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ASSESSMENT THE EFFECT OF SEX ON SELECTED MORPHOMETRIC MEASUREMENTS AND SLAUGHTER YIELDS OF AFRICAN CATFISH *(CLARIAS GARIEPINUS* BURCHELL, 1822)

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Key words: African catfish, gender of fish, morphometric measurements, slaughter yield.

Abstract

This study was aimed at analyzing the results of morphometric measurements and slaughter yield of the carcass of African catfish depending on gender. The experimental material included 60 fish, with a gender ratio of 1:1 (females ♂: males ♀), cultured in the intensive system (pond culture). All fish were fed manually (every 3 h) with pelleted feed prepared at the farm. Morphometric measurements (body weight, total length, body length, side length of the head, head height, the smallest and the largest height of the body and body width) were performed in live fish, whereas *post-mortem* determinations were carried out for contents of particular elements of the carcass (head, viscera, fins, skin, bones and fillets). Results achieved demonstrated that male fish were characterized by greater body length, side length of the head and body height compared to females. They were also characterized by higher body weight, the yield of carcass and fillets without skin, and by higher contents of head, fins and bones in the total body weight. The statistical analysis showed the effect of sex on morphometric measurements and the selected parts of the body of catfish.

Introduction

African catfish (*Clarias gariepinus)* is one of the most important fish species currently being cultured both within and outside its natural range of tropical and subtropical environments (CHEPKIRUI-BOIT et al. 2011). It is one of the most commonly cultured, indigenous species of fish in Africa. It has an almost Pan African distribution (absent from Maghreb, the upper and lower Guinea, the Cape province, probably Nogal province), and also naturally occurs in Minor Asia: Jordan, Israel, Lebanon, Syria and south-

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ern Turkey (TEUGELS 1996). This species has been introduced in Europe, America and south-east Asia for aquaculture purposes (AGNESE et al. 1997). *C. gariepinus* is omnivorous, ability to eat a variety of natural (plant material, plankton, arthropods, mollusks, other fish, reptiles and amphibians) and accepts supplemental feeds, and is resistant to diseases, as well as this fish, can tolerate low oxygen and pH levels (MUSTAPHA et al. 2012). *C. gariepinus* has pseudo-lungs, long bodies and a high capacity to produce mucous as adaptations to live in stagnant environments or out of water (YALÇIN et al. 2001a, VITULE et al. 2006, AMISAH et al. 2009). The reproduction of this catfish is seasonal and linked with the maturation of gonads and it depends on water level, temperature and photoperiod. In the pond culture, females reach sexual maturity after 6–7 months, whereas the gonads of males become well-developed after 1.5–2.0 years (YALÇIN et al. 2001b, ADAMEK 2011). This catfish is sexually dimorphic, males have distinct urogenital sexual papillae, located behind the anus, which are absent in females (BARNHOORN et al. 2004).

Catfish and its hybrids are important worldwide. The total production of African catfish officially reported by FAO is 246,476 t during 2015 (FAO 2017); however, it is expected that the production will increase in the following years. Therefore, detailed characteristics of catfish and its hybrids' meat are of great importance to aquaculture and fish processing sectors in countries where catfish culture is very popular, such as Nigeria, Netherlands, Brazil, and Hungary. This approach is also in line with the Sustainable Development Goals (SDGs) set in 2015 by the United Nations which indicate the need of sustainable food production (UN 2015). In Europe, it was introduced in 1974 first in Cyprus and later in the Czech Republic, Slovakia and the Netherlands (GAVRILOAIE and CHIŞAMERA 2005). *C. gariepinus* is not only a very important aquaculture species in Poland but it is also included in the checklist of non-native fishes that occur in the fresh waters of Poland (NOWAK et al. 2008). According to ADAMEK (2011), fish with an average unitary body weight above 1200 g is the most desired in the Polish market. The intensive culture of catfish tends to achieve possibly the highest body weight of fish in a short period, which is feasible only under optimal conditions. Commercial culture enables the production of fish with a unitary body weight of 800–1000 g within 6–8 months. African catfish is a suitable alternative to tilapia, the yields of catfish from ponds could be as much as 2.5 times higher than those of tilapia (GODA et al. 2007). A high yield of both carcass and fillet are an additional advantage of this fish species. The average slaughter yield of *C. gariepinus* is 38.9%, and the content of total protein in meat reaches 18.6%. The use of industrial feed mixtures may contribute to an increased content of fat not

only in meat but also in the whole body, thereby reducing carcass yield (JANKOWSKA et al. 2007, PUCHAŁA and PILARCZYK 2007, ADAMEK 2011). The meat of this species has an intense red color and a low natural loss, is tender and devoid of intense fishy flavor. In addition, the fillets are almost boneless. These factors make the meat of African catfish highly suitable for culinary and processing (SOBCZAK et al. 2022).

