Research Article

Effects of Stocking Density on the Growth and Survival of Nile Tilapia (*Oreochromis niloticus*) Fry in Floating Cages in Togo

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ABSTRACT

Aim/Background: To determine the optimal stocking density of juvénile *Nile tilapia (Oreochromis niloticus)* allowing better growth and survival of fish in floating cages on the Zio River Dam at Quality Agro-Fish Farm in Togo. **Materials and Methods:** Three stocking densities (D1=350 individuals, D2=500 individuals and D3=750 individuals) were considered in the 1 m3 floating cages. The experiment was carried out in triplicate for 45 days. The subjects were fed 4 times a day at a feeding rate of 8% of their biomass with the Raanan diet. **Results and Conclusion:** The average temperature was 27.11 ± 0.30°C, the average pH 7.18 ± 0, 16 and average dissolved oxygen of 5.2 ± 0.95 mg/L. The initial average was 2 ± 0.09 g, the final average weights were 27.33 ± 0.11 g (D1), 25.42 ± 0.21 g (D2) and 20.05 ± 0.14 g (D3). Mortality was inversely proportional to the experimentation time ($p<0.05$). The highest average weight and survival rate are obtained at the level of the lowest D1 density (27.33 g and 90.86%) ($p<0.05$). The feed index was higher with the high density D3 (3.59), but the lowest and the best feed index was obtained with the low density D1 (2.884) ($p<0.05$). Thus, the optimal density obtained was 350 fry in a floating cage of 1 m^3.

Keywords: Alevin, Growth, Productive performance, Floating Cages, Time of control.

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INTRODUCTION

A very old practice, fish farming was however only recently introduced in sub-Saharan Africa because the first attempts at development date back to the colonial era and more precisely in 1940. This is how several species of fish in particular the Tilapia, have been chosen to be farmed. However, due to the poor mastery of farming techniques and methods, the euphoria aroused by the avenue of fish farming quickly waned. In addition, the considerable increase in the consumption of fish products observed in recent years has prompted some researchers and breeders to take a closer interest in the aquaculture sector and the problems that undermine it. Since the Nile Tilapia (*Oreochromis niloticus*) is one of the most widely used species in aquaculture (ranked second in the world, after carp, for the importance of aquaculture activities), it was then the subject of multiple studies to increase production. Thus, it was discovered that for better growth and production of this species, certain physicochemical and biological parameters should be respected or taken into account. Numerous studies carried out in intensive farming systems have thus revealed that several factors, namely the quantity and quality of the feed[1] and the stocking density of the fish[2-5] influence survival rate, growth, feed efficiency

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and production. The influence of this last factor (density) on growth and survival rate has been studied particularly in the Nile Tilapia (*Oreochromis niloticus*). The start-up phase is essential in any breeding, particular emphasis has been placed on the rearing phase, hence the many studies on the influence of density on the growth and survival rate of fry.[6-8]

It is with the aim of finding the optimal density allowing the best growth and survival of Nile Tilapia (*Oreochromis niloticus*) fry in floating cages that this study was conducted.

MATERIALS AND METHODS

Study zone

This study was conducted at the Quality Agro Fish Farm (QAFF) created in 2020. It is located in the southwest of Togo in the Maritime region, more precisely in the prefecture of Zio about twelve kilometres from the city of Kévé (Figure 1). It is located on the Kévé-Alokoégbé-Tsévié rural track and is surrounded by three villages: Zokopé to the north, Zogbépimé to the south and to the west by the village of Yometché. This farm enjoys a subequatorial or Guinean climate (southern climate) characterized by 2 rainy seasons (March-July and September-October) and 2 dry seasons (November-February and August).[9] It covers a total area of 25 ha. It houses a dam (Figure 2) of one hectare on which the floating cages for fish farming have been placed.

