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### RESEARCH ARTICLE

## REPRODUCTIVE PERFORMANCE AND ECONOMIC ANALYSIS OF FRY PRODUCTION IN THE BRAZILIAN STRAIN OF *OREOCHROMIS NILOTICUS* IN CÔTE D'IVOIRE

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### Abstract

This study evaluated the reproductive performance and fingerling production cost of *Oreochromis niloticus*, Brazilian strain. The trials were conducted in concrete tanks at a stocking density of 1.6 fish/m<sup>2</sup> for broodstock. Larvae, stocked at 1000 larvae/m<sup>3</sup> in 1 m<sup>3</sup> hapas, were reared and fed for 28 days. The total number of larvae produced by 18 females of the Brazilian strain was 5,261 ± 387. The average number of larvae produced per female was 292.28 ± 15.6. The production potential of this strain corresponded to 0.55 ± 0.02 larvae per gram of female body weight. The initial mean larval weight was 0.01 ± 0.001 g. After 28 days of rearing, larvae reached a mean weight of 1.01 ± 0.05 g. The average survival rate obtained was 82.63 ± 3.37%. The average production cost was 0.023USD per fingerling. These results show that the Brazilian strain of *Oreochromis niloticus* exhibits promising reproductive performance and a production cost suitable for the Ivorian market and fish farming environment.

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### Introduction:-

The global supply of aquatic products was estimated at 171 million tonnes in 2016, with more than half originating from capture fisheries, contributing 53.18% of total production (Sissaoet al., 2019). However, aquaculture is experiencing rapid expansion, with an annual growth rate of around 13%, and has been the main source of fish for human consumption since 2014 (FAO, 2018). This trend occurs in a context of increasing global demand for fishery products, mainly driven by population growth and the need for sustainable management of natural resources (Diana, 2009; FAO, 2018). In this context, improving aquaculture production systems has become a priority at the global level. In Côte d'Ivoire, fish farming was introduced as early as the 1950s, but its development remains limited despite significant physical, climatic, human, and hydrographic potential favorable to the growth of the sector. Fish nevertheless represents the main source of animal protein in the diet of Ivorian populations, with an average consumption estimated at 15.4 kg per capita per year (Glasser, 2003). In 2024, national production covered only

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about 15 % of annual fish demand, estimated at 740,000 tonnes, forcing the country to import nearly 85 % of its consumption, mainly in the form of frozen fish (MIRAH, 2025).

Nile tilapia (*Oreochromis niloticus*), particularly the local Bouaké strain, accounts for nearly 90% of the species farmed by Ivorian fish farmers (MIRAH, 2025). However, the relatively low zootechnical performance of this strain has been a major constraint to the development of national aquaculture. To address this limitation, the Government of Côte d'Ivoire introduced an improved strain of *Oreochromis niloticus* from the Federative Republic of Brazil, with the aim of increasing productivity, enhancing the profitability of fish farming operations, and reducing the country's dependence on fish product imports (Tré Bi et al., 2023). In Côte d'Ivoire, increasing evidence has underscored the zootechnical value of the improved Brazilian strain of *Oreochromis niloticus*, introduced to foster the recovery of national aquaculture, with promising performances reported in terms of growth, survival, and adaptability across a range of production systems (Zea Biueet al., 2022; Tré Bi et al., 2023 ; Anvoet al., 2025). Nevertheless, while growth-related traits have received considerable attention in this tilapia strain, the reproductive performance and larval rearing capacity of this strain remain poorly documented under Ivorian conditions. Such knowledge is essential, given that reproductive traits, including spawning frequency, larval productivity, and early survival, are critical indicators for the evaluation and selection of improved strains (Abahoet al., 2025). In this context, the present study aims to analyze the reproductive and growth performance of broodstock and fry from this improved strain, as well as to determine the production cost of fry under station conditions. These parameters are essential indicators for assessing the techno-economic viability and the prospects for sustainable dissemination of this strain in Côte d'Ivoire.

## **Materials and Methods:-**

### **Description of the Study Site:-**

The study was conducted at the Inland Fisheries and Aquaculture Research Station (SRPAC) of the National Center for Agronomic Research (CNRA). It is located in central Côte d'Ivoire, 6 km from Bouaké, specifically within the Kongodékro classified forest (7°37' N latitude and 5°02' W longitude). The station covers an area of 114 ha. The facility includes ponds, tanks, an aquarium room, a hatchery, a biosecure area, and a quarantine unit. It has 50 concrete tanks of various volumes, 14 raceways, and 20 sorting tanks. The station comprises 80 ponds, covering a total water surface area of 2.5 ha. Individual pond sizes range from 50 m<sup>2</sup> to 1000 m<sup>2</sup>. These ponds are arranged in series and are supplied with water by gravity from the Kan dam and by pumping from a borehole.

