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Note

Summer outdoor culture of African catfish (*Clarias gariepinus*) and tilapias (*Oreochromis niloticus* and *O. aureus*)

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Élevage estival du poisson-chat africain (Clarias gariepinus) *et de tilapias* (Oreochromis niloticus) *et* O. aureus), *en bassins en extérieur et sous un climat tempéré.*

INTRODUCTION

In 1989, first pilot experiments were initiated in former Czechoslovakia with pond culture of Nile tilapia (*Oreochromis niloticus*) during the growing season (Adámek, Mareš, 1990). Since they have brought very promising results, the range of tropical fishes cultured by this method was extended by African catfish (*Clarias gariepinus*) in 1990 and recently by blue tilapia (*Oreochromis aureus*).

The production of marketable African catfish is limited by the capacity of culture facilities with heated water under conditions available in the Czech Republic. Suitable temperature conditions are the most important deciding factor on the effectiveness of the outdoor culture of African catfish in ponds of temperate climate. Although these fish are able to withstand an extremely wide temperature range, a period of a few days with temperatures below 15 °C leads to disturbances of their organism and lethal fungal infestation. Experimentally assessed temperature limits for short-time exposure of African catfish range between 7.9-10.1 °C and 38.7-40.1 °C depending on the adaptation temperature (Hamáčková *et al.*, 1992).

Since natural food resources play an important role in outdoor catfish and tilapia culture under tropical climate, we attempted to evaluate the possibilities culturing them in temperate ponds during the period of suitable temperatures. These trials aimed also to test the possibilities of supporting the development of natural food items for catfish and tilapia nutrition in outdoor basins.

African catfish are known to be opportunistic bottom feeders probably also consuming water snails (Slootweg *et al.*, 1993). Cannibalism is considered to be a very serious problem (*e.g.* Hecht and Appelbaum, 1988) but it concerns probably just young fish in high densities of artificial culture units. As observed in our previous experiments (Adámek, Siddiqui unpubl.), even starving clarias are not able to capture a bigger healthy fish prey. They are very clumsy predators and only fish wounded by their repeated attacks are captured and eaten.

MATERIAL AND METHODS

The experiments were performed in ponds and concrete basins with sandy-gravel bottom on the Velký

Table 1. – Characteristics of the experimental units.

Stock	*Clarias*	Cl.+O.n.	Cl.+O.n.+O.a.	Cl.+O.n.	Cl.+O.n.+O.a.
Variant	P	K1	K2	T1	T2
Type	pond	basin			
Bottom	muddy	gravel + sand			
Area (m^2)	4,000	300			
Mean depth (cm)	93 ± 10	118 ± 25	117 ± 8	113 ± 16	107 ± 18
Q (l/sec)	1.25 ± 2.05	0.47 ± 1.02	0	0	0.08 ± 0.08
Transparency (cm)	77 ± 58	59 ± 31	50 ± 40	44 ± 42	70 ± 55
Temperature (°C)	20.5 ± 3.2	20.9 ± 2.9	20.5 ± 3.1	20.5 ± 2.9	20.4 ± 2.8
O_2 (mg/l)	12.56 ± 4.79	13.18 ± 6.19	15.63 ± 6.37	12.85 ± 8.76	15.55 ± 9.77
pH	9.93 ± 0.27	9.31 ± 1.12	10.27 ± 0.59	9.15 ± 1.18	9.15 ± 1.16
B.O.D.$_5$ (mg/l O_2)	6.3 ± 5.7	10.0 ± 5.57	10.7 ± 0.58	13.3 ± 9.0	8.0 ± 5.3
C.O.D.c$_r$ (mg/l O_2)	38.3 ± 11.7	68.3 ± 19.7	76.3 ± 13.8	59.3 ± 22.0	61.7 ± 27.2
Susp. solids (mg/l)	13.3 ± 9.5	25.7 ± 15.5	42.7 ± 14.6	31.3 ± 20.1	25.7 ± 16.2
NH_4^+ (mg/l)	1.10 ± 0.50	1.12 ± 0.49	1.26 ± 0.43	1.20 ± 0.17	1.77 ± 0.85
NO_2^- (mg/l)	0.72 ± 0.47	0.98 ± 1.10	0.22 ± 0.21	0.40 ± 0.33	0.30 ± 0.30
NO_3^- (mg/l)	7.8 ± 8.6	12.8 ± 11.1	2.7 ± 2.7	5.0 ± 4.4	6.3 ± 3.9
PO_4^{3-} (mg/l)	0.20 ± 0.10	0.12 ± 0.15	0.03 ± 0.00	0.10 ± 0.14	0.18 ± 0.15
Zooplankton (Ind/l)	324 ± 179	555 ± 653	708 ± 428	741 ± 549	687 ± 519
Zooplankton (Ind/m^2)	667 ± 729	no sampling			

