REPRODUCTIVE PERFORMANCE OF TILAPIA *OREOCHROMIS NILOTICUS* (LINNAEUS, 1758) IN HAPAS INSTALLED IN PONDS AT THE LAYO EXPERIMENTAL STATION (CÔTE D'IVOIRE).

Abstract:

The limited availability of high-quality fingerlings is a major constraint to the development of fish farming in Côte d'Ivoire. This study aimed to evaluate the reproductive performance of Oreochromis niloticus reared in hapas installed in earthen ponds at the Layo Experimental Aquaculture Station. Two 7.5 m² hapas, each stocked with 42 broodstock (sex ratio of one male to two females; density of 5.6 broodstock/m²), were monitored for six weeks. Water physicochemical parameters and reproductive performance (larval production, apparent production per female, and production per unit area) were assessed. Environmental conditions remained favourable for reproduction (temperature: 29.61 ± 0.94 °C; pH: 6.18 ± 0.47; dissolved oxygen: 4.63 ± 0.65 mg/L; conductivity: 0.214 ± 0.021 mS/cm). Survival rates exceeded 96%, males showed higher weight gains than females, and reproductive performance reached a mean apparent production of 97 larvae per female and a mean production of 362 larvae/m². These results show that the hapa system is a suitable technique for the controlled reproduction of O. niloticus and can contribute to improving fingerling availability in Côte d'Ivoire.

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Key words:-

Oreochromis niloticus, Hapa, Reproduction, Production larvaire, Alevins, Côte d'Ivoire

Introduction:-

Aquaculture is now emerging as a key sector of global food production. According to FAO (2024), world production of aquatic products reached 223.2 million tonnes in 2022, of which 130.9 million tonnes came from aquaculture, representing more than 51% of aquatic products intended for human consumption. This trend reflects the strategic importance of aquaculture in the face of stagnating capture fisheries and growing demand for animal protein (FAO, 2022). Among aquaculture species, tilapia Oreochromis niloticus occupies a prominent place, with world production estimated at over 7.5 million tonnes in 2023 (El Sayed and Fitzsimmons, 2023). In sub-Saharan Africa, it represents the main freshwater farmed species and constitutes an affordable source of protein for low-income populations (Adeleke *et al*., 2021).In Côte d'Ivoire, fishdemandexceeds 700,000 tonnes for an averageconsumption of about 25 kg/inhabitant/year, while local production, estimated at between 90,000 and 100,000 tonnes, remainsinsufficient (FAO,2024). One of the main constraints to the development of fishfarmingremains the limitedavailability of qualityfingerlings. Control over reproduction thusappears as a determining factor for improvingfarmproductivity (Mugwanya *et al.*, 2022). Reproductive performance of broodstockisindeed a central factor in seed production in Nile tilapia:poorgenetic, nutritional, or physiologicalquality of broodstock can significantlyreducelarval production and affect the survival and growth of fingerlings. Similarly, unsuitable practices such as unbalancedfeeding, high stockingdensities, or unfavorablephysicochemical conditions limithatcheryproductivity (Asase*et al*, 2021 ; Engdaw and Geremew, 2021 ; Akian*et al*, 2022).

Among controlled reproduction systems, the hapa (fine-mesh net cage installed in a pond) offers the advantage of better broodstock control, easier larvae collection, and reduced cannibalism, at a moderate installation cost suited to small-scale producers (Bhujel, 2013; El Sayed, 2020). However, quantitative data on its performance under Ivorian conditions remain limited. The present study, conducted at the Layo Experimental Aquaculture Station (Dabou), had the general objective of evaluating the reproductive performance of *O. niloticus* reared in hapas installed in ponds. Specifically, it aimed to analyze the rearing environment conditions, determine the zootechnical performance of broodstock, and characterize their reproductive performance.

Materials and methods: -

Study site and period: -

The study was conducted at the Layo Experimental Aquaculture Station, an annex unit of the Centre de RecherchesOcéanologiques (CRO), located approximately 40 km from Abidjan and 6 km from Dabou, along the Ébrié lagoon (Côte d'Ivoire) (Figure 1). The six-week experiment was carried out in pond N°17 (16.5 m × 13 m; average depth of 0.80 m; surface area of 214.5 m²), supplied from a borehole via a 32 mm diameter PVC pipe.

