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ORIGINAL ARTICLE

Aquacultural Potential of Silver Catfish *Chrysichthys nigrodigitatus* (Lacepede, 1803) Bred in Fresh and Brakish Water in Three Rearing Systems: Enclosures, Cement Tanks and Earth Ponds

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ABSTRACT
The effect of three rearing systems and two types of area, lagoon and fresh water, on growth and mortality rates of Chrysichthys nigrodigitatus was evaluated until 300 days in Côte d'Ivoire. Fish of average weight 21.09 g were stocked at a 10 fish/m^3 density and fed a 35% protein pellet feed. Temperature, oxygen, pH, salinity and conductivity, were monitored. In lagoon, comparing survival rate, final mean weight and length, daily weight gain, specific growth rate and condition factor in the three rearing systems, respectively 70%; 395.29 g; 349 mm; 0.76 g/d, 2.260%/d ; 2.619 in cement tank, 68%; 392.40 g; 346 mm; 0.75 g/d 2.174%/d; 2.515 in enclosure and 70%; 395.53 g; 349 mm; 0,758 g/d. 2.238%/d; 2.520 in pond were noticed. In fresh water, values of these parameters are respectively 68%; 390.31 g; 344.8 mm; 0.746 g/d; 2.238%/d and 2.52. Growth parameters aren't significantly different. This observation is not only between the three rearing systems but also in the two type of water. These similarities observed are link to the fact that firstly the three rearing systems seem to mimic nature. Secondly fish are in good condition because they take advantage of the natural resources in addition to artificial food.
Keywords: *Chrysichthys nigrodigitatus;* rearing system; Côte d'Ivoire; growth parameters.

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INTRODUCTION

From independence to 1980, the prosperity of Côte d'Ivoire was undoubtedly the fact of agriculture. Indeed, this activity played a leading role, because the income it generated were filling well enough the shortcomings encountered in the sectors of activities such as livestock and aquaculture. However, in recent decades, the slump of the main products of speculation on the international market, has deeply affected the national economy then,

the necessity to turn toward the sectors of aquaculture fisheries and livestock. In 2001, the first two sectors have represented 3.1% of agricultural GDP and 0.74% of the total GDP [8][9]. Fish is the first source of animal proteins of Ivorian consumer [7]. This national consumption is between 250000 and 300000 tons/year 11for a local production average of 80000 tons [6][7]. In addition, 67% of the average consumption of fish, estimated at 13.2 kg per capita and per year, were covered by imports. Their magnitude and cost in foreign currency permit government to intensify the development of the fishing and aquaculture sectors. Also it has been assigned specifically to this sector, the rational exploitation of all the potential fishery and the valorization of optimal plans of water [23][26]. In consequence, tilapia catfish and silver catfish were disseminated. Growth performances of *Chrysichthys nigrodigitatus* were significantly superior to *C. walkeri*, that is why, the first specie is the only one used by fish farmers [14].

Of this fact, the rearing of *C. nigrodigitatus* takes of the magnitude in this decade. Also, few studies have shown that the zootechnical performances of this fish are preponderant [14]. The conversion of the feed and the mode of reproduction very suited to captivity allow obtaining easy fingerlings [34, 3, 22, 28, 15]. This fish is an economic challenge because of it high price on the market and it is also more appreciate in the tropics. However, many problems were met in rearing condition of this species, among others the high mortality rate, ruining the hold of fish farmers. What type of farming must be practice to optimize the production while minimizing the major risks? What area is it better? Brackish water or freshwater? This problematic interested at the highest level scientific community. That is why; the main objective of the present study is not only the assessment of growth performances of *C. nigrodigitatus* in pond, enclosure and cement tank but also in freshwater and lagoon.

