# INTENSIVE REARING OF WELS (*SILURUS GLANIS* L.) USING PLANT PROTEIN BASED FEED

**Máté Havasi*, Zoltán Felföldi, Anita Gorzás, Péter Lévai, János Merth, Miklós Bercsényi**

*University of Pannonia, Georgikon Faculty,*
*Department of Animal Sciences and Animal Husbandry*
*P. O. Box 71. Keszthely 16 Deak F. Str H-8361.*
*havasi.mt@gmail.com

***Abstract***

In order to replace growingly expensive fish meal, plant based feeds were compared to commercial wels (*Silurus glanis*) feed in a 60 days experiment. Three types of feed were applied: squealer feed (S), squealer feed combined with forage fish (S+F) and commercial wels feed (W). The feed conversion ratio was 0.88±0.21 at the W group, 1.74±0.21 at the S and 1.48±0.23 in the case of S+F group. Specific growth rate was higher at wels feed (2.34%), than in case of the squealer feed (1.77%) or squealer feed with forage fish addition (1.95%). The slaughter loss was the least at the fish fed with forage fish in addition (34.6±2.0%). The relative size of the liver (2.8±0.32% of body weight) and the fat % of the viscera (4.1±1.0% of body weight) were significantly higher at W group than those of the other treatments.

**Key Words:** wels, intensive rearing, plant protein, growth.

## *Összefoglalás*

Az egyre drágább halliszt kiváltásának érdekében, növényi alapú tápokat hasonlítottunk össze kereskedelmi harcsatáppal egy 60 napos kísérlet során. Háromféle takarmányt alkalmaztunk: harcsatáp (W), malactáp (S), illetve hal-kiegészítés malactáp etetése mellett (S+F). A takarmányértékesítés a harcsatápos kezelés esetében 0.88±0.21 volt, míg a malactápos csoport esetében 1.74±0.21, a hal-kiegészítéses csoportnál 1.48±0.23. A specifikus növekedési ráta a harcsatápos csoport esetében nagyobb (SGR átlag: 2.34%), mint a malactápos (1.77%), ill. a hal-kiegészítéses csoport esetében (1.95%). A törzs vágási veszteségei a hal-kiegészítéses csoport esetén a legkisebbek (34.6±2.0%). A harcsatápos csoport esetében a máj relatív mérete (2.8±0.32%) és a hasűri zsír (4.1±1.0%) szignifikánsan magasabb volt, mint a másik két kezelés esetén.


**Kulcsszavak:** harcsa, növekedés, növényi fehérje, takarmányhasznosítás

## *Introduction*

Majority of the Hungarian fish production is based on carp-dominant polyculture. The profitability of this segment could be improved by increasing the production of valuable predatory fishes. In traditional pond poly-culture the proportion of carnivorous fishes does not exceed 1-2% of the production, though the market requires the constant and reliable production of these valuable species. This could be provided primarily from intensive rearing facilities using artificial feed. For this purpose in Middle-Europe a native European catfish species, the wels (*Silurus glanis,* Linnaeus*,* 1758) seems to be ideal. There are numerous fortunate properties making wels a good choice for intensive aquacul-

ture. The flesh of wels is boneless, delicious, white coloured, tasty and is of high market value. It is easy to rear it on artificial formulated feed and it utilizes the feed efficiently. Wels tolerates handling stress relatively well and its dissolved oxygen demand is similarly low as that of the carp. Wels production in Hungary is ranging between 1-2 % of the total fish pond production. In 2009 the total wels production was 246 tons, while the capture from natural waters amounted only 166 tons in Hungary (*Pintér, 2010*).

Remarkable part of the running costs (50-90%) of fish production in intensive systems is the feed cost (Müller, 1990). For this reason it is of primary interest to decrease the feed prices by using cheaper feed components.

