Archives of Polish Fisheries	Vol. 1	Fasc. 2	113 - 123	1993

EFFECTS OF DIFFERENT FAT LEVEL IN FEEDS UPON SOME CULTURE INDICES OF AFRICAN CATFISH (*CLARIAS GARIEPINUS*) REARED IN CAGES IN COOLING WATER

Jarosław Filipiak, Rajmund Trzebiatowski, Jacek Sadowski

Department of Aquaculture, University of Agriculture in Szczecin

A b s t r a c t. During 37 days of experiment in cooling water canal, African catfish (*Clarias gariepinus*) (initial weight ca 58 g) were fed with feeds containing different lipid level (10.9, 15.0 and 19.9%). The experiment was carried out in triplicates. The stocking density was 150 ind./cage (1 m^3 each). The lipid requirement of African catfish was 15%.

Key words: AFRICAN CATFISH, COOLING WATER, FEEDING, FAT IN FEED

INTRODUCTION

The role of fat in fish feeding is versatile and consists, among others, of supplying the dissolved vitamins, the exogenous fatty acids, and the energy for the vital functions. Therefore, defining of fat demand is one of the most important tasks when elaborating the feeding diet of a given fish species. The investigations which have been carried out up to the present showed that the fish requirement for this component in the fish diet is different and for example in the case of tilapia (*Tilapia nilotica*) it reaches 18%, while the demand of rainbow trout (*Oncorhynchus mykiss*) is on the level of 21%, while the catfish (*Ictalurus punctatus*) requires only 6% (De Silva et.al. 1991, Kim et.al. 1988, Robinson and Wilson 1985). In the recent years studies have been conducted aimed at defining the detailed principles with respect to diet of African catfish, the latter being considered as a new and promising species in the European aquaculture (Machiels and Henken 1985, 1987, Machiels and Van Dam 1987, Henken et.al. 1986). However, the above studies did not include the demand for fat in the diet of African catfish and this problem is dealt with in this paper.

MATERIAL AND METHOD

The experimental part of the studies was carried out in the period 19 June - 25 July 1992, in the Fisheries Experimental Station of the Department of Aquaculture of the University of Agriculture in Szczecin, located near the power plant „Dolna Odra" in

Nowe Czarnowo. The stocking material consisted of 1350 individuals of African catfish having the average weight of the specimen - 58 g (± 10 g). Rearing of this fish was performed in 9 cages (dimensions: 0.75% x 2.0 x 0.8 m and the used volume 1 m^3), at the stocking density 150 ind./cage. This biological material (as the fry - ca 10 g/specimen) was obtained from the Experimental Station of Polish Academy of Sciences in Gołysz, in the last decade of May 1992.

In the experiment, three extruded feed mixtures (each having grannules of 4 mm in diameter), produced thanks to the kindness of the Norwegian firm Norsk För A/S, were tested. They contained nearly the same, and adequately high, for this species, amount of crude protein and differentiated amounts of fat (from 10.9% in the feed used in variant A to 19.9% in the feed in variant C) (Tab. 1). The main source of fat in feeds was the oil from capelin (*Mallotus villosus*). The chemical composition of feeds was determined by the chemical laboratory of the Department of Aquaculture (Tab. 1).

TABLE 1

Chemical composition of experimental diets in African catfish feeding (%)

Chemical composition	Variants		
	A	B	C
Dry matter	92.7	93.6	93.7
Crude protein*	50.8	50.4	48.3
Fat*	10.9	15.0	19.9
Ash*	11.4	10.9	10.5
N–free extract*	19.5	17.1	15.0
Brutto energy (kJ/g)	19.7	20.9	21.8
Metabolic energy (kJ/g)	15.9	17.0	18.1
P/E (mg protein/kcal metabolic energy)	134	124	119

* - *in wet weight*

In all the fish diet variants the same daily portion of feed was used and that depended on temperature of cooling water and on fish individual weight. In the first period of the experiment the daily portion was equal to 6% of the fish weight in the cage, while in the last period to 4%.