MATERIALS AND METHODS

The study was conducted from January 2003 to June 2004 at Jacqueville (5°12' 22'' N, 354°24'44''E), Layo (5°35'47''N, 5°20'27''E), Mopoyem (5°18'45''N, 4°27'56''E) and Anyama (5°31'0''N, 4°1'0''E) located of Côte d'Ivoire in south eastern. Rearing system of this last city is alimented by fresh water and the other by lagoon. Three aquaculture systems and two type of area, fresh and brackish water were experimented. Three experimental enclosures were placed in Layo Lagoon. Each was made of 10 mm mesh plastic netting as described by[18, 19], and had a capacity of 800 m^3 and three 500 l circular tanks for reproduction were install in the same area. At Mopoyem and Anyama three 900 m^3 unfertilized earth ponds were used. Three 240 m^3 cement tanks were used at Jacqueville. Bloodstock of male and female was caught in Layo experimental stock of *Chrysichthys nigrodigitatus*. They were kept in the PVC tube for breeding purposes and put in circular tank. After spawning, eggs are incubated with [33] method. After 4 or 5 days, larva with 0.13 g weight and 26 mm total length were obtained and feed with beef brain in addition with yellow of egg and vitamin (Alvityl) until 45 days. Weights were harvested and moved into different cement tanks for grow-out. When the mean weight of the cat fish fingerlings reached 21.2 g, they were transferred into the rearing structures. Following previous reports, fish were stocked at 10 fish/m^3 in all rearing structures. All fish were fed a 35% protein 4.5 to 9 mm pelleted food manufactured by CRO (Marine Fish Research Center). Food was provided everyday manually twice a day at 09:00 am, and 3:00 pm. The 3% feeding rate varied in relation to fish weight and was adjusted every month according to biomass. Random batches of fish were weighed and measured every month, using 40 fish in each enclosure, pond or tank. At harvest, all fish were counted and batch-weighed and mesured. The water temperature, dissolved oxygen concentration, salinity, conductivity and pH of each rearing system were measured every week, at 9:00 am and 3:00 pm with respectively a thermometer, oxymeter (Weilheim WTW oxy 330) and pH meter (Weilheim WTW pH 330). From the data collected, the following growth parameters were calculated: (1) mean daily weight gain (MDWG) = (MWf – MWi)/d, with MWf = final mean weight (g), MWi = initial mean weight (g), and d = day on trial; (2) specific growth rate (SGR) = 100 X [(ln (MWf) – ln (MWi)]/d, and ln = logarithm; (3) survival rate (SR) = 100 X Nf /(Nf – Ni), with Ni = initial number of fish, Nf = final number of fish; (4) condition factor [21], k = (100×W)/Lb), with W = Fish weight, L = fish lengh and b = allometric coefficient). Survival and growth data were presented as means ± SE (Standard error). Analysis of variance (one-way ANOVA with post hoc (LSD) comparison) was performed using Statistica 7.0 software to compare physico-chemical data between cement tanks, enclosure and earth ponds. Mortality rate, daily weight gain and specific growth rate were also analysed using one-way ANOVA. The Tukey HSD test was used to separate significant differences between rearing structures. Percentage survival and specific growth rates were transformed to arcsine values prior to analysis.

RESULTS

Physico-chemical parameters in cement tanks, enclosure and earth ponds

Fresh and brackish waters temperatures are higher than those of tank and enclosure. They ranged from 30.4 °C to 27.7°C in pond and from 27.8 to 26.3 °C in enclosure and tank (fig. 1). Results of means comparison showed significant differences (dl effect = 380; p-level = 0.00) between ponds, tanks and enclosures values. The dissolved oxygen rate undergoes many fluctuations during the annual cycle. The highest values are observed in January (8.8 mg/l in pond) and in August (7.8 mg/l in tanks). The lowest rate is recorded in this area in July (3.3 mg/l). The statistical analysis shows that the dissolved oxygen rate of enclosure and pond are not different. It is the same for that of Mopoyem and Anyama's pond in brackish and fresh water. By contrast, the dissolved oxygen in tank is significantly different from enclosure.

The pH value of the 3 rearing system is near the neutrality. However, that of pond reaches 8 in January and 7.9 in May. In the last quarter of breeding, the pH of Layo enclosure is superior than 8. Statistically, pH of enclosure differs from that of pond (p= 0.00) and Anyama (p = 0.00). The salinity of Anyama is zero during the whole year. On the 3 other breeding area, the salinity gradually increases to neighboring peaks of 6 mg/l in March. Values fall and in the last quarter of the livestock. Statistical treatment revealed a significant difference between Anyama and sites of Layo (p = 0.00), Mopoyem (p = 0.00) and Jacqueville (p = 0.00). However the salinity of Layo does not differ from those of Mopoyem (p= 0.42) and Jacqueville (p = 0.08).