Materials

Biological material

The studies focused on 6,400 Nile Tilapia fry (*Oreochromis niloticus*) with an average weight of 2±0,09 g from the Lophty Farm fry centre in Avépozo, a locality located about 16 km from the city of Lomé in the Gulf prefecture. To ensure their survival during transport,

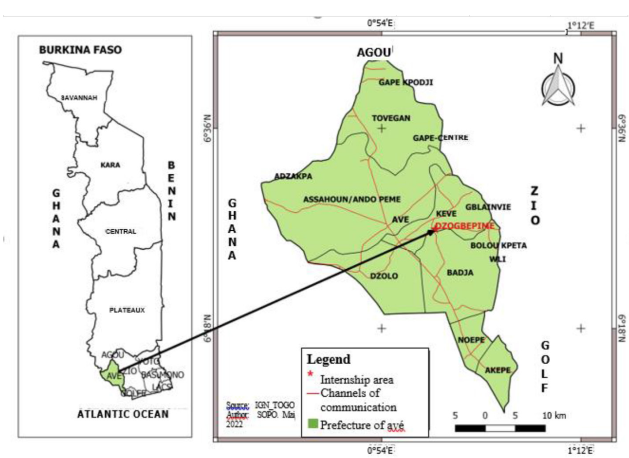

Figure 1: Map of Togo locating the QAFF farm.

Figure 2: Top view of the QAFF farm dam.

the fry was packaged in transparent bags containing hydrogen peroxide. The whole is put in an above-ground container and transported by a truck. The choice of this species is motivated by its robustness, its good growth, its wide diet and its ability to adapt to most breeding environments.

Expérimental material

The breeding equipment is made up of twelve (12) 1 m^3 cages made of norten wire with a 5-6 mm mesh, each containing a pre-fattening net. All these cages are floating and attached to trains. Each cage is covered with a metal frame which serves as a cover to fight against avian predation and four (04) cans serving as floats. Inside each cage, there is a feeding pocket which limits the loss of food. Ballasts (evians filled with sand) ensure the stability and balance of the base of the cage in the water. The experiment was conducted on a dam with an area of 1 ha and an average depth of 3 m. A homemade canoe is used to perform the various tasks on the water.

Expérimental food

The fry were fed a standard food, Rannan imported from Ghana and containing 48% protein, 7% fat and 2.5% crude fiber according to the manufacturer's specifications.[10]

Other material used

A multifunctional portable TDS/pH/TEMP meter with 0.1 accuracy, used for pH and temperature measurements. The dissolved oxygen level was obtained using a VWR – DO210 portable oximeter. A Senssun-EK3212 brand electronic scale, with a capacity of 5 kg and an accuracy of 0.1 g, was also used to check the average weight and to measure the quantity of the rations. Two basins, two buckets, a basket and a landing net were used when handling the individuals

Methods

Experimental apparatus

A device of 03 different batches or treatments (D1 = 350; D2 = 500 and D3 = 750) with 04 repetitions was carried out. Each fry treatment was housed in a

1 m^3 cage, i.e. a total of 12 cages used for the experiment. A minimum distance of 50 cm is left between the cage and the bottom of the body of water. Control fishing is carried out every 15 days.

The experiment is conducted for 45 days. In addition to the biological variables, the monitoring of the breeding has also slightly focused on the physico-chemical variables, the ration and the frequency of feeding. A one-week habituation period was necessary to allow the fish to familiarize themselves with their new living environment.

Production parameters

✓ **Physicochemical variables**

The pH, temperature and dissolved oxygen level were recorded daily at 8 a.m. and 3 p.m. according to the method of Faye *et al.*[8]

Biological variables

- **Growth**

After every 15 days, 10% of the total number of fry stocked in the floating cage was randomly sampled and weighed individually and then the average weight was determined. The following parameters were calculated

- Survival rate;

$$\mathbf{S}(\%) = \frac{\text{Number of fish alive at the end of the experiment}}{\text{Initial number of fish}} \times 100 \quad (1)$$

- Feed conversion rate;

$$\mathbf{IC} = \frac{\text{Quantity of food distributed (kg)}}{\text{Final biomass (kg)} - \text{initial biomass (kg)}} \quad (2)$$

- Average daily gain;

$$\mathbf{GMQ}(g/j) = \frac{\text{Final weight (g)} - \text{Initial weight (g)}}{\text{Breeding time (d)}} \quad (3)$$

Corrected biomass = final biomass (of the living) + biomass of the dead − initial biomass. Biomass = average individual weight (g) × Number of individuals.

Food ration and frequency of feeding

The daily ration distribution was established based on the average initial weight with a feeding rate of 8% of the biomass per day according to the method of Adjanké *et al.*[10] and the quantity of ration is readjusted after each average weight control. The food is distributed on the fly and 04 times during the day (08, 10, 14, and 16 hr).

Financial approach

✓ **Estimation of the cost price of one kilogram of food;** $\text{Pa(FCFA)} = \text{PVa} + \text{F}$ (5)

✓ **Estimation of the food cost of producing one kilogram of fish (CP)**

Table 1: Unit price estimate.

