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# Comparative analysis of the aquaculture potential of hybrid *Tilapia zillii* (male) x *T. guineensis* (female) (Teleostei: Cichlidae) in floating cages, cement tanks and earth ponds

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**The effect of three rearing systems, floating cages, cement tanks and earth ponds, on the growth rate, feeding efficiency and mortality rates of hybrid tilapia — *Tilapia zillii* (male) x *T. guineensis* (female) — was evaluated for 233 days. Fish of average weight 12.59g were stocked at a density of 20 fish $m^{-3}$ and were fed a 30% protein pelleted commercial feed. The pH, degree of aeration and transparency were monitored. The mortality rate, final mean weight, daily weight gain, and feed conversion ratios were significantly different among rearing systems. The highest potential was in earth ponds (2.86%, 171.70g, 0.74g $d^{-1}$, 5.42, respectively), the cages were of intermediate potential (7.50%, 137.22g, 0.57g $d^{-1}$, 7.70) and the lowest potential was in cement tanks (31.86%, 45.23g, 0.15g $d^{-1}$, 10.28). These differences could be linked to the relevant physical and chemical characteristics of the three different rearing systems.**

**Keywords:** Côte d'Ivoire, tilapia, hybrid fish, growth, rearing conditions, physico-chemical factors

## Introduction

Tilapia hybrids are important to the commercial and subsistence fisheries in some Ivorian water bodies (Gourène *et al*. 1999). These hybrids are from crosses between West African *Tilapia zillii,* from the coastal basins, and *Tilapia guineensis,* from the lower courses of rivers (Teugels and Thys van den Audenaerde 1992). Pouyaud (1995) observed these hybrid populations in the Ayamé man-made lake, Côte d'Ivoire, and suggested that, as a result of dam construction, the artificial environment of Ayamé Lake favoured hybridisation. Tilapia hybrids comprise 24% of the lake's cichlid population, while parental *Tilapia zillii* and *T. guineensis* make up 3.5 and 2.2%, respectively (Thys van den Audenaerde *et al*. 1998). These fish are important for both commercial and nutritional reasons, as they are regularly found in the catch of fishermen in most of the inland waters of Côte d'Ivoire.

In the light of the numerical prevalence of hybrids in Ayamé Lake and the fact that these hybrids and other tilapia species (*Sarotherodon melanotheron* and *Oreochromis niloticus*) are food fish (Légendre 1986, Vanga 2001), it is important to have a good understanding of their growth performance in different fish culture systems in order to assess their potential contribution to West African aquaculture. This study aimed to determine tilapia hybrid growth performances — including mortality rate, daily weight gain, specific growth rate and feed conversion ratio — in floating cages, cement tanks and earth pond environments.

## Materials and methods

The study was conducted from January–August 2003 at Ayamé man-made Lake (5°36'N: 3°10'W) and at Aboisso (5°28'N: 3°12'W), Côte d'Ivoire, in three aquaculture systems. Three experimental floating cages were placed in Lake Ayamé. Each was made of 5mm mesh plastic netting as described by Coche (1976) and Cavailles *et al.* (1981), fitted with 1mm mesh netting bottoms to prevent the loss of food, and had a capacity of $1m^3$. At Aboisso (town), that is 20km from Lake Ayamé, five $2.16m^3$ cement tanks (two for reproduction and three for trials) and three $28.26m^3$ unfertilised earth ponds were used. The water flow rate was $2m^3$ $h^{-1}$ and $5m^3$ $h^{-1}$ for the tanks and ponds, respectively. Broodstock of male *Tilapia zillii* (n = 12) and female *T. guineensis* (n = 12) was caught in Ayamé man-made lake and genotyped by mitochondrial DNA analysis, using the Random Amplified Polymorphic DNA (RAPD) method. Groups of six *T. zillii* and six *T. guineensis* were kept in the cement tanks for breeding purposes. After two months, hybrid fingerlings of similar weights were harvested and moved into different cement tanks for grow-out. When the mean weight of the hybrid fingerlings reached 12g, genital papilla dimorphism was used for sex separation and male fingerlings were transferred into the rearing structures. Following the findings from previous reports (Légendre 1986, Légendre *et al*. 1989), the hybrids were stocked at 20 fish/$m^3$ in all rearing structures. A total of 60 fish were transferred into the floating cages, 129 fish into the cement tanks, and 1 695 fish into the earth ponds. One month later, all fish were sorted again in order to correct possible errors of sexing. All fish were fed a 30% protein pelleted commercial food (T2GE) manufactured by FACI (Société de Fabrication d'Aliments en Côte d'Ivoire: 18 BP 686 Abidjan 18). Food was provided manually three times a day at 09:00, 12:00 and 15:00, seven days a week. The feeding rate varied in relation to fish weight and was adjusted every two weeks according to biomass, as suggested by Mélard (1986): $Rmax = 0.139\ P^{0.685}$ [Rmax = maximum daily rate (%); P = total fish weight (%)]. Random batches of fish were weighed every two weeks, using 30% of the total population in each cage, pond or tank. At harvest, all fish were counted and batch-weighed.

