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# EVALUATION OF FIVE DRY DIETS FOR INITIAL FEEDING OF EUROPEAN WELS, *Silurus glanis* L., LARVAE UNDER CONTROLLED CONDITIONS

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A B S T R A C T. Two experimental feeds, two commercial trout starters, and decapsulated *Artemia* sp. cysts were evaluated for initial feeding of wels larvae under laboratory conditions. The diets were used exculsively at 30°C, from the beginning of exogenous feeding (fifth day after hatching) over 9 days. Significantly ($p \leq 0.05$) best results (total length 25 mm, body weight 175 mg, survival rate 97%) were noted in fish fed commercial starter Krystal 3600, at the lowest food conversion ratio 0.8. Experimental starters were reluctantly eaten by wels larvae, which resulted in poor growth (total length 15.2 mm, body weight 25-28 mg) and low survival rates (76-85%). The results of the experiment indicate that commercial trout starters might be used for mass production of wels juveniles under controlled conditions.

Key words: *Silurus glanis*, LARVAE, CONTROLLED REARING, DRY DIETS, SURVIVAL, GROWTH, FOOD CONVERSION

## INTRODUCTION

Wels, *Silurus glanis*, seems one of the most promising aquaculture species in Europe. The fish easily accept pelleted feeds, grow fast and have tasty, boneless meat (Linhart, Proteau 1993). Similarly as in case of other species, intensification of wels culture depends, besides the demand (Linhart, Proteau 1993), on techniques of mass rearing of larvae under controlled conditions, based on dry diets.

Most of authors, however, share a well established opinion that in the initial phase of rearing, wels larvae need oligochaets, *Tubifex* sp. (Támas, Horváth 1976, Horváth 1977, 1979, Krasznai et al. 1980, Horváth et al. 1992). Satisfactory results were also obtained using other live food, such as a mixture of *Tubifex* sp. and zooplankton (Kainz, Oseguera Green 1982, Kouřil, Hamáčková 1982), or pond or lake zooplankton alone (Kainz, Oseguera Green 1982, Kouřil et al. 1984, Jungwirth 1986, Wiśniewolski 1989), or *Artemia* sp. nauplii (Meske, Münster 1984, Hilge 1986, Wolnicki 1995).

Most attempts of experimental initial rearing of wels larvae on starters only gave controversial results of growth rate and survival (Wiśniewolski 1989, Piesker, Reich

1990, Mejza et al. 1993, Kozlowski et al. 1995, Schlumberger et al. 1995, Hamackova, Kouril 1996). Other trials, although generally successful (Wolnicki 1995, Hamackova et al. 1997), are still too scarce to choose best starter for commercial rearing.

The aim of the present study was an evaluation of five dry diets - Polish experimental starters and commercial feeds, in initial rearing of wels larvae, taking into consideration possibility of using them for mass rearing under controlled conditions. Basic chemical parameters of all diets were analyzed, and their usefulness was evaluated according to the final total length and body weight of fish, survival and food conversion coefficient.

## MATERIAL AND METHODS

### FISH

Wels larvae were obtained from spawning of 5 females and 6 males induced using injection with carp pituitary gland (Woynarovich, Horvath 1980). Each experimental tank was stocked with 230 larvae (11.5 ind. $dm^{-3}$), four days after hatching. Initial water temperature was 25°C. Experimental feeding was started on the next day. Initial body weight and total length were 14.2±1.2 mg, and 12.1±0.5 mm respectively.

### REARING FACILITIES AND WATER QUALITY

Ten flow-through aquaria, 20 $dm^3$ each, were regularly supplied with water from a small recirculation system provided with diatomite filter (Wolnicki 1993). At first, water exchanged every 2 h (days 1-4), and beginning from day 5 - every hour. From midnight to 8 am the aquaria were darkened, and from 8 am to midnight lighted with the linear set of fluorescent lamps (2 x 40W) placed obliquely, at about 1 m distance from the aquaria. Light was filtered through a layer of semi-transparent black polyethylene, providing light intensity about 100 lx at the water surface.

Basic water quality parameters were controlled twice a day. Final water temperature (30±0.5°C) was attained at the end of the first day of the experiment. Dissolved oxygen content in the supplying water was about 90% of saturation, and in the aquaria – usually over 60%. Water pH was near 8.0, and nitrite concentration was negligible.

The aquaria were cleaned twice a day, every morning and evening, removing faeces and feed remains. Dead fish were also removed.

