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RESEARCH ARTICLE

Influence of Fertilizer Type on Zooplankton Production, Survival Rate and Growth Characteristics in Sub Adults *Papyrocranus afer* in Ponds

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Abstract

Cameroon's coasts are vulnerable to the effects of coastal erosion and climate change, thus affecting fishing through reduced catches and destruction of habitats. Reducing these risks requires mobilizing several sectors, notably aquaculture through the domestication of endogenous species. In order to evaluate the nutrition of *Papyrocranus afer* Sub Adults their captivity, a diet based on zooplankton production was carried out. This study took place at the Laboratory of Aquaculture and Demography of Fisheries Resources of the Institute of Fisheries Sciences from May to June 2023. 54 Sub Adults of *Papyrocranus afer* with an average length of 31.92 ± 2.30 cm and an average weight of 173.20 ± 1.20 g was used and divided in to treatments: T_0 (*Papyrocranus afer* + Coppens), T_1 (Chicken droppings without *Papyrocranus afer*), T_2 (chicken droppings + *Papyrocranus afer*), T_3 (pig manure without *Papyrocranus afer*) and T_4 (pig manure + *Papyrocranus afer*). Zooplankton sampling was carried out as well as survival and growth. The results show that water temperature and transparency were higher at T_0 (27.41 ± 0.50°c, 7.40 ± 0.23 and 60.10 ± 3.59 cm), ammoniac, nitrites and nitrates were elevated at T_3 (6.93 ± 015, 7.97 ± 0.08 and 40.58 ± 0.10) mg/l. Zooplankton density was high at T_3 (2,268 ind/l) and low at T_0 (746 ind/l). SR, WG, DAG and SRG were significantly elevated at T4 (100%, 255.68 ± 0.8 g, 1.25 ± 0.01 g/d and 0.73 ± 0.52% g/day). It appears that *Papyrocranus afer* can be bred in captivity, providing a sustainable solution to the conservation of this endangered species.

Keywords: Influence, fertilizers, zooplankton, survival, growth, *Papyrocranus afer*, captivity.

1. Introduction

The issue of natural risks in the world today constitutes, through multiple threats, the main environmental, economic and social concern. In Central Africa, and in Cameroon in particular, according to (Mena et al., 2017) the entire Cameroonian coastline suffered, between 1998 and 2016, minor and major disasters (depending on the site and the issues), noting a variation in the levels of exposure and vulnerability of these fishing areas. In Cameroon, fishing is both a source of income for the country, employment and contributes to more than 46% of the nutritional needs of the population in term of animal proteins.

Fish is one of the commonly used and less expensive food sources rich in animal proteins for most of the world's population (Allam et al., 2020; Maulu et al., 2020).

It is a valuable source of essential macronutrients and micronutrients, which strongly contributes to global food and nutrition security (FAO, 2020). Fish is very important in developing countries where it represents 75% of the daily animal protein intake (Willet et al., 2019; Mansour et al., 2021). But in Cameroon, fish contributes approximately 30% of protein intake, and the average consumption per individual per year is 17.9 kg compared to 13.07 kg for meat (Ngok,

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2005). Furthermore, fish production has increased to around 11.8 million tonnes (Muringai et al., 2020). This observed increase in fish production is due to the development of the aquaculture sector, which is recognized as the fastest growing food production sector, overpassing farmed animal meat production and capture fisheries landings (Kumar et al., 2013). Aquaculture recorded a production of 110,200 to 2,196,000 tonnes from 1995 to 2018 with a rate of about 16% per year, and has contribute by weight to total fish production increased from 6.2% to 18, 5% between 2000 to 2017 (Adeleke et al., 2020). This prodigious growth is the result of research and innovations in the control of livestock management and especially in the acquisition of new production techniques. The apparent consumption of fish per capita/year has also increased from an average of 9 kg in 1961 to 20.5 kg in 2018. The first estimates for 2030 fall beneath the 21.5 kg barrier, which still remains well below the 30 kg/capita/year recommended by the FAO (FAO, 2018). Despite this spectacular progress in aquaculture, sub-Saharan Africa countries continues to occupy a minor place (0.16%), despite its natural potential (Pouomogne, 2014). Thus, its per capita fish consumption is the lowest, i.e. 10.5 kg/inhabitant/year in 2014 before falling to 9.9 kg/inhabitant/year in 2017 (FAO, 2020). This low consumption in sub-Saharan Africa results from several interconnected factors, including a population that is growing at a higher rate than fish supplies, stagnant game fish production, and an underdeveloped aquaculture sector (FAO, 2020). In Cameroon, resources from fishing are increasingly reduced due to overexploitation, global warming, destruction of fish habitat, pollution, poor fishing methods and techniques as well as stagnation. In landings (MINEPIA, 2018). To compensate this situation, the Cameroonian state spends more than 120 billion FCFA each year on the importation of frozen fish (MINEPIA, 2018). This situation creates a deficit in the net income of the country. To reduce imports of frozen products, which create dependence on the outside (Marquet, 1985; Imorou, 2007; FAO, 2014), it becomes wise to promote the development of aquaculture (fish farming activities). The development of fish farming in Cameroon is mainly based on four species (*Oreochromis niloticus, Cyprinus carpio, Heterotis niloticus* and *Clarias gariepinus*). However, the priorities of the Cameroonian government's aquaculture sectoral strategy are nowadays focused on the domestication of new (endogenous) species of fish with specific aquaculture potential. Thus, several endogenous species such as *Clarias jaensis, Labeo barbus batesii* and more recently *Papyrocranus afer* are in the process of domestication. Having been the subject of several researches in Nigeria (King, 1994; Edema, et al., 2007) for its use as an ornamental fish, *Papyrocranus afer* is endemic in Africa. In Cameroon, it is still poorly known in captivity. *Papyrocranus afer* is exploited along the Nkam-Wouri watershed by local fishermen in the Nkam division. It is highly appreciated by the population and by scientists because of its zootechnical advantages such as: diversified diet, strong ecological tolerance, rapid growth, highly appreciated flesh and strong resistance to diseases (King, 1994; Edema et al., 2007; Nack et al., 2016), we nevertheless observe its periodic appearance in the Cameroon markets. However, in terms of species exploited in the Nkam-Wouri basin, it comes in fourth position after *Chrysichthys nigrodigitatus, Oréochromis niloticus* and *Heterotis niloticus*.