Designation	Treatments		
	D1	D2	D3
Price of a fry	30	30	30
Price of one kg of Raanan food	750	750	750
Price of one kg of fresh Tilapia	2,000	2,000	2,000
Price of a control fishery	175	250	350
Feeding price	50	70	115

CP (FCFA)=Cost price of one kg of food × Food conversion rate (6)

Labor cost estimate (MO)

✓ **Feeding cost calculation (Cn):**

Cn(FCFA) = Fn × Nn × Nj **(7)**

With Fn: fresh/food; Nn: number of feedings/day and Nj: number of feedings during the experiment.

✓ **Calculation of inspection fishing fees;**

Pc(FCFA) = Np × Fpc **(8)**

With Np: Number of control fishing at the end of the experiment; Fpc: Fee per control fishing

✓ **Gross profit margin; MBB)**

(FCFA) = Products-Expenses **(9)**

✓ **Estimated Unit Prices**

These estimates were made by considering the environment where the farm is located, the number of fry, the costs related to the crushing of the food and the transport of the fry and the food, the energy expended to carry out certain tasks (feeding, control fishing, etc.) and especially taking into account the density or the number of fish stocked in the different cages (Table 1).

Statistical analyzes

The average weights of fish reared at different densities and mortality are compared by analysis of variance and Duncan's test. The intra and inter-batch analyzes are obtained using the Stata IC 13 software. A 95% confidence threshold is chosen with consequently a margin of error of 5%. The calculation of consumption indices and daily growth rates is done with the Microsoft Excel Office 2019 spreadsheet.

RESULTS

Physicochemical parameters of water

The temperature varied from 26.75 to 27.50°C with an average of 27.11 ± 0.30°C. The pH values varied from 7.04 to 7.35 with an average of 7.18 ± 0.16. As for the dissolved oxygen values, they varied from 4.8 to 5.6 mg/L with an estimated average of 5.2 ± 0.95 mg/L.

Biological variables

The nursery rate had a significant influence on the results obtained. Density D3 showed a lower survival rate (87.46 ± 1.01%) than the other two treatments (D1 and D2) (Figure 3) and the highest average weight is obtained with density 1 (27.33 ± 0.15g) (Figure 4). Concerning mortality, the losses of the fry decreased significantly according to the time of control and the most important are observed during the first fifteen days of rearing (Figure 5). On the other hand, the best weight performance is observed in the third fortnight (24.30 ± 3.47 g) (Figure 6). It was also noticed that the fry grew or increased in weight significantly over time (Figures 7 and 8). The same observation was made with respect to the survival rate (Figure 9). Regarding feed, the conversion rate varied with density but not significantly (Figure 10).

Financial approach

Estimation of the average total cost of fingerlings and the cost of production of one kilogram of fish were determined from the prices of one fingerling

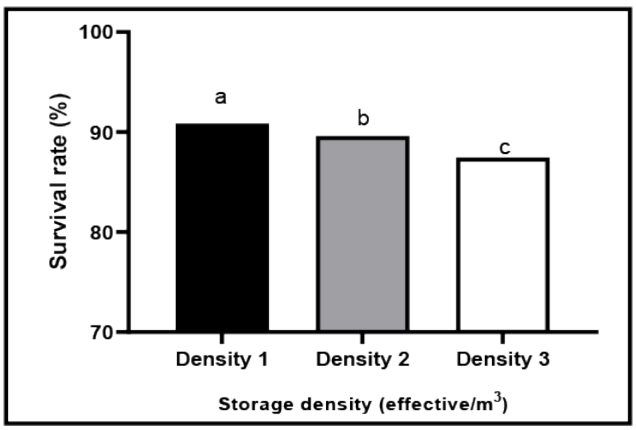

Figure 3: Influence of density on survival.

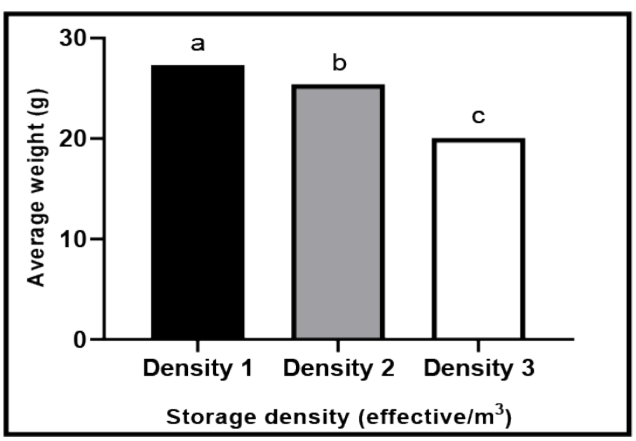

Figure 4: Influence of density on average weight.