Nowadays fish in intensive rearing facilities are usually fed with feeds containing fish meal as primary protein source. The catches of species providing the raw material of the fish meal have been stagnating or decreasing globally since the beginning of the 90's (Astles et al., 2009; Caddy & Garibaldi, 2000; Johnsen, 2005). The total marine fish capture in the recent years reached approximately 81-84 million tons per year (FAO, 2009). Due to the overexploitation of seas the sustainability of this practice became uncertain (Tacon & Metian, 2008). Production cost of fish meal increases extremely fast. Since 2004 the price of fish meal has doubled (FAO, 2009), so it is not only ecological but also commercial interest to reduce the amount of the fish meal in commercial fish diets or substitute it with alternative protein sources e. g. plant protein or fermentation products There are many trials aiming fish meal and fish oil replacement (Dias et al., 2009; Panserat et al., 2009; Sánchez-Lozano et al., 2009; Silva et al., 2009) even in the case of different catfish species (Ai & Xie, 2006; Ambardekar et al., 2009; Davies & Gouveia, 2008; Toko et al., 2008; Webster et al., 1997). Channel catfish production in earthen pond is almost exclusively based on plant

protein (Sink et al., 2010) In the present experiment the possibility of rearing wels on plant based feed was examined.

## *Materials and Methods*

This experiment was carried out in the fish laboratory of the University of Pannonia in Keszthely, Hungary. Fish were held in an approx. 4000L recirculation system, which consisted of 9 fish tanks each of 350L (60cm*50cm*130cm) attached to settling, filtering and puffer tanks of 300L. Perlon wool was used as substrate for biofiltering bacteria. Ion exchange marbles were used to reduce the concentration of harmful $NH_3/NH_4^+$ nitrogen forms. In addition an UV-lamp was built into the system as biocide. The daily water exchange of the whole system was approx. 2.5%. Each fish tanks were supplied with air diffuser. Faeces and uneaten feed were sucked out daily with a rubber pipe. As the wels is a night time predator, the room was dimmed and the temperature was held between 20°C and 25°C (mean±SD: 22.3±1.3°C. Water temperature was measured daily (Figure 1).

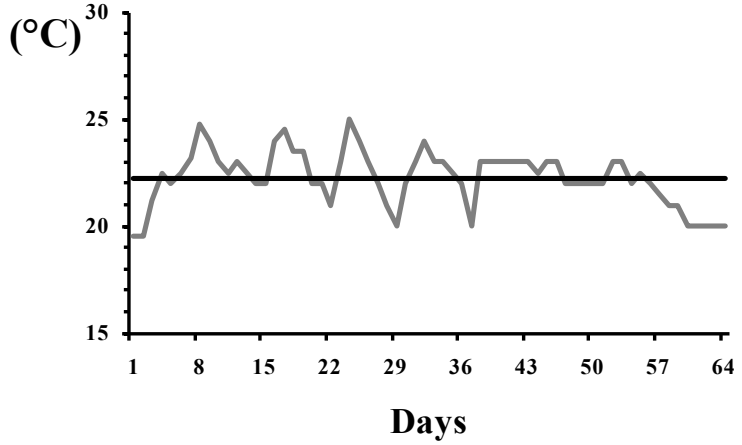


*Figure 1.* Change of water temperature during the experiment

Three treatments were set up and carried out on three size classes. First group (W group) was fed with commercial wels feed (crude protein content 36%), second group (S group) was fed with squealer feed (crude protein content 20%), while the third group (S+F group) was fed with squealer feed and one day pro week with cut forage fish. The squealer feed contained almost exclusively plant protein (mostly corn, wheat and soybean). The only animal component was 5% milk permeatum. Fish were fed three times a day *ad libitum* by hand feeding. Each time as much granulate were offered as the fish consumed immediately. Tiny cut cyprinids were served as forage fish.

*Picture 1.* One of the experimental fish (Photo: M. Havas)

Altogether 139 wels (Picture 1) formerly trained to artificial diet were used in the experiment. Starting weights varied between 28.2 and 125.5g according to normal distribution. Since there was great size heterogeneity in the stock, fish was assorted according to individual weight. Three size classes were formed: „small" (S; $m_{mean}$±SD: 45.9±9.5g), „me-

dium" (M; $m_{mean}$±SD: 54.1±15g) and „large" (L; $m_{mean}$±SD: 77.9±14.2g) class. The specimens within one size group were randomly allocated into each treatment. This resulted that there were no significant differences between the initial mean weights of the same size classes of the treatments. 15-16 individuals were held in each fish tank. All three size classes were represented in each of the treatments.