Nutrition fundamentally affects the production performance of fish (Smith et al., 1979; Kjorsvik et al., 1990; Fernandez-Palacios et al., 1997; Adewumi et al., 2005). Several studies on the diet of *Papyrocranus afer* in a natural environment reveal that it is partly made up of zooplankton (King, 1994); knowledge of feeding in a controlled environment is fundamental for the conservation of this species. The use of a natural diet would affect the survival and growth characteristics of Papyrocranus afer in a controlled environment. The present study aims to contribute in the preservation and enhancement of the biodiversity of endogenous fishery resources in general and of *Papyrocranus afer* in particular by determining an adequate diet. This was more specifically the influence of the type of fertilizer on zooplankton production, survival rate and growth characteristics in Sub Adults *Papyrocranus afer* in ponds.

2. Materials and Methods

2.1 Study Site and Period

The study took place at the Laboratory of Aquaculture and Demography of Fisheries Resources (LADRHa) of the Institute of Fisheries Sciences (I.S.H) of the University of Douala in Yabassi in the Nkam Division of the Littoral Region located between 9°50' - 10°10' LE and 4°20' - 4°40' LN (MINEPAT, 2010). (Fig. 1).

Biological Material

A total of 54 Sub Adults (produce in the laboratory) of *Papyrocranus afer* with an average total length of 31.92±2.3cm and average weight 173.20±1.2g

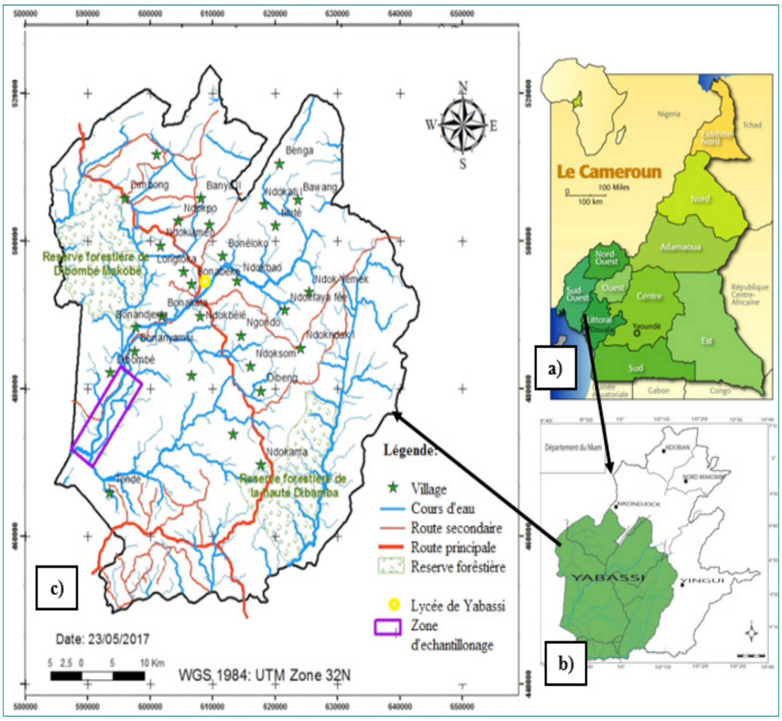


Figure 1. *Location of the study area (INC, 2017; adapted)*

were used at a density of 2 individuals/m^2. They were distributed randomly into three groups each containing 18 fish. Each group was submitted to five treatments with two repetitions each.