## FEED AND FEEDING

In a 9 day long experiment the following dry diets were tested in two replicates:

- S1 and S2 – experimental starters made in the Agricultural Academy in Poznań, Dept. of Experimental Technology and Feed Production in Muchocin;
- AC – decapsulated brine shrimp, *Artemia* sp., cysts of high buoyancy, from Artemia Reference Center, Gent, Belgium;
- FK – commercial extruded trout starter FK-start, fraction „0", made by Felleskjøpet Havbruk AS, Norway;
- KR – commercial extruded trout starter Krystal 3600, fraction „1", made by Aller Mølle A/S, Denmark.

Experimental starters were made of locally available components: fish protein hydrolyzate, dried and modified whey, casein, yeast (*Candida utilis*), potato protein, soybean powder, and rape oilcake. Energy balance was improved using potato starch and glucose. The mixtures were supplemented with Polfamix WP-1, and Witazol $AD_3EC$. Caloric and protein content of S1 and S2 diets was equal, and they differed in the level of two high-protein components: potato protein (14% and 6%, respectively in S1 and S2), and highly soluble modified casein (0% and 8%, respectively). Digestibility and absorption of fat fraction was improved by an addition of rape lecithin and choline chloride. Soybean oil and fish oil were stabilized with commercial Rendox formula containing BHA (butylated hydroxyanisole), in proportion 0.1% of fat content in the diet. Water stability of the diets was increased using Biodone AQ (ISP Technologies, INIC) binder. Starters S1 and S2 were formed using thermopressure method on endogenic extruder N-60. Extrudate was dried on sieves using hot air and crushed in a breakdown rolling mill RUT-10. The particles were sieved into two fractions: „00" (100-250 μm), and „0" (250-400 μm), and coated with soybean and fish oil mixture heated to $50^{o}C$.

Krystal 3600 was applied as a control diet, since it was already proved useful in an initial rearing of wels (Wolnicki 1995, Kamiński, Wolnicki 1996). Chemical composition and level of digestible energy of the diets are shown in Table 1, and their amino acid composition in Table 2.

Buoyancy of the diets differed considerably: it was highest in *Artemia* sp. cysts, and the particles of all starters, especially experimental ones, sank almost immediately. Largest particles had the lowest buoyancy.

In case of S1 and S2 diets, fraction „00" was used for 7 days of rearing, and for the

**TABLE 1**

Proximate composition (%) and digestible energy (kcal/kg) of dry diets tested in the present experiment (diets see text)

| Ingredient | Diet | | | | |
|---|---|---|---|---|---|
| | S1 | s2 | AC | FK | KR |
| Dry matter | 90.5 | 90.6 | 90.1 | 92.4 | 92.1 |
| Total protein | 51.2 | 51.3 | 47.3 | 53.7 | |
| Crude fat | 9.9 | 9.9 | 1.8 | 13.9 | 12.8 |
| Extractable non-nitrogen compounds | 23.7 | 23.7 | 35.1 | 13.5 | 16.1 |
| Crude fibre | 0.9 | 0.8 | 0.0 | 0.0 | 0.0 |
| Crude ash | 4.8 | 4.9 | 5.9 | 11.4 | 9.5 |
| $P_{tot}$ | 1.13 | 0.91 | 0.94 | 1.40 | 1.22 |
| Ca | 1.42 | 1.78 | 0.26 | 1.22 | 1.77 |
| Digestible energy | 4099.2 | 4100.0 | 3500.1 | 4306.2 | 4282.9 |

**TABLE 2**

Exogenous amino acid content (g/100 g protein) and chemical nutritive value of dry diets tested in the present experiment (diets see text)

| Amino acid | Diet | | | | |
|---|---|---|---|---|---|
| | S1 | S2 | AC | FK | KR |
| Arginine | 6.1 | 5.9 | 5.8 | 5.8 | 5.7 |
| Histidine | 2.4 | 2.4 | 2.8 | 2.4 | 2.9 |
| Lysine | 7.0 | 7.2 | 7.4 | 7.4 | 7.4 |
| Tryptophan | 1.3 | 1.3 | 1.1 | 1.2 | 1.2 |
| Phenyloalanine+Thyrosine | 7.9 | 7.8 | 7.8 | 7.6 | 7.5 |
| Methyonine+Cystine | 3.4 | 3.3 | 4.3 | 5.3 | 5.4 |
| Threonine | 4.0 | 3.9 | 5.5 | 4.0 | 3.9 |
| Leucine | 7.5 | 7.5 | 9.6 | 8.4 | 8.4 |
| Isoleucine | 4.4 | 4.5 | 4.6 | 4.3 | 3.9 |
| Valine | 4.9 | 5.1 | 5.2 | 5.3 | 5.5 |
| Chemical Score (CS) | Met+Cys 58.00 | Met+Cys 57.59 | Ile 66.67 | Ile 62.32 | Ile 56.52 |
| Essential Amino acid Index (EAAI) | 80.91 | 80.14 | 83.59 | 83.15 | 82.31 |

last 2 days, fraction „0" was applied. Commercial pellets were initially (days 1-2) ground in a mortar and sieved to a fraction about 300 µm. Later on, the diets were used without breaking down. Diameter of dacapsulated *Artemia* sp. cysts was about 200 µm.