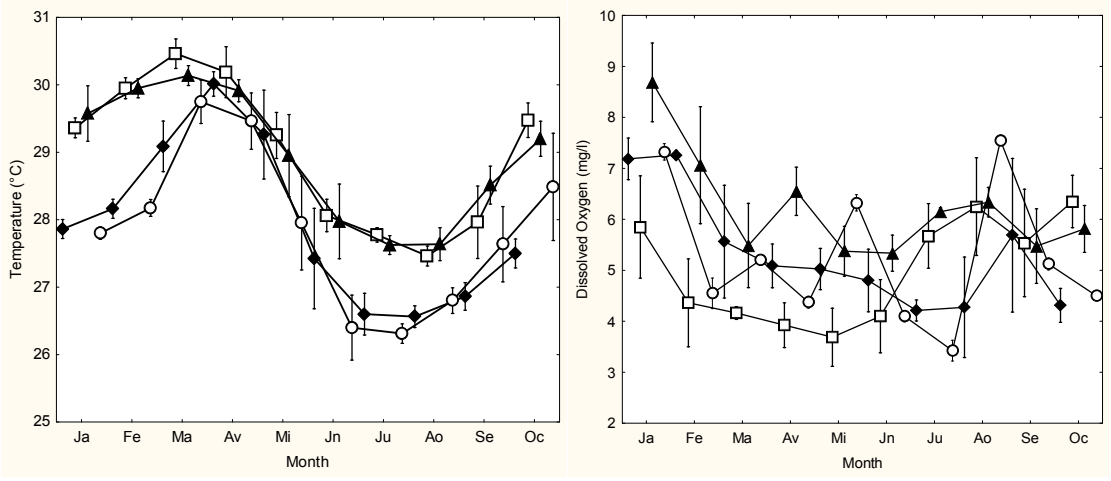
The Mean conductivity of Jacqueville is located between 130 µs/cm and 140 µs/cm). It is the highest (30 µs/cm). The Tukey test shows no difference in conductivity between enclosure, ponds of Mopoyem and Anyama. Contrary, the same test indicates a great significant difference (p= 0.00) between the conductivities of Jacqueville and the three sites cited.

Table 1: Food composition according to CRO (*Centre de recherches oceanologiques*).

Components	Pellet food
Crude protein	35 %
Crude Fat	6 %
Cellulosic material	5 %
Mineral Material	10%
Vitamin A	10000 UI/kg
Vitamin D3	3000 UI/kg
Vitamin E	130 UI/kg
Vitamin C	400 mg/kg
Calcium	2.3%
Phosphor	1.0 %
Sodium	0.4%

Table 2: Initial mean weight (Wi), final mean weight (Wf), initial mean length (Li), final mean length (Lf), survival rate (SR), mean daily weight gain (MDWG), specific growth rate (SGR) and condition factor (K) of *Chrysichthys nigrodigitatus* after 300 days of growth in enclosure (Layo), cement tank (Jacqueville), earth pond (Mopoyem) alimented by lagoon and in Anyama earth ponds receiving fresh water from January to October 2004. Values in the same column with different superscripts are significantly different (P < 0.05).

