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COMPARISON OF THE EFFECTS OF CAGE REARING OF AFRICAN CATFISH (*Clarias gariepinus*) AND NILE TILAPIA (*Oreochromis nilotica*) IN COOLING WATER

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A B S T R A C T. African catfish (*Clarias gariepinus*) and Nile tilapia (*Oreochromis nilotica*) of initial body weight 75 g and 60 g respectively, were reared for 58 days in cages placed in cooling water in densities of 100 ind. per cage (1m^3 of water). Fish were fed with pellets containing 44.5% of protein and 15.5 % of fat, in rates equal to 1.5% and 2.5% of individual metabolic mass. The results show that at higher feeding rate (metabolic daily ration 2.5%), higher growth rate and lower food conversion ratio were obtained for African catfish. At lower feeding rate (metabolic daily ration 1.5%) no significant differences between the species were observed, neither in growth rate, nor in food conversion ratio.

Key words: AFRICAN CATFISH, TILAPIA, COOLING WATER, METABOLIC DAILY RATION

INTRODUCTION

The demand for common pond fish such as rainbow trout and common carp in Europe is steady. To diversify the offer, certain non-European fish such as African catfish and Nile tilapia are introduced on the markets. First attempts of rearing African catfish under controlled conditions were undertaken in Europe in the mid-seventies. In the mid-eighties, in the Netherlands, about 300 tons of fish were produced in water-recirculating farms (Bovendeur et al. 1987). Nowadays production of market-size African catfish reaches 1200 tons, most reared in the Netherlands (815 t) (Verren & Eding 1993).

First succesful cage rearing of African catfish in Poland was carried out in 1990, in cooling water of „Dolna Odra" power plant. The rearing was repeated the following years, in order to develop production technology (Filipiak et al. 1993 a, b, c). Simultaneously, in 1992 and 1993, attempts of cage rearing of Nile tilapia were undertaken. Due to it's tasty flesh, the demand for tilapia in Europe is increasing. Doubling of the production is planned until year 2000 (in 1990 - 500 tons) (Hough & Gabriel 1993).

Data obtained in the present study allowed to compare the results of rearing of tilapia and African catfish fingerlings in cages placed in cooling water, basing on the so-called „metabolic feeding ration" often applied in fish nutrition.

MATERIAL AND METHODS

The experiment was carried out from 20.07 to 15.09 1992 in Fisheries Experimental Station of the Aquaculture Department, Academy of Agriculture in Szczecin. The station is situated at the electric power plant „Dolna Odra" in Nowe Czarnowo. Fish were reared in frame cages of dimensions 0.75 x 2.0 x 0.8 m and water volume $1m^3$. The cages were made of net of mesh size 6 mm.

Experimental fish: 600 individuals of Nile tilapia (60 g ± 10 g per ind.) and 600 individuals of African catfish (75 g ± 15 g per ind.) were stocked separately in densities of 100 ind. per cage. The fish were purchased from the Fisheries Management and Ichthyobiology Experimental Farm of the Polish Academy of Sciences in Gołysz.

In the study four experimental groups were applied, two various feeding rations: 1.5% and 2.5% of metabolic body mass for African catfish (groups C-1.5 and C-2.5) and for Nile tilapia (T-1.5 and T-2.5). All the fish were fed with semi-extruded pellets Aller Mølle 3800-903 of 4 mm of diameter. Chemical composition of the pellets is shown in Table 1. Each experimental group was tested in three replicates. Fish were fed manually every 30 min., from 8:30 a.m. to 3:00 p.m. Feed rations were calculated according to the formula:

$$FR = MFL \cdot N \cdot W^{0.8} \qquad [I]$$

where:

FR - food ration (kg)

MFL - metabolic feeding level (decimal fraction)

N - number of fish (ind.)