The fish were fed manually, supplying equal amounts of feed over the surface, from 8 am to midnight. Feed was supplied to satiation, initially every 2 hours (days

1-5), and later (days 6-9) – every hour. Daily feeding rate was initially about 40% of the fish biomass, and in fast growing groups it was reduced to about 20%.

### CHEMICAL METHODS OF DIET EVALUATION

Experimental diets were analyzed for: total nitrogen, crude fat, ash, and dry matter (Skulmowski 1974). Total protein content was calculated from total nitrogen (N x 6.25). Amino acids of feed protein were separated using AAA-881 analyzer. Tryptophan content was evaluated using colorimetric method (Votisky, Gunkel 1989). Limiting amino acid indices (CS – Chemical Score), and exogenous amino acids (EAAI – Essential Amino Acids Index) were calculated from the results of protein analyzis.

Mineral components of the diets – phosphorus and calcium – were analyzed using atomic absorption spectrophotometer (AAS-3, Carl Zeiss Jena) after mineralization of wet samples in a mixture of nitric, perchloric, and sulfuric acids (Gawęcki 1988).

Digestible energy of the diets was calculated from caloric value of the components in kcal, using digestible energy coefficient for fish (Halver 1988).

### MEASUREMENTS AND CALCULATIONS

Thirty wels individuals were collected as an initial sample. On the fourth and seventh day of the experiment, 15 fish were sampled from each aquarium, and on the nineth day – 30. All the sampled fish were measured (with 0.1 mm accuracy), and individually weighed (0.1 mg). The difference between initial number of fish and final fish stock were attributed to cannibalism, taking into consideration sampled fish and the individuals that died during the experiment. Significance of the differences of fish total length (*longitudo totalis*) and wet body weight among the groups were tested using Duncan's multiple range, test ($p \leq 0.05$). Final fish survival rates expressed in per cent were normalized using varcsin transformation (Sokal, Rohlf 1969), and the differences were considered significant at $p \leq 0.05$. Food conversion ratio was calculated as the ratio of supplied food (dry weight) to the fish biomass gain (wet weight).

## RESULTS

### CHEMICAL EVALUATION OF THE DIETS

Trout starters FK and KR contained the highest level of protein (over 53%) and fat

(13-14%). The lowest content of these components was noted in *Artemia* sp. cysts (47% and 1.8%, respectively). Trout pellets had also the highest level of digestible energy (Tab. 1).

Exogenous amino acid content in the tested diets was variable (Tab. 2). In S1 and S2 diets, methionine and cystine were limiting amino acids (CS index), and in all remaining feeds – isoleucine. Commercial diets AC, KR, and FK had considerably higher (83.59, 83.15, and 82.31, respectively) index of limiting amino acids (EAAI) comparing to the experimental starters S1 and S2 (80.91, and 80.14, respectively) - (Tab. 2).

## FEEDING BEHAVIOR OF FISH

Trout starters and *Artemia* cysts were readily eaten by wels larvae, and fish digestive tracts were completely filled already several hours from the beginning of feeding. S1 and S2 diets were consumed reluctantly over the entire experimental period, and fish digestive tracts were never completely filled. In these groups, fish were always dispersed over the entire tank, and very active during and between feeding. In the other groups – irrespectively of the diet buoyancy – fish grouped together and fed mainly in surface water (0-15 cm), and started to penetrate deeper layers eating food from the bottom only in the last three days of the experiment.

## SURVIVAL

In first five days of the experiment, fish loss was very low, and cumulated mortality in particular groups ranged from 0.7 to 2.4%. Beginning from day 6, mortality increased in groups fed with S1 and S2 diets. At the same time, invasion of protozoans and bacteria was observed in these groups, and the fish were immersed for 2 hours in T-chloramine (0.5 mg $dm^{-3}$) to prevent disease. However, mortality still increased, and from day 7 cannibals were observed. Fish loss due to cannibalism was equal to 2% and 17% of overall mortality in these groups respectively. In the remaining groups, no cannibalism was observed.