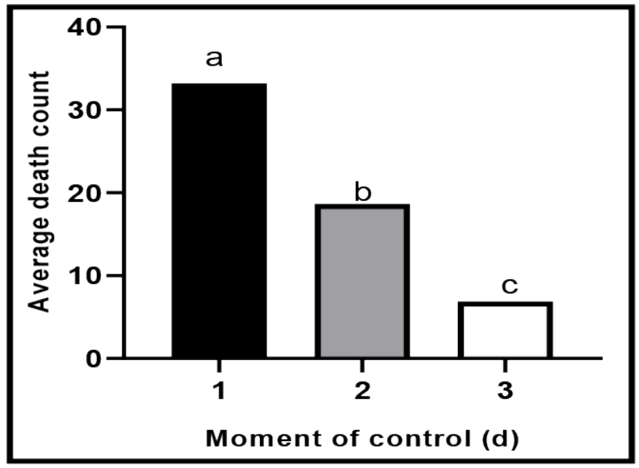

Figure 5: Influence of moment of control on mortality.

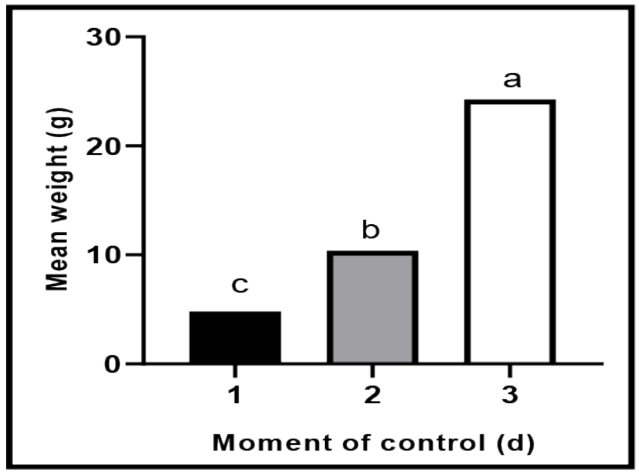

Figure 6: Influence of moment of control mean weigth.

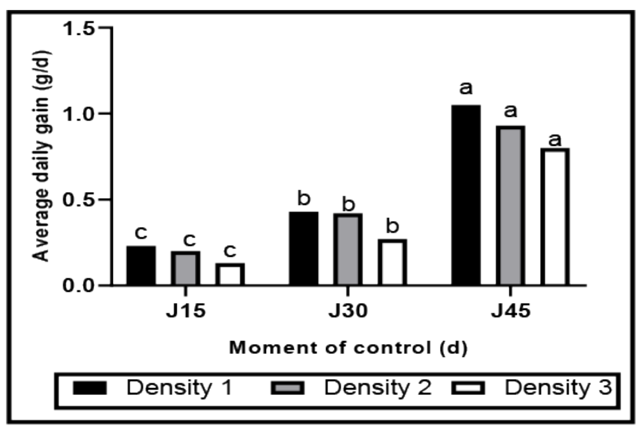

Figure 7: Influence of density and control moment on average daily gain.

and one kilogram of Raanan feed (Tables 2 and 3). The results showed that the D1 treatment presented the lowest production with a better gross profit margin (Table 4).

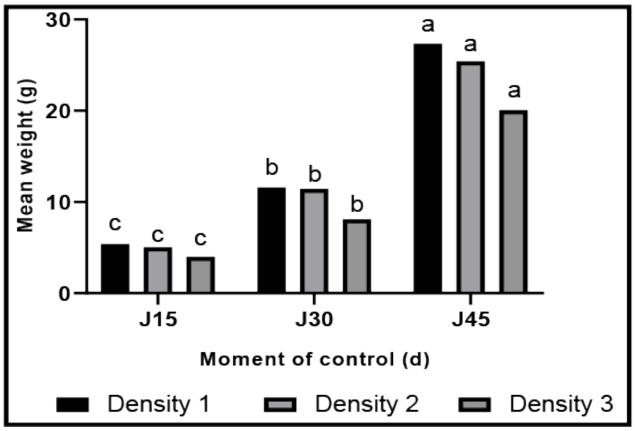

Figure 8: Influence of density and control moment on average weight.