W - mean individual weight of fish (kg)

The formula was applied in order to improve efficiency of feeding. In the fishery practice, food ration is usually calculated as a percent of fish stock mass. The percent is reduced with increasing fish mass but is not related to fish metabolic rate. Feeding

TABLE 1

Chemical composition of diet used in African catfish and tilapia feeding (%)

Dry matter	92.66
Crude Protein*	44.53
Fat*	15.56
Ash*	7.72
N-free extract*	24.84
Metabolic energy**	24.84

**in wet weight*

*** metabolic energy: protein - 16.8 kJ/g; fat - 37.7 kJ/g; N-free extract - 16.8 kJ/g (Henken et al. 1986)*

TABLE 2

Mean individual weight, Specific Growth Rate (SGR) and Food Conversion Rate (FCR) of African catfish and tilapia and in each period of experiment

Variants diet ration	Dates of fish weighing								
	25.07	30.07	5.08	11.08	18.08	25.08	1.09	8.09	15.09
	mean individual weight of fish (g)								
C - 1.5	85	98	115	136	164	195	235	262	282
C - 2.5	92	112	135	163	197	232	280	309	333
T - 1.5	70	82	98	115	138	162	187	205	226
T - 2.5	68	80	95	112	135	159	185	204	225
	SGR - %/day								
C - 1.5	2.69[b]	2.99[b]	2.57[c]	2.80[b]	2.71[a]	2.45[a]	2.66[a]	1.59[a]	1.04[b]
C - 2.5	3.74[a]	3.87[a]	3.17[a]	3.17[a]	2.65[a]	2.38[a]	2.67[a]	1.46[ab]	1.04[b]
T - 1.5	2.85[b]	3.06[b]	3.03[a]	2.61[c]	2.57[a]	2.30[a]	2.08[b]	1.31[b]	1.37[a]
T - 2.5	2.94[b]	3.07[b]	3.00[a]	2.69[bc]	2.64[a]	2.41[a]	2.16[b]	1.40[ab]	1.38[a]
SE	0.04	0.04	0.06	0.04	0.03	0.04	0.04	0.04	0.02
	FCR								
C - 1.5	0.88[a]	0.76[a]	0.86[ab]	0.76[a]	0.75[a]	0.81[a]	0.72[a]	1.20[a]	1.83[b]
C - 2.5	1.02[a]	0.94[b]	1.11[bc]	1.07[b]	1.24[b]	1.34[b]	1.15[c]	2.14[b]	2.95[d]
T - 1.5	0.86[a]	0.77[a]	0.75[a]	0.84[ab]	0.71[a]	0.77[a]	0.96[b]	1.53[a]	1.44[a]
T - 2.5	1.39[b]	1.29[c]	1.26[c]	1.37[c]	1.34[b]	1.43[b]	1.55[d]	2.40[ab]	2.38[c]
SE	0.04	0.02	0.05	0.06	0.02	0.02	0.02	0.05	0.05

based on metabolic mass allows to adjust feed ration to energy demand of fish. This demand, according to Paloheimo & Dickie (1965, 1966 a, b), is directly proportional to 0.8 exponent of body mass, equal to the so-called „metabolic mass".

All the fish were weighed every 5-7 days up to 0.05 kg in order to assess the dynamics of rearing efficiency. The results allowed to calculate for each experimental group the average values of food conversion ratio (FCR), daily specific growth rate (SGR) and indices of retention: apparent net protein utilization (aNPU), energy retained (ER) and fat retained (FR) (Filipiak et al. 1993 a, b). Energy retained was calculated according to the formula:

$$ER = \frac{aNPU \cdot 5.65P + FR \cdot 9.45F}{FE} \qquad [II]$$

where:

P - protein content in feed (decimal fraction)

F - fat content in feed (decimal fraction)

FE - energy content in feed (kcal/kg)

5.65 - gross energy of total protein (kcal/kg)

9.45 - gross energy of fat (kcal/kg)

Duncan's test was applied to check statistical differences in the calculated parameters ($p = 0.05$) among the experimental groups - Tables 2 and 3.

Chemical analysis of pellets was made and content of dry matter, total protein, fat and ash were determined. Carbohydrate content was calculated as a difference between dry mass and sum of the remaining components.

The level of metabolic energy and gross energy of feed were also calculated (Table 1).

At the start and at the end of the experiment chemical analyses of fish body were made using routine methods. Following parameters were estimated: percent of dry matter, total protein content, fat and ash content. Four fish of approximately average body mass from each experimental group were analysed. The results (means of three replicates) are shown in Table 4.

Basic physicochemical parameters of cooling water (temperature, DO level and pH) were monitored every 60 min. using automatic analyser. The results are shown in Figures 1, 2 and 3 as daily means with minimal and maximal values.

