E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(3): 128-134

www.fisheriesjournal.com
Received: 18-03-2020
Accepted: 20-04-2020

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Survival rate and growth performances of post-larvae of the African Cyprinidae *Labeobarbus batesii* (Boulenger, 1903) with different type of food.

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Abstract
In view of contributing to the domestication of *Labeobabus batesii,* the survival and growth performances of post-larvae according to the type of food were studied between November and December 2019. A total of 1200 post-larvae (150 ± 20 mg), grouped in four batches and distributed randomly in 8 tanks (250 ind / m^3), respectively received the compound food (T1), Artemia (T2), cooked egg yolk (T3) and freshwater zooplankton (T4). The results show that: the survival rate and growth performances were significantly (p≤0.05) influenced by the type of food. With the exception of the nutrient quotient whose highest significant (p≤0,05) value was obtained with the egg yolk, the values of the other characteristics were significantly higher (p≤0, 05) with Artemia and the lowest values with freshwater zooplankton. Regardless of the type of food, the post-larvae exhibited minorant allometric growth.

Keywords: *Labeobarbus batesii*; post-larvae; type of food; survival rate; growth performances

1. Introduction

The supply of animal proteins occupies a place of choice today in the fight for food security. In this context, fish, which represents 22% of the animal protein supply in sub-Saharan Africa and close to 50% in Cameroon [1, 2], is a very delicate speculation. However, in Cameroon, this consumption remains dominated by fishing (21%) and imports (56%), [3]. In addition, fresh fish, imported, suffers from transport conditions and delays often long between fishing and consumption, thus deteriorating quality [4]. On the other hand, the stagnation of landings of fishery products in recent years due to the decline in natural fish stocks, caused by excessive and uncontrolled fishing [5], making aquaculture appear to be the only alternative that can fill the fish deficit [6, 2]. According to [7], the development of fish farming would allow disadvantaged populations in rural areas far from rivers and urban centers to be supplied with quality fish. That proves also to be necessary for feeding adequately all human beings, without harming natural resources [8]

Indeed, the development of fish farming in sub-Saharan Africa in general and in Cameroon in particular, has been the subject of numerous attempts from the 1950s and 1960s [9, 10]. The majority of these attempts ended in failure with the major reason of the too short duration of the projects, which did not allow fish farmers to assimilate training on technological production [11]. In addition, the species prospected so far (*Clarias gariepinus*, *Cyprinus carpio* and *Oreochromis niloticus*) are mostly introduced species and therefore not very suitable for our agro-ecological zones. Moreover, according to [12], the species introduced into Africa (common carp and Chinese carp) have not been able to stimulate the development of an aquaculture production sector. However, this continent is sheltering a diversity of freshwater fish species largely sufficient to support sustainable aquaculture development as in Asia. It is in this same view that [13] goes on to say that the most harmful impact of the introduction of exotic species is probably to divert a certain number of countries from the attention given to aquaculture potential of native species. It is therefore clear, facing the above arguments, that the domestication of indigenous species with high aquaculture potential would be a very promising alternative. Today, the species of the Cyprinidae family are the highest in the world, representing 61% of the production in volume [14]; whereas, almost no African cyprinid is currently used in fish farming [15]. This production, based on the domestication of native species, is very important in Asia due to the mastery of farming techniques by fish farmers [12]. However, if cyprinids have been very well studied in Eurasia and North America, this group is still very poorly known in Africa where there are nevertheless nearly 500 species [16]. Still, two genera of African Cyprinidae (*Labeobarbus* and *Barbus*), which are moreover the most privileged in research works, seem to have affinities with Eurasian species in valuation by African producers. The works carried out by [17, 18, 14] and [20] on the bioecology of *Labeobarbus batesii* (endogenous species in Cameroon) in the wild milieu of the Mbô plain show that this species has very high aquaculture potential. According to the same authors, this fish is an omnivorous with an herbivorous tendency and presents an interesting growth potential. However, no study has yet been conducted to assess the aquaculture or zootechnical potential of this specie in captivity. In addition, the major difficulty in a chain of breeding is related to the control of the nursery, which itself depends on the type of food used in this phase. This work is part of a domestication program for African carp *Labeobarbus batesii* in progress at the IRAD station of Foumban. Its general objective is to contribute to the development of the aquaculture potential of endogenous fishery resources in general and of Cyprinidae in particular. It is more specifically a question of evaluating the effect of the type of food (Artemia, freshwater zooplankton, egg yolk and complete compound food) on the survival and growth performances of *Labeobarbus batesii* post-larvae.

Materials and methods

Study period, area and site

The study took place between November and December 2019 at the IRAD station of Foumban, more specifically in his fish farmat Koupa Matapit. This farm, located at9 Km of the Foumban city (West Highlands of Cameroon) is located at 5 ° 45.826 'north latitude and 10 ° 48.516' east longitude with an altitude of 1147 m. The Sudano-Guinean climate includes a rainy season (March - October) and a dry season (November - February). The average temperature and rainfall are 22 ° C and 1800 mm / year respectively [21].

Animal materials

A total of 1200 post-larvae of *Labeobarbus batesii* measuring 25mm total length and 150± 20 mg of average weight was collected in a natural environment from fishermen of the Nkam river and conditioned in oxygenated plastic for their transport to the IRAD station fish farm at Koupa matapit. These post-larvae were stabilized for two days in a nursery tank (previously fertilized using chicken droppings) of the station.

