Journal of Applied Ichthyology

J. Appl. Ichthyol. 31 (Suppl. 2) (2015), 38–44

ISSN 0175–8659

Received: September 12, 2014
Accepted: February 9, 2015
doi: 10.1111/jai.12848

Processing traits of European catfish (*Silurus glanis* Linnaeus, 1758) from outdoor flow-through and indoor recycling aquaculture units

By Z. Adamek[1], I. Grecu[2], I. Metaxa[2], L. Sabarich[3] and J.-P. Blancheton[3]

[1]*Faculty of Fisheries and Protection of Waters, South Bohemian Research Centre for Aquaculture and Biodiversity of Hydrocenoses, Institute of Aquaculture, University of South Bohemia in České Budějovice, České Budějovice, Czech Republic;* [2]*Department of Aquaculture, Dunarea de Jos University, Galati, Romania;* [3]*Station experimentale d'aquaculture, IFREMER, Palavas les flots, France*

Summary

The quality of fish cultured using recycling units may differ from that of fish from outdoor farming units due to a range of deviating environmental determinants. This applies not only to flesh quality but also to morphological (processing) traits. This study evaluates processing yields of sibling fish cultured in two different farming units: (i) an outdoor pond aquaculture system with a flow-through regime (24.6 ± 0.2°C), and (ii) indoor tanks using a recirculation aquaculture system (RAS; 26.0 ± 1.0°C). Clear differences were observed in the most important processing traits, i.e. skinned trunk and fillet yields, which were both significantly higher ($P < 0.01$) in RAS fish due to significantly smaller ($P < 0.05$) head weight in fish of the flow-through system. Skin represented a significantly higher ($P < 0.01$) proportion of total weight in both RAS males and females. The most obvious difference was in the deposited fat weight, which was significantly higher ($P < 0.01$) in RAS fish. Visceral fat deposits were significantly higher ($P < 0.01$) in females and ventral and dorsal fat deposits higher ($P > 0.05$) in males.

Introduction

The European catfish (hereafter 'catfish'), *Silurus glanis* Linnaeus 1758, is a highly valued fish in Europe with a very long tradition in European pond aquaculture, having been cultured extensively in temperate regions for several centuries. In addition to its high quality flesh, catfish were valued (and in extensive pond aquaculture still are) as a 'police' fish, as they are able to utilise low-value non-commercial fish (especially small cyprinids) and thereby control their overpopulation (Proteau et al., 1996). In open public waters, catfish are considered both as important predators as regards biomanipulation and as a highly valued sport and trophy fish in recreational fisheries (Randák et al., 2013).

The flesh of catfish is white, boneless and highly palatable, with a high processing yield, good flavour and texture and a low amount of fat (Proteau et al., 1996). When compared with the two other important silurids (i.e. channel catfish, *Ictalurus punctatus*, and African catfish, *Clarias gariepinus*) in aquaculture, some consumers indicate a clear preference for European catfish based on sensory evaluation alone (Manthey et al., 1988). In the market, catfish are sold whole or whole and eviscerated, cut into skinned steaks or as fillets (skin on or off). Processing may also include smoking (Martin et al., 1995; Fauconneau and Laroche, 1996).

The high quality of catfish flesh, excellent growth performance under high stocking densities, and ability to ingest pelleted diets has led to its wide utilisation in intensive warm-water farming units, with a consequent increase in production. Theoretically, the use of recirculating systems for catfish culture should result in higher growth rates as it eliminates the slow rates of growth observed at ambient water temperatures below 10°C (David, 2006). Recent production levels for catfish in France (produced by small-scale enterprises) are at present around 200–300 tonnes (Linhart et al., 2002), which is unlikely to fulfill future market demands. Despite this, catfish have the potential to cater to the increasing demand for fish (and especially fish fillets) caused by the widening gap produced by dwindling wild fish stocks (Tournay, 2003).

The quality of catfish raised under different aquaculture production systems has been evaluated in a number of recent studies. Linhart et al. (2002), for example, published a synthesis of basic culture principles in the Czech Republic and France, while Martin et al. (1995) summarised data on catfish processing yields, chemical composition and sensory quality. Processing yields and traits have also been reported in contributions by Manthey et al. (1988), Haffray et al. (1998), and Jankowska et al. (2007); these authors accentuate both the quality of catfish flesh, reflected in the consumer's appreciation of the fish as a delicacy, and the high carcass yield. The present study focuses on a comparison of the processing yield in market-sized catfish originating from two different small-scale production units (outdoor flow-through and indoor recycling) in the Montpellier region of France.