Rearing structure	Wi (g)	Wf (g)	Li (mm)	Lf (mm)	SR (%)	MDWG (g/j)	SGP (%/j)	K
Tank (Jacqueville)	21.09	395.29^{a} ±0.43	131	349^{a} ±0.40	70^{a}± 0.18	0.76^{a} ± 0.64	2.26^{a} ± 2.47	2.62^{a} ±1.08
Enclosure (Layo)	21.09	392.40^{a} ±0.67	131	346^{a} ±0,40	68^{a} ± 0,22	0.75^{a} ± 0.61	2.17^{a} ± 2.40	2.51^{a} ±0.96
Fresh water Pond (Anyama)	21.09	390.31^{a} ±0.69	131	344.8^{a} ±0.40	68^{a} ±0.21	0.75^{a} ± 0,66	2,14^{a} ± 2.37	2.08^{a} ±0.47
Brackish water pond (Mopoyem)	21.09	395.53^{a} ±0.37	131	349^{a} ±0.40	70^{a} ± 0.25	0.76^{a} ± 0.65	2.24^{a} ±2.47	2.52^{a} ±1.01



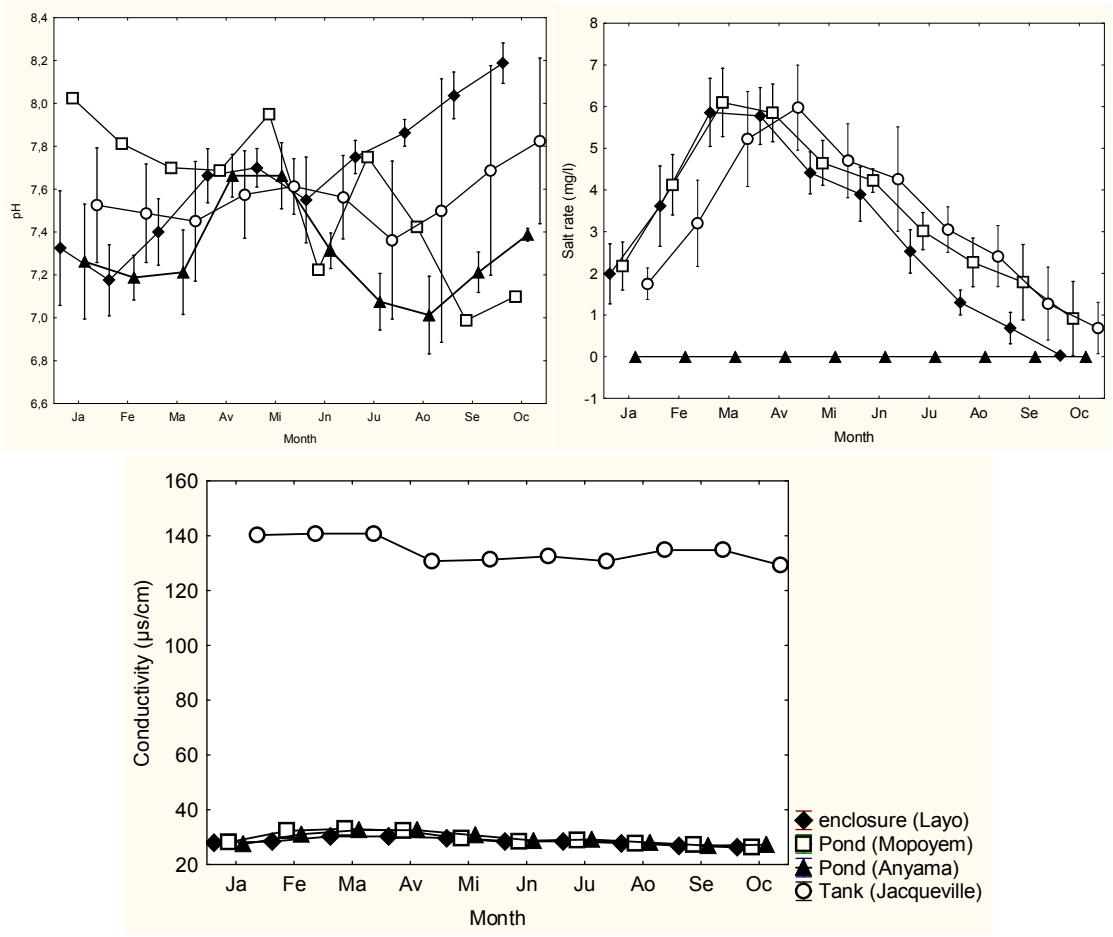


Fig. 1. Monthly averages variations of water temperature (°C), dissolved oxygen (mg/l), pH, salt rate, conductivity in enclosure (Layo), cement tank (Jacqueville), earth pond (Mopoyem) alimented by lagoon and in Anyama earth ponds receiving fresh water, during *Chrysichthys nigrodigitatus* culture from January to October 2004.