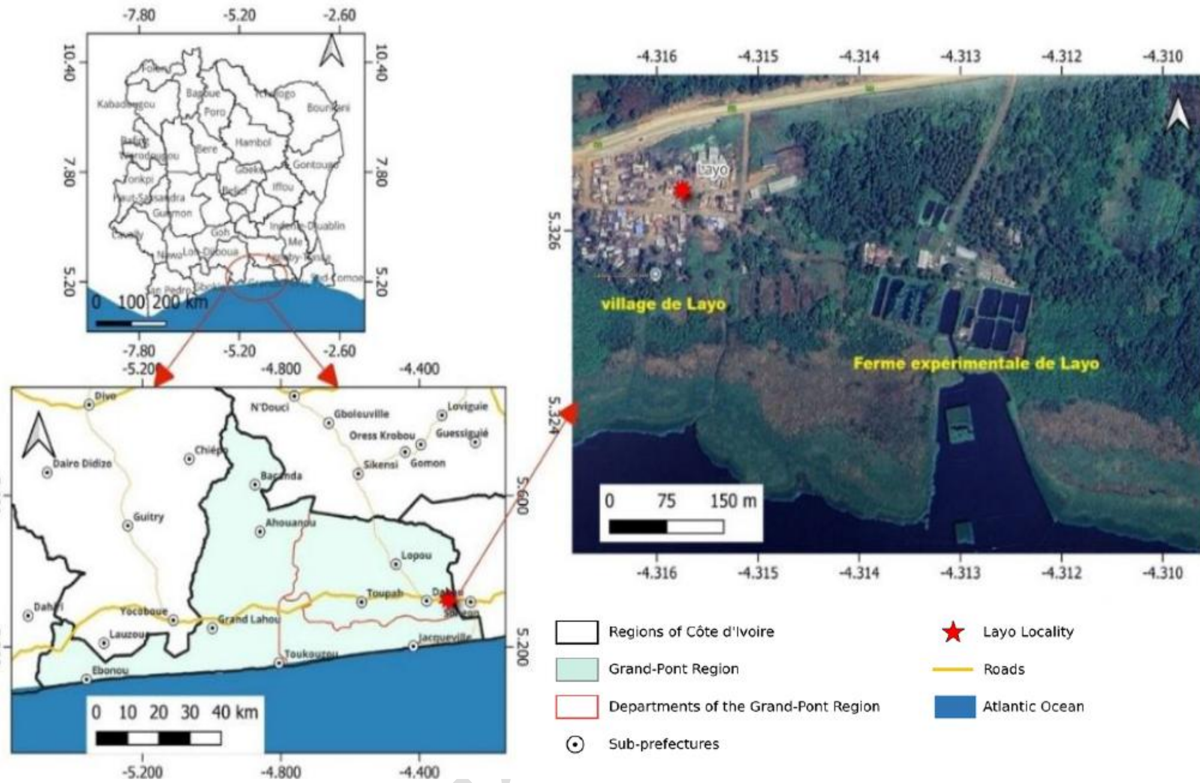

Figure 1: Geographic location of the Layo experimental farm

Biologicalmaterial and experimental design:-

*O. niloticus*broodstockwerecaptured by seine net (12 mm mesh) in a pond at the station, thenselectedbased on the absence of injuries, deformities, and apparent signs of disease;sexingwasperformed by visualexamination of the genitalpapilla. Two rectangular net hapas (1 mm mesh; 3 m × 2.5 m × 1 m; unit surface area of 7.5 m²) wereinstalled in pond N°17 usingbamboo supports. Eachhapawasstockedwith 42 broodstock (14 males and 28 females), corresponding to a sex ratio of 1 male to 2 females and a density of 5.6 broodstock/m². Initial individualbiometry (weight to the nearest 0.01 g using a Fisher Scientific scale; total lengthusing an ichthyometergraduated in millimeters) wascarried out prior to stocking (Table 1)

Table 1. Initial biometric characteristics of broodstock (mean ± standard deviation)

Hapa	Sex	Mean weight(g)	Total length (cm)
Hapa 1	Males	150,48 ± 31,58	21,09 ± 2,09
Hapa 1	Females	112,93 ± 30,77	18,54 ± 1,65
Hapa 2	Males	154,44 ± 32,82	20,70 ± 2,38

Hapa 2	Females	120,47 ± 31,04	18,84 ± 1,54

Rearing management:-

Broodstock were fed three times a day (8 a.m., 12 p.m., and 4 p.m.) with a commercial floating feed (Koudijs Tilapia 4 mm; 32% crude protein), at a feeding rate of 3% of total biomass per day. The dailyfeed ration (RA) wascalculatedusingequation (1):

RA (g) = total biomass (g) × feeding rate (1)

with total biomassobtained as the sum of the products of meanweight by the number of individuals of eachsex. Daily rationswerethus 165.99 g (hapa 1) and 168.78 g (hapa 2). At eachharvest, the hapas in service werereplaced; the removedhapaswerecleaned by brushing, inspected for possible perforations, mended, and then put back into service.