2.2 Experimental Set up

The *Papyrocranus afer* specimens will be raised in ponds (12), measuring 4.5m^3 (length 3m, width 1.5m, depth 1m) at a density of 2 individuals/m^2. These ponds are gravity fed and equipped with an overflow system. A barrier made of protective net and Chinese bamboo of 1 meter high was erected all along the experimental ponds. Before the tests, the ponds were left dry for a period of 7 days, aquatic vegetation and all fish and other predatory species were completely eliminated, then the ponds were limed with quicklime at a dose of 400kg/ha (Boyd, 1982; Bogne et al., 2008). A 50 mm mesh net was attached to the supply pipe of each pond to prevent the intrusion of fish and toads from the reservoir (Fig. 2).

2.3 Structure of the Essay

Three groups, each containing 18 fishes and corresponding to five treatments with three replicates

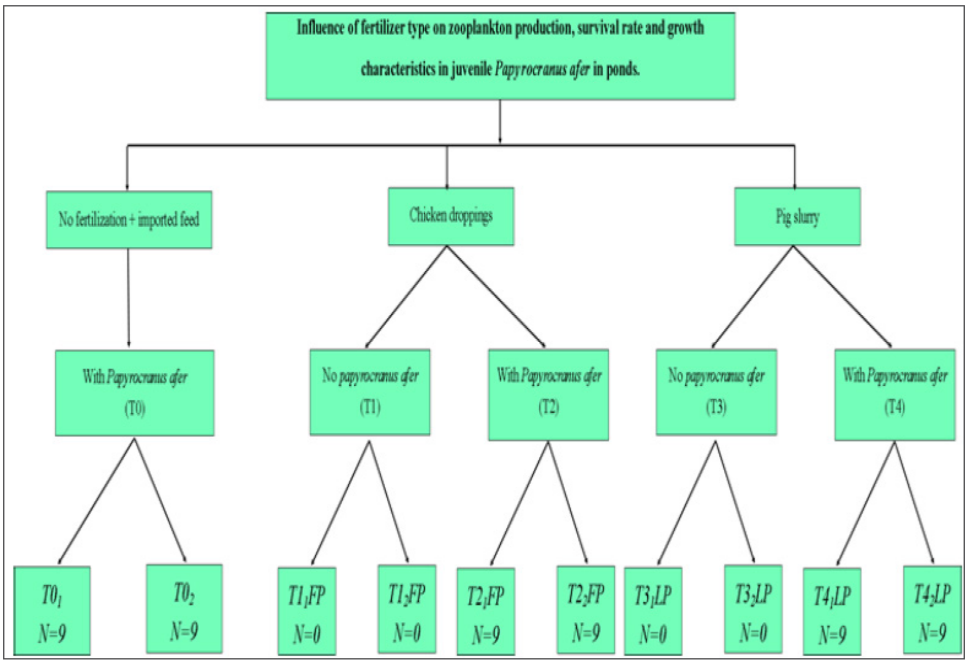


Figure 2. *Expeditionary device*

each, namely T_0 (*Papyrocranus afer* + Coppens), T_1 (Chicken droppings without *Papyrocranus afer*), T_2 (chicken droppings + *Papyrocranus afer*), T_3 (pig manure without *Papyrocranus afer*) and T_4 (pig manure + *Papyrocranus afer*). The Sub Adults of Papyrocranus afer belonging to T_0 were fed every day at a frequency of 2 times/day (6 a.m. and 6 p.m.) at the rationing rate 9% of the ichthyobiomass for each. The water replenishment in the pond was 1/3 of the volume of the pond all the time. The fertilisation was carried out every two months. Water and zooplankton sampling were carried out every three hours between 6 and 8 a.m to prevent the vertical migration of the zooplankton to the bottom after the sunset. Samples were taken from twenty different points in the water column of each pond using a calibrated 1-litre polyethylene container. The water quality parameters (temperature, DO, Transparency, pH, nitrates and phosphates) were monitored using a multiple parameter of brand HANNA HI 3271. A total volume of 20 liters/pond was filtered through a 40 µm mesh plankton sieve. A 40 ml concentrated sub-sample of zooplankton was collected, fixed by adding 5% formalin in the proportions 25% formalin to 75% sample volume (Nguetsop et al., 2009; Zebazé Togouet et al., 2015) and stored in plastic bottles for quantitative and qualitative analyses.

2.4 Parameters Studied

- Density of individuals (D): D = (n x 1000) / V

- Survival: SR (%) = 100 × FN / IN (where IN: initial number and FN: final number);

- Weight gain: WG (g) =Pmf− Pmi (avec Pmf: Poids moyen final, Pmi: Poids moyen initial);

- Daily average gain: DAG (g/j)= $\frac{(Pmf-Pmi)}{\Delta t}$ (Δt: la durée de l'essai en jours);

- Specific rate of growth: SRG (%g/d) = $\frac{(\ln Pmf-\ln Pmi)}{\Delta t}$ x 100 (ln: logarithme népérien);

- Condition factor K: K = W×100/ LT^3 with W: weight (g), LT: Total length (cm).