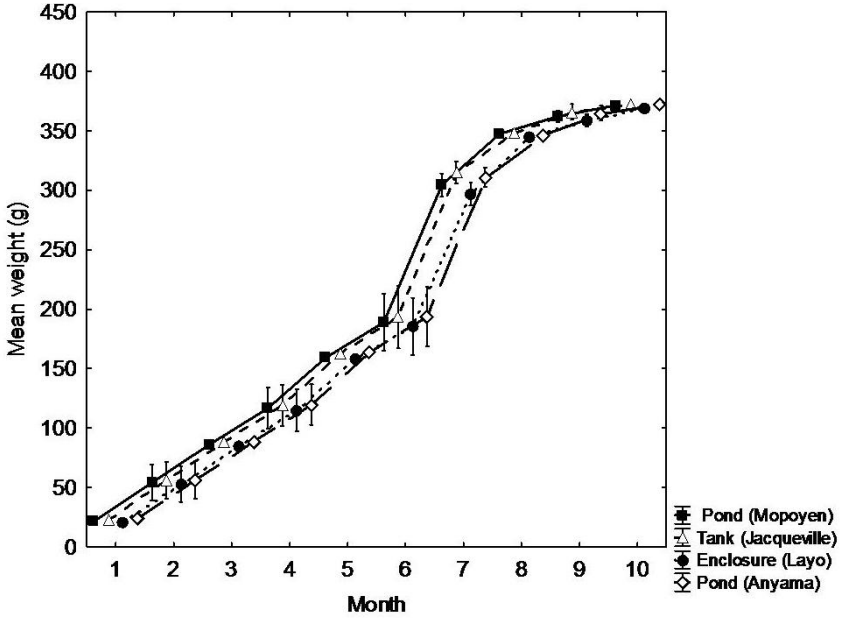


Fig. 2. Mean weight of *Chrysichthys nigrodigitatus* in different rearing systems (Enclosure of Layo, cement tanks of Jacqueville, earth ponds of Mopoyem alimented by lagoon and earth ponds of Anyama alimented by fresh water) 10 month of breeding.

Growth parameters

Comparing fresh water and brackish water values, survival rate of Mopoyem fish is higher (70 %) than that Anyama (66 %). This parameter is higher in tank (70%) than enclosure (66%) and pond (68%). However these rates don't differ statistically. The daily weight gain recorded on the three rearing system are virtually identical, respectively 0.76 g/d, 0.75 g/d and 0.76 g/d at Jacqueville, Layo and Mopoyem. There is no significant difference between the daily growth values. There is also no significant difference between daily growth of brackish and fresh water.

Linear growth values are neighbors in every site. The highest (349 mm) was observed in pond and tank, the lowest (344.8 mm) in fresh water. The Tukey test shows that the monthly average fish size of enclosure don't differ from those of tank (p=0.231), Anyama (p=0.384) and pond (p=0.101) for ddl=3. No significant differences were also found between linear growth of brackish and fresh water. The final mean weight observed in tank (395.29 g) and pond (395.53 g) are higher than that of enclosure (392.4 g). The Tukey test shows no significant difference between enclosure, pond and tank values; (p=0.03), (p=0.41) for ddl=3. This parameter is the lowest in freshwater. The condition factor is higher in freshwater than in brackish water (respectively 2.62 and 2.08). However differences observed between areas and rearing systems are not significant. The specific growth rate shows a few variations in the 3 systems. They are respectively 2.26%/d and 2.23%/d in tank, pond and enclosure. No significant differences was observed between the rates of the three sites (p = 0.62, n= 280) and also that of brackish and fresh water.

DISCUSSION

The significance of the present study is not only comparison of the effects of three rearing systems on *Chrysichthys nigrodigitatus* growth performances, but also the breeding of this specie in two type of area. These are Fresh and brackish waters.

