

A comparative study on the effect of stocking density and feeding regime on the growth rate of *Tilapia camerounensis* and *Oreochromis niloticus* (Cichlidae) in fishculture in Cameroon

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Abstract

Tilapia camerounensis fry were reared in plastic tanks and earthen ponds at the Fishculture Research Station, Foumban, Cameroon. Their growth rate was compared to that of the Nile tilapia (*Oreochromis niloticus*) fry, reared under identical conditions. Different treatments were applied (food or organic manure only; food combined with organic manure); physical-chemical variables were quantified. The best growth rate was recorded for fry reared in tanks receiving both food and organic manure: the daily weight gain of *T. camerounensis* fry in tanks was nearly half of that of the Nile tilapia, while in ponds *T. camerounensis* showed a higher growth rate than *O. niloticus* (0.19 g.d⁻¹ versus 0.13 g.d⁻¹). The growth rate decreased with increasing stocking density. In another experiment *Tilapia camerounensis* fry were reared in aquaria at different stocking densities in a recirculated water system. The highest growth rate was recorded for fry stocked at 0.5 fish.l⁻¹ and receiving daily a feeding rate of 15% of the total biomass. This growth rate was comparable to that of fry stocked at 0.25 fish.l⁻¹ receiving the 5% feeding rate. The latter had the lowest FCR. Mortality due to aggressive interactions increased with decreasing stocking density.

Keywords: *Tilapia camerounensis*, *Oreochromis niloticus*, feeding, stocking density, fishculture, Cameroon.

Étude comparative de l'effet de la densité de stockage et du régime alimentaire sur la croissance de Tilapia camerounensis et Oreochromis niloticus (Cichlidae) en pisciculture au Cameroun.

Résumé

Des alevins du *Tilapia camerounensis* ont été mis en élevage dans des bassins et des étangs, à la Station de Recherches Piscicoles de Foumban au Cameroun. Leur croissance est comparée à celle des alevins du tilapia du Nil (*Oreochromis niloticus*) élevés dans les mêmes conditions. Différents traitements sont appliqués (nourriture; fiente; nourriture et fiente) en suivant l'évolution des variables physico-chimiques de l'eau. La meilleure croissance est observée pour le traitement avec nourriture et fiente; la croissance journalière de *T. camerounensis* dans les bassins est à peine la moitié de celle d'*Oreochromis niloticus*. Dans les étangs en revanche, la croissance de *T. camerounensis* est plus élevée que celle d'*Oreochromis niloticus* (0.19 g.d⁻¹ versus 0.13 g.d⁻¹). La croissance devient plus faible avec des densités de stockage plus importantes. Lors d'une autre expérience des alevins de *Tilapia camerounensis* ont été placés en aquarium, à différentes densités de stockage et en circuit fermé. La croissance la plus élevée est observée pour une densité de stockage de 0,5 poisson.l⁻¹, recevant un taux de nourriture de 15% de la biomasse par jour. Cette croissance est comparable à celle des larves stockées à 0,25 poisson.l⁻¹ et recevant un taux de nourriture de 5% de la biomasse par jour. Ce dernier groupe réalise le taux de conversion alimentaire le plus bas. La mortalité due à l'agressivité, augmente avec la diminution de la densité de stockage.

Mots-clés : *Tilapia camerounensis*, *Oreochromis niloticus*, nutrition, densité de stockage, pisciculture, Cameroun.

INTRODUCTION

Tilapia cameronensis Holly, 1927, a tilapiine substrate brooder, is endemic to the Sanaga River Basin in Cameroon (Teugels and Thys van den Audenaerde, 1991). Its maximal size reported is 321 mm (Thys van den Audenaerde, 1966) and local fishermen regularly collect edible specimens of sizes up to 300 g and more. Preliminary trials in ponds in Cameroon indicated that the species was well adapted to pondculture and readily accepted formulated feeds. As a result, interest in pondculture of *Tilapia cameronensis* emerged. The aim of this study was to compare the growth rate of *T. cameronensis* to that of *Oreochromis niloticus* reared under identical conditions and to assess the influence of stocking density and feeding rate on growth, survival and social behaviour.

MATERIALS AND METHODS

Two experiments were conducted at the Fishculture Research Station of the Institute of Animal and Veterinary research (I.R.Z.V.) at Koupa Matapit (Foumban), Cameroon.