In Poland, *C. gariepinus* has been introduced in the early 90. However, the literature on its taxonomic status is still very scarce and the morphological characteristics of the species from the Polish aquaculture are limited (FILIPIAK et al. 1993, WIĘCASZEK et al. 2010). The morphometric characteristics of this species are significant, because (especially in Asian aquaculture) the hybrids of *C. gariepinus* are cultured with other species. Moreover, the closely related species like *C. anguillaris* or *C. macrocephalus* are cultured at a large scale, thus the detailed characteristics of the morphometric features may be needed to distinguish the different species and hybrids within the *Clarias* genus (WIĘCASZEK et al. 2010).

The available literature provides relatively little data on the technological evaluation of *C. gariepinus* carcasses originating from pond culture on differences to their sex. The research carried out can help farms specializing in the rearing of catfish to adjust the most optimum fattening period and sex choice to obtain the highest fish weight, as well as carcass and fillet yields. For this reason, a study was undertaken to see the effect of different sex (male/female) on the morphometric measurements and slaughter yield/fillet yield of African catfish.

Materials and Methods

Experimental fish, diets and origin

The experimental material included 60 fish of African catfish (*Clarias gariepinus*) with a body weight of approximately 1 kg and an age of 8 months, with a sex ratio of 1:1 (females ♂: males ♀). The fish were purchased after being caught during the autumn-winter season of 2016 at the Agricultural Farm specializing in the culture of fresh-water fish, located in the northern part of Poland. During rearing, the catfish were cultured in a concrete pond (in the intensive system) with a volume of 9,000 L and a closed circuit of water having a temperature of 25 ±1°C. The fish were fed manually (every 3 h) with pelleted feed prepared at the farm. The composition of feed was as follows (per 100 kg): 17.8 kg of fish meal, 44.6 kg of extracted soybean meal, 14.9 kg of wheat grain, 7.4 kg of corn grain, 11.9 kg

of rapeseed cake, 2.4 L of fish oil, and 1 kg of a vitamin-mineral premix. Contents of basic nutrients in feed were determined at the Laboratory of the Department of Animal Nutrition and Fodder Science, University of Warmia and Mazury in Olsztyn (Poland), according to standard methods (AOAC 2005). The pelleted feed mixture contained: 33.57% of total protein, 5.82% of crude fat, 6.45% of crude ash, and 3.80% of crude fiber, whereas its energy value reached 17.229 MJ/kg.

Morphometric measurements and slaughter yield

The fish were caught 48 hours before slaughter and transferred to a separate pond at the farm and subjected to physiological cleansing, then stunned and slaughtered accordingly to standard procedures (EC 2009). The following measurements of live fish were taken (Figure 1): body weight, total length by using a ruler, body length and side length of the head, whereas with the use of a measuring caliper: head height, the smallest and the largest height of the body and body width. The selected morphometric measurements were taken according to WIĘCASZEK et al. (2010). Catfish pre-treatment included: manual evisceration (opening of body cavity, removal of viscera and blood clots), decapitation (cut behind epicranium outgrowths), removal of fins (cutting off: caudal, dorsal, abdominal and pectoral fins ca. 0.5 cm from the base) and filleting. Afterwards, the weight of particular body parts (head, viscera, fins, skin, bones and fillet) was noted using an electronic scale by Radwag (Radom, Poland) with the accuracy of 0.001 g.