Individual weight was measured weekly – biweekly with tenth gram precision in water. One day before measurements fish weren't fed. To avoid parasitic diseases a short, salty (2.5%) bath was applied during the measures. Body length of fish was measured with 0.5cm precision.

Food conversion ratio (FCR), daily absolute growth (G), specific growth rate (SGR) and condition factor (K) were calculated. By the calculation of food conversion ratio the mass of forage fish was corrected according to its dry matter content (20%).

At the end of the experiment 18 individuals were sacrificed. The weight of the torso (carcass), the liver, and the abdominal fat were measured.

Distribution functions were checked with Kolmogorov-Smirnov test. Comparison of mean values was carried out with one-way analysis of variance (ANOVA) and Tukey's post hoc test. Criteria of significance were determined at 95 % probability ($p<0.05$).

## *Results*

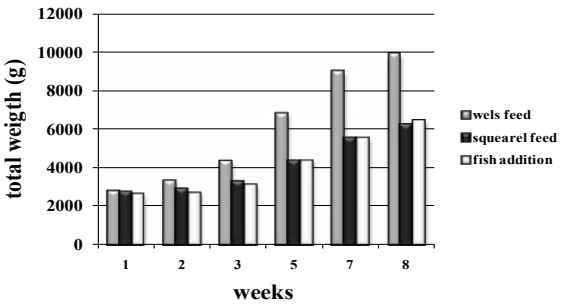


*Figure 2.* The total weight gain in the different treatments

The treatment groups achieved the following weight gains by the end of the experiment: W group: 7240.2g; S group: 3599.3g; S+F group: 4122.5g. At the end of the experiment the total weight gain in the W group was significantly higher than in groups S or S+F, while these two latter ones didn't differ significantly from each other (Figure 2).

Due to the primary assorting there were no significant differences in the initial mean weight inside any of the size classes. At the end of the experiment the individual mean weight was significantly higher in the case of the W group in all of the three sizes classes. There wasn't any significant difference between the growth rate of S group and S+F group (Figure 3).

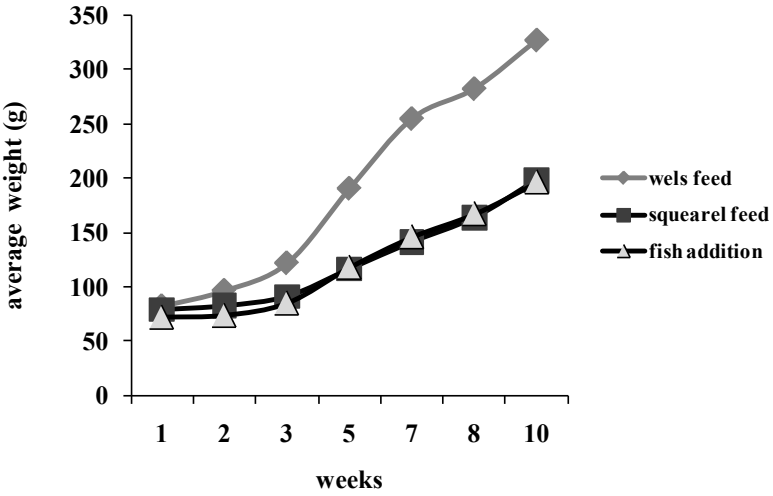


*Figure 3.* The average individual size of wels in the „L" size class

The condition factor of wels individuals was also better in the W treatment (mean±SD: 0.72±0.02) than in the other two groups (0.62±0.02). The condition of the S+F group significantly increased by the end of the experiment. There weren't any changes of condition in the case of the other groups.