All the fishes were weighed (the dates presented in Table 2 denote consecutive experiment stages) every 5 - 8 days in order to determine the dynamics of changes of culture indices in particular variants of the experiment. The results of weighing gave the base for calculations of basic culture indies i.e. Specific Growth Rate (SGR) and Food Conversion Rate (FCR) in the particular stages of the experiment. After the completition of the experiment the apparent Net Protein Utilization - aNPU and the

Energy Retention - ER, were calculated (Filipiak, Trzebiatowski 1992). In addition to that an apparent Fat Utilization - aFU was also calculated from the formula:

$$aFU = \frac{F - F0}{Fp} \cdot 100\%$$

where: F - fat content in fish, after the completition of the experiment (kg)

F_0 - fat content in fish on the first day of the experiment (kg)

F_p - fat content introduced with feed during the experiment (kg)

The above listed indices are presented in Tab. 2 and 3 as mean values of three repeated measurements. For each index the Duncan's test was applied in order to calculate the statistical significance of differences between the variants (at the significance level P = 0.05). In order to illustrate the significance of differences the indices in tables are marked with letters (e.g.: a, b) (the results in particular columns of the tables marked with the same letters do not differ statistically).

TABLE 2

Specific Growth Rate (SGR) and Food Conversion Rate (FCR) of catfish in each period of experiment

Variants	Dates of fish weighing					
	26.06	03.07	10.07	15.07	20.07	25.07
			Mean individual weight (g)			
A	79	106	129	154	184	218
B	79	110	137	167	204	248
C	77	107	130	158	192	233
			SGR - % day			
A	3.58^b	4.14^b	2.82^b	3.53^b	3.54^b	3.39^b
B	3.94^a	4.75^a	3.12^a	3.99^a	3.95^a	3.91^a
C	3.90^a	4.66^a	2.82^b	3.90^a	3.92^a	3.82^a
SE	0.03	0.02	0.01	0.01	0.01	0.01
			FCR			
A	1.45^a	1.56^a	1.28^a	1.04^a	1.03^a	1.08^a
B	1.29^b	1.33^b	1.15^b	0.91^b	0.92^b	0.93^b
C	1.31^c	1.36^b	1.28^a	0.93^b	0.92^b	0.95^b
SE	0.01	0.01	0.03	0.04	0.04	0.05
Food ratio (%/day)	6.0	7.5	4.0	4.0	4.0	4.0

The results in columns with the same letters are not significantly different (P=0.05)
SE - standard error pooled

TABLE 3

Mean body weight, Specific Growth Rate (SGR), Food Conversion Ratio (FCR), apparent Net Protein Utilization (aNPU), Energy Retained (ER) and apparent Fat Utilization (aFU) of African catfish at the end of experiment

Variants	Mean individual weight of fish (g) initial	final	FCR	SGR %	aNPU %	ER %	aFU %
A	59.6	217.8	1.22[a]	3.50[c]	27.42[c]	30.28[c]	61.98[a]
B	57.6	247.6	1.06[b]	3.94[a]	30.84[a]	33.96[b]	57.00[b]
C	56.4	232.9	1.10[b]	3.83[b]	29.08[b]	35.51[a]	56.49[b]
		SE	0.01	0.02	0.18	0.20	0.39

[a, b, c] *see tab. 2*

The content of crude protein, the content of raw fat, the dry mass and the ash were determined with the rutine methods, both in feeds and in fish (3 specimen taken from each variant at the beginning and at the end of the experiment). These parameters were calculated for each of the tested feeds basing on gross values of energy given by Brody (1945) and on the metabolic energy used by Henken et.al. (1986).

During the course of the experiment continuous and automatic measurements of temperature, oxygen content and pH were performed and values of these parameters, as daily means, as well as the maximum and minimum ones, are presented in Fig. 1 and 2.