The water temperature, dissolved oxygen concentration and pH of each rearing system were measured twice every three days between 06:30–07:00 and 15:30–16:00 with a thermometer, an oxymeter (Weilheim WTW oxy 330) and pH meter (Weilheim WTW pH 330), respectively. Transparency was measured with a Secchi disk. These measurements were taken at 0.5m maximum depth.

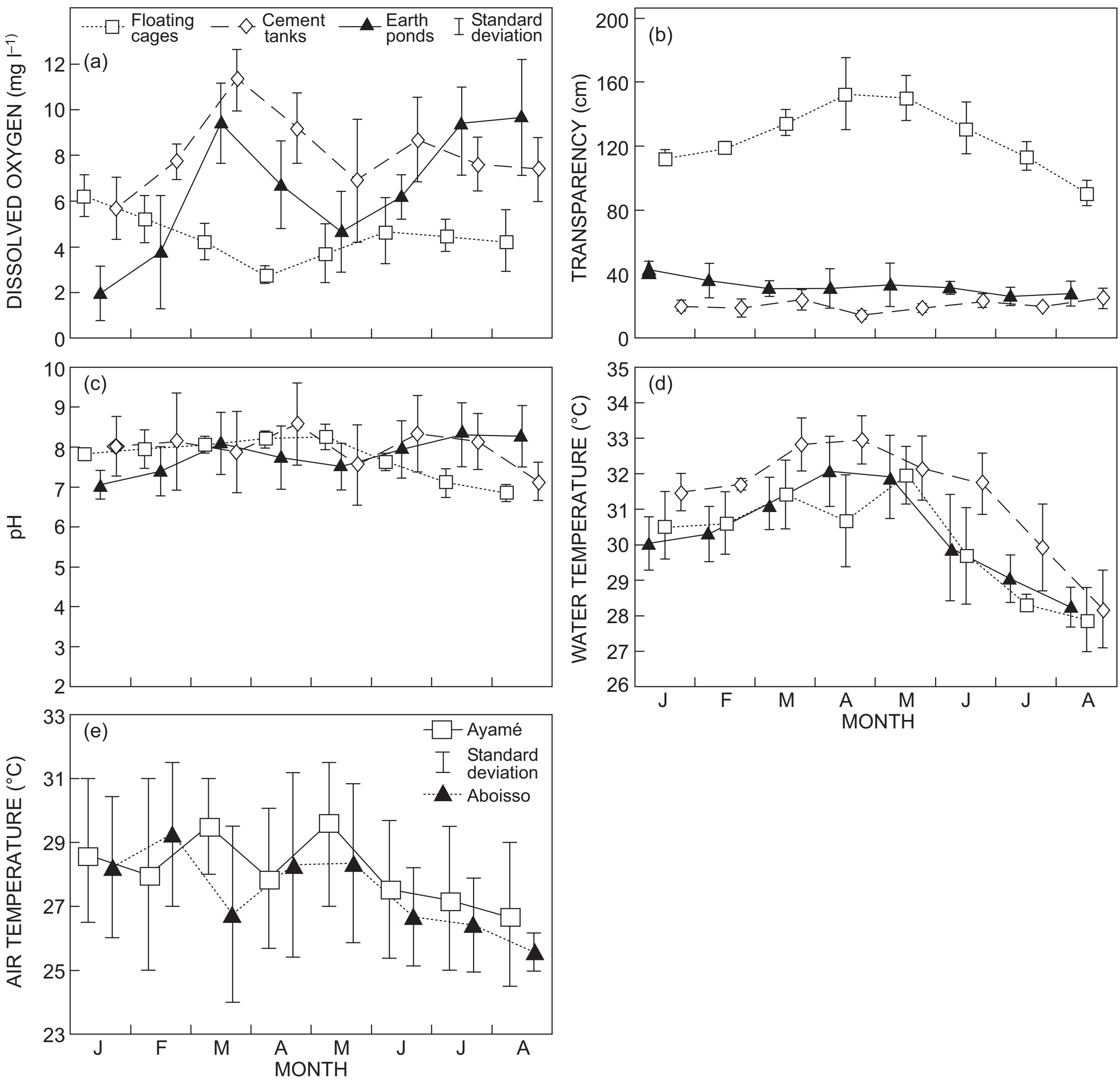


**Figure 1:** Monthly averages of (a) dissolved oxygen (mg $l^{-1}$), (b) transparency (cm), (c) pH, (d) water temperature (°C) in floating cages, earth ponds and cement tanks, (e) air temperature variations during the culture of male hybrid tilapia [*T. zillii* (male) x *T. guineensis* (female)] from January–August 2003

From the data collected, the following growth parameters were calculated:

(1) mean daily weight gain (MDWG) = (MWf – MWi)/d; where MWf = final mean weight (g), MWi = initial mean weight (g), and d = growth period in days;

(2) specific growth rate (SGR) = 100 x [(ln (MWf) – ln (MWi)]/d; where MWf = final mean weight (g), MWi = initial mean weight (g), d = day on trial (d), and ln = logarithm;

(3) mortality rate (MR) = 100 x (Ni – Nf) / Ni; where Ni = initial number of fish, Nf = final number of fish;

(4) feed conversion ratio (FCR) = F/(TWf – TWi); where F = total weight of food intake (g), TWf = final total weight of fishes (g), TWi = initial total weight of fishes (g).

