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Effect of Three Commercial Feeds on the Growth and Survival of Juvenile Jawfish (Chrysichthys Nigrodigitatus) Rered in Happas at the Layo Experimental Aquaculture Station (Dabou, Côte d'Ivoire)

Kouamé Marcel N'DRI[1*], Yao Laurent ALLA[2], Moustapha DIABY[1], Sery Daniel Romaric ZA BI[1], Kouassi TANO[2], Dramane DIOMANDE[3]

[1]Institute of Agropastoral Management, Peleforo GON COULIBALY University (PGCU), Korhogo, Côte d'Ivoire
[2]Department of Aquaculture, Oceanological Research Center (CRO), Abidjan, Côte d'Ivoire
[3]Faculty of Sciences and Environment Management, NANGUI Abrogoua University (NAU), Abidjan, Côte d'Ivoire

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***Corresponding author:** Kouamé Marcel N'DRI
Institute of Agropastoral Management, Peleforo GON COULIBALY University (PGCU), Korhogo, Côte d'Ivoire

Abstract | **Original Research Article**

A six-week study was carried out at the Layo experimental station (Dabou) to investigate the effect of three commercial feeds on the growth and survival of *Chrysichthys nigrodigitatus* juveniles in happas. To this purpose, 225 fish with an initial average weight of 22.80 ± 4.05 g and an initial average length of 141.00 ± 11.00 mm were used to form three batches (batch 1, batch 2, batch 3) in triplicate, in 50-liter happas, at a density of 0.5 individuals per liter. The fish were fed at 10% of their biomass with Biomar inicio plus (batch 1), Alimpoi (batch 2) and Koudijs (batch 3). Ten individuals, randomly sampled per week, were weighed and measured individually. The average values for temperature, dissolved oxygen and pH were 28.20 ±1.80°C, 5.80 ± 0.60 mg/L and 6.10 ± 0.30 respectively. At the end of the experiment, the results show that the highest values for weight growth, total average length, ADG and CI were recorded in individuals fed with Alimpoi feed, at 35.43 ± 0.98 g, 156.67 ± 0.76 mm, 0.30 ± 0.06 g/d and 3.00 ± 26.96 respectively. Survival rate and biomass were higher in individuals fed with Biomar. The respective values obtained were 69.33 ± 4.98% and 624.17 ± 36.52 g. It would be desirable to include the economic aspect in the study, in order to assess the production costs for each feed.

Keywords: *Chrysichthys nigrodigitatus*, Commercial feed, Growth, Survival, Happa.

INTRODUCTION

Fish provides many nutrients that are often difficult to find in most other foods. It contains essential fatty acids, vitamins, calcium, iodine, zinc, iron, selenium and other trace elements essential for good health [1]. It is also an important source of high-quality animal protein.

In recent years, annual landings of this foodstuff supplied by the world's fisheries have stagnated or even fallen, to around 90.3 million tonnes per year [2]. The strong growth in the world's population has led to an increase in demand for fish products. According to the FAO [2], worldwide per capita human consumption of fish has exceeded 21.4 kg.

In Côte d'Ivoire, the yearbook of fisheries and aquaculture statistics puts average per capita consumption per year at 25.6 kg [3]. Yet national fisheries production is struggling to reach 100,000 tonnes for a requirement of over 618,182 tonnes [4]. The shortfall is made up by imports of frozen fish, which result in a significant outflow of foreign currency. To facilitate local self-sufficiency in fish, the Ivorian government has created research structures, including the Oceanological Research Center (ORC). One of the ORC's main missions is to identify and study local species with high aquaculture potential, in order to make them available to fish farmers. Among these species, the jawfish *Chrysichthys nigrodigitatus* is a good candidate for fish farming. Its flesh is highly prized by the population [5]. In addition, the species also shows good resistance to handling and an ability to withstand momentarily low oxygen levels [6, 7] adds that *C. nigrodigitatus has* good commercial value. However, while the breeding of this species is very well mastered

in Côte d'Ivoire [8], it is currently encountering difficulties, in particular a dependence on high-protein diets for breeding [8].