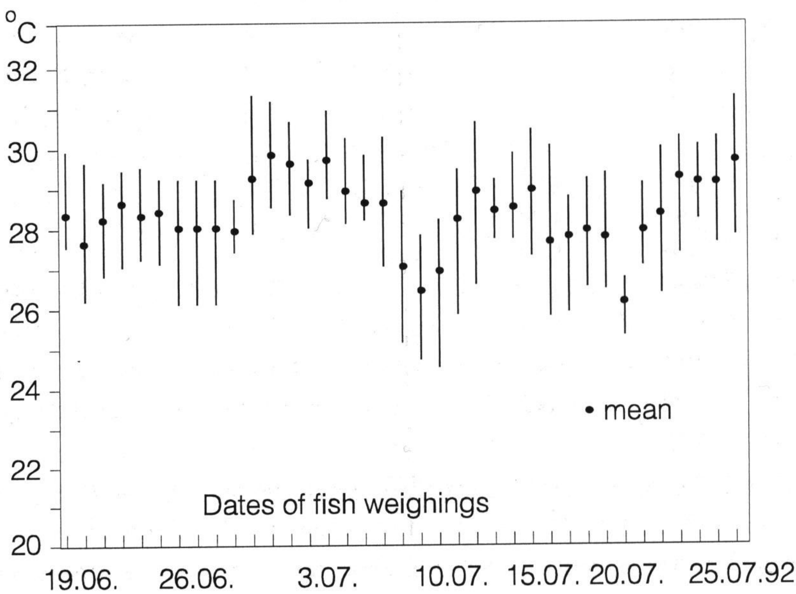

Fig. 1. Cooling water temperature during the experiment

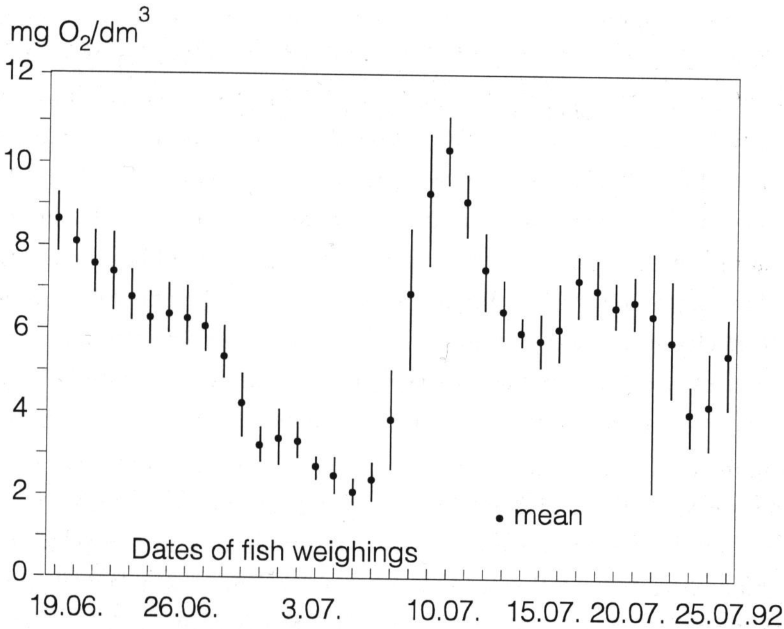

Fig. 2. Oxygen content in cooling water during the experiment

RESULTS AND DISCUSSION

The African catfish belongs to the stenothermal fish and according to Babiker (1984) the water temperature in the range 18 - 45°C does not have a negative influence on growth and survival of this species, but in the temperature below 15°C and above 50°C this fish stops feeding. According to Clay (1979) the optimum temperature for growth of African catfish fry is in the range from 25.5°C - 37.5°C, and the most favourable is the temperature of 32.7°C (± 1.5°C). Hogendoorn et.al. (1983) limited the temperature range to 27.5°C - 32.5°C, and only to fry (0.5 g/specimen), and at the same time they stated that water temperature of 25 - 27.5°C was required in the case of bigger African catfish (ca 200 g/specimen) in order to facilitate their proper growth. A similar temperature range (25 - 30°C was considered by Viveen et.al. (1985) as an optimum one.

During the experiment which lasted 34 days the cooling water temperature changed within the range 24.5 - 31.2°C, thus it remained in the temperature range considered to be an optimum one for the African catfish growth. The mean temperature was equal to 28.8°C and maximum daily amplitude of this parameter was low and did not exceed 4.0°C (Fig. 1).