Materials and methods

Evaluation of processing yields was performed on marketable 18-month-old catfish originating from two different farming units: (i) an outdoor open-pond aquaculture system with a flow-through regime, and (ii) an indoor tank aquaculture system utilising a recirculation regime (RAS). The experimental fish in both systems were all siblings originating from a single induced stripping of one female and one male, stocked into both units at an average weight of 28 g. During culture, both flow-through and RAS fish were supplied with a pelleted feed mixture (Ecolife 15No8 Biomar) comprising 45% protein and 16% fat.

In the flow-through system (Viviers de la Castillonne, Montagnac, France), 500 fish were cultured in a 50 m^3 (10 × 5 × 1 m) earthen pond, which resulted in a density of 10 fish per m^3 and a biomass of around 22.3 kg per m^3 over the sampling period. The outflow area of the pond was partly covered with 2 × 5 m metal roof plates to provide shelter for the fish. Water was supplied from a geothermal source (approx. depth 1500 m, constant temperature 26.4°C; Ribes and Ribes, 1994), the inflow being adjusted to 15 m^3 per hour in order to exchange the entire pond volume once per 3 h 20 min. Water temperature and oxygen concentration were relatively stable throughout the sampling period, amounting to 24.6 ± 0.2°C and 6.84 ± 0.44 mg L^{-1}, respectively. Fish were fed manually with pelleted feed corresponding to 0.3% of their total biomass per day. In addition, approx. 5000 ornamental live-bearing fish (*Xiphophorus helleri* and *X. variatus*; mean total length (TL) 37 ± 4.6 and 24 ± 9.5 mm, respectively) were also present in the pond at an approximate ratio of 1 : 6.

The RAS system (IFREMER Experimental Aquaculture Station, Palavas les flots, France) consisted of two 10 m^3 self-cleaning tanks connected by a recirculating water system. Temperature and photoperiod were maintained at a constant 26 ± 1°C and 4 h of light per day, respectively; pH was maintained at around 7.1 by continuous injection of a sodium hydroxide solution; and pure oxygen was supplied to ensure a minimum concentration of 6.5 mg L^{-1}. Replacement water was added at a controlled flow rate corresponding to 0.75 m^3 per kg of feed supplied. During the experiment, fish biomass varied around 150 kg m^{-3}. Fish were fed 1.2% of their total biomass per day using disc feeders.

At slaughter, the variables measured were:

- total length (TL, mm), standard length (SL, mm)
- total weight (Wt, g), eviscerated weight (Wev, g), skinned trunk weight (Wst, g), head weight (Wh, g), fillet weight (two manually prepared fillets with skin, ribs and pelvic basipterygia removed; Wfil, g)
- liver weight (Wl, g), fin weight (Wfin, g), skin weight (Ws, g), gonad weight (Wg, g).

Special attention was given to weight of fat deposits at different locations:

- fat ligaments in the body cavity (mesenteric adipose tissue) – visceral fat weight (Wvif, g)
- adipose tissue on top of the caudal peduncle [intermediate tissue between lateral muscles (*musculus lateralis major*)] – dorsal fat weight (Wdf, g)
- adipose tissue surrounding the anal fin pterygiophores in the caudal peduncle – ventral fat weight (Wvef, g).

The indices calculated from the data of fish evaluation were:

- viscerosomatic index (VSI) as a percentage of Wev to Wt
- hepatosomatic index (HSI) as a percentage of Wl to Wt
- gonadosomatic index (GSI) as a percentage of Wg to Wt
- condition coefficients (Ct and Cev) as

$Ct = 10^5 \times (Wt/SL^3)$ and $Cev = 10^5 \times (Wev/SL^3)$, respectively.

In total, 25 fish were evaluated from the flow-through system and 28 from the RAS. The mean initial Wt of females and males was 2117 ± 376 and 2373 ± 535 g in the flow-through system, respectively; and 2460 ± 512 and 2451 ± 589 g in the RAS, respectively (Table 1). Differences in length and weight between males and females in the two systems, and of individual sexes within each system, were not significant ($P > 0.05$). Final processing trait data were calculated as parameters related to Wt. In all cases, one-way ANOVA was applied for statistical analysis, except for the comparison between processing yield of left- and right-hand fillets, for which the paired Student *t*-test was used.

In addition to processing yield, the stomach contents of all slaughtered fish were evaluated to check for occurrence of natural food items in the diet. Results were evaluated with respect to experimental conditions (intensive culture) as frequency of occurrence $FO = 100 \times (n_i/n)$; where n_i is the number of fish with food item i in their digestive tracts and n is the total number of fish examined.