2.5 Statistical Analysis

The descriptive statistics of growth parameters (density, mean ± standard deviation and ~~as~~ percentages fraction) and curves of results visualization were done using Microsoft Office Excel 2016. The ANOVA test was used to verified the significance level of the descriptive parameters within the different set up.

3. Results

3.1. Influence of fertilizer type on physico-chemical parameters

Parameters varied throughout the test period, with respect to the type of fertilizer and *Papyrocranus afer* (Table 1). Results showed that dissolved oxygen, transparency, nitrite, nitrate and phosphate were significantly affected by the type of fertilizer and the presence or absence of *Papyrocranus afer*, and were significantly higher in ponds fertilized with pig manure (Table 1).

3.2. Effect of fertilizer type on zooplankton production

The richness of zooplankton families as a function of fertilizer type, as summarized in Table 2.

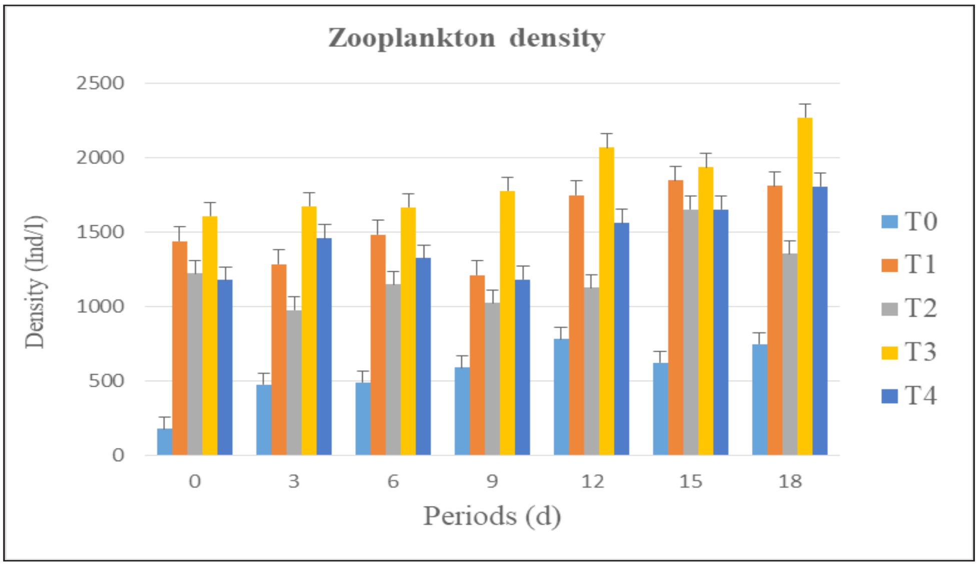
Table 1. *Physicochemical characteristics of water as a function of fertilizers and presence of Papyrocranus afer*

Physicochemical characteristics		Fertilizer types and presence of *Papyrocranus afer*			
	Control	Chicken droppings (kg/ha)		Pig slurry (kg/ha)	
	T0 (No fertilization + imported feed + *Papyrocranus afer*)	T1 (No *Papyrocranus afer*)	T2 (With *Papyrocranus afer*)	T3 (No *Papyrocranus afer*)	T4 (With *Papyrocranus afer*)
Température (°C)	27.41±0.50	27.02±0.47	27.00±0.44	26,92± 0,49	26,66± 0,61
Hydrogen potential (UI)	7.40±0.23	7.37±0.14	7.26±0.26	7,17± 0,13	7,14± 0,16
Conductivity (µs/cm)	34.47±0.68	37.69±0.89	36.94±0.28	42,49± 0,65	37,32± 0.71
Oxygen dissous (mg/l)	5.34±1.42	3.37 ±4.00	4,09 ± 0,05	3,42± 0.08	3,20±3.44
Transparency (cm)	60.10±3.59	48.10±10.61	32.29±2.50	54,30± 4,66	47,00 ± 8,20
NO2-(mg/l)	1.56±0.15	5.15±0.10	4.53±0.11	6,93± 0,15	6,43± 0,17
NO3-(mg/l)	2.44±0.12	6.15±0.10	5.53±0.11	7,97± 0,08	7,48± 0,06
PO43-(mg/l)	35.21±0.11	37.44±0.20	36.45±0.15	40,58± 0,10	38,32± 0,06