Important fluctuations of dissolved oxygen level were observed in all rearing system but it was relatively high (5.80 to 8.80 mg/l) in fresh water ponds. While temperature was low in cemented tank (average 26°C). According to [20] high temperature in tanks could stress the fish and have an adverse effect on their growth rate. However, water characteristics measured during the experimental period were within the range recommended for aquaculture [11]. Results of this study seem to mean that very high different level of salinity between fresh (0 mg/l) and brackish water (maximum 6 mg/l) has few effects on *C. nigrodigitatus* growth performances. Indeed, in natural area, silver cat fish live comfortably as soon as in brackish water than in fresh water [24, 36], even if [1] estimate that difference in the type of water body and water stability can affect growth pattern of *C. nigrodigitatus*. Concerning this specie, growth in nature area and survival of larvae were most studied[4, 35]; but data of growth performances are scarce.

Final mean length and weight recorded in the three rearing systems of the present
study are close to those observed in Nigeria nun river from November to may during three years of sampling (between 292 g and 383 g). However, in the same period,
length in natural area are higher than in rearing condition (from 489 mm to 571 mm) [1]. It mean that after 10 month in captivity, silver catfish culture can really bring to population, fish with interesting marchand size as well as those captured in natural area. The lower daily weight gain obtained in this study is 0.63 w/d and the higher is 0.76 w/d. In Côte d'Ivoire, precisely in cage enclosure of Layo alimented by brackish water, [10] get from 0.73 g/d to 0.88 g/d as daily weight gain value but using demand feeder. With results of condition factors values (2.08 to 2.61) fish rare overweight. In the present work, whatever the rearing system and the type of water, no significant differences were recorded between the growth parameters of *C. nigrodigitatus*. In ponds, cement tanks and cage enclosures, final mean weight and length, survival rate, daily weight gain, specific growth rate and condition factor were almost in the same range order. Similar results have previously been reported from experiments with other fish species. Contrary, according to [25], for many fish studied, mortalities at unit weight were significantly lower in tanks than in ponds and cages. Results of [2] indicated that final mean weight of *Clarias gariepinus* was greater in earthen pond than in concrete tank. Despite higher survivability (70%) recorded in concrete tank against 60% in earthen pond, [37] noticed that silver perch stocked in cages grew significantly faster and were in better condition than in tanks. Several results on an african cat fish, *Heterobranchus longifilis*, reported that highest daily mean weight were recorded in enclosures, those of earthen ponds and cage enclosures were intermediate and the lowest were observed in floating cage culture [13] [23]. In natural area, faster growth rates of this specie can be consider as defensive mechanism against predators or an adaptation of survival [18][31]. In the present work, results seem to show that the three rearing systems which are ponds of Mopoyem, enclosure of Layo, cemented tank of Jacqueville and also two type of water quality, fresh an brackish, have in the common an important natural productivity. As water of these rearing systems come from lagoon or source, it can provide to fish

organic detritus, vegetable and animal remains, seeds, gastropods, batrachians larvae, insect, aquatic vertebrates and planktonik preys [17]. *C. nigrodigitatus* are omnivorous fish, they can take advantage directly and indirectly of the natural resources in addition to artificial food. Manufactured food provides mineral nutrients that may stimulate primary production, which then serves as the basis of autotrophic food webs. Phytoplankton communities are an essential component of most pond aquaculture systems. They are considered beneficial because they supply dissolved oxygen and consequently decrease transparency [27]. According to [12] and [13], species reared in floating cages depend exclusively on artificial food. In contrast, as enclosures used in Layo are very wide, thought earthen pond and concrete tank, they mimic nature and this may be responsible for fish growth [2]. It explains the good condition factors in each rearing system. In addition to it, *C. nigrodigitatus* is known to have good condition in captivity than *C. auraus* and *C. walkeri* [14]. Various factors that affect the condition of a fish species include environmental factors such as aquatic vegetation, food, stage of maturity, state of stomach fullness and genetic factors [16] [29] [30]. Those systems often allow water to be ventilated should be encouraged [2]. But catfish growth is often affected by many parasites [5][32]. That observation is a real problem in catfish breeding.

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