Final survival of wels in S2 group was significantly ($p \leq 0.05$) lower than in the remaining groups (Tab. 3). The highest survival rates were noted in AC and KR groups (98.6 and 96.5%, respectively), and the difference between these values was insignificant.

## GROWTH AND FOOD CONVERSION

At the beginning of the experiment, the fastest growth was observed in fish fed with

**TABLE 3**

Average total length (mm), average wet body weight (mg), survival rate (%) and food conversion ratio (FCR) of *Silurus glanis* on the final day of the experiment (diets see text)

| Diet | mm | mg | % | FCR |
|---|---|---|---|---|
| S1 | $15.2^{d}$ | $25.2^{d}$ | $85.0^{c}$ | 8.0 |
| S2 | $15.2^{d}$ | $27.6^{d}$ | $75.7^{d}$ | 9.3 |
| AC | $24.1^{b}$ | $134.4^{b}$ | $98.7^{a}$ | 0.9 |
| FK | $23.2^{c}$ | $110.1^{c}$ | $93.3^{b}$ | 1.2 |
| KR | $25.4^{a}$ | $174.8^{a}$ | $96.5^{ab}$ | 0.8 |

*Data with the same superscripts are not significantly different ($p \leq 0.05$)*

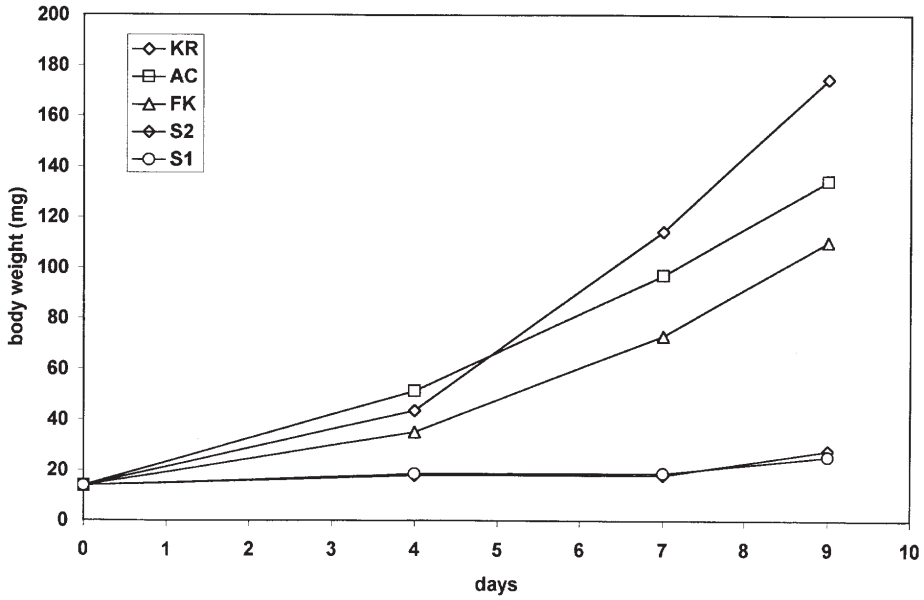


Fig. 1. Increase in body weight of *Silurus glanis* fed different dry diets (diets see text)

cysts, and later on – in KR group (Fig. 1). Fish fed with the experimental diets grew very slowly over the entire experiment. On days 4 and 7 they reached about 18 mg, and were significantly ($p \leq 0.05$) lighter, comparing to the remaining groups. On the last day of the experiment, KR fish attained average body weight of 175 mg, and 25.4 mm total length, while the fish fed with experimental diets – 25.2 and 27.6 mg respectively, at 15.2 mm TL (Tab. 3).

Food conversion ratios in groups fed commercial diets and *Artemia* cysts were similar (Tab. 3), and ranged from 0.8 (KR) to 1.2 (FK). In S1 and S2 groups FCR was

8.0-9.3.

## DISCUSSION

According to the literature on traditional extensive methods of wels rearing in earthen ponds, stocking material should be at least 25 mm long, after initial rearing under controlled conditions (Horvath 1977, 1979, Krasznai et al. 1980, Horvath et al. 1992). It is also well known that wels larvae fed appropriate live food in sufficient quantity grow much faster than on any dry feed tested (Hilge 1986, Szlamińska 1986, Wolnicki 1995, Hamackova, Kouril 1996). Scarce data showing better fish growth on dry diets comparing to live food (Kozlowski et al. 1995, Schlumberger et al. 1995) indicate insufficient supply of the latter. Feeding with starter Krystal 3600, used in the present study as a control diet, resulted in similar survival as in the group fed live food, fish growth was however considerably slower (Wolnicki 1995). It should be stressed that feeding wels larvae with Krystal 3600 for 9 days enables production of appropriate size stocking material (Tab. 3).