Results

Processing yield

The viscerosomatic index (VSI) was higher in fish from the RAS compared to fish from the flow-through system, and in males compared to females, although the differences were not significant ($P > 0.05$; Fig. 1). The proportion of skinned trunk to total fish weight ranged between 55 and 60%, being significantly higher ($P < 0.05$) in RAS females compared to females from the flow-through system (59.5 ± 1.7 vs 57.0 ± 2.1, respectively; Fig. 1). Fillet yields (%) were slightly higher in RAS than in fish from the flow-through trial (45.4 ± 1.9 vs 41.9 ± 2.3, $P < 0.01$ [females] and 44.8 ± 4.2 vs 42.2 ± 2.7, $P > 0.05$ [males], respectively; Fig. 1). No significant differences were observed between left- and right-hand fillet (21.9 ± 1.5 and 21.7 ± 1.7, respectively; $P = 0.11$; Fig. 2).

Table 1
Length-weight characteristics of 18-month-old catfish, *Silurus glanis*, (mean ± SD) from pond (flow-through; n♀ = 14, n♂ = 11) or recycling systems (RAS; n♀ = 18, n♂ = 9)

Culture system	Sex	n	TL (mm)	SL (mm)	W (g)
Flow-through	F	14	645 ± 33	581 ± 30	2117 ± 376
	M	11	623 ± 174	564 ± 159	2373 ± 535
	Significance		NS	NS	NS
RAS	F	18	655 ± 37	595 ± 37	2460 ± 512
	M	9	619 ± 199	564 ± 180	2451 ± 589
	Significance		NS	NS	NS
Flow-through × RAS	F		NS	NS	NS
	M		NS	NS	NS

TL, total length; SL, standard length; *W*, weight; NS, not significant.

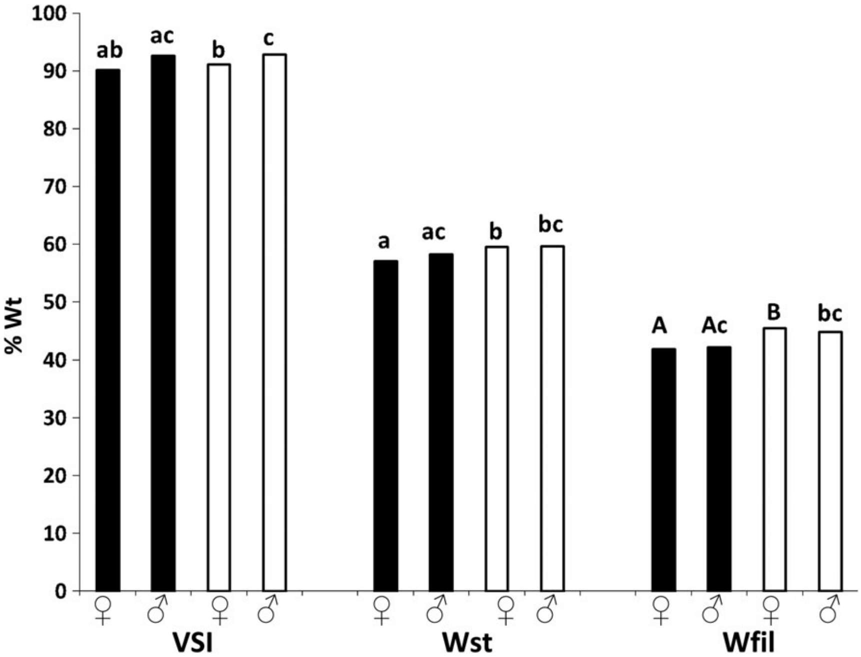

Fig. 1. Mean value of processing yields in % fish total weight (% Wt) in 18-month-old catfish, *Silurus glanis*, from pond (flow-through; dark bars; n♀ = 14, n♂ = 11) and recycling (RAS; white bars; n♀ = 18, n♂ = 9) aquaculture systems. Note: VSI, viscerosomatic index; Wst, skinned trunk weight; Wfil, fillet weight. Different lower case and capital letters = significance at P < 0.05 and P < 0.01, respectively