The present study, entitled "Effect of three commercial feeds on the growth and survival of juvenile jawfish (*Chrysichthys nigrodigitatus*) reared in happas at the Layo experimental aquaculture station (Dabou)", was initiated with the aim of finding a high-performance feed that could provide good growth and survival rates. Its overall aim is to determine which of the three commercial feeds used gives the best growth and survival results for juvenile jawfish *Chrysichthys nigrodigitatus*.

MATERIALS AND METHODS

Study area

The study took place at the experimental aquaculture station of Layo, from April 30 to June 12, 2023, i.e. for 42 days. This site is located in the north bank of the Ebrié Lagoon, about 40 km west of Abidjan on the Abidjan-Dabou axis (Figure 1).

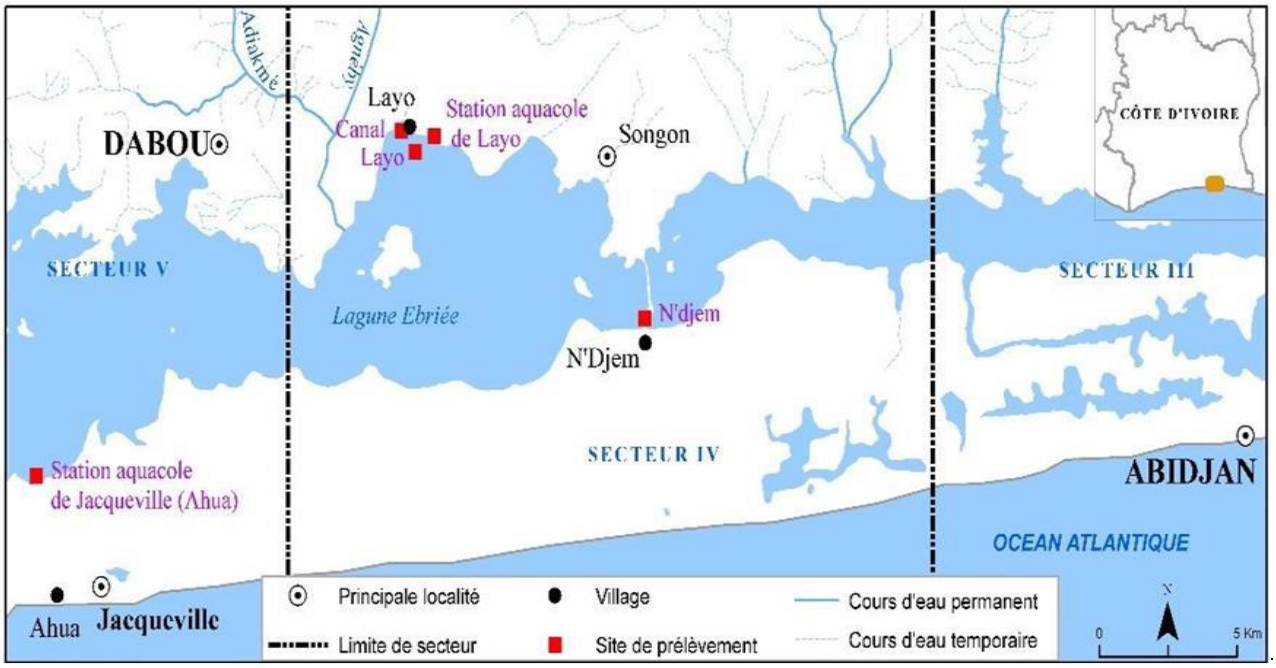

Figure 1: Location of Layo experimental station (Dabou)

Biological Materials

The biological material used (Figure 2) consisted of 225 *Chrysichthys nigrodigitatus* juveniles with an initial average weight of 22.82 ± 4.05 g and an initial average length of 145.00 ± 11.00 mm. These juveniles were caught in the ponds of the Experimental Aquaculture of Layo.