Note: O.n. – Nile tilapia (*Oreochromis niloticus*); O.a. – blue tilapia (*Oreochromis aureus*); Cl. – African catfish (*Clarias gariepinus*); P – pond culture; K – control in basins; T – grass supplied in basins

Dvůr fish farm in Southern Moravia (the warmest region of the Czech Republic) in 1991 and 1993. The earthen rectangular pond (4,000 m^2) was stocked with monoculture of *Clarias gariepinus* while in concrete basins (300 m^2) bicultures with Nile (*Oreochromis niloticus*) and blue tilapia (*O. aureus*) were tested. The details concerning the characteristics of the experimental units are presented in *table* 1.

Before filling the culture units with water (end of May), about 3 t.ha^{-1} of cow manure were applied in each of them. Fish were stocked in early June when water temperature exceeded 18 °C. The stocking scheme is presented in *table* 1. From August, fish were fed daily with trout feed mixture PD2 (43.8 % of crude protein). The total amount of feed supplied represented 1.2-1.4 % of stock biomass daily. The experimental culture lasted for 100-110 days and fish were harvested by 20th September.

The experiment was arranged in three variants in 1993: pond monoculture (P) and two replicates of culture in basins with application of fresh grass and meadow plants (T) and without it (K). Plants were supplied to basins weekly (ca. 150 kg.ha^{-1}). The aim of this treatment was to support the development of phytophilic animals serving as food for catfish and to supply plant material for tilapia nutrition. Although this substrate was not sampled for the assessment of colonization intensity, it is known that chironomid flies are attracted to lay eggs in response to specific odours produced by decaying organic matter (Yashouv, 1970).

Hydrochemical and hydrobiological analyses were performed at three-week intervals. Fish sampled on 9-10 August 1993 were investigated for food composition. No feeds were given to fish two days before sampling to eliminate the artificial food ingestion and to force fish to employ exclusively natural food resources. The share of individual food items is expressed in volume percentage. Except for the food spectrum, the food electivity was assessed according to Ivlev's (1955) index which expresses the ratio between food supply (e) and food ingested (g): $S = g - e/g + e$. Food competition between African catfish and Nile tilapia was evaluated on the base of index of food similarity after Shorygin (1952) which represents the percentual share of conforming food items consumed by both species evaluated. The index of alimentary tract filling was expressed as percentual proportion of stomach and gut content on total fish weight.

RESULTS AND DISCUSSION

Production results 1993 are presented in *table* 2. Farming of African catfish in monoculture resulted in extremely high mortality (3.3 % survival rate) and slow growth of fish (SGR 3.38 %.day^{-1}). As evident from *table* 1, the temperature regime of the larger pond was comparable with that in relatively small concrete basins but some hydrochemical parameters (e.g. B.O.D., C.O.D., suspended solids) differ from those in basins due to higher stability of pond ecosystem.

Temperature conditions as the most important factor cannot be considered as sufficient from the point of view of African catfish requirements. The mean temperature during the period of culture was ca.

Table 2. – Stocking scheme and production results.

Var.	Spec.	Stocking N	Stocking kg	Stocking Mean W (g)	Production N	Production kg	Production Mean W (g)	Increment (g/ind)	Increment (kg)	Increment (kg/ha)	Survival (%)	SGR (%/day)
	O.n.	91	6.100	67.0	84	17.840	212.3	145.3	11.74	391	92.3	1.09
	Cl.	500	0.960	1.9	195	17.730	90.9	89.0	16.77	559	39.0	3.72
K1	Σ	591	7.060		279	35.570			28.51	950		
	O.n.	92	7.100	77.2	86	20.330	236.3	159.1	13.23	441	93.5	1.06
	O.a.	5	0.270	53.0	5	0.830	165.0	112.0	0.56	19	100.0	1.087
	Cl.	500	0.960	1.9	125	13.680	109.7	107.8	12.72	424	25.0	3.90
K2	Σ	597	8.330		216	34.840			26.51	884		
	O.n.	92	5.900	64.1	88	21.100	239.8	175.7	15.20	507	95.7	1.25
	Cl.	588	2.040	3.5	192	23.200	120.9	117.4	21.16	705	32.7	4.23
T1	Σ	680	7.940		270	44.300			36.36	1212		
	O.n.	92	5.400	58.7	86	20.120	234.0	175.3	14.72	491	93.5	1.31
	O.a.	5	0.260	51.9	5	0.900	180.0	128.1	0.64	21	100.0	1.181
	Cl.	500	0.960	1.9	128	18.070	141.1	139.2	17.11	570	25.6	4.15
T2	Σ	597	6.620		219	39.090			32.47	1082		
P	Cl.	8 800	12.6	1.4	290	12.86	44.3	42.9	0.26	1	3.3	3.38

Note: For abbreviations see *table* 1.

