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Technical analysis of tilapia *Sarotherodon melanotheron* Rüppell, 1852 reared in lagoon pens during the grow-out phase (Layo, Côte d'Ivoire)

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ABSTRACT

This study was carried out to analyze the growth and survival performance of *Sarotherodon melanotheron* reared in lagoon enclosures. A total of 1,000 individuals with an initial average weight of 148.19 ± 33.37 g and an initial average length of 201.9 ± 20.56 mm were monitored for 5 weeks in a 200 m² enclosure, at a density of 5 ind./m². The fish were fed at 10% of their biomass with koudijs feed containing 35% of crude protein. One hundred (100) fish were sampled at random each week, weighed and measured individually. The physico-chemical parameters of the water were also measured weekly. At the end of the experiment, physico-chemical parameters averaged 29.26 ± 0.19°C, 6.20 ± 0.18 mg/l and 6.97 ± 0.40 respectively for temperature, dissolved oxygen and pH. At zootechnical level, averages of 225 ± 14.43 g, 224.3 ±9.27 mm, 2.19± 5.01 g/d and 94.2 ± 1.12% were observed over the entire trial period, respectively for average weight, average length, ADG and Survival Rate. However, growth performance showed an exponential rate during the first two weeks, before slowing down until the end of the experiment. In short, this study should be repeated in the dry season with single-sex males to gain a better understanding of the factors influencing growth and survival in this species.

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INTRODUCTION

In Côte d'Ivoire, the population's annual need for fish is around 650,000 tonnes for an estimated production of 108,000 tonnes (FISH4ACP, 2023). According to Yao *et al.* (2017), national aquaculture production is low, despite immense human, geographical and natural potential and the many efforts deployed in Ivorian fish farming. As a result, the country imports fish in frozen form to make up the shortfall. According to MIRAH (2022), fish imports cost the state budget 300 billion FCFA in 2020. With a view to raising the level of national aquaculture production, the Ivorian government adopted the National Policy for the Development of Livestock, Fisheries and Aquaculture (PONADEPA 2022-2026), launched in 2022. It aims to promote fish self-sufficiency. To achieve this objective, the State has entrusted research structures such as the Oceanological Research Center, with the mission of identifying and studying local species with high aquaculture potential, in order to make them available to fish farmers. Catfish (*Heterobranchus longifilis; Heterobranchus bidorsalis; Clarias gariepinus*), jawfish (*Chrysichthys nigrodigitatus*) and Tilapia (*Oreochromis niloticus*; *Coptodon guineensis; Sarotherodon melanotheron*) have been identified and are already being farmed in Côte d'Ivoire (INFOPECHE, 2024). Like the Nile tilapia *Oreochromis niloticus*, *Sarotherodon melanotheron*, a species characteristic West African estuaries and lagoons, is also a good candidate for the promotion of tilapiaculture (Amoussou *et al.*, 2016). In addition, the quality of its flesh and its rapid reproduction in captivity make it a fish of great interest (Awa, 2012).

In terms of rearing structures, diversion and dam ponds, floating cages, happas, cement and aluminum ponds are the most commonly used for rearing tilapia. However, what is the effect of the lagoon enclosure on *S. melanotheron* growth and survival?

The aim of this work is to contribute to the improvement of rearing techniques for this species. The specific objectives will be to assess the quality of the farm water and to determine the zootechnical parameters of the fish.

MATERIALS AND METHODS

Study area

The study was carried out at Layo Aquaculture Station (Fig. 1), from April 12 to June 10, 2024.

This experimental site is located on the north bank of the Ebrié Lagoon, about 40 km west of Abidjan on the Abidjan-Dabou road.

Biological materials

A total of 1,000 juvenile *S. melanotheron* of average initial weight 148.19 ± 33.37 g and average initial length 201.9 ± 20.56 mm were used. These fish (Fig. 2a) were caught in ponds at the Layo Aquaculture Station.

They were fed with commercial "Koudijs" brand feed with a diameter of 2 mm and 35% crude protein (Fig. 2b).

Technical equipment

It was composed of :

- Two 0.01g precision digital scales (Fisher Scientific brand) were used to weigh the fish and feed Fig. 3a ;
- A 50 cm ichthyometer to measure fish size during sampling Fig. 3b ;
- An HQ Series multi-parameter was used to determine the Temperature, Dissolved Oxygen and pH of the rearing water Fig. 3c ;
- A fishing seine (12 mm mesh, 35 m long and 9 m drop) catching fish during sampling Fig. 3d ;
- A landing net with 6 mm mesh handles for collecting juveniles during sampling;
- Buckets, dustbins and other plastic containers for transporting fish during sampling;
- Rubber bowls to serve the daily ration;
- Trays to carry the daily ration; etc.