Chrysichthys nigrodigitatus juvenile Alimpoi Biomar Koudijs Experimental foods

Figure 2: Biological materials

Technical equipment

The technical equipment used consisted of:

- a digital precision balance from Fisher Scientific with a maximum capacity of 620 g and an accuracy of 0.001 g for weighing juveniles during sampling;
- an OHAUS digital kitchen scale with a maximum capacity of 2000 g and accuracy of 0.0 g for weighing the daily ration;
- a 50 cm ichthyometer to measure fish size during sampling;
- a fishing seine (12 mm mesh, 35 m long and 9 m drop) to catch fish in the ponds;
- two landing nets with 6 mm mesh handles for fishing juveniles in happas;
- a multi-parameter type HANNA for the determination of some physico-chemical parameters of farm water;
- two brushes used to clean happas;
- buckets, dustbins, basins and other plastic containers for transporting fish during sampling;

Applied methodology

Happas installation

For this study, 9 identical 1.5 mm mesh happas were used (Figure 3). They were installed in three rows of three happas in a previously tended fish pond. Each row was supported by eight three-meter-long Chinese bamboo poles. The happas were suspended in the water on the bamboo at about 20 cm from the sediment. The average volume of each happa is 50 liters.

Setting up experimental batches

Before the batches were set up, the selected juvenile jawfish were kept for two weeks in a cage previously installed in the experimental pond, to enable them to adapt to their new environment.

To set up the experimental batches, 30 juveniles were taken at random from the batch of fish stored in the conditioning cage, weighed and measured individually to determine initial average weight and length. After this, 225 juveniles were divided into three batches of 25 individuals each in the happas, at a density of 0.5 individuals/L. Each batch was tested in triplicate. The batches formed were:

- batch 1: 25 juveniles fed with Biomar inicio plus Alo (53% crude protein) ;
- batch 2: 25 juveniles fed with Alimpoi (40% crude protein) ;
- batch 3: 25 juveniles fed with Koudijs (35% crude protein).

Figure 3: Happas installed in a fish pond for experimental purposes

Breeding

Three commercial pelleted feeds (Biomar, Alimpoi and Koudijs) were tested during this work. The ration was calculated by applying a rationing rate of 10% to the total biomass in each happa and distributed in three meals a day at the following times: 7 am, 12 pm and 4 pm, for 6 weeks. It was adjusted every week after sampling.

During the weekly samplings, 10 individuals were taken at random from each happa for individual weighing and measurement, using a Fisher Scientific precision balance and an ichthyometer respectively. This operation made it possible to monitor the growth and survival of the juveniles. After weighing, the fish in each happa were counted to determine the biomass and readjust the next ration.

During the study, a number of physico-chemical water parameters (temperature, dissolved oxygen content, pH) were measured every day at 7 a.m. prior to feeding. The HANNA multi-parameter probe was immersed directly in the water, and the measured parameters were displayed on the screen. At the end of the trial, all subjects were weighed, measured individually and counted by batch.

Zootechnical parameters assessed

Average daily gain (ADG)

It is calculated from the following relationship:

ADG (g/d) = (Final average weight – Initial average weight) / Rearing period

Consumption index

The consumption index was calculated in each happa from the quantity of food distributed using the following formula:

CI = Quantity of feed consumed / (Fbm - Ibm), where Fbm: Final biomass and Ibm: Initial biomass

Survival rate (SR)

SR (%) = (Number of fish remaining / Number of initial fish) x 100

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 factor K

The condition factor K reflects the overweight of the poisons and is determined by:

K= $\frac{W}{L^3}$ X 1OO, Where W = total weight of fish in g and L = total length of fish in cm.

Total biomass

It represents the total mass of all remaining individuals per batch at the end of the experiment.

Data processing and analysis

Descriptive statistics were used to analyze the data series collected. Data were expressed as average ± standard deviation. Excel version 2016 was used to enter and organize the data, and to produce graphs to highlight certain trends. An analysis of variances (ANOVA) was then performed using SPSS 22.0 software to compare averages. In the case of homogeneity of variances, the ANOVA table was observed, and in the case of heterogeneity of variances, the Welch test was performed. Where there was a significant difference ($p < 5\%$), Tukey's HSD test was used to separate the means.

RESULTS

Physico-chemical parameters of farm water

During this study, the water temperature in the happas varied between 30.13 ± 0.13 and 30.40 ± 0.14°C. The average value obtained was 30.26 ± 0.19°C. Dissolved oxygen values ranged from 6.00 ± 0.12 to 6.30 ± 0.14 mg/L, with an average of 6.20 ± 0.18 mg/L. As for pH, the data recorded ranged from 6.86 ± 0.41 to 7.07 ± 0.67, with an average value of 6.97 ± 0.48.