Table 2. *The richness of zooplankton families as a function of fertilizer type*

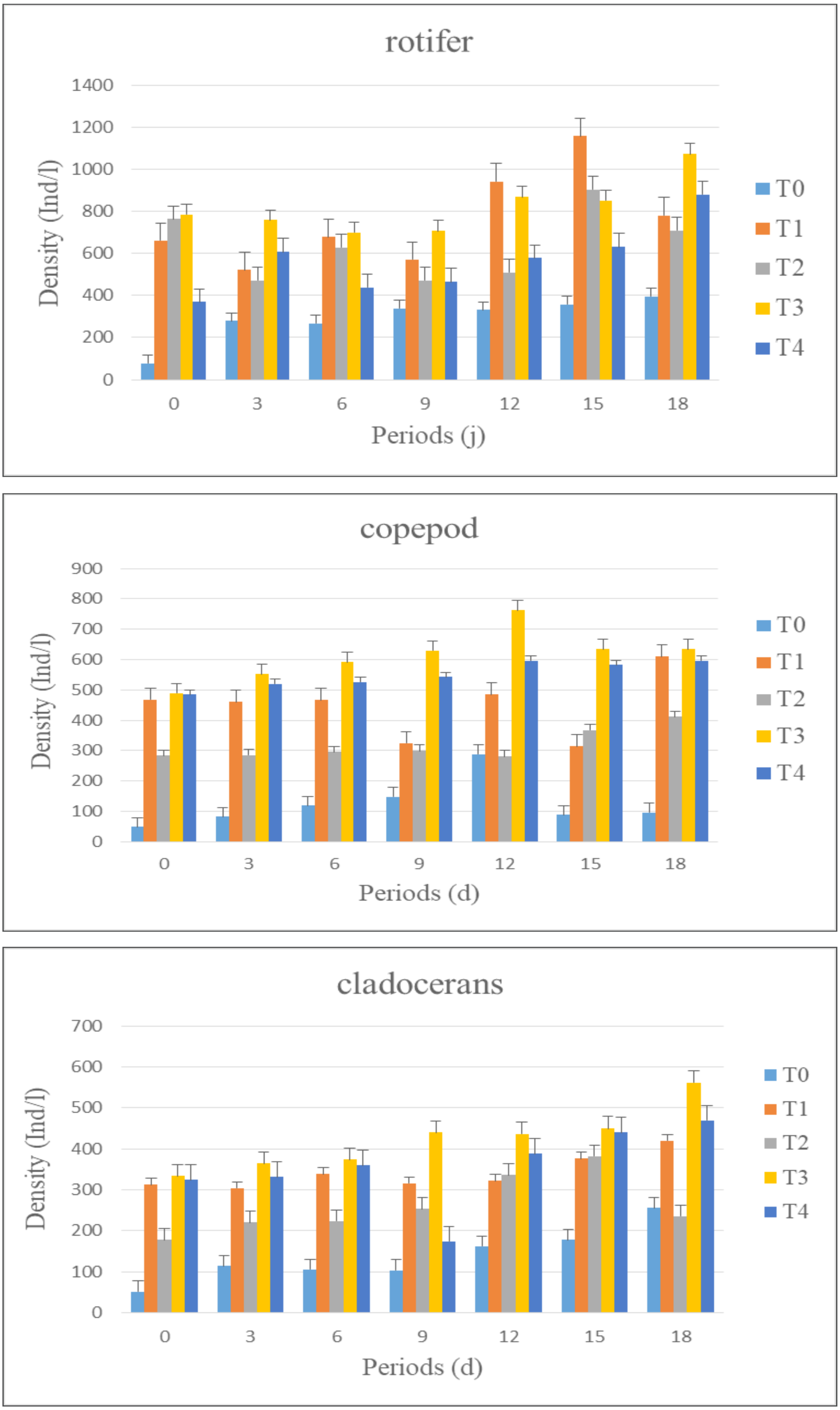
Groups / Families / Genus / Species	T0 (No fertilization + imported feed + *Papyrocranus afer*)	T1 (Chicken droppings + No *Papyrocranus afer*)	T2 (Chicken droppings + with *Papyrocranus afer*)	T3 (Pig slurry + No *Papyrocranus afer*)	T4 (Pig slurry + with *Papyrocranus afer*)
Rotiferes					
Brachionidae					
Brachionus	X	X	X	X	X
Keratella	X	X	X	X	X
Lecanidae					
Lecane	X	X	X	X	X
Philodinidae					
Rotaria	X	X	X	X	X
Trichocercidae					
Trichocerca	X	X	X	X	X
Asplanchnidae.					
Asplanchna	X	X	X	X	X
Synchaetidae					
Ploesoma	X	X	X	X	X
Copépodes					
Diaptomidae					
Neodiaptomus	X	X	X	X	X
Pseudodiaptomidae					
Pseudodiaptomus	X	X	X	X	X
Larves Nauplius	X	X	X	X	X
Cladocères					
Moinidae					
Moina	X	X	X	X	X
Daphniidae					
Daphnia	X	X	X	X	X

Was highest in the pig manure treatments and lowest in the treatment without fertilization (control) (Fig. 3). Nevertheless, during the trial period, rotifer density was highest in treatment T_1, corresponding to fertilization with and lowest in treatment T_0, then droppings without the presence of *Papyrocranus afer* where no fertilization was applied, while copepod and cladoceran densities were high in treatment T_3 corresponding to fertilization with hog manure without the presence of *Papyrocranus afer*, and low in T_0. An abundance of the Brachionus genus for rotifers, of the Pseudodiaptomus genus for copepods and of the Daphnia genus for cladocerans was observed during the trial in all treatments (Fig. 4).