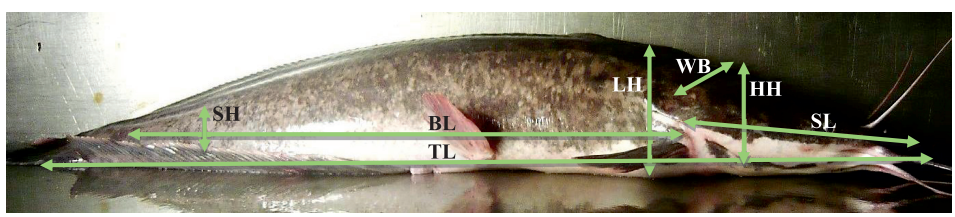

Fig. 1. Diagram of measurement points of morphometric evaluation of African catfish (HOLČIK 1989, WIĘCASZEK et al. 2010; with own modifications): TL – total length; BL – body length; SL – side length of the head; HH – the height of the head; LH – the largest height of the body; SH – smallest height of the body; WB – width of the body

Source: photo by I. Chwastowska-Siwiecka

Statistical analysis

The results were processed statistically by one-way analysis of variance in the Statistica computer software version 13.3 program (2017). They were presented in tables as mean values, standard deviation and

standard error of the mean (SEM). The significance of differences ($P \leq 0.05$ and $P \leq 0.01$) between the mean values of the analyzed parameters was determined with the t-student's test.

Results and Discussion

The analysis of results of morphometric measurements of the evaluated fish species (Table 1) demonstrated that the total length and body length (without head and caudal fin) of males were significantly greater ($P \leq 0.01$) than females, by 3.67 and 2.51 cm, respectively. The male fish were also characterized by a greater side length of the head (by 1.14 cm), which was confirmed statistically ($P \leq 0.05$). In contrast, head height was similar in both sexes and reached 5.31 cm on average. Data collated in Table 1 demonstrate that the height measured (before caudal fin) at the smallest height of the body in males reached 4.09 cm and was statistically higher ($P \leq 0.01$) than in female fish. Simultaneously, in the group of ♂, was observed for higher values of the largest body height (7.06 cm). This experiment showed no effect of sex on the body width of African catfish. The statistical analysis of values of this morphometric parameter did not show any significant differences in the analyzed experimental groups, however, the females were characterized by greater body width, 7.49 vs. 6.72 cm, which could be due to the fact that they had already reached sexual maturity.

Table 1

Morphometric measurements of *C. gariepinus* (mean ± SD)

Specification	African catfish		SEM
	male (n = 30)	female (n = 30)	
Total length (TL) [cm]	54.55^{A} ±1.62	50.88^{B} ±1.43	0.537
Body length (BL) [cm]	47.33^{A} ±0.95	44.82^{B} ±0.46	0.331
Side length of the head (SL) [cm]	12.45^{a} ±0.80	11.31^{b} ±1.14	0.251
The height of the head (HH) [cm]	5.37 ±0.83	5.25 ±0.82	0.181
The largest height of body (LH) [cm]	7.06 ±0.79	6.56 ±0.36	0.145
The smallest height of body (SH) [cm]	4.09^{A} ±0.32	3.54^{B} ±0.39	0.100
Width of the body (WB) [cm]	6.72 ±0.59	7.49 ±1.00	0.200

Mean values denoted by different letters in the row are statistically significantly different at: $^{A, B}$ – $P \leq 0.01$; $^{a, b}$ – $P \leq 0.05$; SEM – standard error of means

The body sizes of fish play a significant role in the analysis of their utility value. From the technological perspective, less valuable within a species are small fish that are characterized by greater losses of body

parts during manual pre-treatment of carcasses and lower fat content, as well as higher water holding capacity of meat. Fishes with a higher body weight allow obtaining regular pieces of meat, suitable for culinary and processing purposes (SKAŁECKI et al. 2008, KUŹMIŃSKI 2012, SKAŁECKI et al. 2013b). According to KLASA and TRZEBIATOWSKI (1992), African catfish – in the weight category of 951 to 1051 g – reached an average total length of 49.77 cm and body length of 45.6 cm. In a study by STANCHEVA et al. (2014), the total body length of European catfish with an average body weight of 3050 g was 65 cm, whereas in carp with a body weight of 1220 g it reached ca. 55 cm. In turn, as reported by SKAŁECKI et al. (2008), in cod with the average body weight of 1550 g the value of this parameter reached 59.25 cm and thus significantly exceeded the protective/commercial dimensions, which is set at 38 cm for this species. Investigations conducted by TURAN et al. (2005) point to great differences in morphological parameters in the *C. gariepinus* population inhabiting rivers of Turkey, which might be due to diversified environmental conditions, like temperature, turbidity, feed availability and depth of water. According to SOBCZAK et al. (2022), the sex of the fish (*C. gariepinus* x *Heterobranchus longifilis*) did not affect any of the tested biometric traits, although females had higher body (1169 g) and fillet weights (301,8 g), respectively. However, males had higher carcass weight (732 g) and carcass yield (64.4%).