TABLE 3

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

Variations diet ration	Mean individual weight of fish (g)		FCR	SGR (%/day)	aNPU (%)	ER (%)	FR (%)
	initial	final					
C - 1.5	74	282	0.93[a]	2.31[b]	46.57[a]	37.91[a]	49.38[a]
C - 2.5	76	332	1.42[b]	2.55[a]	30.15[c]	27.10[c]	40.66[b]
T - 1.5	61	225	0.97[a]	2.25[b]	43.57[b]	30.99[b]	30.90[c]
T - 2.5	59	225	1.63[c]	2.31[b]	25.70[d]	20.88[d]	27.05[d]
SE			0.01	0.01	0.10	0.09	0.12

TABLE 4

Chemical body composition (%) of African catfish and tilapia at the start and at the end of experiment

Variants	Dry matter	Crude protein	Fat	Ash
Start of experiment				
African catfish	25.37 (0.07)	15.67 (0.16)	7.33 (0.06)	2.23 (0.04)
Tilapia	28.03 (0.14)	16.41 (0.11)	9.18 (0.07)	2.29 (0.09)
End of experiment				
C - 1.5	27.59 (0.03)	18.30 (0.17)	7.18 (0.08)	2.23 (0.10)
C - 2.5	29.25 (0.10)	18.30 (0.10)	8.61 (0.07)	2.19 (0.06)
T - 1.5	26.24 (0.17)	18.11 (0.06)	5.87 (0.34)	2.31 (0.04)
T - 2.5	27.95 (0.04)	18.07 (0.13)	7.47 (0.09)	2.33 (0.09)

( ) - standard deviation

RESULTS AND DISCUSSION

During the experiment the mean daily water temperatures fluctuated within the range of 21.5 - 30.1°C. Most of the time it exceeded 25°C but during last 14 days decreased to about 22°C (Fig. 1). This indicates that for most of the experiment duration, except the last period, the temperature remained within the optimum range for tilapia and African catfish (Hogendoorn et al. 1983).

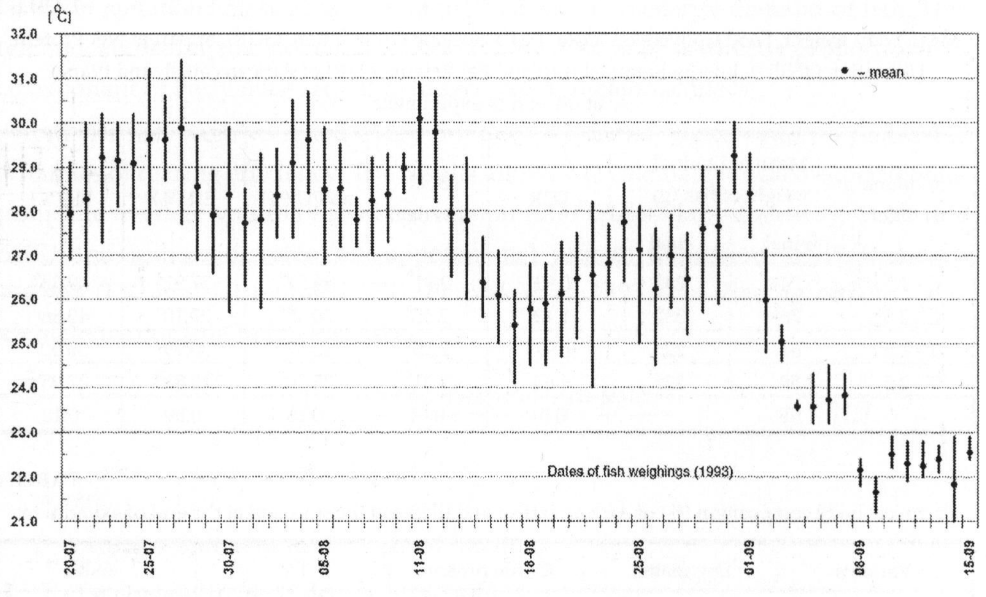

Fig. 1. 24-hour range of cooling water temperature during the experiment

The average DO concentration changed within the range of 1.5 - 9.0 mg/dm^3 (Fig. 2). During hot days, from the last decade of August until the begining of September, water level in Odra River dropped considerably. It caused a distinct decrease of DO level, down to 1.5 mg/dm^3 in the river and in the cooling water. It did not, however, threat either of the reared fish species as both are fairly tolerant to poor oxygen conditions. Tolerance of fish was confirmed by the fact that neither health nor survival of the fish was adversely affected by variable environmental conditions during the experiment (see also water pH, Fig. 3).