In the first experiment, the growth rate of *Tilapia cameronensis* was studied in one earthen pond (404 m²) and in plastic tanks (1.7 m × 1.7 m × 0.5 m) under different treatments and compared to that of the Nile tilapia (*Oreochromis niloticus*).

The study began by filling up tanks on day zero (D0) and consisted of 6 treatments in a completely randomized design (table 1). All treatments except two, included two replicates. On D0, Nile tilapia fry, descending from a cross between Lagdo (Benue system) and Lake Mape (Sanaga River Basin) strains (average weight 1.0 ± 0.1 g), were stocked at random into 2 containers at a density of 15 fish m⁻². *Tilapia cameronensis* fry, descending from a strain collected in the Noun river (Sanaga River Basin) at Bangourem (average weight 2.0 ± 0.1 g), were stocked

Table 1. – Species and treatments studies in the first experiment over 35 days. The group with an (*) was studied for growth rate comparison only.

Species	Group	Treatment	Repli- cates	Stocking (× m ⁻²)	Unit
<i>T. cameronensis</i>	A	control	1	15	tank
<i>T. cameronensis</i>	B	10% feed	2	15	tank
<i>T. cameronensis</i>	C	10% feed + dung	2	15	tank
<i>T. cameronensis</i>	D	dung	2	15	tank
<i>O. niloticus</i>	E	10% feed + dung	2	15	tank
<i>T. cameronensis</i>	F	10% feed	1	2.5	pond
<i>O. niloticus</i>	G*	10% feed	2	15	pond
		10% feed	2	3	pond

at random in 7 containers (15 fish.m⁻²) and in a pond (2.5 fish.m⁻²).

For growth rate comparisons, *Oreochromis niloticus* fry (same strain as above) (2.1 ± 0.3 g) were stocked in 4 earthen ponds (475 ± 53 m²) at 15 and 3 fish.m⁻².

Eight treatments were tested (table 1). Each treatment was replicated except for the control (group A, *Tilapia cameronensis*) and treatment F. Two containers (B), included *Tilapia cameronensis* receiving feed at a daily rate of 10% of the total biomass (10% BW.d⁻¹); two containers (group C) received rabbit dung at a rate of 14 kg.ha⁻¹.d⁻¹ and feed at a daily rate of 10% BW.d⁻¹; two containers (group D) received rabbit dung at a rate of 14 kg ha⁻¹.d⁻¹ and two containers (group E, *Oreochromis niloticus*) had the same treatment as group C. Fry in ponds (group F, *T. cameronensis* and group G, *O. niloticus*) received the same treatment as group B. Food was not pelleted and ingredients were: 50% soyabean cake, 20% cotton cake, 1% shells, 19% maize shoots cake, 5% oil, 5% concentrate of amino-acids and minerals. The proximate analysis of feed was: 97.02% dry matter, 36% protein, 8% fat, 15.3% carbohydrates, 5% cellulose, 8% ash. The digestible energy content was 2600 kcal.kg⁻¹. Diurnal rabbit dung was air dried before application.

In all tanks and pond (F) the following variables were measured daily between 8.00 and 9.00 am. from D0 onwards at 0.1 m from the water surface: pH; dissolved oxygen (polarographic dissolved oxygen meter); maximum and minimum water temperature at 0.1 m from the water surface; water temperature. Titrimetry was performed weekly between 9.00 and 10.00 am to measure nitrite, nitrate, ammonia and phosphate concentrations. The dissolved oxygen and the pH were recorded weekly from D0 onwards just before sunrise (at 5.00 am) and at 4.00 pm.

In all treatments fish growth was monitored every two weeks and the feeding rate was adjusted accordingly. Fish (25% of total population) were sampled with a seine net and were not anesthetized. The mean initial weight (W1), mean final weight (W2), daily weight gain (DWG), specific growth rate [SGR = 100 × (lnW2 - lnW1)t⁻¹], relative weight gain [RWG = 100 × ((W2 - W1)/W1)t⁻¹] and the survival rate (SR) for all groups were recorded.

The experiment continued for 35 days in the dry season; tanks were not refilled to accommodate evaporative losses and no aeration was applied. No rainfall was noted.

In the second experiment, we studied the effect of different feeding rates and stocking densities on growth rate and we examined the social behaviour of *Tilapia cameronensis* in aquaria.