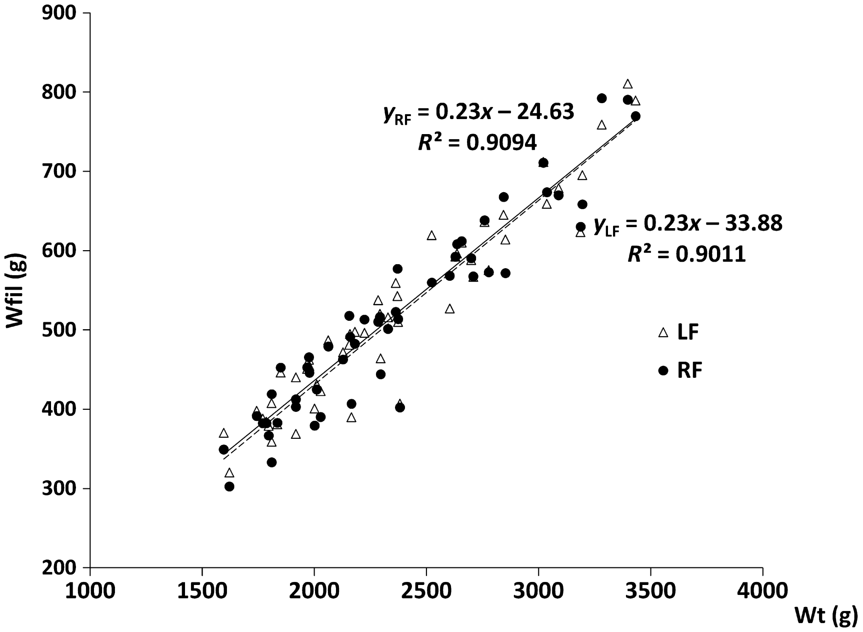

Fig. 2. Relationship between left (LF; dashed line) and right (RF; solid line) fillet weight (Wfil) and total weight (Wt) in 18-month-old catfish, *Silurus glanis*, (n = 52 each) from pond and recycling aquaculture systems

Processing offal

Catfish heads represented 20.7–21.2% of total fish length, and no significant differences (P > 0.05) were observed between flow-through system and RAS fish or between males and females. Mean relative head weight (%) fluctuated between 22.3 ± 1.3 and 25.3 ± 1.5 in RAS females and males from the flow-through system, respectively (Fig. 3), resulting in significantly higher (P < 0.05) head/body length and weight ratios in fish in the flow-through system.

Relative skin weight in slaughtered fish, representing around 5% of total weight, was significantly higher (P < 0.01) in RAS fish (Fig. 3). The relative weight of fins was also higher, although the difference was not significant (P > 0.05). Fins were missing or damaged to various extents in 69% of fish from the RAS and only 16% of fish in the flow-through trials. Ventral fins were the most affected (48 and 16% of fish from RAS and flow-through units, respectively), followed by the pectoral (28%), anal (10%), caudal (7%) and dorsal (7%) fins

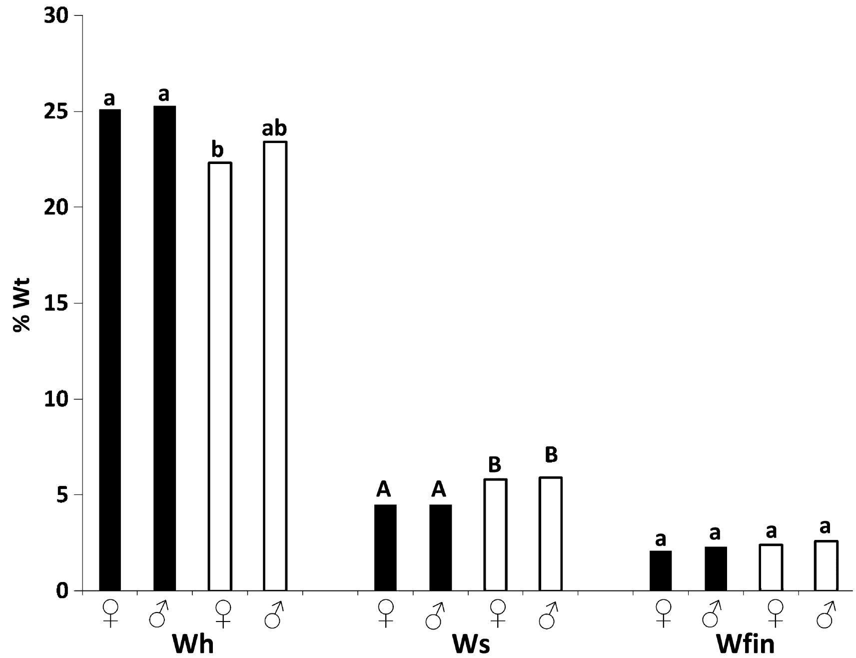

Fig. 3. Mean proportion in % fish total weight (% Wt) of processing offal (weight of head – Wh, weight of skin – Ws, and weight of fins – Wfin) in 18-month-old catfish, *Silurus glanis*, from pond (flow-through; dark bars; n♀ = 14, n♂ = 11) and recycling (RAS; white bars; n♀ = 18, n♂ = 9) aquaculture systems. Note: different lower case and capital letters indicate significance at P < 0.05 and P < 0.01, respectively