Analysis of variance (one-way ANOVA with *post hoc* (LSD) comparison) was performed using Statistica 5.0 software to compare physico-chemical data between cement tanks, floating cages and earth ponds. Mortality rate, daily weight gain, food conversion ratio 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 mortality and specific growth rates were transformed to arcsine values prior to analysis.

## Results

### *Physico-chemical parameters in cement tanks, floating cages and earth ponds*

Ponds and cement tanks displayed higher dissolved oxygen mean values (11.50 and 9.80mg $l^{-1}$, respectively) in March and August respectively (Figure 1a). Dissolved oxygen fell to 5.80mg $l^{-1}$ in the ponds and 1.80mg $l^{-1}$ in the tanks in January. In contrast, in the floating cages the average monthly dissolved oxygen levels varied less, ranging from 3.00mg $l^{-1}$ in April to 6.30mg $l^{-1}$ in January. The difference observed after comparison of dissolved oxygen values among the three types of rearing structures was significant (dl effect = 2; MS effect = 257.58; MS error = 9.34; F value = 27.57, p-level < 0.05).

In the ponds, the temperature ranged from 28.2–33.0°C, which was higher than in the tanks and cages, in both of which similar temperatures, from 28.00–32.00°C, were observed (Figure 1b). Results of means comparison showed significant differences (dl effect = 2; MS effect = 13.02; MS error = 2.66; F value = 4.89, p-level < 0.05) between the values in ponds and tanks and also between ponds and cages. The ambient temperature did not vary significantly between Ayamé and Aboisso.

