Growth response of Nile tilapia to cow manure and supplemental feed in earthen ponds

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ABSTRACT

Triplicate groups of Nile tilapia (Oreochromis niloticus) *juveniles (10 g) were grown in nine earthen ponds for 90 days. Three of the ponds were fertilized with cow manure, three received a compounded diet (27 % crude protein), and the remaining three ponds received both manure and supplemental feed. Results showed that weight increases were significantly ($p < 0.05$) higher in fed ponds; survival rates were significantly higher ($p < 0.05$) in ponds receiving both manure and supplemental feed (86 %); corresponding fish productions were 820, 2200 and 2900 kg/ha/yr for only manured, only fed and both manured and fed ponds respectively, the differences being highly significant ($p < 0.01$) among the treatments. With respect to feed efficiency, the compounded diet was better utilized when cow manure was added (feed gain ratio : 2.3, against 2.9). While confirming the poor efficiency of manuring alone with cow dung, this study shows how supplemental feed can be economically used when natural productivity is stimulated.*

KEY WORDS : Aquaculture — Tropical environments — *Tilapia* — *Oreochromis* — Cameroon.

RÉSUMÉ

CROISSANCE DU TILAPIA *OREOCHROMIS NILOTICUS* EN ÉTANGS FERTILISÉS À LA BOUSE DE BŒUF ET RECEVANT UN ALIMENT EXOGÈNE

*Trois lots de juvéniles d'*Oreochromis niloticus *(10 g) ont été testés en triplicats stochastiques dans neuf bassins en terre de 400 m². Trois des bassins étaient fertilisés à la bouse de bœuf (75 % de matières sèches; traitement M), trois recevaient un aliment composé (27 % de protéines brutes; traitement F), et les trois restant recevaient à la fois le fertilisant et l'aliment (traitement MF). Au terme des 90 jours d'élevage, les gains de poids étaient significativement plus élevés ($p < 0,05$) dans les traitements recevant l'aliment exogène (F et MF); les meilleurs taux de survie ($p < 0,05$) étaient enregistrés dans les étangs MF (86 %); les productions piscicoles étaient de 820, 2 200 et 2 900 kg/ha/an respectivement pour les traitements M, F, et MF, les différences étant hautement significatives ($p < 0,01$). En terme d'efficacité alimentaire, l'aliment composé était mieux utilisé en présence du fertilisant (indice de consommation égal à 2,3 pour le traitement MF, contre 2,9 pour le traitement F). Cette expérimentation confirme l'efficacité très limitée de la bouse de bœuf à l'état sec comme fertilisant en pisciculture; elle suggère en même temps que l'utilisation d'un aliment exogène par le tilapia peut être optimisée en stimulant la productivité naturelle.*

MOTS CLÉS : Aquaculture — Milieu tropical — *Tilapia* — *Oreochromis* — Cameroun.

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INTRODUCTION

Addition of manure to fish ponds is a traditional method for increasing the productivity of natural food chains in ponds. In intensive pond fish farming, fish density is so great that the amount of natural food available per fish becomes an insignificant frac- [illegible]

[illegible] constitutes an actual challenge in most developing countries, particularly in Africa where the traditional market value of fish and fish products is low. The use of animal protein-enriched pellets in fish ponds is therefore very limited, a more convenient feeding system being the combination of natural and supplementary cheaper foods to meet the nutritional [illegible] earthen pond environment. How to optimise this combination remains a wide research field (COLMAN and EDWARDS, 1987).