Slaughter yield and meat quality of fish are determined by species, size, physiological condition, sex, age, motility of fish, environmental conditions (pH and temperature of water) as well as by the method, type of feeding and catch season (BUCHTOVA et al. 2007, MENOYO et al. 2007, GULER et al. 2008). An important parameter of utility value is also the content of edible parts in the carcass (SKAŁECKI et al. 2013a).

Based on results concerning the content of selected body parts of African catfish (Table 2), it can be stated that the mean weight of male fish reached 1062.80 g and was statistically higher ($P \leq 0.01$) compared to females by 109.20 g. In addition, the males were characterized by a significantly higher yield of the carcass without a head which accounted for 65.10%. Data presented in Table 2 and Figure 2 demonstrate that in the case of *C. gariepinus* females, the fillets constituted 41.82% of the total body weight, whereas in the case of males – 44.69% ($P \leq 0.01$). The male fish of the analyzed species were characterized by significantly higher head weight compared to females (by 1.93%), which was also confirmed in their higher body weight. The statistical analysis demonstrated a highly significant difference ($P \leq 0.01$) in the content of viscera which in the case of females was as high as 14.30%, whereas, in the case of males, it reached 6.51%.

Table 2

Percentage share of body parts of the carcass of *C. gariepinus* (mean ±SD)

Specification	African catfish		SEM
	male (n = 30)	female (n = 30)	
Body weight [g]	1062.80^{A} ±65.04	953.60^{B} ±49.93	17.699
Carcass without head [%]	65.10^{A} ±1.25	60.51^{B} ±1.85	0.628
Fillets [%]	44.69^{A} ±1.07	41.82^{B} ±1.22	0.413
Head [%]	27.2^{A} ±1.51	25.28^{B} ±1.76	0.421
Guts [%]	6.51^{B} ±0.34	14.30^{A} ±0.58	0.900
Fins [%]	5.06^{A} ±0.74	4.10^{B} ±0.89	0.209
Bones [%]	9.62^{A} ±0.82	7.51^{B} ±0.84	0.302
Skin [%]	5.85^{B} ±0.76	6.53^{A} ±0.67	0.173

Mean values denoted by different letters in the row are statistically significantly different at: $^{A, B}$ – $P \leq 0.01$; $^{a, b}$ – $P \leq 0.05$; SEM – standard error of means