Fish were fed with Aller Møllе 3800-903 pellets containing 44.53% of total protein and 15.56% of fat which well met the needs of African catfish (Filipiak et al. 1993 a, b, c). Protein content was also near the optimum for tilapia, established by El-Sayed & Teshima (1992) at 45%, although according to Appler & Jauncey (1983) it is lower and equal to about 30%, and according to De Silva et al. (1989) to 34-35%.

Due to the monitoring of fish weight every 5-7 days, the experiment was divided into 9 periods. Data in Tab. 2 show that in all the experimental groups specific growth rate (SGR) decreased and food conversion ratio (FCR) increased with time. Most pronounced decrease of catfish and tilapia growth rate took place in the last two

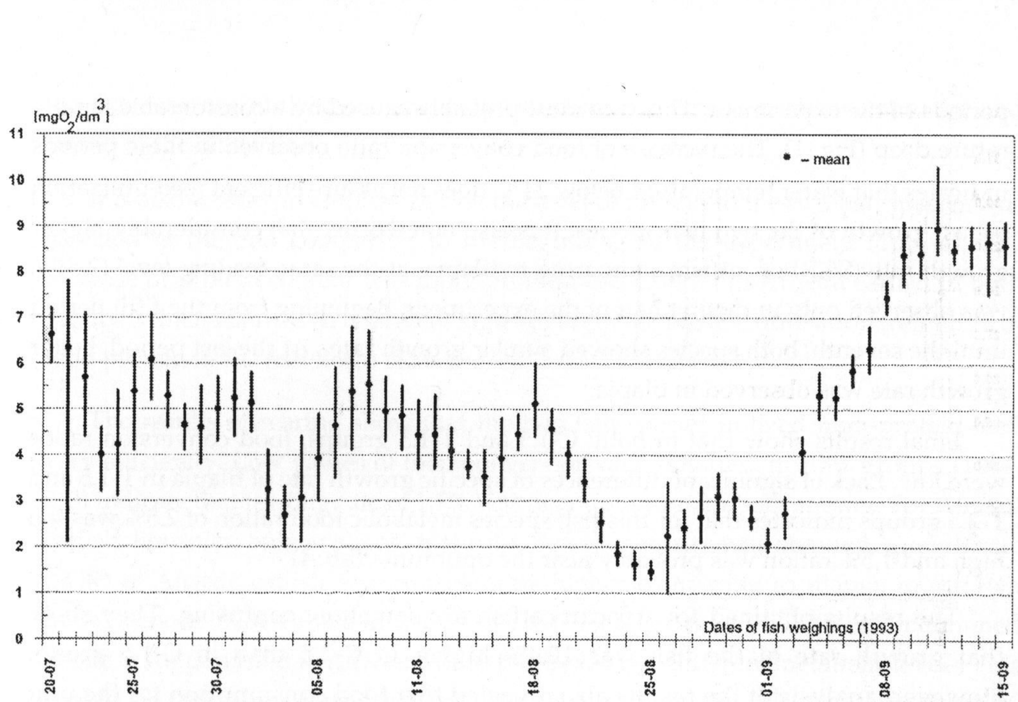

Fig. 2. 24-hour oxygen range of cooling water during the experiment

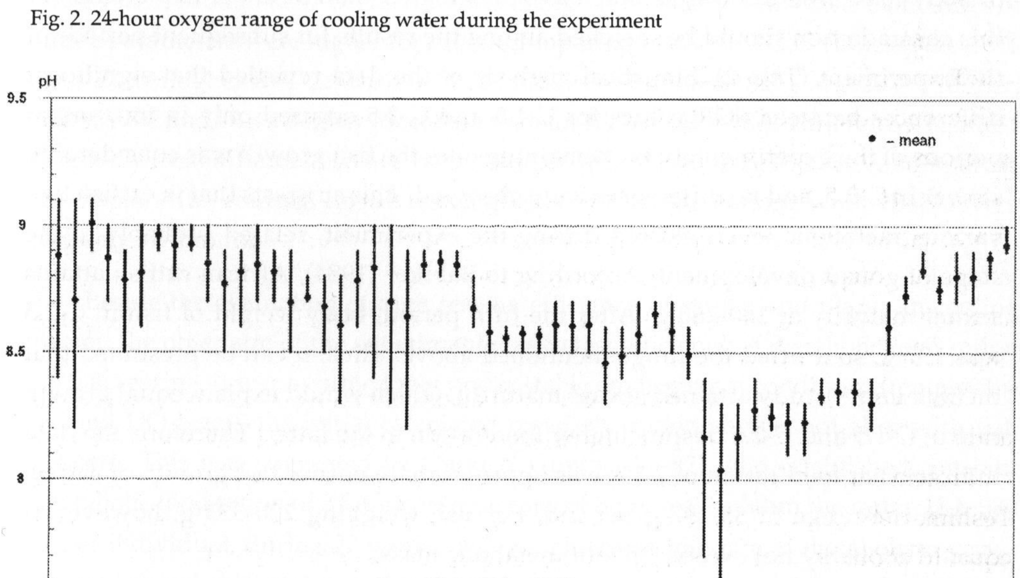

Fig. 3. 24-hour pH range of cooling water during the experiment

periods of the experiment. This was most probably caused by a considerable temperature drop (Fig. 1). The increase of food conversion ratio observed in these periods indicates that water temperature below 24°C does not assure efficient feed utilization or fast growth of the two fish species. It is also noteworthy that considerably higher growth rate (SGR) of catfish, comparing to tilapia, at the same feeding level (2.5%), was observed only in thefirst half of the experiment. Beginning from the fifth period until the seventh, both species showed similar growth rate . At the last period, better growth rate was observed in tilapia.

Final results show that in both: C-1.5 and T-1.5 groups, food conversion ratios were low. Lack of significant differences of specific growth rate of tilapia in T-1.5 and T-2.5 groups indicates that for this fish species metabolic food ration of 2.5% was too high and 1.5% ration was probably near the optimum (Tab. 4).