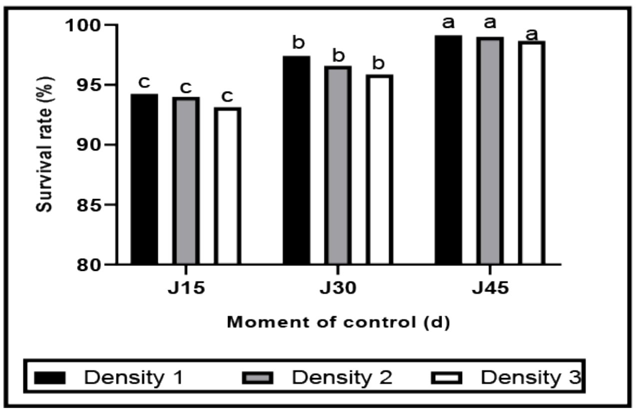

Figure 9: Influence of density and control moment on survival rate.

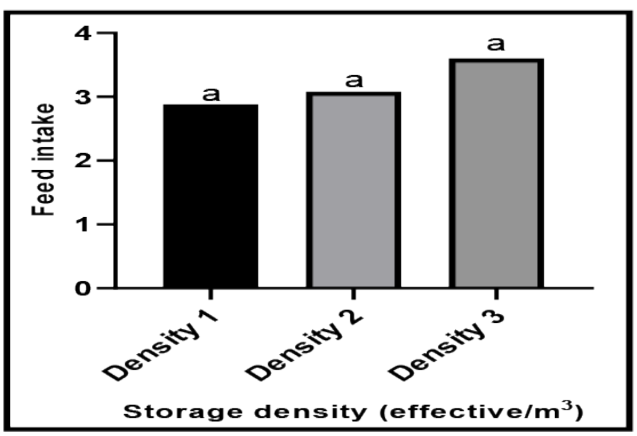

Figure 10: Influence of density on feed intake.

Table 2: Estimated average total fry cost.

Density	Price of a fry (F CFA)	Number of fry	Average total cost of fry (F CFA)
D1		350	10,500
D2	30	500	15,000
D3		750	22,500
Traitements(D)	30	1, 600	48,000

Table 3: Estimation of the cost of producing one kilogram of fish.

Density	Price per kilogram (F CFA)	IC	Production cost of one kg of fish (F CFA)
D1		2.884	2,163
D2	750	3.075	2,306.25
D3		3.596	2697
Total	750	9.555	7, 166.25

Table 4: Gross profit margin.

	Heading	Treatments		
		D1	D2	D3
Products	Initial number of fry	350	500	750
	Mortality	30	51	76
	Final number of fry	320	449	674
	Biomass produced at the end of the trial (kg)	9. 87	12.71	14.54
	Production value (F CFA)	19,740	25,420	29,080
Expenses	Quantity of feed distributed (kg)	10.526	14.054	16.886
	Total feed cost (F CFA)	7,894.5	10,540.5	12, 664.5
	Workforce 1: Feeding cost (F CFA)	9,000	12,600	20,700
	Workforce 2: Control fishing price (F CFA)	525	750	1,125
	Value of expenses (F CFA)	17,419.5	2,389.5	34,489.5
	Gross profit margin (F CFA)	2,320.5	1,529.5	-5,409.5

DISCUSSION

Physicochemical variables

The temperature varied between 26.75 and 27.50°C with an average of 27.11 ± 0.30°C throughout the test. This result is similar to that obtained (27.2 ± 1.24°C) in water from Lac de Guiers, Sénégal with the same species by Faye *et al.*[8] This result also confirms those found by New *et al.*[11] for the cultivation of Tilapia in the Nile in Egypt. The lower and upper lethal temperatures for this fish are respectively 11-12°C and 42°C, while the optimum temperatures are between 31 and 36°C according to FAO,[12] we can therefore say that the temperatures obtained during the test correspond to the optimal values for good growth of the species. Water pH varied between 7.04 and 7.35; with an overall mean of 7.18 ± 0.16. The dissolved oxygen values recorded during this study fluctuate between 4.8 and 5.6 mg/L with an overall average of 5.2 ±0.95 mg/L. It emerges from this study that the values of the physicochemical parameters of the water (temperature, pH and dissolved oxygen level) collected during the test tally perfectly with the values recommended.[13-15] Therefore, these physicochemical variables did not influence the performance expression of Nile Tilapia fry.