Many works do exist on pond manuring and supplemental feeding. Results of experiments conducted at Auburn (Al, USA) (BOYD, 1979) and at Dor (Israel) (HEPHER, 1962, SCHROEDER, 1974, 1985) have been widely used in fertilizing programs. Moreover, a good range of data are available on the feeding of tilapia with alternate cheap feed ingredients, mainly agricultural by-products in Africa (MESCHKAT, 1967 ; DE KIMPE, 1971 ; LAZARD, 1984 ; POUOMOGNE *et al.*, 1992 ; etc.). However, few studies have been conducted on the combination of pond manuring and supplemental feeding, and some controversy do exist in the available data about the effects of manure on supplemental feed optimisation and fish yield. In a study of 26 commercial fish ponds in Israel, SCHROEDER (1973) reported that feed-gain ratios of supplemental feeding were very positively correlated to the amount of natural food ; he suggested that when natural food is present in excess supply, the use of less protein-enriched pellets was advisable. In Honduras, layer chicken litter (applied at 500 kg total solid/ha/week) could replace up to 58 % of pelleted supplemental feed (23 % crude protein, applied at 1.5 % fish biomass/day) without significantly affecting tilapia yield (GREEN, 1992). DEGANI *et al.* (1984) reported that equivalent growth was registered when *Oreochromis aureus* was fed either 5 % of the body weight with pellets (27 % crude protein), or 2.5 % of the body weight with pellets and 2.5 % of the body weight with cow manure (dry weight). Net extrapolated yield of 3.1 t/ha/yr could be obtained with buffalo manure loaded at 6 kg of dry matter / 200 m^2 pond/day (ODA, 1986).

On the other hand, daily growth rate of tilapia varied from 1.36 to 1.32 g/day when liquid cow manure was added into pond with tilapia fed a supplemental feed (25 % crude protein and 12.5 kJ/kg gross energy) (RAPPAPORT *et al.*, 1977). Moreover, results from an experiment conducted in 280-m^2 ponds for 146 days clearly indicated that chicken manure is neither a preferred source of particulate [illegible] provide N and P for production of natural foods in Thailand aquaculture ; definitely, according to the author, addition of chicken manure to inorganic fertilization did not enhance production of Nile tilapia (KNUD-HANSEN *et al.*, 1992).

The present study was conducted at the Foumban Fishculture Research Station of the Cameroonian Institute of Animal and Veterinary Research to sup- [illegible]

MATERIALS AND METHODS

Nine fish ponds were used in the study. Their size varied from 350 to 450 m^2, and they were 0.9 m deep near the outlet and 1.3 m near the draining pipe. They were individually supplied by gravity from the surface water of an upstream reservoir.

Pond bottoms were exposed to sun for one month. Cleaning and quicklime application (125 kg/ha) were performed a week before the start of the trial to eradicate wild fish and to improve water alkalinity. In ponds receiving fertilizing treatments, a compost bamboo frame was made to receive a mixture of 150 kg/ha of cow manure and 150 kg/ha of chopped elephant grass *(Pennisetum purpureum)* (dry matter) for basic manuring.

Ponds were then filled and stocked with unsexed juveniles of *Oreochromis niloticus* (mean weight 10.0 + 1.0 g) at a density of 1.55 ind./m^2 (155 kg/ha). These juveniles were obtained from the spawning of brooders captured from the River Benoue (Niger basin). Twenty five *Hemichromis fasciatus* averaging 11 g were stocked as predator fish (LAZARD, 1984). Two tilapias per pond were removed for proximate carcass analysis of the initial group.

Each of the following treatments was assigned at random in three replications : (i) single organic manuring with cow dung (treatment M), (ii) single feeding with a compounded feed (table I) (treatment F), and (iii) both manuring and feeding with the above manure and diet (treatment MF). Manure was collected at least one week after defecation from the open air cow-sheds of wandering stockbreeders' herds in the surroundings of the Station (mean che-