Zootechnical performance

Weight growth

Figure 4 shows the evolutionary curves of the average weight of juveniles over the six weeks of rearing.

From week 0 to week 2, weight growth was low and identical for all feeds. Juvenile weights rose from 22.80 ± 4.05 to 26.54 ± 0.42 g on the Biomar feed, to 27.81 ± 1.67 g on the Alimpoi feed and to 26.97 ± 1.07 g on the Koudijs feed.

From the second week to the end of the experiment, weight growth was greater. The average weight of juveniles reached its highest value (35.43 ± 0.98 g) with the Alimpoi feed, compared with the lowest value obtained with the Koudijs feed (32.44 ± 1.22 g). Biomar feed gave an intermediate weight growth of 33.44 ± 1.00 g. No significant difference between the mean values of the batches was observed ($p > 0.05$).

Growth in length

Unlike weight, fish length growth was improved by the different feeds from the first week to the end of the experiment (Figure 5).

The highest average total length of 15.67 ± 0.76 cm was observed in individuals fed with Alimpoi. Individuals fed with Biomar showed the lowest growth in length at 14.79 ± 0.89 cm. Conversely, fish fed with Koudijs showed intermediate growth (15.42 ± 3.75 cm). Statistical analysis showed a significant difference between the average size of fish fed with Biomar and those fed with the other feeds (Alimpoi and Koudijs) during all weeks of the experiment ($p < 0.05$).

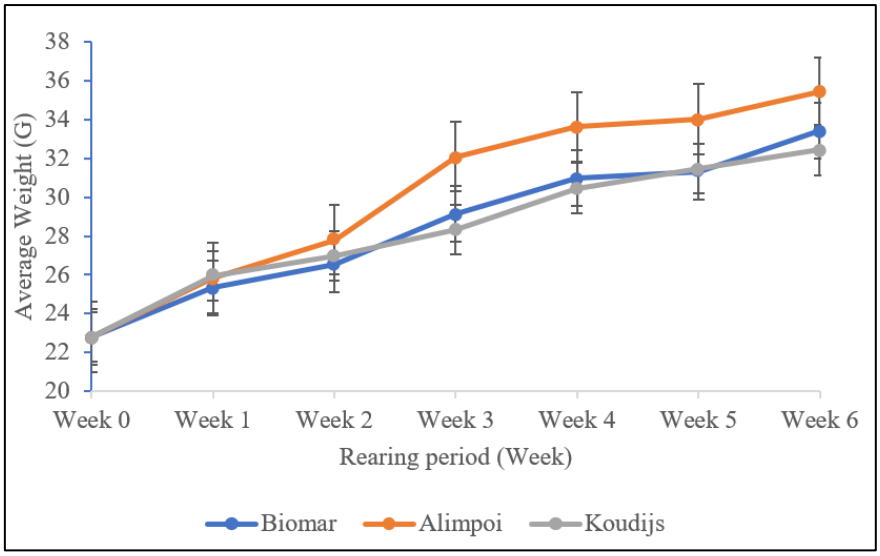

Figure 4: Weight growth of *C. nigrodigitatus* juveniles taking into account the rearing period