The results obtained for African catfish are somehow confusing. They show that growth rate of the fish was 10.4% higher in C-2.5 than in C-1.5 group. However, analysis of the results also revealed that food consumption for the unit of body mass in C-2.5 was as much as 52.7% higher than in C-1.5. Explanation of this contradiction should be searched among the results for subsequent periods of the experiment (Tab. 2). Statistical analysis of the data revealed that significant differences between SGR values for C-1.5 and C-2.5 occured only in four initial periods of the experiment. In the remaining ones the fish growth was considerably slower in C-2.5, and no differences were observed. This suggests that in catfish two various metabolic levels existed during the experiment, related probably to the stage of gonad development. According to Babiker (1984), African catfish attains sexual maturity at 180-260 g. After the fifth period, body weight of fish in C-2.5 was 197 g, so it fitted the range mentioned above. Thus, it can be presumed that the fish under study attained sexual maturity, which would explain equal growth rate in C-1.5 and C-2.5 despite higher food ration in the latter. Therefore, the data indicate that food ration of 2.5% was appropriate to ensure fast growth of catfish within the range of 85-197 g per ind. For fish weighing 200-333 g, however, it should probably not exceed 1.5% of metabolic mass.

It is noteworthy that at metabolic ration of 1.5%, African catfish achieved higher values of apparent net protein utilization (NPU), fat retained (FR) and energy retained (ER) than tilapia. In C-2.5 and T-2.5 groups fat content in the fish bodies was considerably higher than in C-1.5 and T-1.5. This indicates that part of the feed consumed by the fish was not utilized for energy production but was transformed into fat and stored in the fat tissue.

It is also worthy to emphasize that the level of protein in the two fish species was elevated at the end comparing to the beginning of the experiment (Tab. 4). The increase of protein content was more pronounced (2.63%) in African catfish in both groups, which resulted in relatively high apparent net protein utilization (retention of food protein in the fish flesh) (Tab. 3).