The absolute daily growth of the W group - in the first weekly interval of the experiment - was more than twofold higher (3.60g day$^{-1}$) than in the other two groups (S group: 1.34 g day$^{-1}$; S+F group: 1.22 g day$^{-1}$), though later on this value decreased progressively resulting 2.77g day$^{-1}$ value in the last weekly interval. In groups S and S+F an increase was recorded regarding daily growth resulting 2.56g day$^{-1}$ and 2.73g day$^{-1}$ values respectively in the last two weeks (Figure 4).

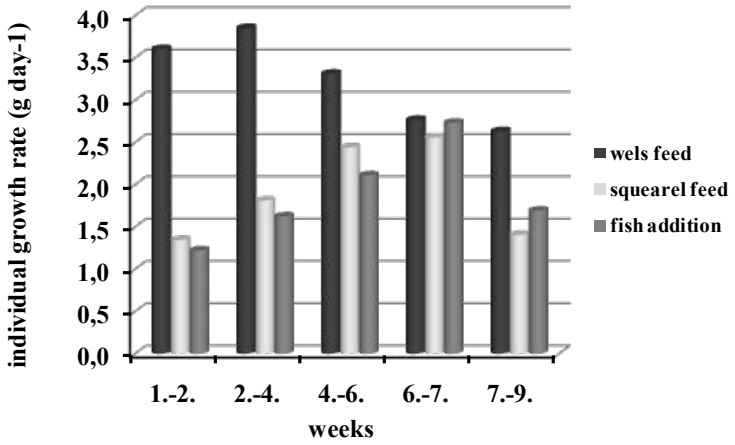


*Figure 4.* Dial absolute growth rate in the "M" size class

Specific growth rates followed trends similar to individual absolute growth. SGR value varied between 0.89% (S group) and 4.60% (W group). At the beginning of the survey the growth of the individuals fed with wels feed was faster in all of the three size classes (Figure 5). By the end this value decreased to its third. S and S+F groups did not show similar trends regarding changes of SGR values during the experiment.

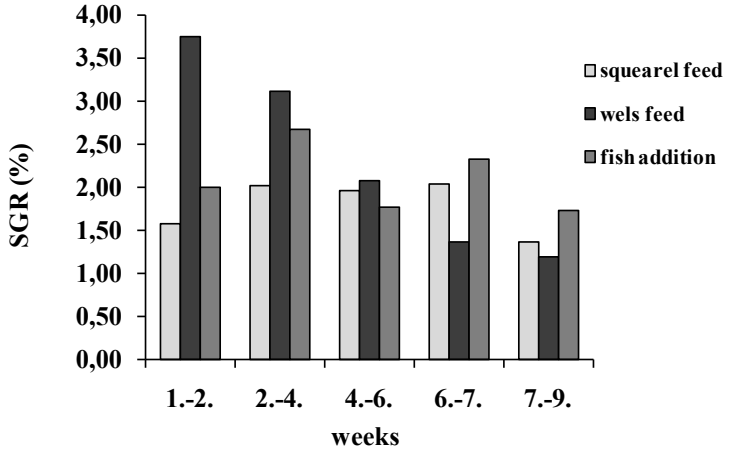


*Figure 5.* Changes in the specific growth rate during the experiment in the „S" size class

By the calculation of food conversion ratio the quantity of forage fish was considered according to its dry matter content (20%). FCR was the lowest in case of W group, and was highest in case of the S group (Table 1). Food conversion declined in all of the treatments during the experiment.

| *FCR* | | *wels feed* | | | *squealer feed* | | | *fish addition* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Nr. of fish tank* | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| *weeks* | 1.-2. | 0.64 | 0.65 | 0.67 | 1.54 | 1.60 | 1.64 | 1.21 | 1.37 | 1.25 |
| | 2.-4. | 0.68 | 0.68 | 0.67 | 1.58 | 1.57 | 1.54 | 1.29 | 1.34 | 1.27 |
| | 4.-6. | 0.88 | 0.91 | 0.84 | 1.83 | 1.67 | 1.94 | 1.70 | 1.53 | 1.68 |
| | 6.-7. | 1.17 | 1.13 | 1.15 | 1.56 | 1.89 | 2.29 | 1.47 | 1.54 | 1.48 |
| | 7.-9. | 1.06 | 1.01 | 1.12 | 1.78 | 1.95 | 1.77 | 1.31 | 1.97 | 1.82 |
| *mean* | | 0.88 | 0.87 | 0.89 | 1.66 | 1.73 | 1.83 | 1.40 | 1.55 | 1.50 |
| *SD* | | 0.23 | 0.21 | 0.24 | 0.14 | 0.18 | 0.30 | 0.20 | 0.25 | 0.25 |