### **Biological Material:-**

The tilapia species used in this study was *Oreochromis niloticus* (Brazilian strain). This strain is considered improved because its growth performance has been enhanced compared to the local strain through selective breeding and crossbreeding. The broodstock used in this experiment consisted of representatives of the 39th selected generation originating from Brazil. These fish were introduced to the SRPAC in July 2014. A total of 48 broodstock were used, including 12 males and 36 females. These broodstock were used to produce larvae, which were subsequently reared into fry.

### **Measurement of Physicochemical Parameters:-**

The monitoring of water physicochemical parameters was carried out twice a week throughout the experimental period. Measurements were taken using a HANNA multiparameter device. The device was switched on, then the probe was immersed in the water in order to record temperature, pH, and dissolved oxygen values.

### **Experimental Procedure:-**

Before the onset of reproduction, male and female broodstock were kept separately in holding tanks to ensure proper physiological conditioning. Each individual was then weighed before being introduced into the reproductive units. The sample size (a total of 48 broodstock, including 12 males and 36 females) was determined based on the available experimental infrastructure capacity, while ensuring a sufficient number of individuals to guarantee regular larval production and the representativeness of reproductive performance. The composition of the broodstock, following a sex ratio of 1 male to 3 females (El-Sayed, 2020), was adopted to optimize fertilization, reduce male-to-male competition, and limit aggressive behavior, while maximizing larval output per spawning cycle. Two reproduction cycles were conducted in two concrete tanks of 15 m<sup>2</sup> each. The stocking density was set at 1.6 individuals/m<sup>2</sup>, corresponding to 6 males and 18 females per tank. The average weight of males was 996 ± 87 g, while that of females was 527 ± 58 g. The broodstock were fed a commercial pelleted feed containing 36% crude protein, administered at a daily ration equivalent to 2–3% of biomass (El-Sayed, 2020). Fourteen days after stocking

for reproduction, larvae were collected. A total of 200 larvae were individually weighed to determine their initial mean weight. The broodstock were then individually weighed and returned to resting tanks according to sex and weight class. This rotation system helps reduce physiological stress and prepares the fish for subsequent reproductive cycles. For larval rearing, 3000 larvae were stocked in three hapas at a density of 1000 larvae/m<sup>3</sup>. The larvae were fed a commercial feed containing 55% crude protein. Feeding rates were gradually adjusted according to age (El-Sayed, 2020). Thus, feeding rates of 25%, 20%, 15%, and 10% of biomass were applied during the first, second, third, and fourth weeks, respectively. During each weekly sampling, 50 larvae were randomly collected from each hapa and individually weighed to determine the mean weight, which was used to adjust the feeding ration. The larval rearing period lasted 28 days.

#### **Zootechnical and Reproductive Parameters:-**

**Zootechnical and reproductive performances were evaluated using the following parameters (Castel and Tiews, 1980; Guillaume et al., 1999):**

**Daily growth (g/day)**=(final weight – initial weight) / (rearing duration)(1)

**Survival rate (%)** = ((number of survivors) / (initial number) x 100)(2)

**Number of fry per female (Fry/female)** =

(total number of fry produced per collection) / (total number of females )(3)

#### **Economic Parameters:-**

The economic analysis focused specifically on production costs related to feed, which is considered the main expense in aquaculture. Labor cost for the 42-day rearing period was set at 37.5USD, corresponding to 0.89 USD per day.

#### **Several economic parameters were calculated:**

**Cost of broodstock feed (USD)** =Quantity of feed used x Cost per kilogram of feed (2.58USD / Kg)(4)

**Cost of fry feed (USD)** = Quantity of feed used x Cost per kilogram of feed (16.07 USD / Kg)(5) ;

**Total expenditure (USD)** =Cost of broodstock feed (USD) + Cost of larval feed (USD) + Labor cost (USD) (6) ;

**Production cost (USD per fry)**=Total expenditure (USD) / Number of fry (7).

#### **Statistical analysis:-**

The data were recorded in Excel (version 2016). Descriptive statistics (means and standard deviations) were calculated for each zootechnical and reproductive parameter.