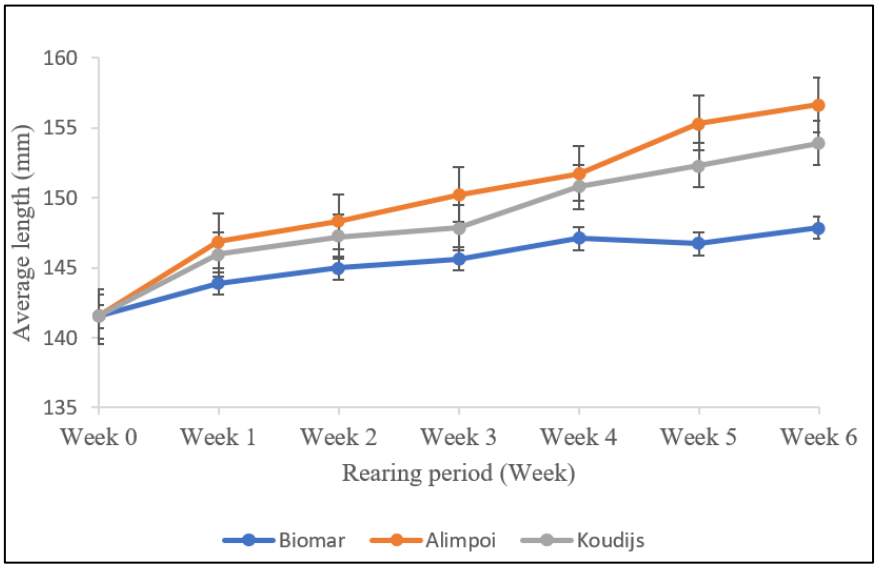

Figure 5: Variations in size of *C. nigrodigitatus* juveniles taking into account the age and feed consumed

Average daily gain (ADG)

Table I shows the ADGs calculated for each feed over the duration of the experiment.

From the beginning to the end of the experiment, ADG values evolved in a sawtooth pattern for all treatments. However, it was observed that juveniles fed with the Alimpoi feed recorded the highest ADG (0.61 ± 0.24 g/d) at week 3. The lowest value (0.05 ± 0.14 g/d) was obtained by individuals fed Biomar at week 5.

Over the entire duration of the experiment (from week 0 to week 6), the ADG was also higher in individuals fed with Alimpoi feed (0.30 ± 0.06 g/d), followed by those fed with Biomar feed and finally those fed with Koudijs feed. However, the ADGs of the three batches were not significantly different ($p > 0.05$).

Consumption index (CI)

From week 0 to week 6, the best CI was recorded in individuals fed with Alimpoi (3.00 ± 26.96), followed by those fed with Koudijs. The lowest CI value was obtained in individuals fed with Biomar (Table 1). However, there was no significant difference between the CIs obtained with the three feeds ($p > 0.05$).

Survival rate (SR)

The highest survival rate was recorded in individuals fed with Biomar (69.33 ± 4.98%), while the lowest was observed in those fed with Koudijs. The value obtained with the Alimpoi feed was intermediate (Table 1). Statistical analysis showed a significant difference between the average values recorded with the Koudijs feed and those of the other two feeds (Alimpoi and Biomar) ($p < 0.05$).

Coefficient of variation for weight and length (CV)

Coefficients of variation (CV) for average weight and total average length of juveniles were calculated for the different feeds tested. With regard to average weight (Table I**),** the CV value for individuals fed with Biomar was relatively higher (7.09 ± 2.52%) than for other batches. In contrast, individuals fed with Koudijs had the lowest value (5.57 ± 1.22).

For total average length, CV values were 4.45 ± 0.98%, 4.41 ± 0.65% and 3.10 ± 0.46% respectively for subjects fed with Biomar, Alimpoi and Koudijs. For all parameters, CV values ranged from 2 to 30%.

Table 1: ADG, CI, SR and Fish CV Weight as a function of foods

Experimental feeds	ADG(g/d)	CI	SR (%)	CV Weight (%)
Biomar (batch 1)	0.26±0.02	3.68±12.77	69.33±4.8	7.09 ±2.52
Alimpoi (batch 2)	0.30±0.06	3.00±26.96	68.00±4.0	5.85±2.36
Koudijs (batch 3)	0.23±0.03	3.6±26.5	46.67±92	5.57±1.22

Condition coefficient (K)

At the end of the experiment, the K values of *C. nigrodigitatus* juveniles for the different feeds were 0.88 ± 0.03%; 0.89 ± 0.03% and 0.93 ± 0.02% respectively for the Koudijs feed, the Alimpoi feed and the Biomar feed. Statistical analysis showed no significant difference between the condition coefficient values obtained for the three feeds ($p > 0.05$).

Total biomass

The highest final total biomass was obtained in individuals fed Biomar, followed by those fed Alimpoi and Koudijs. The respective values corresponding to these feeds were 624.17 ± 36.52, 523.08 ± 37.94 and 283.81 g ± 105.95 g. It was lower in individuals fed with Koudijs.