Fig. 3 shows some of the technical equipment used.

Breeding structure

The fish were reared in a rectangular enclosure set up in the Ebrié lagoon. It measured 20 m long by 10 m wide, with a depth of 1 m, providing a total volume of 200 m³. It was equipped with a 14 mm mesh seine net.

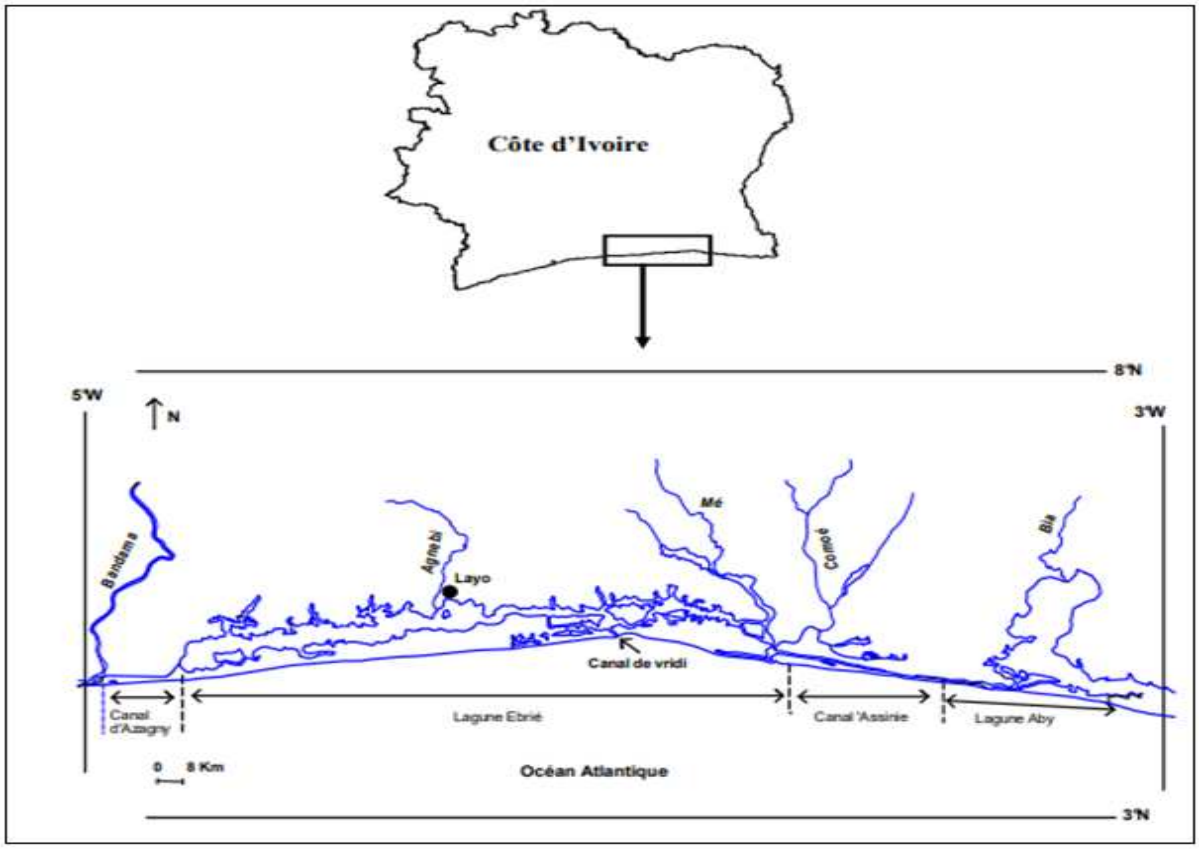

Fig. 1. Geographical location of the Ebrié lagoon and location of the aquaculture experimental station (N'dri *et al.*, 2025).

Methods

Fish catching and packaging

Juveniles of *S. melanotheron* were caught in ponds using a 12 mm mesh seine. After fishing, they were sorted to retain only those uniform weight and size, and stored in a 6 m² happa previously installed in the experimental enclosure (Fig. 4). The fish spent two weeks in the happa, acclimatizing to their new environment. During this period, the fish were fed ad libitum three times a day (7:30 am, 11:30 am and 3:30 pm) with a commercial "Koudijs" feed.

Stocking

At the end of the conditioning phase, 100 fish were taken at random, weighed and measured individually to determine average weight and average starting length. After this operation, 1,000 fish were stocked in the chosen pen, at a stocking density of 5 fish/m².