The study was conducted in 9 glass aquaria (60 l) and 9 plastic tanks (60 l) placed in the hatchery in a recirculated system (1 l.min⁻¹).

The study consisted of 6 treatments. *Tilapia cameronensis* (same strain as above) of similar body weight (average weight 7.0 ± 0.7 g) were stocked randomly in triplicate groups of 30 ($0.5 \cdot l^{-1}$ in the aquaria) and 15 ($0.25 \cdot l^{-1}$ in the tanks). Fish were not acclimatized to diet and during the first week dead fry were replaced. Feeding rates tested were: 5%, 10% and 15% of total fish biomass daily, provided as two meals (8.00 am and 2.00 pm). The feed used was the same as in the first experiment. Uneaten food was siphoned daily before the first feeding.

Dissolved oxygen, pH, and water temperature were measured daily from D0 onwards. Nitrite, nitrate and ammonia concentrations were measured weekly from D0 onwards.

Mean mass weight was taken weekly and feeding rate adjusted accordingly. Fish were not anesthetized. Mortality was recorded daily and intermediate total biomass was estimated by subtracting the individual weight of dead fish, after which the ration was adjusted. No estimate of uneaten food was made. Food conversion ratio ($FCR = \text{feed offered per fish} / \text{weight gain per fish}$) was calculated.

During the first 20 days, fish movements were monitored visually (5 days a week, between 10.00 and 12.00 am) for 5 minutes per aquaria (tank) by counting the number of times any fish directly encountered another with aggression (Suresh and Lin, 1992). The experiment was carried out for 49 days. Results obtained were subjected to analysis of variance (one-way ANOVA). Duncan's multiple range test was used to evaluate significant differences ($p < 0.05$) between the treatment means.

RESULTS

Experiment 1

Growth rate

The mean initial weight, mean final weight, daily weight gain, specific growth rate, relative weight gain and the survival rate for all groups are given in table 2. The corresponding growth curves are illustrated in figure 1. Figure 2 illustrates the growth curve for *Oreochromis niloticus* and *Tilapia cameronensis* in ponds.

A negative growth rate was recorded for the *Tilapia cameronensis* fry in the control and in the treatment receiving only manure. *Tilapia cameronensis* fry receiving food and manure (group C), had a significantly lower growth rate than *Oreochromis niloticus* fry receiving the same treatment. The growth rate ($0.19 \text{ g} \cdot \text{d}^{-1}$) of *T. cameronensis* in ponds was significantly higher than in the tanks and slightly higher ($p > 0.05$) than the growth rate of *O. niloticus* fry in the ponds ($0.13 \text{ g} \cdot \text{d}^{-1}$). When looking at fry receiving the same treatment but stocked at different densities, *T. cameronensis* fry in ponds ($2.5 \cdot \text{m}^{-2}$) have a similar growth rate ($0.19 \text{ g} \cdot \text{d}^{-1}$) as *O. niloticus* fry in ponds stocked at a density of 3 m^{-2} ($0.15 \text{ g} \cdot \text{d}^{-1}$). With higher densities ($15 \cdot \text{m}^{-2}$), the growth rate of *O. niloticus* decreased slightly (0.13 and $0.12 \text{ g} \cdot \text{d}^{-1}$ in tanks and ponds respectively). However, the growth rate of *Tilapia cameronensis* decreased significantly to $0.10 \text{ g} \cdot \text{d}^{-1}$ in tanks. Survival rate was significantly higher for fry receiving manure and food (94%) than in the other treatments. In all groups there was no within-treatment variability for the growth rate, SGR and RWG except for the Nile tilapia in ponds.

Table 2. – Mean initial weight (W1), mean final weight (W2), specific growth rate (SGR), daily weight gain (DWG), relative weight gain (RWG) and the survival rate (SR) for *Tilapia cameronensis* fry (groups A, B, C, D and F) and *Oreochromis niloticus* fry (groups E and G) in tanks and ponds. This first study lasted for 35 days. A: control; B: tanks receiving feed; C: tanks receiving feed and manure; D: tanks receiving manure; E: tanks receiving manure and feed; F and G: ponds receiving feed. Figures in the same column with different superscript are significantly different ($p < 0.05$). Figures with an (*) have significant within-treatment variability ($p < 0.05$).