The average oxygen content in the cooling water was equal to 5.8 mg O_2/dm^3, with the extreme values being of 2.1 and 10.2 mg O_2/dm^3 during the course of the experiment (Fig. 2). A relatively low oxygen content was observed in the period 30 June - 06 July (2.1 - 3.4 mg O_2/dm^3) and it resulted not from the high temperature of cooling water (27.0 - 28.6°C) but rather from the low level of water in the Odra river and, in consequence, higer concentration of organic matter. The decomposition of organic matter caused a significant decrease in oxygen content both in the river, and in the outflowing cooling water (the decrease in oxygen content observed on 21 July resulted from cleaning of oxygen sensor in the sound). The African catfish belongs to rare fish species which can breath atmospheric oxygen, therefore uneasiness among the fishes was not observed during periods of oxygen drop in the cooling water.

During the experiment the pH of cooling water was fairly stable (from 8.0 to 9.2) and on the average it was equal to 8.8. These values are characteristic for the outflowing water in the electric power plant „Dolna Odra" in the summer periods (Filipiak and Trzebiatowski 1992, Filipiak et.al. 1993 a, b). There is a lack of data in the accessible literature on pH range preferred by the African catfish. The paper by Viveen et.al. (1985) is an exception. It gives an information that good growth is achieved in water with pH in the range 6.5 - 8.0, while in the case of pH above the given values to ca 11.0 a slow growth is observed. Unfortunately, these authors clearly emphasize that the given criteria of water quality for the studied species are not the result of experiments, but are based on values accepted as optimum ones for the rainbow trout.

Neither death of fish nor the fish deseases were observed during the experiment. This may lead to the conclusion that both the different level of fat in feeds and the varying physico-chemical conditions in the cooling water did not visibly affect the health of the African catfish.

The data obtained in the control fish weighings allowed to calculate the Food Conversion Rate (FCR) and the Specific Growth Rate (SGR) in every of the 6 experiment stages. As it arises from Table 2, in the majority of experiment stages, the least promising breading effects, measured with SGR and FCR indices, were obtained in variant A, i.e. for the feeds with the lowest fat content (10.9%). In the remaining stages, with the exception of the third one, the obtained values of SGR and FCR were more favourable in variants B and C. It is worth pointing that there was no statistical difference between SGR and FCR values in the two variants.

In the third stage of the experiment the less favourable and, at the same time, statistically identical values of SGR indices were obtained in variants A and C; the most favourable indices were found in variant B (Tab. 2). It should be pointed out that in this stage and in all the variants the fish showed lower increase in mass. The cause of decrease in growth rate should not be related to limitation to 4%, of daily diet. Also in the next, e.g. the fourth stage of experiment, the same daily diet was applied but still the comparison of these stages showed that in the third stage the daily growth rate of individuals was lower in variant A - by 20.1, variant B - by 21.8 and variant C - by 27.7%. The decrease in the fish growth resulted from a drop in oxygen content in cooling water, to about 3 mg/dm^3 in the days 3 - 6 July. Although the African catfish has an ability to breath atmospheric oxygen, the smaller individuals - up to about 160 g each, in over 90% have to satisfy their respiration demands using the oxygen dissolved in water (in the third stage their weight was 137 g/ind.) (Babiker 1984). As compared with the fourth stage, the lowering of oxygen level in the third stage caused an increase in indices of feed - up to 23.1% in variant A, 26.4% - in B, 37.6% - in C. These numbers suggest that in unfavourable environmental conditions the digestibility and assimilability of feeds showed by the African catfish decreased with increasing fat level in the fodder.

As it arises from the data in Table 3 - in spite of short period of the experiment (37 days) - the increase in an individual weight of African catfish reached on the average: 366% - in variant A, 430% - in B and 413% - in C (just for comparison - carps reared at the same time by the Fisheries Experimental Station increased their individual weight by about 120%). On the one hand these values indicate an exceptionally high growth potential of African catfish, on the other hand they indicate a considerable assimilability of feeds which underwent the process of extrusion; their relatively low diet indices confirm that. However, it should be emphasized that the lowest and at the same time not statistically differing values of that index were obtained in variants B and C and, for example, variant A was lower by 13% than the two above ones. Variant A showed also lower indices of SGR, aNPU and ER. This means that 10.9% fat level in feed turned out to be unsatisfactory for the fast growth of African catfish and caused limitation in proteins and energy retention from feed in the fish body.