#### **Results:-**

##### **Physicochemical characteristics of the rearing environment:-**

Figure 1 shows the evolution of the physicochemical parameters of water during the larval rearing period. Temperature (Figure 1A) ranged from approximately 26.2 °C to 30.6 °C, with a decrease observed between day 0 and day 7, followed by a progressive increase up to day 21, and then a slight decline at day 28. Dissolved oxygen (Figure 1B) fluctuated within a narrow range of approximately 4.2 to 4.9 mg/L, with a slight decrease at day 14, followed by an increase up to day 21 and stabilization at day 28. pH (Figure 1C) varied between approximately 6.75 and 7.45, showing a decrease between day 0 and day 7, an increase at day 14, another decrease at day 21, and a final increase at day 28. Overall, the three parameters exhibited temporal variations with relatively limited amplitudes.

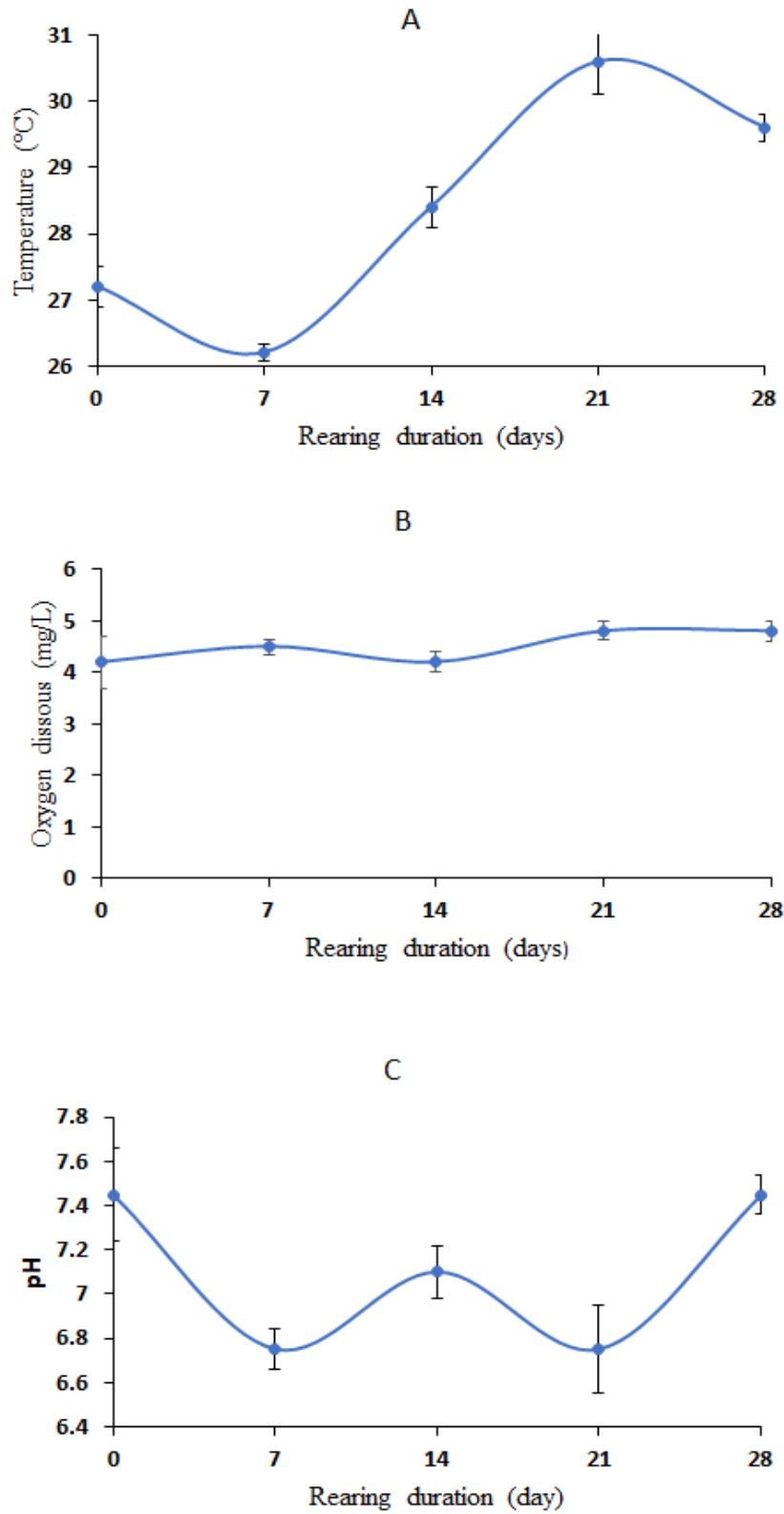


Figure 1 : Physicochemical changes in water quality parameters during larval rearing

**Weight growth and survival rate of broodstock:-**

During the reproduction period, broodstock of the «Brazil» strain showed a moderate increase in their mean body weight (Table I). In males, weight increased from  $996 \pm 87$  g to  $1,034 \pm 79$  g, whereas in females it rose from  $527 \pm 58$  g to  $572 \pm 68$  g. The recorded daily growth rate was estimated at  $1.2 \pm 0.39$  g/day for males and  $1.4 \pm 0.40$  g/day for females.