Breeding

For the feeding of the fish, the commercial feed "Koudijs" titrated to 35% crude protein was used. The fish were fed at 10% of their biomass with a daily ration distributed manually at 7:30 am, 11:30 am and 3:30 pm.

Weekly sampling was carried out to monitor fish growth. To do this, 100 individuals were taken at random, weighed and measured individually using a precision balance (Fisher Scientific brand) and an ichthyometer.

The ration was readjusted after each sampling, once the total biomass had been determined by extrapolation. At the end of the trial, all subjects were weighed, measured individually and counted.

In addition, a number of physico-chemical water parameters (temperature, dissolved oxygen content, pH) were measured in the enclosure at 7 a.m. prior to feeding. The probe of the HQ Series multi-parameter was immersed directly in the water. Once the device had stabilized, the values of the parameters measured were displayed on the screen.

Zootechnical parameters determined

- Growth in weight and length

The average weight was estimated using the following formula:

Aw (g)= Sum of the weights of the individuals weighed / Total number of subjects weighed

The average length was calculated as follows:

Al (cm)= Sum of lengths of subjects weighed/Total number of subjects weighed

- Average daily gain (ADG)

It is calculated from the following relationship :

ADG (g/d)= (Average final weight- Average initial weight)/Rearing time

- Coefficient of variation (CV)

It is determined by the following formula :

CV (%)= (Standard deviation/Average) X 100

- For a CV of less than 2%, the population is said to be very homogeneous;
- When the CV is between 2 and 30%, the population is said to be homogeneous;
- If CV is greater than 30%, the population is said to be heterogeneous.

- Condition coefficient K

The condition factor K is determined by the formula K= (Total weight / Total length^3) X 100; With total weight in g and total length in cm.

- Survival rate (SR)

SR (%)= (Number of fish remaining / Initial number of fish) X 100

Data processing

The data collected was first analyzed using descriptive statistics. Some data were represented graphically or tabulated to highlight certain trends.

Statistical indicators such as the average and standard deviation were also calculated.

Word version 2016 was used for data entry. On the other hand, Excel version 2019 was used to organize the data and produce the graphs.

RESULTS

Physico-chemical parameters of water

The values of the physico-chemical water parameters recorded are shown in Table 1.

Table 1. Water physico-chemical parameters recorded during.

Week	Temperature (°C)	Oxygen levels dissolved (mg/l)	pH
Week 1	29.13 ± 0.13	6.00 ± 0.12	6.86 ± 0.41
Week 2	29.20 ± 0.14	6.10 ± 0.13	6.92 ± 0.45
Week 3	29.26 ± 0.19	6.20 ± 0.18	6.97 ± 0.40
Week 4	29.33 ± 0.14	6.30 ± 0.14	7.02 ± 0.50
Week 5	29.40 ± 0.14	6.30 ± 0.14	7.07 ± 0.67
Average	29.26 ± 0.19	6.20 ± 0.18	6.97 ± 0.40

Temperatures ranged from 29.13 ± 0.13°C to 29.40 ± 0.14°C, with an average of 29.26 ± 0.19°C.

Dissolved oxygen levels ranged from 6.00 ± 0.12 mg/l to 6.30 ± 0.14 mg/l, with an average of 6.20 ± 0.18 mg/l. pH data ranged from 6.86 ± 0.41 to 7.07 ± 0.67, with an average of 6.97 ± 0.40.

Zootechnical performance

Weight growth

The variation in average fish weight is illustrated in Fig. 5a From 148.19 ± 33.37 g at the start of the experiment, the average weight of the subjects reached 225 ± 14.43 g. However, there were two main phases in this weight growth.

During the first two weeks, there was a spectacular increase in the average weight of the subjects. From 148.19 ± 33.37 g (beginning of Week 1) to 218.3 ± 18.19 g (end of Week 2). From week 3 to the end of the experiment, moderate growth was observed. Average weight increased from 218.3 ± 18.19 g to 225 ± 14.43 g.

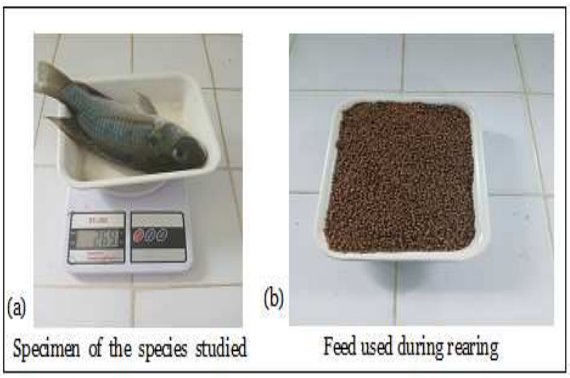

Fig. 2. Biological materials used the experiment.