T_0 : No fertilization + imported feed + *Papyrocranus afer* T_1 : Chicken droppings + No *Papyrocranus afer* T_2 : Chicken droppings + with Papyrocranus afer T_3 : Pig slurry + No *Papyrocranus afer* T_4 : Pig slurry + with *Papyrocranus afer*

Figure 3. *Evolution of zooplankton density as a function of treatment and time*



T_0 : No fertilization + imported feed + *Papyrocranus afer* T_1 : Chicken droppings + No *Papyrocranus afer* T_2 : Chicken droppings + with Papyrocranus afer T_3 : Pig slurry + No *Papyrocranus afer* T_4 : Pig slurry + with *Papyrocranus afer*

Figure 4. *Evolution of zooplankton group density as a function of fertilizers and the presence of Papyrocranus afer*

3.4 Effect of Fertilizer Type on Survival and Some Zootechnical Parameters

Survival Rate

Figure 5 shows the survival rate of *Papyrocranus afer* as a function of fertilizer type.

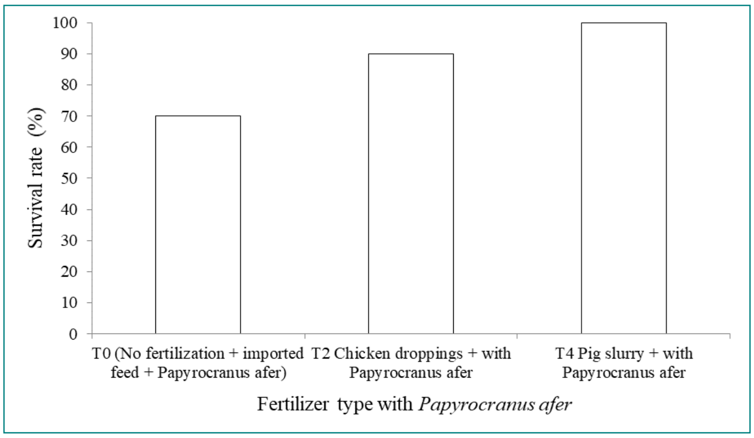


Figure 5. *Variation in the survival rate of Papyrocranus afer depending on the type of fertilizer*

The survival rate of *Papyrocranus afer* was highest at T_4 (100%) and lowest at T_0 (70%).

Weight Gain

Figure 6 illustrates the evolution of the average weight of *Papyrocranus afer*; it appears that whatever the period, the average weight increased regularly regardless of the treatment. The highest value being obtained for treatment T_4 (255.68g) and low at T_0 (212.54g).

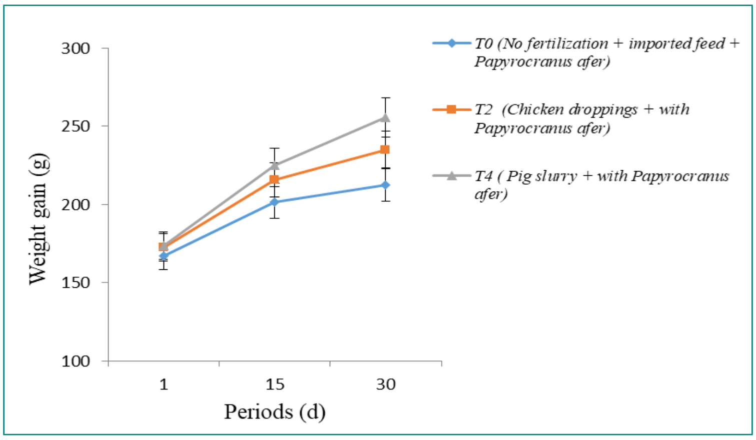


Figure 6. *Daily evolution of the average weight of Papyrocranus afer depending on the different treatments*

Daily Average Gain

Figure 7 illustrates the evolution of the average daily gain of *Papyrocranus afer* according to the different treatments

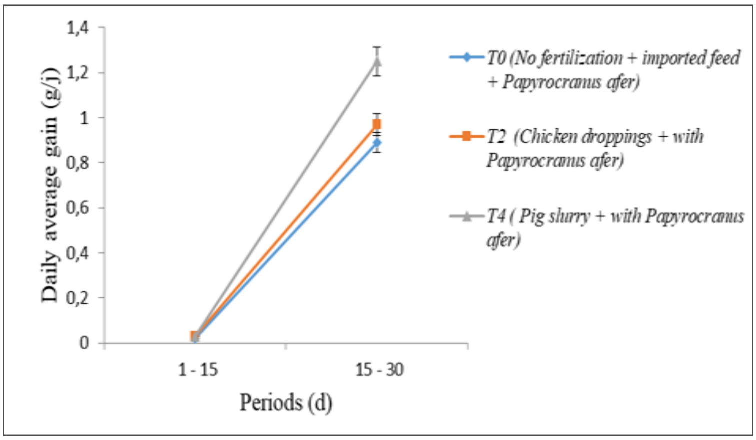


Figure 7. *Daily evolution of the average daily gain of Papyrocranus afer depending on the different treatments.*