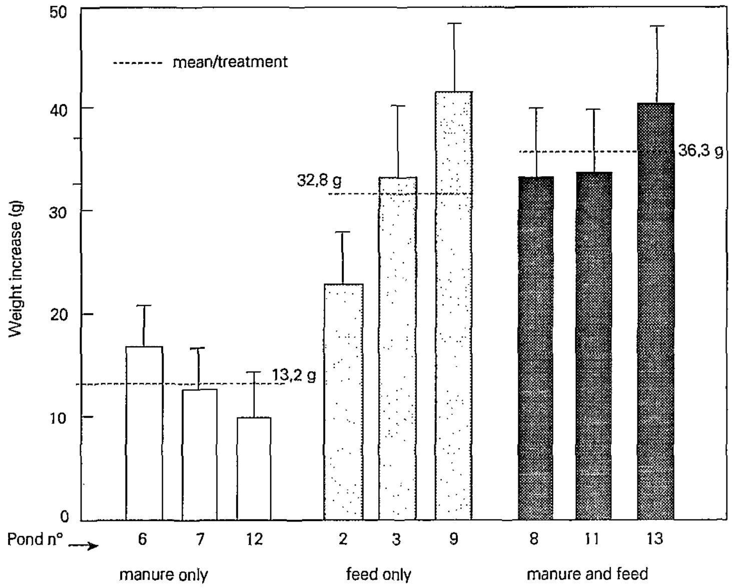

FIG. 1. — Comparative weight increase of *Oreochromis niloticus* in the three experimental feeding environments.
Gain de poids moyen de Oreochromis niloticus *en fonction des traitements.*

mical composition : 75 % dry matter, 9 % Kjeldahl nitrogen, 0.6 kcalg^{-1} crude energy, 55 % ash). It was first diluted in a bucket and spread over the entire surface of ponds, at a daily rate of 125 to 250 kg/ha dry matter depending on the estimated body weight of fish in ponds (SCHROEDER, 1985). Fed fish received 6.6 to 3 % of the body weight in six equal meals per day in a floating bamboo frame prepared at the left downstream corner of the pond; fortnightly body weight estimates were based on data (average periodic weights of intermediate fishing) of previous studies conducted at the station in similar conditions (POUOMOGNE, 1991). Manuring and feeding was done five days a week, and the trial lasted for 13 weeks. At the end of the trial, all fish were counted and weighed; in addition, weight and total length were recorded individually for a sample of 60 fish in each pond. Two fish per pond were removed for proximate carcass analysis.

Water temperature and transparency (Secchi disk) were measured daily; dissolved oxygen, pH and total hardness (Hach test kit model FF-2) were monitored weekly. Moisture, crude protein (Nx6.25), crude fat (ether extracted) and ash levels in the experimental diet and manure, and the fish samples were determined according to AOAC standard methods (AOAC, 1975). Gross energy content was measured by direct calorimetry (adiabatic bomb calorimeter, Gallenkamp CB 100).

Growth and feed utilization parameters were computed. Data were subjected to analysis of variance, and Duncan multiple-range test was used to evaluate specific differences between the treatment means.

RESULTS

Mean water quality parameters, with few variations within and between treatments throughout the study were as follows : 25 to 28 °C for midday temperatures; 60 cm (in two fertilized ponds) to more than 100 cm for transparency, 6 to 7 for pH (with a tendency of relative increment in fertilised ponds); 4 mgl^{-1} for early morning dissolved oxygen, less than 2 mgl^{-1} for total nitrogen, 25 to 35 mgl^{-1} $CaCO_3$ for total hardness.

Data on fish growth (Fig. 1) and feed utilization are presented in table II. Survival rates varied from 77 % to 86 %, with significant difference ($p < 0.05$) between treatments M and F (77 and 79 %) on the one hand, and treatment MF (86 %) on the other hand. Average growth rate was significantly higher ($p < 0.05$) in fed ponds (0.54 and 0.59 g/day for treatments F and MF respectively, against 0.21 g/day for treatment M). Quantities of supplemental feed consumed showed no significant difference ($p > 0.05$) between treament F and treatment MF;

TABLE I

Composition of the diet «Tilapia II» (% of dry matter)
Composition de l'aliment « Tilapia II » (en % de la matière sèche)