DISCUSSION

During our study, the averages for temperature, dissolved oxygen and p H in the rearing structures were 30.26 ± 0.19°C, 6.20 ± 0.18 mg/L and 6.97 ± 0.48 respectively. These factors remained relatively stable. According to [9], these values fall within the range recommended for good growth in farmed fish. It could therefore be concluded that these parameters did not negatively influence the growth and survival of *C. nigrodigitatus* juveniles.

Juvenile jawfish *C. nigrodigitatus* weight growth curves *show* an ascending trend for all three feeds. The same is true for total length. Both parameters are therefore evolving in the same direction. These results may indicate that the feed was of good quality and enabled the juveniles to grow. However, weight growth is very low during the first two weeks of rearing. The low weight growth observed during this period could be considered as a period of adaptation of the fish to their new living environment, reflecting a non-significant effect of the different feeds on fish growth. After the second week, the weight growth of juveniles is greater. This would indicate that the fish had taken advantage of the feed they had been given. However, we note that at the end of the experiment, growth is better in individuals fed with Alimpoi feed, certainly due to its high protein content (40%) compared to the other two feeds. In addition, Alimpoi had the lowest feed conversion ratio (3.00 ± 26.96). Juveniles fed with Koudijs had the lowest growth. These growth results are confirmed by the ADG values obtained with the three feeds. Indeed, over the entire duration of the experiment, the ADG observed in individuals fed Alimpoi (0.30 ± 0.06 mg/d) was higher than those recorded in fish fed with the other feeds.

Our results differ from those obtained by [10] for weight, length, ADG and feed conversion ratio. Indeed, they obtained a feed conversion rate ranging from 1.27 ± 0.08 to 1.50 ± 0.12 and an ADG of 0.75 g/d. Similarly, for an initial length of 14.30 ± 2.35 cm and an initial weight of 24.80 ± 0.99 g, they reported 19.3 ± 0.31 cm and 67.20 ± 2.07 g respectively for juvenile jawfish fed twice a day for eight weeks on a commercial diet purchased from "Aller Aqua" in Ghana containing 58% protein. This difference could be due to the rearing time, the feed used and feeding frequency. Indeed, in the study by [10], a reduction in growth performance was observed when Bagrid catfish (*Chrysichthys nigrodigitatus*) were fed three and four times a day. This finding confirms the results of [11], which indicate that a reduction in growth was recorded after a certain feeding frequency. This difference in growth due to feeding frequency can be justified in three ways. Firstly, energy expenditure may increase due to the increased swimming activity resulting from feeding for longer periods of the day [12]. Secondly, feeding at shorter intervals results in the passage of food through the digestive system. Transit is faster, resulting in less efficient digestion [13]. Finally, poor growth could be the result of reduced absorption efficiency resulting from gastric overload due to feeding at relatively short intervals compared to the time required for fish to regain their appetite [14].

In terms of survival rates, fish fed with Biomar (69.33 ± 4.98%) and Alimpoi (68.00 ± 4.80) had survival rates above 50%. However, those fed with Koudijs gave values below 50% (46.67%). These results show that rearing conditions were relatively good. The mortalities recorded during this experiment could be explained by the stress involved in handling the individuals during sampling.

With regard to the Coefficient of Variation, the values obtained for weight during the experiment ranged

from 2 to 30% for all three feeds. The same applies to the total length of juveniles. These results suggest that juvenile growth is homogeneous across the three batches. This homogeneity may be linked to the fact that the jawfish is a farmed fish with low growth rates.

CONCLUSION

After six weeks of rearing, all three feeds tested on juvenile jawfish *Chrysichthys nigrodigitatus had* a positive effect on growth and survival. A comparison of the parameters studied showed that juveniles fed with Alimpoi showed the strongest growth in weight and length. They also achieved the best ADG and CI. In terms of survival rate (SR) and total biomass, juveniles fed with the Biomar feed showed the best values over the whole duration of the experiment. It was also observed that the three feeds tested produced homogeneous juvenile growth. Looking ahead, it would be interesting to extend the experiment up to grow-out and in other rearing structures (lagoon enclosure, pond), using a feeding frequency of twice a day. An economic study could also be carried out to better assess the results obtained.

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