Analysis of SGR and aNPU indices shows that their highest values were observed in variant B, i.e. when the feed contained 15.0% of fat. Higher fat content - 19.9% - in variant C resulted in a slight, though statistically significant, decrease in SGR and aNPU index, and in an increase in energy retention. It is worth mentioning that in all the variants the value of aNPU was higher than 30%, thus over two times exceeded the results obtained in the experiments when nonextruded feeds were used (Filipiak et.al. 1993 a, b).

The stage by stage analysis as well as the final analysis of rearing indices allow to state that the African catfish reared in cages in cooling water prefer the fat level in feed not exceeding 15.0%. It arises from the accessible literature that no experiments have been undertaken focused on determination of optimum fat level in feed in the case of African catfish. However, some authors suggested that the optimum equaled to 11.5% and that too high a level of fat - 22% - caused decrease in growth rate, the latter resulting from considerable fish fatness (Machiels and Henken 1985, 1987). Some other authors stated that fat requirement by the African catfish depended on proteins level in feed. For example Henken et.al. (1986) concluded that the fastest growth of African catfish could be observed when diet providing 60% of casein and 16.1% of fat, the latter being a mixture of the soya oil, the fish oil and the lecithin at the ratio 1:1:0.7, was applied. Lowering of casein level in diet down to 50% caused, according to these authors, that fishes living on feeds containing 20.5% of lipides mixture showed the most pronounced increase in weight. They also showed, on the way of application of mathematic model, that at the temperature of 24°C the African catfish should achieve the maximum growth rate when fed with feeds containing 49.4% of proteins and 19.5 kJ/g of metabolic energy; an increase in temperature up to 29°C caused a decrease in optimum energy level in feed down to 18.7 kJ/g, but this took place at the cost of an increase of proteins level to 65.5%. In the performed experiment the average temperature of cooling water was lower only by 0.8°C as compared with the temperature (29°C) mentioned by Henken et.al. (1986), but the biggest increase in fish weight was observed in the case of fish fed with fodder having much lower level of metabolic energy (17.0 kJ/g) and of the crude protein (50.3%).

An adequate relation between the crude protein content (P) and the metabolic or digestive energy level (E), expressed in mg per kg of feed, is an important element in fish feeding. For example, the feed for channel catfish should contain from 111 to 125 mg of protein/kcal of digestive energy (Lovell 1984). Henken et.al. (1986) stated that ratio P/E in feed for the African catfish, reared at water temperature of 24°C, should be equal to 106, and at the temperature 29°C - 145 mg of protein/kcal of metabolic energy. In the experiment presented in this paper, the temperature of cooling water was close to 29°C (on the average - 28.3°C), and the most favourable values of the majority of rearing indices were obtained at P/E being equal to only 124 mg protein/kcal metabolic energy, thus by 14.5% (21 mg of protein) lower than in the case of the referred paper.

The basic role of fat in feed does not consist only in supplying the energy essential for all the vital functions, but also in supplying the Essential Fatty Acids (EFA), such as linoleic acid (18:2 ω6) and linolenic acid (18:3 ω3), necessary compounds for the fish growth. For example, carp (*Cyprinus carpio*) and rainbow trout show a proper growth when fed with feed containing up to 1% of the two acids (Csengeri et.al. 1977, Takeuchi and Watanabe 1977, 1982). The linolenic acid requirement showed by the channel catfish is on the level of 1% and probably some small amounts of arachidonic acid (20:5 ω3) and of clupanodonic acid (22:6 ω3) are needed by this species, but there is no requirement for the linoleic acid (Stickney and Hardy 1989). According to the data given by the National Research Council (1983) the stenothermal fish need from 0.5 to 2% of exogenous fatty acids in their diet. The demand of African catfish for exogenous fatty acids is not known up to now, but it seems that 15% content of capelin's fat in the feed satisfied to a high degree the demands, and the positive breeding effects obtained in variant B speak for that. According to Ackman (1969) the Norwegian oil from the capelin contained about 1.7% of linoleic acid, 0.5% of linolenic acid, 5% of arachidonic acid and 3% of clupanodonic acid.