It appears that the average daily gain of *Papyrocranus afer* increased throughout the trial. At the end of the trial, the highest values were obtained in treatment T_4 (1.25g/d) followed by T_2 (0.97g/d) and the lowest in T_0 (0.89g/d)

Specific Rate of Rrowth

Figure 8 illustrates the evolution of the Specific Growth Rate of *Papyrocranus afer* depending on the different treatments

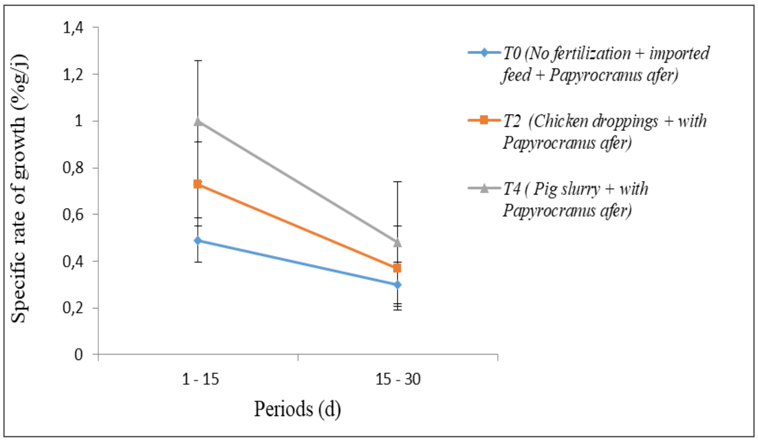


Figure 8. *Daily evolution of the Specific Growth Rate of Papyrocranus afer depending on the different treatments*

Throughout the trial, the Specific Growth Rate decreased regardless of the treatment. However, the highest value was obtained for treatment T_0 followed by T_2.

Condition Factor K

Figure 9 illustrates the evolution of the Condition Factor K of *Papyrocranus afer* according to the different treatments

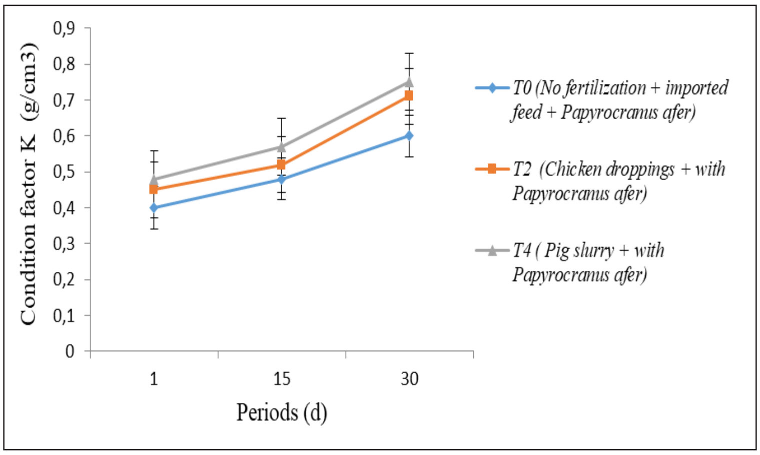


Figure 9. *Evolution of the Condition Factor K of Papyrocranus afer depending on the different treatments*

It appears that the condition factor K increased throughout the test for all treatments. The highest values were obtained in treatment T_4 (0.75g/cm3) followed by T_2 (0.71 g/cm3) and the lowest in T_0 (0.6g/cm3).

4. Discussion

The highest values of physicochemical characteristics (Dissolved oxygen, transparency, nitrate, nitrites and phosphates) and densities were recorded in the fertilized treatments compared to the control (unfertilized). The results obtained in the different treatments for the physico-chemical parameters of the water remained within the optimal ranges reported by Boyd (1982), namely 24-28°C suggested for optimum development of the natural food. These physicochemical characteristics are nevertheless within the tolerated ranges for the development of zooplankton FAO (2016). We note low concentrations of dissolved oxygen and low transparencies in the fertilized treatments compared to the control treatment T_0 (unfertilized). These results corroborate with the results observed by Njine et al. (2007) and would be linked to the biological activity of the microorganisms which are more abundant there. The levels of dissolved nutrient compounds (NO2, NO3-) remain above the threshold of 2.1 mg/l for nitrites and nitrates, 2.3 mg/l; below these values, a proliferation of phytoplankton to the detriment of zooplankton would be more abundant in concrete tanks (Balarin et al., 1982). The high content of nitrates and nitrites in treatments fertilized with pig manure could be explained by the high nitrogen content in the latter compared to chicken droppings.