Measurement of physicochemicalparameters: -

Temperature (°C), pH, dissolvedoxygen (mg/L), and electricalconductivity (mS/cm) weremeasured once a week, between 7 a.m. and 9 a.m., using a LovibondSensoDirect 150 portable multi-parametermeter.

Larvae collection and evaluatedparameters:-

Larvae were collected every two weeks. A bamboo pole slid under the net made it possible to isolate broodstock and larvae on one side of the hapa; larvae were then collected using a fine-mesh sieve and transferred into buckets. The total mass of collectedlarvaewasmeasured, then a representativesamplewasweighed to estimate the meanweight. The total number of larvae (N) wasestimatedgravimetricallyusingequation (2):

N = total weight of larvae / mean unit weight of larvae (2)

Collectedindividualsweretransferredinto nursery hapas (1 mm mesh) and feddailywith a powderedfeedcontaining 45% crudeprotein. Performance wasevaluatedusing the followingindicators:

Survival rate (SR, %) = (final number / initial number) × 100;

Weight gain (WG, g) = final meanweight − initial meanweight;

Apparent production per female (APF, larvae/female) = total number of larvae / number of females;

Production per unit area (PUA, larvae/m²) = total number of larvae / hapa surface area.

Statisticalanalysis:-

Data wereprocessedusingspreadsheet software (Microsoft Excel 2013) and expressed as mean ± standard deviation. Given the number of experimentalunits (twohapas), comparisonsbetweenhapas are based on descriptive analysis.

Results:-

Water physico-chemical parameters:-

The physico-chemical parameters remained generally stable over the six weeks (Table 2). pH ranged from 5.28 to 6.60, with a mean of 6.18 ± 0.47; dissolved oxygen ranged from 3.87 to 5.00 mg/L (4.63 ± 0.65 mg/L); temperature ranged from 28.13 to 30.70 °C (29.61 ± 0.94 °C); and conductivity ranged from 0.194 to 0.249 mS/cm (0.214 ± 0.021 mS/cm).

Table 2. Weekly evolution of the physico-chemical parameters of the water during the experimental period.

Week	**pH**	**Dissolved O_2 (mg/L)**	**Temperature (°C)**	**Conductivity (mS/cm)**

W1	6,19	5,00	30,03	0,204
W2	6,13	4,83	29,73	0,194
W3	6,45	3,87	30,17	0,249
W4	5,28	4,73	28,13	0,227
W5	6,43	4,37	28,87	0,213
W6	6,60	4,97	30,70	0,196
Mean	6,18 ± 0,47	4,63 ± 0,65	29,61 ± 0,94	0,214 ± 0,021
Minimum	5,28	3,87	28,13	0,194
Maximum	6,60	5,00	30,70	0,249

Survival and weight gain of broodstock:-

Survival rate was 100% in hapa 1 (males and females) and 96.43% in hapa 2, with the onlymortality (one male) occurring at the end of the experiment. In bothhapas, males recordedhigherweight gain thanfemales (Figure 2): 27.07 g versus 17.72 g in hapa 1 (a difference of 9.35 g) and 27.02 g versus 16.34 g in hapa 2 (a difference of 10.68 g)