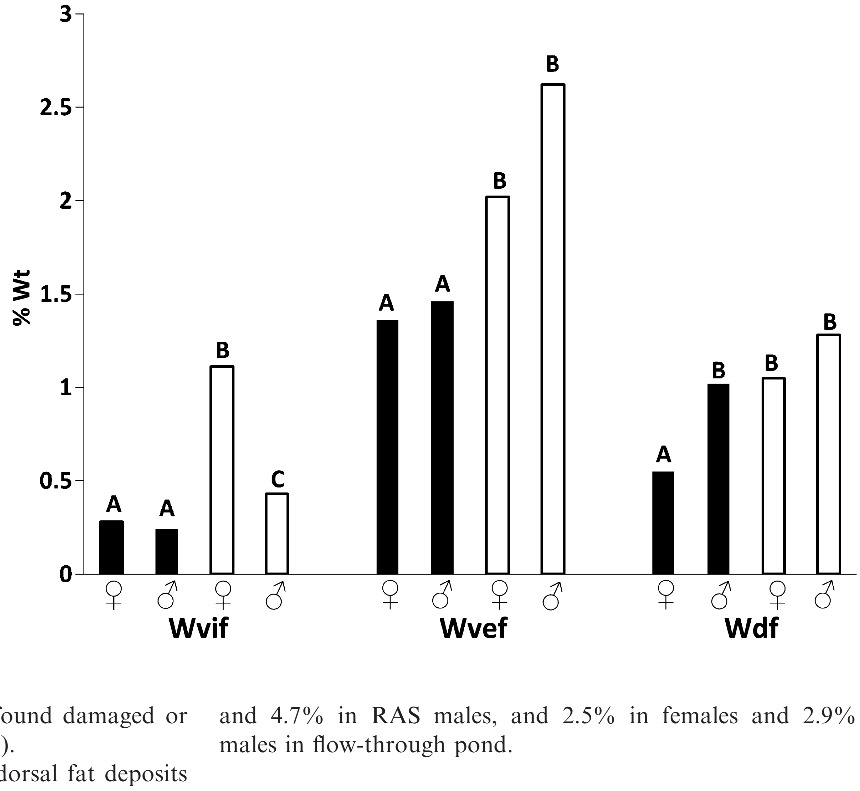

Fig. 4. Mean proportion of fat deposits in % fish total weight (% Wt) in 18-month-old catfish, *Silurus glanis*, from pond (flow-through; dark bars; n♀ = 14, n♂ = 11) and recycling (RAS; white bars; n♀ = 18, n♂ = 9) aquaculture systems. Note: Wvif, visceral fat weight; Wvef, ventral fat weight; Wdf, dorsal fat weight. Different capital letters indicate significance at P < 0.01

in RAS fish (none of the latter fins were found damaged or missing in fish from the flow-through system).

The proportion of visceral, ventral and dorsal fat deposits as a percentage of total fish weight was significantly higher ($P < 0.05$) in RAS fish compared to fish from the flow-through system trials (Fig. 4), differences being highest in the proportion of ventral fat ligaments, which was 4.0 and 1.8 times higher in RAS females and males, respectively. On average, total fat deposits represented 4.6% in RAS females and 4.7% in RAS males, and 2.5% in females and 2.9% males in flow-through pond.

Condition coefficients

Average condition coefficients related to total body biomass fluctuated within a very narrow range in all examined fish, with lowest values in males from the flow-through system (1.05 ± 0.28). Both Ct and Cev coefficients were higher in

RAS fish, with no obvious differences between females and males (Table 2).

Gonad development

Female percentage ripeness was considerably higher in the flow-through trials (71%) compared to RAS females (22%). Similarly, mean GSI was higher in flow-through females compared to RAS females (3.86 ± 2.01 vs 1.55 ± 1.47, P < 0.01) and in males of the flow-through pond compared to RAS males (0.70 ± 0.10 vs 0.53 ± 0.31, P > 0.05). Both absolute and relative fecundity of ripe females, however, were higher in RAS fish (NS, Table 3).