20.5 °C with lowest values at the end of the growing period when temperatures dropped at 16.6-18.1 °C. According to Szumiec (1994) the sudden drop of the air temperature has a much more harmful effect on the health of airbreathing catfish.

Expressively higher production results (by 25.1 % in average) were reached in variant T with the application of grass and fresh plants but the difference was not statistically significant. This higher yield resulted from higher individual increments expressed as specific growth rate (SGR) at comparable survival rates. Fish from treated basins ingested the natural food with higher intensity as evident from the index of filling of alimentary tract which was higher (not significantly) in fish from treated basins (K-0.43 ± 0.18 %, T-0.48 ± 0.29 %). Since the total amount of artificial feed with declared conversion rate of 2.1, which was supplied to fish from August, was quite low (1.3 % of stock weight daily), it can be calculated that only 7.6, 9.7, 6.8 and 6.3 % of the total weight gain originated from this food source in individual control (K1, K2) and treated variants (T1, T2) respectively.

Also the food spectrum of catfish the two variants differed quite clearly (*table* 3). While bottom detritus prevailed in their guts in control basins, food items of animal origin were more important in the variant were grass was introduced. Chironomid larvae (*Chironomus plumosus*) and cladocerans (*Daphnia galeata*) were ingested with highest intensity in variant T. The electivity index for *Daphnia* amounted to –0.20 and + 0.66 there, whilst it was always negative (–0.40 and –0.86) in control variant. The other representatives of zooplankton were not ingested at all ($S = -1.00$). The importance of Daphnidae in African catfish nutrition

Table 3. – Food composition (%) electivity index of zooplankton (E) in African catfish.

Food item	K1 %	K1 E	K2 %	K2 E	T1 %	T1 E	T2 %	T2 E
Daphnia	20.8	–0.40	4.2	–0.86	20.3	–0.20	24.6	+0.66
Bosmina	0.1	–0.98		–1.00		–1.00		
Ostracoda					+			
Asellus	+		1.00		3.2		+	
Corixa	+		8.1		+		7.0	
Oecetis	14.1		18.0		+		4.4	
Cloeon					0.3			
Phytotendipes	6.1		0.6		2.8		1.1	
Chironomus			4.0		63.2		28.2	
Procladius			0.6		2.8		1.1	
detritus	58.9		63.5		7.4		33.6	
N	5		5		5		5	
Without food	0		0		0		0	
Index of filling (%)	0.4 ± 0.2		0.5 ± 0.2		0.7 ± 0.2		0.3 ± 0.1	
Ind. W (g)	67.5 ± 21.1		64.5 ± 28.2		53.2 ± 34.8		63.4 ± 38.1	

Note: For abbreviations see *table* 1.

under natural conditions was proved also by Doergeloh (1985). Catfish clearly orientated their food pressure on caddisfly larvae (*Oecetis ochracea*) in those control basins where no green matter was given.

Food competition between tilapia and African catfish in biculture was characterized by 20.9-67.7 % food similarity (*table* 4). When detritus is excluded as an item of probably no importance for competition then it is evident that the food requirements of these two species overlap by approximately one quarter. The ingestion of bigger cladocerans (*Daphnia*) and chironomid larvae colonizing green matter can

Table 4. – Food competition between Nile tilapia and African catfish expressed as index of food similarity (FS). The proportion of conforming items on competition is given in parentheses.

	K1	K2	T1	T2
FS	25.8	67.7	20.9	34.6
Conforming items	*Daphnia* (20.8) detritus (5.0)	*Daphnia* (4.2) detritus (63.5)	*Daphnia* (10.7) *Phytotendipes* (2.8) detritus (7.4)	*Daphnia* (24.6) *Chironomus* (5.1) *Oecetis* (2.2) detritus (2.7)

Note: For abbreviations see *table* 1.

be considered as the most important competitive relationship. The mixed culture of tilapia and African catfish brings (Hogendoorn and Koops, 1983) 2.5 times higher production as compared with tilapia monoculture without growth depression of any species. As presented in our pilot study, their seasonal polyculture does not evoke any stronger competition and/or do conditions of temperate climate and this type of culture could be realized during the growing season here.

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