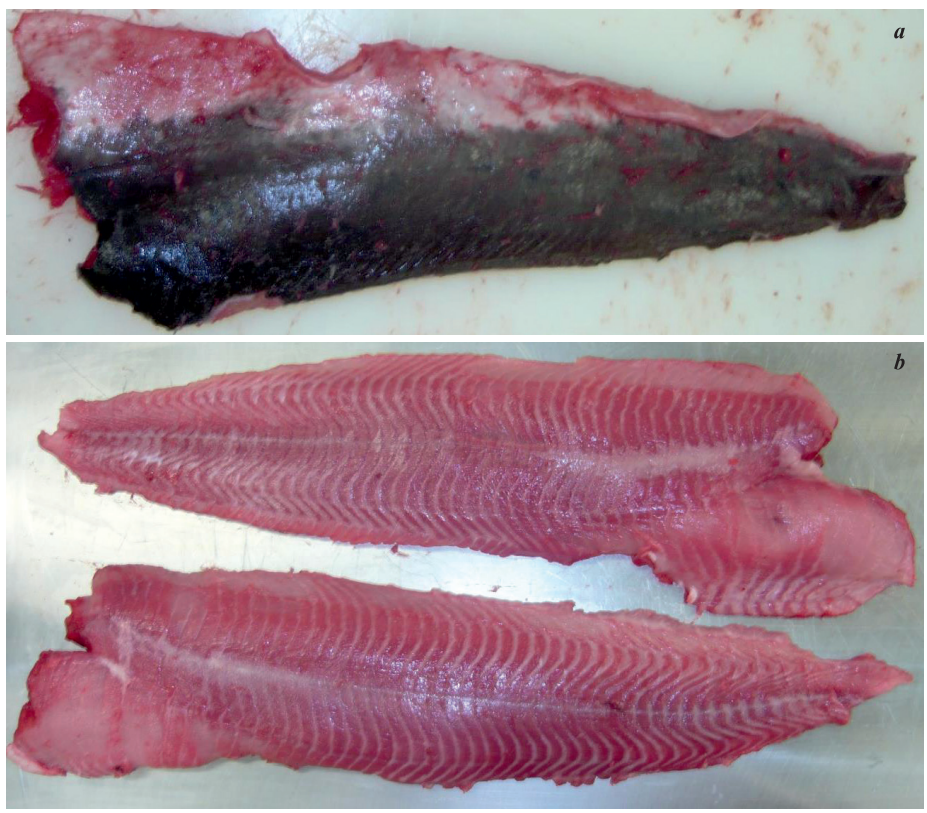

Fig. 2. Fillet of *C. gariepinus* with skin (*a*) and without skin (*b*)

Source: photo by I. Chwastowska-Siwiecka

This relatively large difference resulted from the presence of intensively developed female gonads filled with a high amount of roe, and viscera, constituting the majority of their body weight. Simultaneously, it was demonstrated that the content of bones separated during manual treatment of African catfish (♀) was lower (by 2.11%) compared to individuals from the other analyzed experimental group. In males, the average weight of fins reached 5.06% and was significantly higher than the percentage value determined for female individuals. In turn, an opposite statistical correlation was noted for the weight of skin, which was significantly higher in the females (6.53%) (Table 2). The research showed the share of non-edible by-products obtained from the carcass of females was 57.72% and was higher compared to males by 3.5% (Figure 3).

Fig. 3. Non-edible by-products of the carcass of *C. gariepinus*
Source: photo by I. Chwastowska-Siwiecka

African catfish is characterized by a relatively high technological yield of meat in both forms: carcass – 66.5%, fillet with skin – 51.6%, and fillet without skin – 45.4%. The total slaughter yield of catfish is satisfactory at mechanical processing and reaches 42 –43%, whereas at manual processing it accounts for 50–52%; in addition, it is correlated mainly with the size of fish (KLASA and TRZEBIATOWSKI 1992, KAPELIŃSKI 2003). The catfish is usually sold in fillets (ALFARO et al. 2014). Data reported by KLASA and TRZEBIATOWSKI (1992) concerning the effect of the sex of African catfish on the technological yield of the obtained elements indicate that during the processing of males it was higher by 3–4% than in females, however, the highest values were reported in the weight category of 1001–1051 g (ca. 5%). In the case of fillets with skin and skinned fillets, in the weight category of 951–1001 g, a slightly higher yield was noted in the female than male catfish (respectively: fillet with skin – by 2.8%, fillet without skin –

by 2.5%). According to SOUZA and MARENGONI (1998), the yield of catfish fillets averages 32.83%, while of by – products (for example: bones, skin and heads) obtained during processing account for about 67%. Catfish skin, comprising about 5% of the whole fish, has become an interesting raw material for gelatin production (ALFARO et al. 2014). The study by SKAŁECKI et al. (2013a) on the weight of edible parts of rainbow trouts (aged 1+) and carps (aged 3+), demonstrated that in the case of the first fish species the contents of meat and fillets reached 43.80% and 54.30%, and were significantly higher (by respectively 13.17% and 16.64%) compared to the other fish species. The analysis of data achieved by these authors demonstrates that the carp were characterized by a significantly higher content of head (26.30%) and bones (14.37%), whereas the contents of skin and fins were similar in both species. According to MARCU et al. (2010), an increase in slaughter yield of carps was strongly correlated with their body weight, where in the case of fish with a body weight of 785 g it reached 50.68%, and in the case of fish with the body weight of 2010 g it reached up to 60.28%. When analyzing the percentage content of the main body parts of catfish, BUD et al. (2008) showed a higher slaughter yield (69.35%) and a higher share of meat (53.00%) to the compared to own study. Whereas in the case of the non-edible parts of the catfish, the cited authors reported a lower share of the head (20.80%) and fins (2.25%) in related to the total weight of those fish, than noted in own study.

Conclusions

Results of the study demonstrated that the morphometric characteristics such as total length, and body length were significantly higher in males. Simultaneously, they were characterized by a significantly higher value of the side length of the head and body height measured at the smallest height of the body. In comparing catfish of both sexes at age 8 months, it was concluded that the females were characterized by lower body weight, the yield of carcass and fillets without skin and a lower percentage share of head, fins and bones in the carcass.

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