicki, J., Myszkowski, L., Korwin-Kossakowski, M., Kamiński, R., Stanny, A., 2006. Effects of different diets on juvenile tench, Tinca tinca (L.) reared under controlled conditions. Aquacult. Int. 14:89-98.

Wolnicki, J., Sikorska, J., Kamiński, R., 2009. Response of larval and juvenile rudd (Scardinius erythrophthalmus (L.) to different diets under controlled conditions. Czech J. Anim. Sci. 54:331-337.