Biological variables

Mean fry weight was a function of density and time of control, and lower densities had better growth and survival. Mortality also varied over time. The most losses ($p<0.05$) of fry (33%) are observed during the first fortnight of rearing. These can be explained, among other things, by the stress associated with transport and handling, the difficulties of adapting to the new environment or the fragility of the fry acquired (too young).

In addition, the average weight is also influenced by the time of control and the best average weights were observed during the 3rd fortnight (24.30 g) of breeding followed by the second fortnight (10.40 g) and the first fortnight (4.80 g). All these results agree with those of Faye *et al.*[8] and confirm those of[16] on the mean body weight of monosex male Tilapia.

The average weight is also influenced ($p <0.05$) by the density with a high average weight (27.33 g) obtained with the D1 treatment followed by that of D2 (25.42 g) and finally D3 (20.05 g).

Growth is also a function of density and control moment. The results of the first fortnight show a low Average Daily Gain, linked to the adaptation of individuals to new farming conditions and stress. On the other hand, a better ADG is observed during the 2nd and 3rd fortnights with better growth results obtained with the D1 treatment. These results are slightly better than those obtained by Faye *et al.*[8] with D2 and D3 treatments, which can be explained in the present case by the use of a more protein-concentrated feed and better feed fragmentation (04 times/day). Gueye[17] and Gomez-Marquez *et al.*[16] estimate for their part that from the fry stage to a biomass of 300 g, a population (male and female) of Tilapia grows on average 1 g/day/individual.

The survival rate was influenced by both density and time of control. Over the entire duration of the trial (45 days), this rate is relatively very high. The best survival rate is obtained with the D1 treatment. The survival rate obtained during the 45 days of experimentation is in perfect harmony with the optimal values for this type of breeding concerning several species. Considering the time of control, the best chance of survival (99.14%) is still recorded at the level of treatment D1.

The best feed conversion rate (2.884) is obtained here with treatment D1. The results found are less good compared to those obtained by Faye *et al.*[8] The best food conversion rates, like the other consumption indices (3.075 and 3.596) belonging respectively to the D2 and D3 treatments, are not within the acceptable limits (below 2) to hope for economic profitability. This can be explained by the difficulties of apprehension of the food by the fry (fragile) or by the diffusion of the food beyond the meshes of the nets of the cages during feeding, which prevents the fry from consuming all of the feed served. This consumption index also reflects the quality of the food used to feed the fish. However, it should also be noted that the growth rate decreases when the biomass of fish increases and this phenomenon is observed in all fish species.[17] Treatments with fewer numbers therefore make better use of the food than those with a larger size. This hypothesis is also verified in the case of our study.

CONCLUSION

At the end of this study, it should be noted that the physicochemical variables of the water recorded are adequate for the breeding of Nile Tilapia and therefore they did not influence the results of the test. On the other hand, the density and the moment of control had an effect on the density and the survival of the subjects. Mortality is higher during the first fifteen days of the experiment, hence the importance of taking all the necessary precautions to reduce this mortality. It will then be necessary to seek to reduce or eliminate the stress linked to transport and handling, better organize the habituation of the fry to their new environment or better still order more rustic and resistant fry. The best growth performances are observed during the third control, the same for the average weight, which means that the food used is of good quality and that the experimental conditions favor a good increase in the average weight.

In view of the expression of biological performance (growth and survival) and from the point of view of profitability, the D1 treatment (350 fry/m^3) proved to be more interesting and more beneficial.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

ABBREVIATIONS

CERSA: Regional Center of Excellence on Avian Sciences; **ESA/UL:** Higher School of Agronomy, University of Lomé; **LARASE:** Research Laboratory on Agroressources and Environmental Health; **QAFF:** Quality Agro Fish Farm. **ISMA/UK:** Higher Institute of Agricultural Professions of the University of Kara.

SUMMARY

Rearing is a very important phase in fish farming. To make it more successful, it is important to take into account the quantity and quality of the food and the stocking density of the fry. Because these factors positively influence the survival rate, growth, feed efficiency and larval production. Thus, for the best technical and economic success of this start-up phase, it is important to respect the density of 350 fry per 1 m3 cage and feed them with the standard food (Raanan) 4 times a day at a feeding rate 8% of their biomass.

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