Growth in length

The length curve for reared individuals is shown in Fig. 5b. The evolutionary profile of average total length followed a similar trend to that of weight growth. It also has two parts.

In the first two weeks, the length rapidly increased. From 201.9 ± 12.1 mm (beginning of week 1), it reached 222.6 ± 6.47 mm by the end of week 2. From week 3 to the end of the study, average total length stabilized at 224.3 ±9.27 mm, with slight fluctuations.

Average daily gain (ADG)

The weekly weights recorded were used to determine the Daily Weight Gain. Tested fish showed a D.W.G. of 2.19± 5.01 g/d over the entire test period. The highest value was observed in the first week, corresponding to 6.65± 4.70 g/d. This was followed by the second week (3.35± 2.37 g/d). The lowest GMQ values were recorded during the last three weeks of rearing, with the fourth week coming last (0.14± 0.10 g/d).

Coefficient of variation (CV) and Condition coefficient (K)

Coefficients of variation (CV) for average weight and average total length of tilapia *Sarotherodon melanotheron* were calculated. The values obtained were 6.58 ± 2.55% for weight and 2.02 ± 0.62% for average total length.

However, CV values ranged from 2% to 30%. The condition coefficient (K) is a key indicator of fish overweight.

In this study, the subjects' K was 0.9 ± 0.02 at the end of the experiment.

Survival rate

At the end of rearing, the results showed that the survival rate of reared fish reached a remarkable 94.2 ± 1.12%.

Fig. 3. Some technical equipments used during breeding.

DISCUSSION

The physico-chemical parameters recorded varied moderately. Average values for temperature, dissolved oxygen and pH were 29.2¬6 ± 0.19; 6.20 ± 0.18 mg/L; 6.97 ± 0.40 respectively. These values obtained are in line with those recommended by Ouattara *et al.* (2005), who stated that in *S. melanotheron*, the thermal preference is between 22 and 32°C, and by Ouattara *et al.* (2003), who consider that the normal pH should be between 3.5 and 7.6). For Apenuvor (2014), temperature is recognized as one of the most important abiotic factors affecting fish growth, food intake and feed conversion. With regard to Dissolved Oxygen Rate, the average value obtained is higher than the critical value reported by Ross (2000), which is 2.3 mg/L for the species *Sarotherodon melanotheron*. Similarly, (Ouattara *et al.* (2003) showed that it tolerates low levels of dissolved oxygen and does not encounter particular metabolic difficulties if the level of dissolved oxygen

in water is not lower than 3 mg/l. The values obtained for the various parameters are comparable to those of Alla *et al.* (2024). Our results show that the fish were reared in a suitable environment. This could be justified by the fact that the water in the enclosure is permanently renewed.

Fig. 4. Fish conditioning.

With regard to the growth in weight and length of the reared fish, the curves show a sharp increase in both parameters during the first two weeks, before slowing down until the end of the experiment. This rapid evolution of weight and size at the start of rearing could be attributed to the good quality of the feed and rearing environment. Also, the fish, initially confined during the conditioning phase, enjoyed greater freedom when released into the low-density enclosure. They were thus able to benefit from the nutrients present in the natural environment in addition to the artificial feed provided. These results run counter to those of Alla *et al.* (2024) in their study of the effect of density on the same species. These authors showed that growth rates (weight and length) were low in all batches during the first two weeks of rearing. For them, this situation could be considered as a period of adaptation of the fish to their new living environment. The same observation was made by N'dri *et al.* (2024) during their experiment on the effect of rationing rate in *Sarotherodon melanotheron* Rüppell, 1852 fry.

From the third week to the end of the experiment, fish growth really slowed down. This could be explained by several factors. Firstly, the rainy season, which had begun at this precise time, disrupted the consumption of the feed distributed to the fish. Indeed, during heavy rains, fish do not eat enough of the feed distributed to them. Secondly, *Sarotherodon melanotheron* larvae were observed in the enclosure. This was proof that the fish had returned to reproduction. However, tilapias incubating by mouth were unable to feed properly. These phenomena would explain the poor growth in weight and length observed during the last three weeks of the study.