**Reproductive performance:-**

Reproduction of broodstock from the «Brazil» strain yielded an average of  $5,261 \pm 387$  larvae per cycle. The mean individual weight of larvae at collection was  $0.01 \pm 0.001$  g. Each female produced an average of  $292.28 \pm 15.6$  larvae, corresponding to a specific productivity of  $0.55 \pm 0.02$  larvae per gram of female (Table I).

**Larval growth and survival:-**

After 28 days of rearing in happas, the larvae reached the fingerling stage, with a mean weight of  $1.01 \pm 0.05$  g. The daily growth rate during this phase was estimated at  $0.033 \pm 0.0094$  g/day. The average survival rate obtained was  $82.63 \pm 3.37\%$  (Table I).

**Table I: Zootechnical and reproductive parameters of the «Brazil» strain of Nile tilapia (*Oreochromis niloticus*)**

Phases	Parameters	Mean values
<b>Broodstock</b>	Initial male weight (g)	$996 \pm 87$
	Final male weight (g)	$1,034 \pm 79$
	Initial femaleweight (g)	$527 \pm 58$
	Final femaleweight (g)	$572 \pm 68$
	Daily growth rate – males (g/day)	$1.2 \pm 0.39$
	Daily growth rate – females (g/day)	$1.4 \pm 0.40$
	Survival rate (%)	$100 \pm 0$
<b>Larval phase</b>	Number of larvae produced per cycle	$5,261 \pm 387$
	Meanlarvalweight (g)	$0.01 \pm 0.001$
	Number of larvae per female	$292.28 \pm 15.6$
	Number of larvae per g of female	$0.55 \pm 0.02$
<b>Fingerling phase</b>	Final mean weight of fingerlings (g)	$1.01 \pm 0.05$
	Daily growth rate (g/day)	$0.033 \pm 0.0094$
	Survival rate (%)	$82.63 \pm 3.37$

**Economic parameter:-**

The economic parameters related to larval production are presented in Table II. The cost of feed for broodstock amounted to 14dollars, while that used for larvae reached 51.42dollars. The total number of fingerlings produced during the trial was 4363 individuals. In addition, the total expenditure was estimated at 102.93dollars, corresponding to a unit cost of 0.023 dollars per 1 g fingerling produced.

**Table II: Selected economic parameters of larval production**

Parameters	Mean values
Broodstockfeedquantity (g)	5412
Broodstockfeedcost (USD)	14

Larval feed quantity (g)	3209
Larval feed cost (USD)	51.42
Labor cost (USD)	75
Total expenditure (USD)	102.93
Number of fingerlings	4363
<b>Production cost per fingerling (USD)</b>	<b>0.023</b>

### Discussion:-

During this study, the physicochemical parameters of the water remained within the ranges considered optimal for the reproduction and growth of Nile tilapia (*Oreochromis niloticus*), namely a temperature between 26 and 30 °C, a dissolved oxygen concentration above 4 mg/L, and a pH ranging from 6.5 to 8.0 (El-Sayed, 2006; FAO, 2019).

The weight evolution of *Oreochromis niloticus* broodstock of the «Brazil» strain showed a clear increasing trend in both sexes, rising from 996 ± 87 g to 1034 ± 79 g for males and from 527 ± 58 g to 572 ± 68 g for females. This progression reflects the good adaptation of the broodstock to the experimental conditions, characterized by favorable water quality and a protein-rich diet. The differences observed between sexes can be explained by distinct physiological strategies: males allocate a significant portion of energy from feed to somatic growth, whereas females invest more in vitellogenesis and egg production (Toguyenet al., 2002 ; 2009). This differential energy allocation justifies the slightly higher growth observed in females. Furthermore, the daily growth rate of broodstock, estimated at 1.2 ± 0.39 g/day for males and 1.4 ± 0.40 g/day for females, appears higher than values reported in earlier studies conducted in Côte d'Ivoire (Lazard, 1980), but is consistent with results obtained in genetic improvement programs in West Africa, where rates between 1.0 and 1.5 g/day have been reported (Bentsen et al., 2017). The 100% survival rate confirms the robustness of the rearing protocol and the good control of experimental conditions, largely exceeding the minimum threshold of 90% generally accepted in tilapia aquaculture (Mabroket al., 2018).