The results of chemical analyses obtained after the experiment showed that the more fat contained the tested feeds, the higher the fat level in the fish body, and the lower crude protein level (Tab. 4). It is worth pointing out that the fat level in African catfish was two times higher as compared with the results obtained in the previous years (Filipiak et.al. 1993 a, b). As a result, the high retention of fat from feed in the fish body (aFU), exceeding 50%, was observed and that suggested only limited degree of fat utilization for energetic needs (Tab. 3). This may testify that a high lipid demand in African catfish diet does not result from the energetic requirements of this species, but rather from the necessity of providing the fish with fatty acids or vitamins contained in fat.

TABLE 4

Chemical body composition (%) of African catfish (at the start and at the end of experiment) fed with fodder having different fat contents

Variants	Dry matter	Crude protein	Fat	Ash
Start of experiment	25.42	15.53	7.51	2.28
	(0.16)	(0.08)	(0.26)	(0.05)
End of experiment				
A	27.04	16.62	8.04	2.31
	(0.12)	(0.31)	(0.27)	(0.12)
B	27.30	16.25	8.70	2.29
	(0.03)	(0.14)	(0.35)	(0.13)
C	28.88	15.45	11.17	2.27
	(0.19)	(0,29)	(0.08)	(0.12)

( ) - standard deviation

The research work was carried out in the frame of project No. 5 0685 01 01 financed, in the years 1991–1992, by the Scientific Research Committee

Trans. by Maria Bnińska

REFERENCES

Ackman R.G., Ke P.J., MacCallum W.A., Adams D.R. 1969 - Newfoundland Capelin Lipids: Fatty Acid Composition and Alteration During Frozen Storage - J.Fish.Res. Board of Can. 26(8): 2037–2059

Babiker M.M. 1984 - Aspect of the biology of the catfish *Clarias lazera* to its economic cultivation - Hydrobiol. 110: 295–304

Brody S. 1945 - Bioenergetics and growth - Reinholt, New York

Clay D. 1979 - Population biology, growth and feeding of African catfish (*Clarias gariepinus*) with special reference to juveniles and their importance in fish culture - Arch.Hydrobiol. 87 (4): 453–482

Csengeri I., Majoros F., Olah J., Farkas T. 1977 - Investigation of essential fatty acids requirement of carp - Intern.Sem. on Fish Nutrition and Diet Development. Szarvas 19–24 Sept. 1977: 93–113

De Silva S.S., Gunasekera R.M., Shim K.F. 1991 - Interactions of varying dietary protein and lipid levels in young red tilapia: evidence of protein sparing - Aquaculture, 95: 305–318

Filipiak J., Trzebiatowski R. 1992 - Określenie optimum zapotrzebowania białkowego dla różnej wielkości karpi (K_{1-2}) chowanych w wodzie pochłodniczej - Zesz.Nauk. AR Wrocław, Zoot. 37 (218): 61–71

Filipiak J., Trzebiatowski R., Sadowski J. 1993 - Optymalny poziom białka ogólnego w paszach dla młodocianego suma afrykańskiego (*Clarias gariepinus*) chowanego w wodzie pochłodniczej - Zesz.Nauk. AR Szczecin, Ryb.Mor. 156 (20), in press

Filipiak J., Trzebiatowski R., Sadowski J. 1993 - Określenie optimum zapotrzebowania białkowego dla różnej wielkości sumów afrykańskich (*Clarias gariepinus*) chowanych w wodzie pochłodniczej - Zesz.Nauk. AR Szczecin, Ryb.Mor. 156 (20), in press

Henken A.M., Machiels M.A.M., Dekker W., Hogendoorn H. 1986 - The effect of dietary protein and energy content on growth rate and feed utilization of the African catfish *Clarias gariepinus* (Burchell, 1822) - Aquaculture 58: 55–74

Hogendoorn H., Jansen J.A.J., Koops W.J., Machiels M.A.M., Van Ewijk P.H., Van Hees J.P. 1983 - Growth and production of the African catfish *Clarias lazera* (C and V). II. Effect of body weight, temperature, and feeding level in intensive tank culture - Aquaculture 34: 265–285

Kim J.D., Pascaud M., Kaushik S.J. 1988 - Effects des taux lipidiques et proteiques alimentaires sur la crocissance et la composition en triute arc-en-ciel - Ichtyophysid. Acta 12: 7–25