In ponds and tanks the transparency levels (Figure 1c) were very low, ranging from 15–20cm and from 30–42cm, respectively. In cages the mean transparency values (90–150cm) were higher than in the tanks and ponds. The difference observed among transparency values of the three rearing structures was significant (dl effect = 2; MS effect = 222259.2; MS error = 226.01; F value = 983.39, p-level < 0.05), and the pH values varied slightly among rearing systems.

### *Growth parameters in the three rearing systems*

Figure 2 shows the mean weight of the tilapia hybrids as a function of days and rearing system. In all rearing systems, the mean weight increased as the trials progressed. The highest average mean weight was found in the ponds, the lowest in the cement tanks, with the floating cages being intermediate.

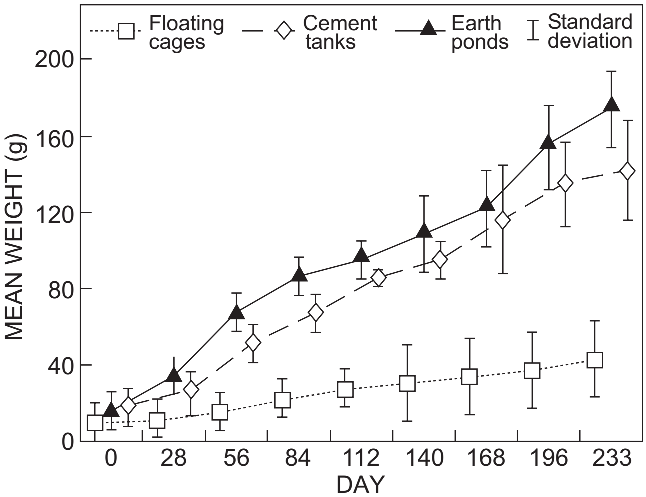


**Figure 2:** Mean weight of male tilapia hybrids [*T. zillii* (male) x *T. guineensis* (female)] in three different rearing systems (floating cages, cement tanks and earth ponds) as a function of time

The growth parameters of the hybrids are given in Table 1. The mortality rate in cement tanks (31.86 %) was higher than those in the cages (7.50 %) and ponds (2.86 %). The result of ANOVA (one-way ANOVA with the Tukey's HSD test) comparing mortality rates of hybrid tilapias showed significant differences between cement tanks and earth ponds, and between cement tanks and floating cages (dl effect = 2; MS effect = 0.15; MS error = 0.01; F value = 13.18; P-level < 0.05). The daily weight gain and specific growth rate of hybrids reared in ponds (0.74g $d^{-1}$ and 1.50%/d respectively) was significantly higher (daily weight gain: dl effect = 2, MS effect = 1.45, MS error = 0.07, F value = 20, p-level < 0.05; specific growth rate: dl effect = 2, MS effect = 2.12, MS error = 0.54, F value = 3.92, p-level < 0.05) than those in cages (0.57g $d^{-1}$ and 1.10%/d respectively) and cement tanks (0.15g $d^{-1}$ and 0.70%/d respectively). The feed conversion ratio of hybrids reared in ponds was low (5.42) and that of hybrids reared in cement tanks was high (10.28), and the difference observed was significant (dl effect = 2, MS effect = 1 269.95, MS error = 409.90, F value = 3.03, p-level < 0.05).