Ingredients	%
Rice bran	30
Cottonseed oilcake	18
Sojabean meal	17
Brewery draff	16
Peanut oilcake	15
Palm kernel meal	1
Vitamin/mineral Premix (1)	2
L-Lysine	0.5
Limestone	0.5
Total	100
Proximate analyses (dry matter basis)	
Crude protein (%)	27.5
Crude fat (%)	12.8
Ash (%)	13.6
Gross energy (kJ/g)	18.1

(1) Provided by a local animal feed manufacturer and said to contain per kilogram : 27 g calcium, 10 g phosphorus, 6 g iron, 3.5 g zinc, 2.4 g manganese, 600 mg copper, 20 mg iodine, 26 mg cobalt, 4 mg selenium, 45000 IU vitamin A, 140000 IU vitamin D, 90 mg vitamin E, 18 mg vitamin K, 16 mg vitamin B12, 113 mg pentothenic acid, 27 mg riboflavin.

TABLE II

Growth performance and feed utilization parametters for *O. niloticus* in the three experimental feeding environments
Croissance et utilisation des nutriments par Oreochromis niloticus *dans les trois environnements nutritionnels*

Parameters	Treatments		
	Manure	Feed	Both
Average initial weight Wi (g)	10.0	10.0	10.0
Average final weight Wf (g)	23.2	42.8	46.3
Survival rate (%)	79.1^a	76.7^a	86.4^b
SGR (%/day)	1.38^a	2.38^b	2.51^b
DGR (g/fish/day)	0.21^a	0.54^b	0.59^b
Feed intake (g DM/fish)	/	96.1^a	82.0^a
Feed gain ratio (FGR)	/	2.93^b	2.26^a
Protein efficiency ratio (PER)	/	1.25^b	1.62^a
Nutrient retention efficiencies (NRE)			
Protein	/	16.8^a	27.0^b
Fat	/	19.0^a	18.5^a
Energy	/	11.9^a	13.6^a
Average weight gain for the *predator fish (Hemicromis)*	47^b	48^b	43^a
Number of tilapia fries/pond	0.3	2.6	7
Total fish production t/ha/year	0.82^a	2.2^b	2.9^c

SGR = 100 (ln Wf-ln Wi)/growth period
DGR = (Wf-Wi)/growth period
FGR = Dry food intake/weight gain
PER = Weight gain/protein intake
NER = Nutrient gain/nutrient intake; nutrient gained = Wf* final body nutrient — Wi* initial body nutrient.
abc : figures in each line having different superscripts are significantly different ($p < 0.05$) from each other.

on the other hand, feed gain ratios (FGR, table II) were significantly different ($p < 0.01$) between the two treatments (2.9, versus 2.3). Protein efficiency ratios (PER) followed the same trend, i.e. supplemental feed protein was better utilised in ponds that received manure in addition (table II).

Carcass composition (table III) was significantly affected by the pond treatment. Moisture content of tilapia from only manured ponds was significantly ($p < 0.05$) higher. Protein content of fed fish in ponds receiving cow manure in addition was significantly ($p < 0.05$) higher (15 % wet weight, against 13 % for the other treatments). On the other hand, the highest body fat content was registered in fish receiving the supplemental feed only (5.6 %, against 4.2 and 1.6 % for treatment MF and treatment M respectively). Significant differences ($p < 0.05$) were however observed for nutrient retention coefficients only for protein, with fish from MF ponds retaining more protein in their body (27.0 %, against 16.8 % for fish from the F ponds, table II).

Few tilapia fingerlings were observed in all ponds (table II), thus showing *Hemichromis* predating efficiency on tilapia offsprings in all types of treatments.

Due to unavailability of adequate materials, natural productivity (i.e. phytoplancton and zooplancton) could unfortunately not be analysed.