The results revealed different value of the tested dry diets for initial rearing of wels larvae. None of the diets, taking into consideration fish growth and food conversion ratio, was as good as Krystal 3600. The latter was better than trout starter FK, successfully tested by Kozlowski et al. (1995), and even than *Artemia* cysts. Initially slower growth of fish given this starter, comparing to *Artemia*-fed ones (Fig. 1), can be explained by feeding habits of wels which gathered at the water surface. Thus, AC fish fed in better conditions than KR group, in which most food immediately sank to the bottom and was not consumed. In the second phase of the experiment, when wels started to feed in the entire water column, KR fish were privileged, provided with large food particles much bigger than *Artemia* cysts. Undoubtedly, decapsulated *Artemia* cysts, due to small size, are appropriate for fast-growing wels larvae only during the initial period of rearing. Faster fish growth on KR feed, comparing to AC group, observed in the second phase of the experiment, might also have reflected differences in chemical composition of the diets, especially in protein and fat content, and the level of digestible energy (Tab. 1).

It is hard to explain why wels larvae did not accept experimental diets. Their uselessness may be only partly explained by their chemical composition. Although energy-protein ratio was equal in all diets, in the experimental formulas S1 and S2, protein, fat and digestible energy levels were lowest (Tab. 1). Commercial starters FK and

KR were more balanced in terms of amino acids, especially sulfur-containing ones – methionine and cystine, which is reflected in EAAI index (Tab. 2). S1 and S2 formulas contained high-protein, soluble local components (dried whey, potato protein, modified casein as sodium caseinate) which did not cover nutritive demand of wels. Thus, they cannot replace Scandinavian fish meals. Comparison of chemical composition of the diets, however, does not explain why wels consumed little S1 and S2 diets, and did not filled their digestive tracts.

Contrary to the earlier beliefs, the results of the present study revealed that live food was not essential in the earliest phase of wels rearing. In mass culture of wels juveniles for further rearing in ponds or under controlled conditions, live food may be replaced with good quality trout starters, such as Krystal 3600. It should be emphasized that food conversion ratios obtained with this starter were comparable to those reported in the literature for other *Siluriformes*, especially for *Clarias*, which is known for very efficient food conversion (Van Weerd 1995).

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## STRESZCZENIE

OCENA PRZYDATNOŚCI PIĘCIU DIET SUCHYCH DO WSTĘPNEGO ŻYWIENIA LARW SUMA EUROPEJSKIEGO *Silurus glanis* L. W WARUNKACH KONTROLOWANYCH

Larwy suma europejskiego *Silurus glanis* L. w obsadzie ll.5 szt./dm$^3$ karmiono wyłącznie dietami suchymi od początku egzogennego odżywiania się, tj. od piątego dnia po wykluciu. W 9-dniowym teście

w temperaturze 30°C użyto dwóch starterów doświadczalnych (receptura Akademii Rolniczej w Poznaniu), dwóch komercyjnych starterów pstrągowych (FK, Krystal 3600) oraz zdekapsułowanych cyst *Artemia* o zwiększonej pływalności. Startery doświadczalne, w których recepturze substytutem skandynawskich mączek rybnych były krajowe komponenty wysokobiałkowe (białko ziemniaka, serwatka suszona, modyfikowana kazeina), były zjadane niechętnie i okazały się dla suma całkowicie nieprzydatne (końcowa długość całkowita ryb 15 mm, masa ciała 25 -28 mg, przeżywalność 76-85%, współczynnik pokarmowy równy 8.0-9.3). Wśród pozostałych diet wyraźnie najlepszą okazała się dieta kontrolna, którą był starter Krystal 3600 (końcowa długość całkowita 25 mm, masa ciała 175 mg współczyrmik pokarmowy równy 0.8). Nie stwierdzono istotnych ($p \leq 0.05$) różnic pod względem końcowej przeżywalności suma w tej grupie oraz w grupie żywionej zdekapsułowanymi cystami *Artemia* (odpowiednio 97% i 99%). Wyniki doświadczenia dowodzą, że: (1) we wstępnej fazie kontrolowanego podchowu larw suma europej skiego nie jest konieczne stosowanie pokarmu żywego; (2) masowa produkcja młodocianych stadiów suma europejskiego w warunkach kontrolowanych mogłaby zostać oparta o łatwo dostępne na rynku startery pstrągowe

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