Regarding reproductive performance, the average number of larvae produced per cycle was 5,261 ± 387, corresponding to a mean fecundity of 292.28 ± 15.6 larvae per female and 0.55 ± 0.02 larvae per gram of female. These results are comparable to those obtained with other improved strains in Ghana and Nigeria, where fecundity levels ranging between 200 and 300 larvae per female have been reported (Ayinla et al., 2019; Attipoet al., 2021). Nevertheless, the nutritional quality of the diet, particularly energy, lipid, and protein levels, represents a key factor in regulating sexual maturation, fecundity, and larval survival (Masrizalet al., 2015; Ribeiro et al., 2017). At the larval stage, the individual weight of collected larvae (0.01 ± 0.001 g) is consistent with standards reported for *Oreochromis niloticus* (Ridha & Cruz, 2018). However, after 28 days of rearing in happas, the average survival rate recorded (82.63 ± 3.37%) remains below international benchmarks, which generally range between 85 and 95% under controlled conditions (Azevedo et al., 2015; Abdel-Tawwab et al., 2020). Several factors may explain this reduced survival rate. On one hand, the larval stocking density applied (1000 individuals/m<sup>2</sup>) likely increased feeding competition and promoted cannibalism, a well-documented phenomenon in tilapia (El-Sayed, 2020; Abdel-Tawwab, 2012). On the other hand, the nature of the feed provided, consisting of a powdered diet with 67% protein, although energy-rich, may have presented limitations in terms of digestibility and availability of polyunsaturated fatty acids, which are essential for larval development (El-Sayed et al., 2019). Finally, the manual “broadcast feeding” method used under field conditions results in heterogeneous feed distribution, which may increase growth disparities and mortality.

These findings raise several avenues for improvement. The incorporation of live feeds such as rotifers or natural zooplankton during the first days post-hatching could enhance larval survival, as demonstrated by recent studies conducted in Côte d'Ivoire and Cameroon (Konan et al., 2022; Nguemmet al., 2023). Moreover, reducing initial stocking densities or transferring larvae earlier into ponds could limit the intensity of cannibalism and improve survival rates. Finally, more rigorous monitoring of physicochemical parameters, particularly ammonia and nitrites, would help better identify the causes of the observed mortalities. From an economic perspective, although the quantity of feed distributed to broodstock was higher than that provided to larvae, larval feed was more expensive due to its higher protein content (55% compared to 36% for broodstock feed). According to Thabet (2017), the production cost of a 2 g fingerling in geothermal water, including all fixed and variable costs, is estimated at 0.023 USD. In the present study, the production cost of a 1.06 ± 0.6 g fingerling was slightly lower, at 0.023 USD. This

relatively small difference can be explained mainly by two factors. First, the infrastructure used in the experimental setup has already been depreciated, thereby reducing fixed costs (equipment depreciation and initial investments). Second, some operational costs were not fully integrated into the estimation, particularly certain indirect and variable expenses (full maintenance, indirect labor, energy, or secondary inputs, depending on the case). Thus, the observed cost reflects more an experimental or partially consolidated production cost rather than a complete economic cost. Nevertheless, these results indicate that fingerling production in hatchery conditions can achieve a relatively competitive cost level, which represents a potential advantage for the aquaculture sector by facilitating farmers' access to quality fingerlings at lower cost.

### Conclusion:-

This study highlighted the reproductive and economic performance of the Brazilian strain of *Oreochromis niloticus* under controlled conditions in Côte d'Ivoire. The results show a satisfactory larval production ( $292.28 \pm 15.6$  larvae per female), a high larval survival rate ( $82.63 \pm 3.37\%$ ), and good growth up to the fingerling stage ( $1.01 \pm 0.05$  g after 28 days). The relatively low production cost (0.023 USD per fingerling) confirms the economic competitiveness of this strain. Overall, these performances indicate that the Brazilian strain represents a promising alternative for improving productivity and profitability in aquaculture of Côte d'Ivoire.

### Conflict of Interest:-

The authors declare that they have no conflict of interest.

### Authors' Contributions:-

All authors contributed to this article according to their respective roles.

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