Stomach contents

Stomach inspection confirmed that all fish from RAS and from the flow-through system ingested feed pellets. In addition, fish from the flow-through system also ingested detritus (64% FO) and organic debris (36% FO), including plant fragments and filamentous algae (*Vaucheria*, *Spirogyra*, *Chara* and Rhodophyceae). Periphytic diatoms were also observed in the stomach contents of five fish (20% FO). Items of zero nutritional value included small stones (up to 11 mm diameter) and woody debris, which were registered in 36 and 16% of fish, respectively. Additionally, snails [e.g. *Physa* sp. (32%)] and chironomid larvae (4%) were also consumed. Snail numbers ranged from 1 to 78 individuals, all of which appeared to be of relatively uniform size (7.80 ± 0.76 mm, n = 10), though many were present as broken shells only. No fish remains were recorded in the stomach contents of catfish held in the flow-through system.

Pellets, at various stages of digestion, were the only food type recorded in RAS fish stomachs.

Table 2
Condition coefficients (mean ± SD) in 18-month-old catfish, *Silurus glanis*, reared in a pond (flow-through system; n♀ = 14, n♂ = 11) or a recycling system (RAS; n♀ = 18, n♂ = 9)

Culture system	Sex	n	Ct	Cev
Flow-through	F	14	1.07 ± 0.08	0.97 ± 0.06
	M	11	1.05 ± 0.28	0.97 ± 0.26
	Significance		NS	NS
RAS	F	18	1.14 ± 0.11	1.04 ± 0.09
	M	9	1.12 ± 0.10	1.04 ± 0.09
	Significance		NS	NS
Flow through × RAS	F		NS	NS
	M		NS	NS

Ct, condition coefficient (whole fish); Cev, condition coefficient (eviscerated fish); NS, not significant.

Discussion

The adaptability of the catfish enables farming this fish in various types of systems (e.g. as a predator in polyculture), in open warm-water systems (e.g. power plant effluents) and in recirculating systems (Proteau et al., 1996).

As shown by stomach analysis, all fish ingested pelleted food. Catfish of the flow-through system also ingested a proportion of natural food items. Despite the known predatory behaviour of this size of catfish, no fish was observed in the diet, despite being present in high numbers in the pond (~100 individuals per m^2).

All experimental fish, being siblings from the stripping of a single female and male, showed the same growth rate in both culture systems. Catfish in the flow-through units were fed manually, which enabled the person responsible to regulate feeding (intentionally or subconsciously) based on perceived level of satiation (i.e. feeding would stop, or subsequent feeds reduced, when fish showed no further interest in feeding); RAS catfish, on the other hand, were fed using automated disc feeders. As a result, RAS fish were supplied with a daily feed ration about four times greater than that of fish in the flow-through units (1.2 and 0.3% of stock biomass, respectively), indicating a better feed conversion rate under pond conditions. The better feed conversion rates were also associated with lower fat deposits in fish from the flow-through system (Fig. 4). Note, however, that food conversion rates were not within the original scope of this experiment and, therefore, the causes are speculative, since the feeding level also differed between the two systems. For example, factors such as higher stress (under the RAS system?) and/or improved fish welfare (under the flow-through system?) may also account for better food utilisation. Further studies are required to prove this speculative assumption.

Table 3
Hepatosomatic (HSI) and gonadosomatic (GSI) indices and relative fecundity (RF; 103 eggs kg_1) in 18-month-old cultured *Silurus glanis*. Data represent means ± SD from pond (flow-through system; n♀ = 14, n♂ = 11) or recycling systems (RAS; n♀ = 18, n♂ = 9)

System	Sex	n	HSI	GSI	RF
Flow-through	F	14	1.11 ± 0.31	3.86 ± 2.01	16.65 ± 1.56 (n = 10)
	M	11	1.09 ± 0.32	0.70 ± 0.10	–
	Significance		NS	**	–
RAS	F	18	1.11 ± 0.29	1.55 ± 1.47	18.04 ± 5.15 (n = 4)
	M	9	0.94 ± 0.14	0.53 ± 0.31	–
	Significance		NS	*	–
Flow-through × RAS	F		NS	**	NS
	M		NS	NS	–

NS, not significant.
*P < 0.05.
**P < 0.01.

According to Fauconneau and Laroche (1996), catfish processing potential is high in terms of mechanisation but rather low in terms of processing yield. Filleting, however, gives added value to the fish and facilitates marketing (Proteau et al., 1996). Our results show that more than half of the fresh fish weight is composed of offal. The proportion of skinned trunk as a product of catfish processing corresponds to around 60% (58.2–60.0%), thus subsequent losses (fat, bones and associated flesh) due to filleting correspond to about 14.1–18.0%.