For Amoussou *et al.* (2016), tilapia *Sarotherodon melanotheron* growth is discontinuous, characterized by a succession of periods of slow and rapid growth.With regard to Average Daily Gain, the results showed a progressive decrease with each sampling. In fact, the fish gained less and less weight after the first two weeks of rearing. This situation could be explained by poor climatic conditions (in particular untimely rainfall) on the one hand, and on the other by the reproduction observed in the pen, which would certainly be due to seing errors, competition for food resources or stress linked to handling. However, the overall ADG value obtained over the duration of the experiment (2.19 g/d) was better than that observed by Koumi *et al.* (2011) and Yao *et al.* (2013), who respectively obtained 0.67 ± 0.03 g/d and 0.21 ± 0.02 g/d in a previous study. Our results were also superior to those of Ouattara *et al.* (2005), who obtained 0.42 ± 0.00 g/d in their freshwater floating cage study, and Gbaï *et al.* (2014), who found a value of 0.35 g/d in a lagoon environment.

CV values (weight and length) ranged from 2 to 30%, indicating that the growth of the fish in the pen was relatively homogeneous. Furthermore, the Condition Coefficient K was very close to 1, justifying a good state of overweight of the fish. This homogeneity correlated with a good state of overweight could be explained by the fact that, in addition to a better aquatic environment, the feed distributed enabled the fish to be in optimal growth conditions. Another explanation could be that the fish species chosen had genetic traits favorable to uniform growth.

This is in line with the observations of Khaw *et al.* (2020) cited in Touré (2024). These authors have shown that genetic selection for traits favorable to uniform fish growth can reduce variability in size and weight, thus improving the consistency of overall results.In terms of survival rate, the best result obtained is linked to the favorable rearing conditions and stress resistance of this species. Our results are superior to those of N'Zué and Kouadio (2021) cited in Touré (2024), who obtained a survival rate of around 85% in similar systems during their work on the evaluation of growth performance and survival of tilapia *Sarotherodon melanotheron* in lagoon enclosures in Côte d'Ivoire. On the other hand, our observations are very close to those reported by Alla *et al.* (2024). These authors obtained a value of 95.00 ± 1.33% for the same species reared in happas.

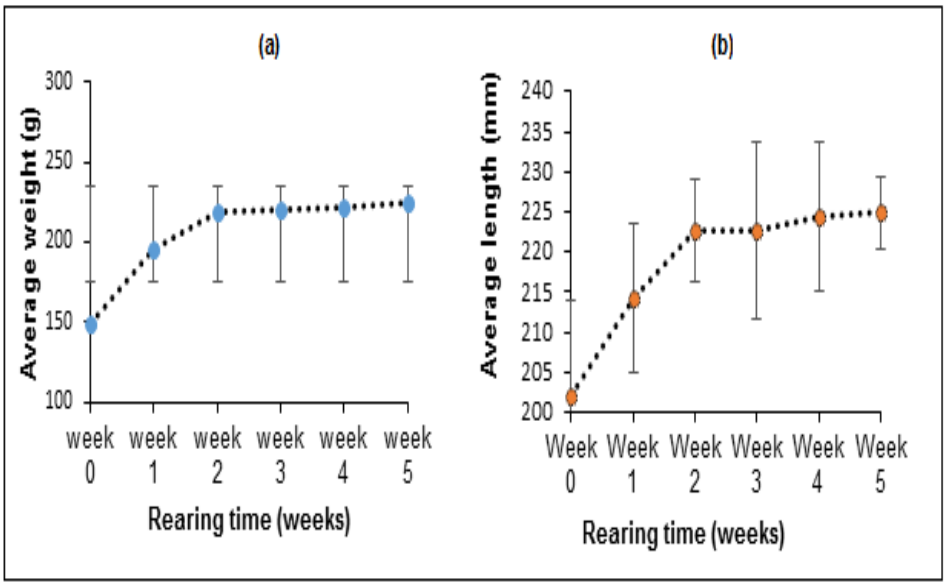

Fig. 5. Evolution of growth in weight (a) and length (b) of reared fish in relation to age.

Our results are superior to those of Ouattara *et al.* (2005), who showed a survival rate of 72.8 ± 3.9% in earthen ponds for the same species.

CONCLUSION

This study assessed growth performance and survival of juveniles of *Sarotherodon melanotheron*. The results show that this species adapts well to rearing in enclosures. In fish farming, *Sarotherodon melanotheron* is able to withstand variations in environmental factors (climatic factors in particular). However, beyond a certain value (high and untimely rainfall), these parameters can affect biological functions such as growth and survival rate. Sexing errors also influence the growth of this species during the grow-out phase. Looking ahead, it would be interesting to repeat this experiment in the dry season with single-sex males in order to better understand and control the factors influencing the growth and survival of *S. melanotheron* juveniles, with a view to disseminating them to fish farmers.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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