DISCUSSION

It derives from the present study that addition of cow manure in *Oreochromis niloticus* ponds improves

TABLE III

Gross body composition (% wet weight) of *Oreochromis niloticus* reared in the three experimental feeding environments for 13 weeks

Composition corporelle (poissons entiers) de Oreochromis niloticus *soumis aux trois environnements nutritionnels pendant 91 jours (% du poids frais)*

Components	Initial	Treatments Manure	Feed	both
Moisture	81.1	79.6[c]	76.5[a]	77.2[b]
Crude protein	12.2	13.3[a]	13.1[a]	15.1[b]
Crude fat	1.5	1.6[a]	5.6[c]	4.2[b]
Energy	3.6	3.7[a]	5.6[b]	5.2[b]
Ash	5.1	4.5[b]	3.2[a]	3.4[a]

Figures of experimental groups in each line bearing the same superscipts are not significantly different ($p > 0.05$) from each other.

TABLE IV

Nitrogen budget of *Oreochromis niloticus* in the three experimental feeding environments (g Kjeldahi N/kg of live weight/day)

Disponibilité réelle et rétention de l'azote dans les environnements expérimentaux (g de N/kg de biomasse/jour)

Parameters	Treatments Manure	Feed	Man. + Feed
Manure or feed distributed (g/fish)	1050	96.1	1050+82.0
N distributed[1]	10.2	1.76	11.43+1.41
N retained[2]	0.19	0.29	0.37
Nitrogen retention efficiency[3]	1.9	17.6	3.2

1 = (supplemental feed or cow manure distributed per fish *% crude protein : 6.25) / (Average initial weight + Average final weight) : 2/length of the trial.
2 : from carcass composition (table III).
3 = 2/1

the utilization of supplemental feed (FGR, PER, NRE) and fish growth. These observations fit with the results registered in Israel by SCHROEDER (1973) and DEGANI *et al.* (1984). This is very important in areas such as the one of the present study, where the availability of cow dung in the surroundings renders the latter nearly free of charge, thus lowering the production cost of the fish.

However, fish in fed-only ponds grew far better than fish in manured-only ponds (2.6 times). In addition, daily growth rate in manured-only ponds (0.21g/d) appears to be low in this study. Growth rates superior to 0.5 g/day have been often registered in ponds receiving only cow manure (VAN DER LINGEN, 1959; MILLER, 1975; SCHROEDER, 1974; ODA, 1986; HU BAOTONG, *pers. comm.*). This is probably due to the poor manure quality; SCHROEDER (1980) suggested that the maximum ash level in cow manure should be 30 %, and loss of its liquid content be prevented, since much of the nitrogen is in the urine. In the present situation with high ash level (55 %, probably because of a great inclusion of foreign non essential material) and less moisture (25 %, due to liquid infiltration in the soil and evaporation in the open-air pens where the manure was collected), the quantity of manure to apply should have been increased. As an indicative guide, SCHROEDER (1974) suggests that the quantity of manure to be added in the pond shall be guided by early morning dissolved oxygen concentrations (if it is assumed for instance that the minimum safe dissolved oxygen level in a tilapia pond is 2.5 ppm, higher data for this parameter registered at dawn should be considered as a sign of under-manuring). In addition, while using fermented cow manure in outdoors containers, DEGANI *et al.* (1982) showed that a higher growth of *Sarotherodon aureus* was registered with the manure in its liquid form rather than in its dry form; according to the author, the percentage of colloidal matter is low in the dry form and consequently, the assimilation of the manure in the food chain is much slower. In fact, cow manure is known to be inferior to many other farm animal manures such as chicken droppings, duck manure or swine wastes (RAPPAPORT and SARIG, 1978, BUCK *et al.*, 1978, ODA, 1986). Definitely, manure composition should be assessed prior to deciding the manuring rate to apply into ponds.