For the majority of comparisons, fish from the RAS and flow-through units showed significant differences between the total proportions of final products ($P < 0.05$). Only VSI (eviscerated fish) was similar in both females and males of both systems (Fig. 1). While processing yields (eviscerated fish, skinned trunk, fillet) were significantly higher ($P < 0.05$) for RAS females, differences between males of the flow-through trials and RAS for all final products were insignificant ($P > 0.05$), despite the proportion of final product yield to total weight being higher in RAS fish (Fig. 4). Data from the yield of offal products (Fig. 3) suggest that the main reason for this difference was the significantly bigger head of the fish in the flow-through system – about 1.9 and 2.8% larger in females and males (both $P < 0.05$). The average total proportion of processing offal (viscera, head, skin, fins, fat deposits) amounted to 39.0% in females and 37.5% in males of the flow-through system, but only 36.6% (females) and 37.1% (males) in the RAS (differences were insignificant [$P > 0.05$] due to high variability in the proportions of individual items). Comparisons of individual offal between fish from RAS and the flow-through system, however, were mostly significant, with the head proportion significantly bigger ($P < 0.05$) in the flow-through system fish and the proportion of skin and fins significantly larger ($P < 0.01$) in RAS fish. The minimal differences in skinned trunk weight in fish between RAS and in the flow-through system, therefore, resulted from a higher relative head weight of fish in the flow-through system, which was compensated for by higher relative weight of skin, fins and fat deposits in RAS fish.

Stejskal et al. (2008) undertook a similar study to ours on Eurasian perch (*Perca fluviatilis*). In accordance with our results, the authors found no significant difference between weight of eviscerated perch from the RAS and flow-through system. The relative weight of skinned perch fillets was 0.7% higher in RAS perch ($P > 0.05$) but 3.2% higher ($P < 0.05$) in the RAS catfish in our study. Whereas RAS cultured perch showed a significant increase ($P < 0.05$) in HSI, our study showed no significant differences ($P > 0.05$) between the flow-through system and RAS cultured catfish. RAS culture resulted in a significant increase in the proportion of visceral fat and a reduced GSI in both perch (Stejskal et al., 2008) and catfish (our study). These differences were particularly obvious as regards visceral fat, with respective RAS and flow-through values of 2.9 vs 1.0 in perch and 0.98 vs 0.29 in catfish (without taking gender into consideration).

Damaged fin condition is a regular phenomenon associated with intensive fish farming (Latremouille, 2006). It has been recorded, for example, in rainbow trout (*Oncorhynchus mykiss*; St-Hilaire et al., 2006; Ellis et al., 2009), salmon (*Salmo salar*; Jones et al., 2011), perch (Stejskal et al., 2011), sea bass (*Dicentrarchus labrax*; Person-Le Ruyet and Le Bayon, 2009), cod (*Gadus morhua*; Hatlen et al., 2006), and many others, and is usually a result of bacterial infection and/or aggressive behaviour of fish cultured at high densities (e.g. Jobling et al., 1998).

No significant differences ($P > 0.05$) were observed between left- and right-hand fillet weights (Fig. 2), indicating that the skill of the person undertaking the filleting does not affect filleting yield.

Our results support the view that the RAS culture methods represent a good means of fish aquaculture that minimises the potentially adverse ecological impacts of intensive aquaculture on the surrounding environment. In addition, it provides opportunities for reducing water usage and improving water management and nutrient recycling (Martins et al., 2010). Operationally, the warm-water RAS system used in this study proved highly suitable for the culture of European catfish, resulting in good processing traits.

Acknowledgements

This study was supported by the ASEFAF project (IFREMER France) and by the Ministry of Education, Youth and Sports of the Czech Republic - projects 'CENAKVA' (No. CZ.1.05/2.1.00/01.0024) and 'CENAKVA II' (No. LO1205 under the NPU I program)

References

David, J. A., 2006: Water quality and accelerated winter growth of European catfish using an enclosed recirculating system. Water Environ. J. **20**, 233–239.

Ellis, T.; Hoyle, I.; Oidtmann, B.; Turnbull, J. F.; Jacklin, T. E.; Knowles, T. G., 2009: Further development of the "Fin Index" method for quantifying fin erosion in rainbow trout. Aquaculture **289**, 283–288.

Fauconneau, B.; Laroche, M., 1996: Characteristics of the flesh and quality of products of catfishes. Aquat. Living Resour. **9**, 165–179.

Haffray, P.; Vauchez, C.; Vandeputte, M.; Linhart, O., 1998: Different growth and processing traits in males and females of European catfish, *Silurus glanis*. Aquat. Living Resour. **11**, 341–345.

Hatlen, B.; Grisdale-Helland, B.; Helland, S. J., 2006: Growth variation and fin damage in Atlantic cod (*Gadus morhua* L.) fed at graded levels of feed restriction. Aquaculture **261**, 1212–1221.