Group	W1 (g)	W2 (g)	DWG ($\text{g} \cdot \text{d}^{-1}$)	SGR ($\% \text{ d}^{-1}$)	RWG ($\% \text{ d}^{-1}$)	SR (%)
<i>Tilapia cameronensis</i>						
A	2.0 ± 0.1^a	1.7 ± 0.4^a	-0.008^a	-0.46^a	-0.43^a	76
B	2.0 ± 0.1^a	5.1 ± 0.5^b	0.088^b	2.67^b	4.43^b	89
C	2.0 ± 0.1^a	5.0 ± 0.1^b	0.085^b	2.62^b	4.28^b	94
D	2.0 ± 0.1^a	1.8 ± 0.2^a	-0.005^a	-0.30^a	-0.28^a	82
<i>Oreochromis niloticus</i>						
E	1.0 ± 0.1^b	5.7 ± 0.1^b	0.134^c	4.97^c	13.42^c	71
<i>Tilapia cameronensis</i>						
F	2.0 ± 0.1^a	8.7 ± 0.4^c	0.191^d	4.20^d	9.57^d	71.5
<i>Oreochromis niloticus</i>						
G	2.1 ± 0.3^a	$6.8 \pm 2.6^{c,*}$	$0.134^{c,*}$	$3.36^{d,*}$	$6.39^{d,*}$	–

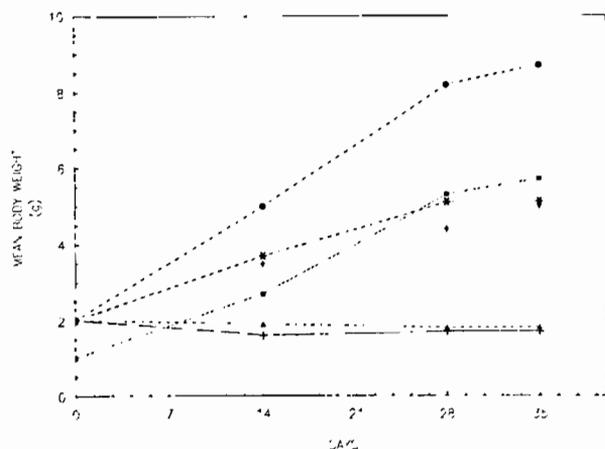


Figure 1. – Growth of *Tilapia cameroneensis* in controls (+), in tanks receiving food only (*), in tanks receiving food and manure (◆), in tanks receiving only manure (▲), in a pond receiving food (●) and of *Oreochromis niloticus* in tanks receiving food and manure (■).

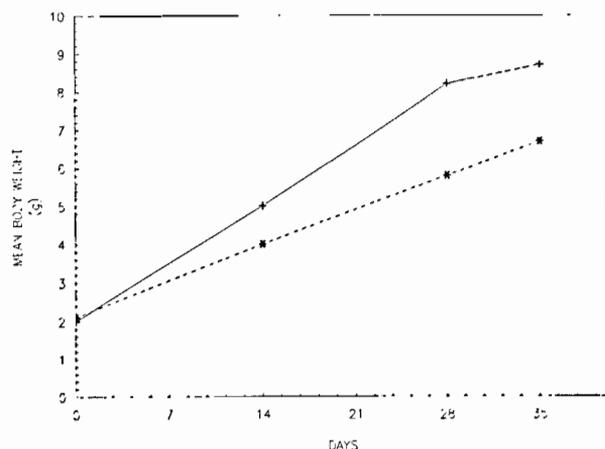


Figure 2. – Growth of *Tilapia cameroneensis* (+) and *Oreochromis niloticus* (*) in ponds receiving the same feeding regime and at similar stocking densities (2.5 versus 3 fish m² respectively).

Table 3. – Mean initial weight (W1), mean final weight (W2), specific growth rate (SGR), daily weight gain (DWG), relative weight gain (RWG), food conversion ratio (FCR) and survival rate (SR) for *Tilapia cameroneensis* fry in aquaria and in plastic containers. The experiment lasted for 49 days. A: receiving feed at a daily rate of 5% of the total biomass; B: receiving feed at a daily rate of 10% of the total biomass and C: receiving feed at a daily rate of 15% of the total biomass. Figures in the same column with different superscript are significantly different ($p < 0.05$). Figures with an (*) have within-treatment variability ($p < 0.05$).