*Table 1.* Food conversion ratio values during the experiment

The slaughter values showed that the amount of the fat in the abdomen and the size of the liver were bigger in the case of the W

group. This difference was multiple by the fat content (Table 2). The gut length/total body length ratio was also the biggest in this group.

| *%* | *torso* | *liver* | *fat* | *intestine (length)* |
|---|---|---|---|---|
| wels feed | 64.5±1.8 | 2.3±0.3 | 4.1±1.0 | 71.4±10.4 |
| squearel feed | 64.1±2.0 | 1.8±0.3 | 1.0±0.8 | 59.7±6.5 |
| fish addition | 65.4±2.0 | 1.8±0.2 | 0.5±0.3 | 60.9±4.2 |

*Table 2.* Slaughter values in the proportion of body weight and body length

## *Discussion*

There is practical progress on the field of fish meal partial replacement in feeds of a couple of farmed fishes (Dias et al., 2009; Sealey et al., 2009; Silva et al., 2009). Nowadays feeds used in salmon producing contains only 30% fish meal instead of the former 50% (*FAO Fisheries and Aquaculture Department, 2009*). Up to now it was little done in this direction on wels (*Silurus glanis* L.). In our study we made a tentative experiment what showed that wels can also be reared on plant protein based diet, although the growth rate remained under the growth rate of fish fed by commercial wels feed. This may be due to the differences between both the source and the content of protein in the feeds. There was no mortality neither health problems during the experiment, although the high fat content of the abdomen and the excessive size of the liver can be indicative of health problems may occur if applying the commercial wels feed for longer duration. The increasing speed of daily weight gain indicates that continuing the examination for a longer time would provide better results in the case of the squealer groups. It cannot be excluded that the duration of this examination wasn't long enough for the enzyme system to adapt to the alternative diet. The digestibility of plant source

nutrients - especially for piscivorous fish - is worse than that of the animal nutrients (Cho & Bureau, 2001). It is possible that the duration of this examination wasn't long enough for the enzyme system to adapt to the alternative diet. Panserat et al. (2009) conducted a survey to examine the physiological effects of the total replacement of fish meal and fish oil in the diet of rainbow trout. It was found that diets containing 100% plant protein had no negative effect on the liver functions and metabolism. By today at some industrially farmed species the fish meal has been replaced already in the commercial feeds. The protein in channel catfish feeds applied in the American catfish farms is almost exclusively of plant origin as mostly soybean meal, corn meal and cottonseed (Stickney, 2010).

Further examinations are necessary to develop plant protein based feeds for wels what may result growth rates close to that achieved by using fish meal based feeds. Beside plant protein fermentation product protein should be considered as well. We would like to attain a new type of intensive wels culture in traditional carp ponds.

## *References*

Ai Q., Xie X. 2006. Effects of dietary soybean protein levels on metabolic response of the southern catfish, *Silurus meridionalis*. *Comparative Biochemistry and Physiology* **144** 41-47.

Ambardekar A. A., Reigh R. C., Williams M. B. 2009. Absorption of amino acids from intact dietary proteins and purified amino acid supplements follows different time-courses in channel catfish (*Ictalurus punctatus*). *Aquaculture* **291** 179-187.

Astles K. L., Gibbs P. J., Steffe A. S., Green M. 2009. A qualitative risk-based assessment of impacts on marine habitats and harvested species for a data deficient wild capture fishery. *Biological Conservation* **142** 2759-2773.