The results of rearing show that the two fish species utilized high-protein feed very efficiently. Low values of food conversion ratio obtained in 1.5% groups (Tabs. 2, 3) indicate that feeding rate of 1.5% was near optimum for both species. For African catfish, however, only at sexual maturity. Before maturity was attained, growth rate (SGR) of African catfish was considerably higher comparing to tilapia; in the two initial periods SGR values in C-2.5 was 26.5% higher than in T-2.5. As mentioned above, it suggests that in African catfish there exist two different metabolic levels. This should be taken into consideration when feeding rates are calculated for this fish. Analysis of protein (aNPU), fat (FR) and energy (ER) retained revealed that values of these parameters were higher for catfish comparing to tilapia. NPU values were 6.9% and 17.8% higher in C-2.5 than in T-2.5. Values of ER were 18.8% and 29.7% higher, FR - 59.8% and 50.3% higher for catfish than for tilapia. Such high differences resulted probably from different fish behavior. African catfish used to be less active comparing to tilapia. After feeding, catfish rested quietly on the cage bottom, while tilapia were actively swimming.

Beside the evaluation of cage rearing efficiency of catfish and tilapia in cooling water, the other aim of the experiment was to test efficiency of metabolic food ration in fish rearing. It was assumed that under stable environment conditions (temperature and DO level), the initial calculated metabolic ration should not alter with fish growth. This was suggested by Omar & Gunther (1987) who established constant metabolic food ration of 2% for common carp of body mass within the range 18.8-980 g per individual, during 22 weeks in 24°C. However, the rate of metabolism varies during sexual maturation and in periods of considerable temperature fluctuations. Our results show that in such cases lower food rations should be applied.

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STRESZCZENIE

PORÓWNANIE EFEKTÓW CHOWU SUMA AFRYKAŃSKIEGO (*Clarias gariepinus*) I TILAPII NILOWEJ (*Oreochromis nilotica*) W SADZACH W WODZIE POCHŁODNICZEJ

Celem doświadczenia trwającego od 20.07 do 15.09.1992 r. było prównanie efektywności chowu w sadzach w wodzie pochłodniczej dwóch gatunków ryb: suma afrykańskiego i tilapii. Doświadczenie zostało przeprowadzone w Rybackiej Stacji Doświadczalnej w Nowym Czarnowie, działającej w oparciu o wody pochłodnicze elektrowni Dolna Odra. Materiał doświadczalny stanowiło po 600 szt. tilapii nilowej (60 g/szt.± 10 g) i sumów afrykańskich (75 g/szt.± 15 g), obsadzono w liczbie 100 sz./sadz. Doświadczenie obejmowało 4 warianty, których wyznacznikami były metaboliczna dawka paszy (1,5% oraz 2,5%) i gatunek ryby. Warianty C-1,5 i C-2,5 obejmowały sumy afrykańskie, a T-1,5 i T-2,5 tilapie. W okresie doświadczenia temperatura wody pochłodniczej zmieniała się w zakresie od 21,5 do 30,1°C, a zawartość tlenu w wodzie od 1,5 do 9,0 mg/dm^3. Na podstawie analizy wyników końcowych i etapowych stwierdzono, że zarówno tilapie jak i sumy afrykańskie są rybami wybitnie ciepłolubnymi, które do szybkiego i efektywnego wzrostu potrzebują temperatury wody powyżej 24°C. Wykazano, że użyta w doświadczeniu wysokobiałkowa pasza (o zawartości 44,53% białka ogólnego) spełniała wymogi pokarmowe tilapii i sumów afrykańskich (małe końcowe współczynniki pokarmowe: 0,97 (wariant T-1,5); 1,63 (T-2,5); 0,93 (C-1,5); 1,63 (C-2,5) i dość duże wartości dobowego przyrostu średniej masy jednostkowej - SGR: 2,25 (T-1,5); 2,31 (T-2,5); 2,31 (C-1,5); 2,25 (C-2,5). Stwierdzono, że dla tilapii dawka metaboliczna paszy użytej w doświadczeniu nie powinna przekraczać 1,5%, dla suma afrykańskiego jest zmienna i zależna od masy jednostkowej ryb (od 85 do 200 g/szt. - 2,5% od 200 do 333 g/szt. - 1,5%).

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