	W1 (g)	W2 (g)	DWG (g.d ⁻¹)	SGR (% d ⁻¹)	RWG (% d ⁻¹)	FCR	SR (%)
<i>Tilapia cameroneensis</i> fry in aquaria							
A	6.9 ± 0.3 ^a	7.4 ± 0.3 ^a	0.01 ^a	0.14 ^a	0.15 ^a	30 ^a	79.9*
B	6.7 ± 0.3 ^a	8.4 ± 1.0 ^b	0.03 ^b	0.46 ^b	0.52 ^b	14.5 ^b	33.3*
C	6.8 ± 0.3 ^a	8.7 ± 0.9 ^b	0.04 ^b	0.50 ^b	0.57 ^b	19.3 ^b	31.0*
<i>Tilapia cameroneensis</i> fry in plastic containers							
A	6.5 ± 0.4 ^a	7.8 ± 1.7 ^a	0.03 ^a	0.37 ^a	0.41 ^a	5.4 ^a	24.4*
B	6.4 ± 0.2 ^a	7.4 ± 1.0 ^a	0.02 ^a	0.30 ^b	0.32 ^b	15.2 ^b	22.2*
C	6.8 ± 0.3 ^a	7.5 ± 0.4 ^a	0.01 ^a	0.20 ^c	0.21 ^c	43.4 ^c	26.6*

Physical-chemical variables

Mean water temperature during the experiment was $26.1 \pm 2.0^\circ\text{C}$ and $27.8 \pm 2.0^\circ\text{C}$ in tanks and ponds respectively. No significant differences were observed within treatments. However, mean water temperature in ponds was significantly higher than in tanks.

The mean dissolved oxygen concentration in the morning was significantly lower in the pond and in tanks receiving food (group B) or food plus manure (group C) than in the other groups (mean dawn D0 = $5.5 \pm 0.2 \text{ mg.l}^{-1}$ versus $7.43 \pm 0.13 \text{ mg.l}^{-1}$). The evening D0 was significantly lower in the pond ($5.94 \pm 0.10 \text{ mg.l}^{-1}$) than in the tanks ($9.00 \pm 0.54 \text{ mg.l}^{-1}$).

In the tanks pH fluctuated between 7.95 (morning) and 9.07 (evening). These values were significantly higher than in the pond (6.64-6.75). The pH in the control was not significantly higher than in the other tanks.

In all tanks the mean NO₂ concentration was 0.010 mg.l^{-1} , with no significant differences among treatments. In all treatments no presence of NO₃ nor NH₄ was recorded.

The phosphorus concentration (mean value 0.01 mg.l^{-1}) increased insignificantly in tanks receiving food (group B) and in tanks receiving food and manure (group C).

Experiment 2

Effect of stocking density.

The mean initial weight, mean final weight, specific growth rate, relative weight gain, food conversion ratio and the survival rate for all groups in aquaria and in tanks are given in table 3.

In all treatments daily growth rates were very low and no within-treatment variability was recorded. The highest growth rate (0.04 g.d^{-1}) was observed for fish in the aquaria receiving a daily food rate of 15% of total biomass. Fish in the tanks receiving a daily

rate of 5% and in aquaria receiving a rate of 10% had a daily growth rate of 0.03 g. Mortality decreased with increasing stocking density and was significantly lower in the aquaria receiving the 5% treatment. The mean weight of dead fish in aquaria and tanks receiving a 5% feeding rate (6.4 ± 1.2 g and 6.7 ± 1.0 g respectively) was significantly lower than in the other treatments (7.6 ± 0.1 g and 7.5 ± 0.2 g in aquaria and tanks respectively). There was no statistical within-treatment variability ($p > 0.05$).

Social behaviour

In all treatments fry showed a very pronounced territorial behaviour. Each fish tried to occupy a place preferable near the sides at the bottom. Fish in corners defended aggressively their position and chased intruders all over the aquarium. Interactions were reduced for a short period during feeding. The lowest number of encounters (17 ± 3) was recorded at the highest densities (0.5 l^{-1}) but was not significantly lower than that recorded (20 ± 4) in the tanks (0.25 l^{-1}). No within-treatment variability was recorded.