Caddy J. F., Garibaldi L. 2000. Apparent changes in the trophic composition of world marine harvests: the perspective from the FAO capture database. *Ocean & Coastal Management* **43** 615-655.

Cho C. Y., Bureau D. P. 2001. A review of diet formulation strategies and feeding systems to reduce excretory and feed wastes in aquaculture. *Aquaculture Research* **32** 349-360

Davies S. J., Gouveia A. 2008. Enhancing the nutritional value of pea seed meals (*Pisum sativum*) by thermal treatment or specific isogenic selection with comparison to soybean meal for African catfish, *Clarias gariepinus*. *Aquaculture* **283** 116-122.

Dias J., Conceicao L. E. C., Ribeiro A. R., Borges P., Valente L. M. P., Dinis M. T. 2009. Practical diet with low fish-derived protein is able to sustain growth performance in gilthead seabream (*Sparus aurata*) during the grow-out phase. *Aquacultur*e **293** 255-262.

FAO Fisheries and Aquaculture D. 2009. The State of World Fisheries and Aquaculture-2008. http://www.fao.org/docrep/011/i0250e/i0250e00.htm, 2010. 04. 25.

Johnsen J. P. 2005. The evolution of the „harvest machinery": Why capture capacity has continued to expand in Norwegian fisheries. *Marine Policy* **29** 481-493.

Müller F. 1990. Economical analysis of some superintensive technologies for fish production in Szarvas. *Aquacultura Hungarica* **VI** 235-246.

Panserat S., Hortopan G. A., Plagnes-Juan E., Kolditz C., Lansard M., Skiba-Cassy S., Esquerré D., Geurden I., Médale F., Kaushik S., Corazze G. 2009. Differential gene expression after total replacement of fish meal and fish oil by plant products in rainbow trout (*Oncorhynchus mykiss*) liver. *Aquaculture* **294** 123-131.

Pintér K. 2010. Magyarország halászata 2009-ben. *Halászat* **2010/2.** 43-49.

Sánchez-Lozano N. B., Martínez-Llorens S., Tomás-Vidal A., Cerdá M. J. 2009. Effect of high-level fishmeal replacement by pea and rice concentrate protein on growth, nutrient utilization and fillet quality in gilthead seabream (*Sparus aurata* L.). *Aquaculture* **298** 83-89.

Sealey W.M., Barrows F. T., Smith Ch. E., Overturf K., LaPatra S. E. 2009. Soybean meal level and probiotics in first feeding fry diets alter the ability of rainbow trout *Oncorhynchus mykiss* to utilize high levels of soybean meal during grow-out. *Aquaculture* **293** 195-203.

Silva J. M. G., Espe M., Conceicao L. E. C., Dias J., Valente L. M. P. 2009. Senegalese sole juveniles (*Solea senegalensis* Kaup, 1858) grow equally well on diets devoid of fish meal provided the dietary amino acids are balanced. *Aquaculture* **296** 309-317.

Sink T. D., Lochmann R. T., Kinsey N. R. 2010. Growth and survival of channel catfish, *Ictalurus punctatus*, fry fed diets with 36 or 45% total protein and all plant or animal protein sources. *Journal of the World Aquaculture Society* **41** 124-129.

Stickney R. R. 2010. Cultured Aquatic Species Information Programme, *Ictalurus punctatus* (Rafinesque, 1818). In: FAO Fisheries and Aquaculture Department, http://www.fao.org/fishery/culturedspecies/Ictalurus_punctatus/en 2010. 05. 29.

Tacon A. G. J., Metian M. 2008. Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds: Trends and future prospects. *Aquaculture* **285** 146-158.

Toko I. I., Fiogbe E. D., Kestemont P. 2008. Mineral status of African catfish (*Clarias gariepinus*) fed diets containing graded levels of soybean or cottonseed meals. *Aquaculture* **275** 298-305.

Webster C. D., Tiu L. G., Tidwell J. H., Grizzle J. M. 1997. Growth and body composition of channel catfish (*Ictalurus punctatus*) fed diets containing various percentages of canola meal. *Aquaculture* **150** 103-112.