Lovell R.T. 1984 - Energy requirements - In: Nutrition and Feeding of Channel Catfish (Ed.) E.H. Robinson and R.T. Lovell, Southern Cooperative Series Bull.296, Texas A&M University

Machiels M.A.M., Henken A.M. 1985 - Growth rate, feed utilization and energy metabolism of the African catfish, *Clarias gariepinus* (Burchell 1822), as affected by dietary protein and energy content - Aquaculture 44: 271–284

Machiels M.A.M., Henken A.M. 1987 - A dynamic simulation model for growth of the African catfish, *Clarias gariepinus* (Burchell 1822). II. Effect of feed composition on growth and energy metabolism - Aquaculture 60: 33–53

Machiels M.A.M., Van Dam A.A. 1987 - A dynamic simulation model for growth of the African catfish, *Clarias gariepinus* (Burchell 1822). III. The effect of body composition on growth and feed intake - Aquaculture 60: 55–71

National Research Council (NRC) 1983 - Nutrient requirements of warmwater fishes and shellfishes - National Academy Press, Washington, DC

Robinson E.H., Wilson R.P. 1985 - Nutrition and Feeding.:323–404 - In: Channel catfish culture (Ed.) C.S. Tucker, Elsevier, Amsterdam

Stickney R.R., Hardy R.W. 1989 - Lipid requirements of some Warmwater species - Aquaculture 79: 145–156

Takeuchi T., Watanabe T. 1977 - Requirement of carp for essential fatty acids - Bull.Jap.Soc.Sci.Fish. 43: 541–551

Takeuchi T., Watanabe T. 1982 - Effect of various polyunsaturated fatty acids on growth and fatty acids compositions of rainbow trout *Salmo gairdneri*, coho salmon *Oncorhynchus kisutch*, and chum salmon *Oncorhynchus keta* - Bull.Jap.Soc.Sci.Fish. 48: 1745–1752

Viveen W.J.A.R., Richter C.J.J., Oordt P.G.W.J., Janssen J.A.L., Huisman E.A. 1985 - Practical manual for the culture of the African catfish (*Clarias gariepinus*) - Netherland's Ministery for Development Cooperation, Section for Research and Technology, Haga 1985

The research work was carried out in the frame of project No. 5 0685 01 01 financed, in the years 1991–1992, by the Scientific Research Committee

STRESZCZENIE

ODDZIAŁYWANIE RÓŻNEJ ZAWARTOŚCI TŁUSZCZU W PASZACH NA NIEKTÓRE WSKAŹNIKI CHOWU SUMA AFRYKAŃSKIEGO (*CLARIAS GARIEPINUS*) W SADZACH W WODZIE POCHŁODNICZEJ

Celem doświadczenia trwającego od 19 czerwca do 25 lipca 1992 r. było określenie optymalnego poziomu tłuszczu w paszach dla suma afrykańskiego, chowanego w sadzach usytuowanych w wodzie pochłodniczej elektrowni „Dolna Odra" w Nowym Czarnowie. Materiał obsadowy stanowił narybek o średniej masie ok. 58 g/szt., który chowano w zagęszczeniu 150 szt/sadz (150 szt/m^3 wody), w 9 sadzach (po trzy w wariancie). Ryby żywiono codziennie trzema paszami granulowanymi (średnica granul 4 mm) zawierającymi odpowiednio ok. 48 - 50% białka ogólnego oraz 10,9, 15,0 i 19,9% tłuszczu w postaci oleju z gromadnika. Doświadczenie wykazało, że największą średnią masę jednostkową - 247,6 g, dobowy przyrost średniej masy jednostkowej (SGR) - 3,94%, najmniejszy współczynnik pokarmowy (FCR) - 1,06, jak również największy poziom retencji białka (aNPU) - 30,84% oraz stosunkowo wysoki poziom retencji tłuszczu (aFU) - 57,0% i energii (ER) - 33,96% uzyskały ryby żywione paszą zawierającą 50,4% białka ogólnego i 15,0% tłuszczu.

Adres Autorów:
dr Jarosław Filipiak
prof.dr hab. Rajmund Trzebiatowski
mgr Jacek Sadowski

Akademia Rolnicza
Instytut Akwakultury i Techniki Rybackiej
ul. Kazimierza Królewicza 4
71-550 Szczecin