Physical-chemical variables

Water temperature in the tanks remained nearly constant throughout the experiment ($21.5 \pm 1.0^\circ\text{C}$). In all treatments fluctuations of DO concentration were similar. However, the mean DO in the treatments receiving food at a rate of $15\% \text{ BW} \cdot \text{d}^{-1}$ ($4.80 \pm 0.08 \text{ mg} \cdot \text{l}^{-1}$) (group C), was significantly lower than in the other treatments ($5.09 \pm 0.06 \text{ mg} \cdot \text{l}^{-1}$). Mean morning pH (6.00) was similar in all treatments. NO_2 concentration remained quite constant in all treatments ($0.004 \pm 0.001 \text{ mg} \cdot \text{l}^{-1}$). No presence of NO_3 nor NH_4 was recorded in any treatment.

DISCUSSION

In both experiments water parameters were favourable for fishculture purposes except for the low pH (mean value 6 in the second experiment) which was below the values recommended by Huet (1972). Temperatures were low but remained within those recommended for growth of *Oreochromis niloticus* ($20\text{-}35^\circ\text{C}$) (Balarin and Haller, 1982).

The overall growth rates obtained in both experiments and for both tilapia species are very low but other studies (Hogendoorn and Koops, 1983; Poumogne and Mbongblang, 1993) recorded similar growth rates for tilapia in this area.

In the tanks the specific growth rate of *Tilapia cameronensis* receiving only food was similar to that of those receiving food and manure but it was significantly lower than that of *Oreochromis niloticus* fry in tanks receiving food and manure. The *O. niloticus* fry probably utilized the feed supply more efficiently and benefited also more of the phytoplankton abundance favoured by the addition of rabbit dung

(Breine *et al.*, 1995). Opposite to *O. niloticus*, known as a phytoplankton feeder when it is abundant (Trewavas, 1983), *T. cameronensis* has few gill rakers on the first branchial arch and is therefore no plankton feeder but probably an omnivorous feeder and the provided feed did probably not satisfy completely their needs. However, in ponds the growth rate, SGR and RWG were similar for both species. In the ponds more natural food was available and the diet was therefore more complete. Although the applied feed had a relatively high protein content (36%), the overall growth rate was small. El-Dahhar and El-Shazly (1993) showed that the replacement of animal proteins by plant proteins significantly reduced the weight gain. The same authors also reported a decrease in growth performance in aquaria with *O. niloticus* when the protein source was of plant origin only. This is the case in both our experiments where soyabean cake was the main source of protein. Jackson *et al.* (1982) stated that unless the concentration of soyabean meal is less than 25% of the total protein supplied, it had a low nutritional value for tilapia compared with fish meal. The lower digestible energy ($2.6 \text{ kcal} \cdot \text{g}^{-1}$) compared to that of the diets used by El-Dahhar and El-Shazly (1993), could explain the lower growth rate and FCR. The higher growth rates in ponds could be explained by the additional natural food available and also by the higher water temperatures.

In the second experiment, the growth rate for both species decreased with increasing stocking densities. This corresponds with observations reported in several other studies (Dambo and Rana, 1992; Liu and Chang, 1992; Suresh and Lin, 1992).

In the aquaria, FCRs were high and the overall growth rates were even lower than those recorded in the first experiment. Aggressive interactions probably account for this. Because of this agonistic and competitive behaviour (Robinson and Doyle, 1990) and due to the fact that fish were not acclimatized to the diet, feed was not eaten readily. An important amount of uneaten food was removed daily. The low feed utilization together with the high mortality rate explain the high FCR. It is also possible that certain biochemical inhibitory factors released by the fish were concentrated in the recirculated system. This could have an unfavourable effect on the growth rate as reported by Henderson-Arzapalo *et al.* (1980).

Aggressive interactions decreased at the higher stocking density. The higher growth rates observed at the higher stocking density correspond with observations made by Honer *et al.* (1987), with the tilapia *Sarotherodon galileus*. Suresh and Lin (1992) observed the opposite in red tilapia. However, the best food consumption was recorded in the lowest density treatment receiving a 5% feeding rate but in general the individual growth rate, FCR and survival rate were better in the high density treatments. Mortality rates recorded were higher than those given by Balarin and Haller (1979) (5% during the growing phase of 10-20 g *Oreochromis niloticus* at high densities).

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