Jankowska, B.; Zakes, Z.; Zmijewski, T.; Ulikowski, D.; Kowalska, A., 2007: Slaughter value and flesh characteristics of European catfish (*Silurus glanis*) fed natural and formulated feed under different rearing conditions. Eur. Food Res. Technol. **2254**, 453–459.

Jobling, M.; Koskela, J.; Pirhonen, J., 1998: Feeding time, feed intake and growth of baltic salmon, *Salmo salar*, and brown trout, *Salmo trutta*, reared in monoculture and duoculture at constant low temperature. Aquaculture **163**, 73–84.

Jones, H. A. C.; Noble, C.; Damsgard, B.; Pearce, G. P., 2011: Social network analysis of the behavioural interactions that influence the development of fin damage in Atlantic salmon parr (*Salmo salar*) held at different stocking densities. Appl. Anim. Behav. Sci. **133**, 117–126.

Latremouille, D. N., 2006: Fin erosion in aquaculture and natural environments. Rev. Fish. Sci. **11**, 315–335.

Linhart, O.; Stech, L.; Svarc, J.; Rodina, M.; Audebert, J. P.; Grecu, I.; Billard, R., 2002: The culture of the European catfish, *Silurus glanis*, in the Czech Republic and in France. Aquat. Living Resour. **15**, 139–144.

Manthey, M.; Hilge, V.; Rehbein, H., 1988: Sensory and chemical evaluation of three catfish species (*Silurus glanis*, *Ictalurus punctatus*, *Clarias gariepinus*) from intensive culture. Arch. Fisch. Wiss. **38**, 215–227.

Martin, J. F.; Poli, J. M.; Petillot, F.; 1995: La transformation du Silure Glane (*Silurus glanis* L.). Rendement du filetage. La pisciculture francaise **121**, 51–55. [In French].

Martins, C. I. M.; Eding, E. H.; Verdegem, M. C. J.; Heinsbroek, L. T. N.; Schneider, O.; Blancheton, J. P.; Roque d'Orbcastel, E.; Verreth, J. A. J., 2010: New developments in recirculating aquaculture systems in Europe: a perspective of environmental suitability. Aquacult. Eng. **43**, 83–93.

Person-Le Ruyet, J.; Le Bayon, N., 2009: Effects of temperature, stocking density and farming conditions on fin damage in European sea bass (*Dicentrarchus labrax*). Aquat. Living Resour. **22**, 349–362.

Proteau, J. P.; Hilge, V.; Linhart, O., 1996: Etat actuel et perspectives de la production aquacole de poissons-chats (Siluroidei) en Europe. Aquat. Living Resour. **9**, 229–235.

Randák, T.; Slavík, O.; Kubečka, J.; Adámek, Z.; Horký, P.; Turek, J.; Vostradovský, J.; Hladík, M.; Peterka, J.; Musil, J.; Prchalová, M.; Jůza, T.; Kratochvíl, M.; Boukal, D.; Vašek, M.; Andreji, J.; Dvořák, P., 2013: Fisheries in open waters. FROV JU, Vodňany, 434 pp.

Ribes, A.; Ribes, G., 1994: Reproduction artificielle et elevage larvaire de *Silurus glanis* en toutes saisons. In: International Workshop on the Biological Bases for Aquaculture of Siluriformes, Montpellier, France, 178 pp.

Stejskal, V.; Vejsada, P.; Vácha, F.; Kouřil, J.; Hamáčková, J.; Cepák, M., 2008: Comparative study of the slaughter yield and sensory analysis of flesh Eurasian perch (*Perca fluviatilis* L.) culture in intensive and extensive conditions. Bull. VÚRH Vodňany **44**, 37–43. (In Czech with English summary).

Stejskal, V.; Policar, T.; Křišťan, J.; Kouřil, J.; Hamáčková, J., 2011: Fin condition in intensively cultured Eurasian perch (*Perca fluviatilis*). Fol. Zool. **60**, 122–128.

St-Hilaire, S.; Ellis, T.; Cooke, A.; North, B. P.; Turnbull, J. F.; Knowles, T.; Kestin, S., 2006: Fin erosion on rainbow trout on commercial trout farms in the United Kingdom. Vet. Rec. **159**, 446–451.

Tournay, B., 2003: Rapid growth for recirc Euro catfish. FFI:27.

Author's address: Z. Adamek, Faculty of Fisheries and Protection of Waters, South Bohemian Research Centre for Aquaculture and Biodiversity of Hydrocenoses, Institute of Aquaculture, University of South Bohemia in České Budějovice, Husova tř. 458/102, 370 05 České Budějovice, Czech Republic.
E-mail: adamek@ivb.cz