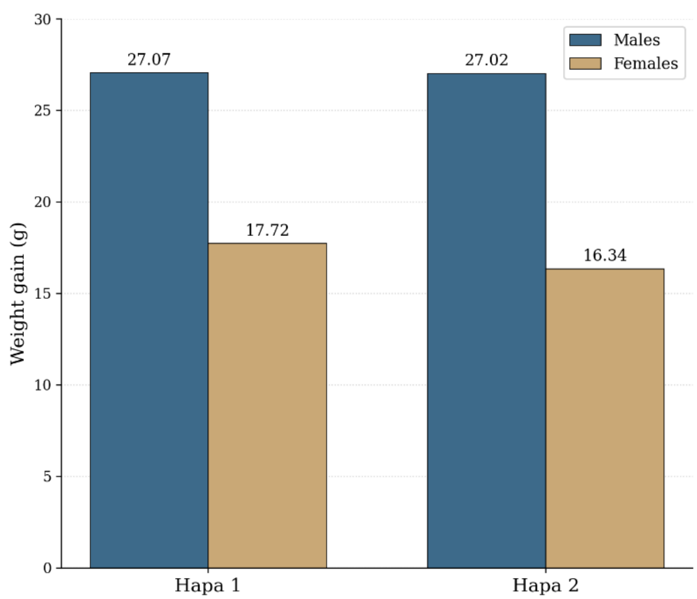

Figure 2: Weight gain of broodstock by sex and hapa.

Reproductive performance:-

Total larval production was higher in hapa 1 (2903 larvae) than in hapa 2 (2518 larvae), while the average unit weight of the larvae was slightly higher in hapa 2 (0.07 g versus 0.05 g) (Table 3). Apparent production per female

(APF) reached 104 larvae/female in hapa 1 and 90 larvae/female in hapa 2 (mean: 97 larvae/female); production per unit area (PUA) was 387 and 336 larvae/m² respectively (mean: 362 larvae/m²).

Table 3. Total larval production, average larval weight, and reproductive indices by hapa.

Parameter	**Hapa 1**	**Hapa 2**
Total larval production	2 903	2 518
Average larval weight (g)	0,05	0,07
APF (larvae/female)	104	90
PUA (larvae/m²)	387	336

Discussion:-

The physico-chemicalparametersrecordedremainedgenerally favorable for the reproduction of *O. niloticus*. The meantemperature (29.61 °C) fallswithin the optimal range of 26-30 °C recognized for the reproductive activity of Nile tilapia (Melard, 1986 ; El Sayed, 2020), and the low amplitude observedreflects good thermal stability of the environment. The mean pH (6.18), althoughslightlybelow the generallyrecommended optimum of 6.5-8.5, did not constitute a limiting factor, as the speciestolerates a wide range of pH values (Egemen, 2012). The meandissolvedoxygen concentration (4.63 mg/L) remained close to the favorable threshold of 5 mg/L (Choudhary and Sharma, 2018), with the speciesmoreover able to withstandlowerlevelsthanks to itscapacity to use oxygenfrom the air-water interface (Boyd and Turkey, 2012). Finally, the meanconductivity (0.214 mS/cm) reflectssatisfactorymineralization of the environment.

The high survival rates (100% and 96.43%) reflect the good adaptation of the broodstock to the hapa system. The isolatedmortality of one male at the end of the experimentislikelyattributable to individual stress ratherthan to a generaldeterioration of rearing conditions. Comparable survival rates werereported by Akian*et al*., (2022) for *O. niloticus*reared in hapas in Côte d'Ivoire.
In bothhapas, males showedhigherweight gains thanfemales. This differenceislargelyexplained by maternalmouthbroodingbehavior : during the period of carryingeggs and larvae, femalessubstantiallyreducetheirfeedintake, whichlimitstheirgrowth (Kuwaye *et al*., 1993). This growthdimorphism, welldocumented in the species (Trewavas, 1993), also justifies the interest in all-male monosex culture for commercial production.
The reproductive performance obtained confirms the suitability of the hapa system for ensuring effective larval production. The mean APF (97 larvae/female) is very close to the productivity of 93.1 larvae/female reported by Akian*et al*., (2022) for the same species in Côte d'Ivoire, attesting to the consistency of these results with regional references. The differences observed between hapas namely the higher total production in hapa 1 and the higher larval mass in hapa 2 may result from individual differences in fecundity, size, or physiological state of the females, as well as from the temporal variability of reproductive cycles characteristic of the species (Coward and Bromage, 2000). The PUS values (336-387 larvae/m²) reflect good productive efficiency of the system while optimizing the use of available surface area.

Conclusion:-

This study shows that the reproduction of Oreochromis niloticus in hapas installed in ponds at the Layo Station took place under favorable physico-chemical conditions, with high survival rates and satisfactory reproductive performance (mean APF of 97 larvae/female; mean PUA of 362 larvae/m²), consistent with regional references. The hapa system thusappears to be a simple and low-cost controlled reproduction technique, capable of contributing to improvedfingerlingavailability and to the sustainabledevelopment of Ivorianfishfarming.

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Conflicts of Interest:-

The authorsdeclare no conflicts of interestregarding the publication of thispaper.

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