Regarding zooplankton diversity, we note the presence of rotifers (07 species), cladocerans (02 species) and copepods (03) in all treatments. We observe throughout the period of the test that rotifers of the genus Asplanchna appear most in the treatments (T_1 and T_2) receiving chicken droppings and the genus Brachionus compare to treatments (T_3 and T_4) receiving slurry. pig, these results differ from the observations made by Agadjihouèdé et al., (2011) with chicken droppings, where *Brachionus sp* species were dominant but corroborate the results obtained by Pouomogne et al., (2022). The densities recorded in this study remain higher than those obtained by Akodogbo et al., (2014), whose value was 1071ind/l in water fertilized with pig manure compared to 145ind/L in unfertilized water. These differences in results would certainly be attributable to the typology of the fertilizer, but more to the intrinsic conditions of the experiment (altitude, breeding system). However, we note during the period of the test with regard to the zooplankton density that it generally decreases with the presence of *Papyrocranus afer* indicating the consumption of zooplankton by *Papyrocranus afer*. Survival rate values were relatively high (>50%) in all treatments. The highest survival rate of *Papyrocranus afer* Sub Adults (100%) was obtained with the T_4 pig manure treatment. This value is greater than 97% obtained by Agadjihouèdé et al., (2012) in larvae of *Clarias gariépinus* and larvae of *Heterobranchus longifilis* fed with zooplankton from pig droppings. The survival rate obtained at T_2 (90.00%) is nevertheless lower than 95.52% in ponds fertilized with chicken droppings and 94.91% in unfertilized ponds obtained by Kouakou Y. et al., (2021) at the fry of *Oreochromis niloticus* after 60 days. This difference could be due to the difference in age, physiological states and the conditions of the test, namely the physicochemical characteristics of the environment and its duration. The highest final average weight (255.68g) recorded at the end of the trial was noted with the treatment with pig manure (T_4), which shows that the Sub Adults of *Papyrocranus afer* enhance zooplankton. The average daily gains (ADG) varied upwards with the different treatments. However, the values obtained at T_2 (0.97g/d) remain low at 1.04g/d in ponds fertilized with chicken droppings, but those obtained in unfertilized ponds (0.89g/d) are greater than 0.69g/d. j obtained by Kouakou Y. et al., (2021) in *Oreochromis niloticus* fry after 60 days. As for the highest value 1.25g/d (T_4) it remains higher than 0.29g/d reported by Djikengoue et al., in 2020 among post larvae of common carp *Cyprinus carpio* by fertilization with droppings of chicken. The growth differences observed at the end of the test between these batches could be linked to a difference in physiological states and the conditions of the test, namely the food used in an unfertilized environment. The specific growth rates (SGR) obtained (0.30 to 0.48%/d) at the end of the trial remain lower than those obtained by Kouakou Y. et al., 2021 (4.07 to 4.71%/ j), and also remains lower than those (11.28 to 14.29%/d) obtained by Agadjihouèdé et al., (2012) in larvae of *Clarias gariépinus* and larvae of *Heterobranchus longifilis* fed with zooplankton from droppings of pork and 8.07%/d obtained by Djikengoue et al., in 2020 in post larvae of common carp *Cyprinus carpio* by fertilization with chicken droppings.

The low values of this test could be explained on the one hand by the stocking density for the test, and the physicochemical parameters of the rearing environment. The highest condition factor K (0.75) obtained at the end of the test is lower than 0.89 and 1.24 reported respectively by Tonfack et al., in 2020 in the larvae of African cyprinids *Labeobarbus batesii* and Djikengoue and al., in 2020 in post larvae of common carp *Cyprinus carpio* by fertilization with chicken droppings. This difference could be explained by exogenous factors such as the breeding infrastructure, and endogenous factors, namely the size and strain of the fish which were different.

5. Conclusion

At the end of this trial which proposed a lasting solution for the conservation of the endogenous species Papyrocranus afer which is in danger of disappearing in Cameroonian waters due to the vulnerability of the Cameroonian coasts, a trial of domestication of this species in a controlled environment. In order to propose a diet, a study focused on the influence of the type of fertilizer on the production of zooplankton, the survival rate and the growth characteristics of Sub Adults *Papyrocranus afer.* It emerged that the conservation and valorization of this species through the knowledge of its ecology and its diet, the results showed that the physicochemical characteristics of the water have evolved with the type of fertilizers applied without however being different from those observed in a natural environment. In addition, the density of zooplankton is influenced by the presence of Papyrocranus afer and the type of fertilizer. The highest zooplankton density was observed in ponds fertilized without *Papyrocranus afer*, which would indicate that zooplankton provide a food source for Papyrocranus afer. Concerning the survival rate and growth characteristics of *Papyrocranus afer*, these were affected by the type of fertilizer. Indeed, the survival rate, average weight, average daily gain, specific growth rate and condition factor K were higher in fish fed with zooplankton from pig manure followed by those having received zooplankton. . made from chicken droppings. This test showed that in a controlled environment, *Papyrocranus afer* better values its living prey. As a result, this study contributes to the preservation of this endogenous species with high aquaculture potential, threatened with extinction due to the deterioration of their living environment due to the vulnerability of the Cameroonian coasts where they develop well. Difficulties were encountered during this particular study; in particular the impossibility of having samples available at any time, hence an un representative number of samples used as well as the duration of the test. However, it would be desirable to repeat this study and extend this analysis to all subsequent stages of development of *Papyrocranus afer*.

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