## Discussion

Significant differences were recorded between the growth parameters of tilapia hybrids reared in ponds, cement tanks and floating cages. Mortality rate, final mean weight, daily weight gain, specific growth rate and feed conversion ratio were highest in ponds, intermediate in cages and lowest in cement tanks. Similar results have previously been reported from experiments with other fish species. Coche (1976) and Mélard (1986) compared the growth of *Oreochromis niloticus* in 150m² ponds, and 1m³ tanks and cages. With a starting mean weight of 20g and after 200 days of rearing,

**Table 1:** Initial mean weight (W1), final mean weight (W2), mortality rate (MR), mean daily weight gain (MDWG), specific growth rate (SGR) and feed conversion ratio (FCR) of male tilapia hybrids [*T. zillii* (male) x *T. guineensis* (female)], after 233 days of growth in cement tanks, floating cages and earth ponds. Values in the same column with different superscripts are significantly different (P < 0.05)

| | W1 (g) | W2 (g) | MR (%) | MDWG (g d$^{-1}$) | SGR (%/d) | FCR |
|---|---|---|---|---|---|---|
| Floating cages | 12.80 | 137.22 | 7.50$^{b}$ ±1.53 | 0.57$^{b}$ ±0.31 | 1.10$^{b}$ ±0.15 | 7.70$^{b}$ ±0.65 |
| Cement tanks | 12.21 | 45.23 | 31.86$^{a}$ ±5.76 | 0.15$^{a}$ ±0.09 | 0.70$^{a}$ ±0.08 | 10.28$^{a}$ ±0.77 |
| Earth ponds | 12.76 | 171.70 | 2.86$^{b}$ ±1.89 | 0.74$^{c}$ ±0.34 | 1.50$^{c}$ ±0.19 | 5.42$^{c}$ ±0.33 |

the final mean weight of the fish was higher in ponds (650g) than in tanks (300g) and cages (150g). Mélard and Philippart (1982) also showed that the daily weight gain of *O. niloticus* fingerlings was higher in ponds (2.94g d$^{-1}$) than in tanks (1.66g d$^{-1}$). Similarly, Breine *et al*. (1995) found that the daily weight gain of *Tilapia cameronensis* fry was higher in ponds (0.19g d$^{-1}$) than in tanks (0.09g d$^{-1}$).

In this study, the dissolved oxygen levels and temperatures in the ponds were relatively high (5.80–11.50mg l$^{-1}$ and 28.2–33°C, respectively) while transparency was low (average 20cm). According to Breine *et al*. (1995), natural food in ponds contributes, together with artificial food, to enrich and complete the fish's diet. Fish growth in earth ponds is based on several food sources. Manufactured food may be consumed directly by the fish, or may be converted to higher quality feed through the action of heterotrophic organisms (Boyd and Tucker 1998). The detritus as well as the zooplankton and benthic macroinvertebrate consumers are food sources for fish in ponds (Schroeder 1978), as are autotrophic organisms (Schroeder *et al.* 1990). 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. *Tilapia zillii* and *T. guineensis* consume macrophytes, invertebrates, algae and detritus (Fagade 1971, Abdel-Malek 1972, Buddington 1979). Their hybrids appeared to eat artificial food, as well as detritus on the bottom of the pond, resulting in improved fish yield. The increase of temperature in pond aquaculture systems also favours fish growth (Boyd and Tucker 1998).

In floating cages, the availability of natural food for fish is probably insignificant. Fish appear to eat only the food supplied to their cages (Shell 1967). The levels of dissolved oxygen was low and did not fluctuate as much as in other systems, because the water was aerated by mixing. The relatively high transparency level in the floating cages (90–150cm) could indicate a low concentration of phytoplankton (Légendre 1996), unlike the situation in ponds.

In the cement tanks, dissolved oxygen fluctuated widely and sometimes fell below the 3mg l$^{-1}$ minimum value recommended for tilapia culture (Philippart and Ruwet 1982, Mélard 1986). According to Henderson-Arzapalo *et al.* (1980) high temperature in tanks could stress the fish and have an adverse effect on their growth rate. In the cement tanks, feed conversion rates were high and growth rates were low. Robinson and Doyle (1990) reported that aggression between fish could well account for such a result. These reasons could explain the observed higher rate of mortality in the tanks (31.86%) than in the ponds (2.81%) and cages (7.50%). The high mortality recorded in the tanks reduced the stocking density and could have increased territoriality and aggression, as previously demonstrated by Mélard (1986). The same phenomenon can also negatively affect growth rate (Watanabe *et al*. 1990).

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