When fish groups receiving the supplemental feed is considered, SGR still remains relatively low compared to other studies. Tilapia growth in ponds receiving supplemental feed with a composition similar to the one used here is usually 2 to 4 times better (RAPPAPORT *et al.*, 1977, LAZARD, 1984). One reason could be the water quality, precisely water temperature, pH and alkalinity which were not in the optimum range (26 to 32 °C for temperature, 7.5 to 8.5 for pH, and 80 to 100 mg $CaCO_3$ for total hardness, after OMBREDANE *et al.*, 1990). Another reason could be the animal material, grown from an old and probably inbred broodstock. It can be suggested for future studies to use a new and better defined tilapia strain.

Though the lack of adequate materials did not allow the analysis of natural feed in pond water or in the gut contents of fish, previous works can help us to better assess our own results. Many studies on pond fertilization have shown that chlorophyll *a* concentrations, which is used directly or indirectly by tilapias, were higher in fertilized water environments and positively correlated ($r > 0.7$) to fish yields (DEGANI *et al.*, 1984; ODA, 1986; DIANA *et al.*, 1988; TEICHERT-CODDINGTON *et al.*, 1992). Fish yield was negatively correlated with the carbon : nitrogen ratio (evaluated at about 10 :1 and 25 :1 for chicken and cow manure respectively) (ODA, 1986). In an experiment using cow shed fluid manure, SCHROEDER (1973) reported that cladocera and rotifers alone were found in non manured ponds; copepods, which are an indication of higher planktonic production, appeared in manured ponds. Crude protein content of 150 µ zooplancton was 56 % (dry matter basis) with an *in vitro* digestibility of 55 %. Thus, cow manure contributes to fish growth in the water through natural foods which are stimulated by its application; this process is well analysed by ALMAZAN and BOYD (1978). With *Tilapia aurea*, feed supplement introduced into the ponds had to pass through benthos elements (Oligochaeta, Chironomidae, Ostracoda and detritus) in order to be utilized (SPATARU, 1976); as a consequence, feeding this tilapia species in ponds receiving cow manure did not have much additional effect on fish growth (MOAV *et al.*, 1977). This seems not to be the case for *Oreochromis niloticus* used in our study, since the growth difference between fish in ponds receiving manure only and those receiving supplemental feed in addition was very high. In the present situation, manuring appears to improve the feed gain ratio of the supplemental feed. This confirms the observations of SCHROEDER (1973).

When we look into data for total fish production, a relation of additivity appears, i.e., the sum of manure only (treatment M) and feed only (treatment F) slightly equals to both manure and feed (0.8 + 2.2 # 2.9). This observation matches to a certain extent with the synergy effect of manure and feed reported by LOVSHIN *et al.* (1974), i.e., fish production in ponds receiving both manure and feed is higher than the sum of fish production in ponds receiving manure and feed separatively. If the positive interaction effect of manure and feed does not appear in the present study, this is probably due to the low stocking density adopted, which did not allow all the feeding niches of treatment MF particularly to contribute to fish production; many authors have indeed stressed on the positive correlation, to a certain extent, between stocking density and fish production (SCHROEDER, 1980; HOPKINS and CRUZ, 1982; ZONNEVELD and FADHOLI, 1991; DIANA *et al.*, 1991).

In a nutritional point of view, cow manure clearly appears to be an inferior food. It can be seen from table IV that retained / distributed ratio for Kjeldahl nitrogen is 1: 50 and 1: 3 for cow manure and the experimental feed respectively, i.e., the latter is 17 times more efficient than cow manure in terms of N retention. This is due to the fact that the crude protein content of the manure is not actually protein, but rather uric acid or other non protein nitrogen (NPN) compounds that are not normally assimilable by the fish. In open pond however, as the case of the present study, the pond-fish combination becomes an aerobic version of a rumen and its owner, within which NPN is probably incorporated into microbial production chains (SCHROEDER, 1980).

CONCLUSION

The addition of cow manure in ponds receiving supplemental feed enhanced fish growth and survival rate. However, cow manure used alone resulted in poorer growth, comparatively to direct feeding with a compounded plant diet. Consequently, in areas with relatively poor water quality as in the case of our study, cow manure should be utilised for fish production if its economic cost is sufficiently low.

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