Breeding structure

The test was carried out in 8 identical concrete tanks of 0.6m^3 (1.2 x 0.75 x 0.65m),coveredby a mosquito net to prevent predation.Each tank was equipped with supply channels and overflow pipe. Two weeks before the start of the test, the tanks were washed and disinfected with bleach (1mL / 200litres) then put in dry for 3 days, at the end of which a filling was made.

Food formulation

Chicken eggs were bought at the local market, cooked and then the yolk extracted, dried under the sun for 05 days before being grind [22]. As for the compound food, it was made from the following ingredients: 50% fish meal, 25% brewer's yeast, 22% bone meal and 3% premix 2%. The powdered Artemia was purchased from a specialized feed store in the localityjust like the previous ingredients. The whole, in a ration of 20 mg/larva in 4 meals per day, was served between 6 am and 6 pm [23]. Concerning freshwater zooplankton, they were produced by fertilization from chicken droppings (600g/m^3) according to the method recommended by [24] and used by [25]. In order to evaluate the density of zooplankton in the tanks fed with freshwater zooplankton, a water sample was taken at the beginning and then every week, then evaluated (quality and quantity) with a monocular microscope of the Motic brand with a 10x objective in the aquaculture laboratory of the IRAD station of Foumban. The weekly evolution profile of the zooplankton in these tanks throughout the test is illustrated by the Figure 1. Every two weeks, fertilization was renewed in these tanks in order to maintain the natural productivity of the environment.

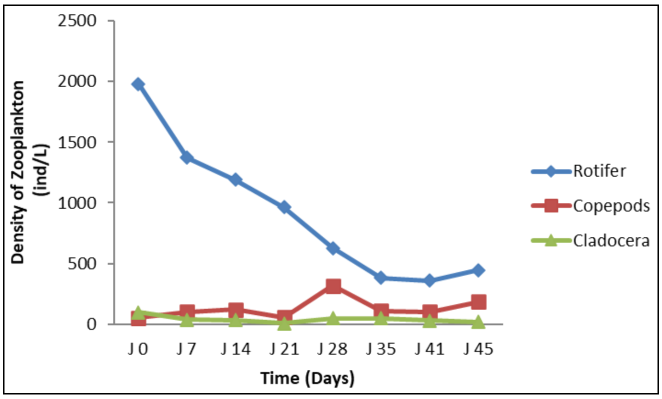

Fig 1: Weekly evolution of the density of freshwater zooplankton in the T4 treatment (tanks fertilized with chicken droppings) during the observation period

Experimental design

The 1200 post-larvae were randomly distributed in 08 concrete tanks at a density of 150 post-larvae per tank according to a system of total randomization comprising four treatments repeated twice. Each treatment received a specific type of food, namely complete compound food (T1), Artemia (T2), cooked egg yolk (T3) or freshwater zooplankton (T4).

Conduct of the test

During 45 days of the trial, the post-larvae of the T1, T2 and T3 treatments were fed 4 times a day, between 6 am and 6 pm at 20 mg/post-larva [23]. The natural production of freshwater zooplankton was stimulated in the batches T4 by weekly addition of 600g/m^3 of chicken droppings [25]. Body measurements were made at the beginning of the trial and then all the two weeks following control fisheries to assess survival, weight and linear growth at the same time as the physicochemical characteristics were measured. A sample of water was taken weekly from the tanks T4 in order to establish the zooplankton profile in this treatment. The physicochemical characteristics of the water such as pH, dissolved oxygen, temperature, conductivity, transparency and depth were measured in situ at the beginning of the test and then each week between 6 and 8 am. The means of the values of those characteristics are fund in Table 1.

Tableau 1: Water physicochemical characteristics according to the type of food

Physicochemical characteristics	Type of food			
	Compound food	**Artemia**	**Eggs yolk**	**Fertilization**
Temperature (°C)	26,89 ± 0,15	26,79 ± 0,73	27,01 ± 0,26	27,35 ± 0,38
pH	09,78 ± 0,23	09,75 ± 0,22	09,44 ± 0,28	10,16 ± 0,11
Dissolved oxygen (mg/l)	9,59 ± 0,42	8,98 ± 0,69	7,94 ± 0,40	7,21 ± 0,35
Conductivity (µs /cm)	105,56 ± 4,19	109,00 ± 13,23	140,56 ± 12,62	242,78 ± 9,77
Transparency (cm)	70, 10 ± 1,15	70,83 ± 1,04	70,43 ± 0,81	69,73 ± 1,20
Depth (Cm)	70, 10 ± 1,15	70,83 ± 1,04	70,43 ± 0,81	69,73 ± 1,20

Data collection, parameters and characteristics studied

Every two weeks, a control fishery was carried out during which 10% of the quantity of each tanks was sampled, the total and standard lengths were measured using a millimetered ichtyometer and the weight measured using a 2mg sensitivity electronic scale. The live weight, the total lengths and the standards collected allowed us to evaluate the following growth parameters:

- Weight gain (GP) = $\text{final weigth} - \text{initial weigth}$
- Average daily gain (GMQ) = $\frac{\text{final weigth} - \text{initial weigth}}{\text{Time (number of days)}}$
- Specific growth rate (TCS) = $\frac{(\ln \text{poids final} - \ln \text{poids initial}) \text{ X } 100}{\text{Time (number of days)}}$ (ln = neperian logarithm)
- Nutritive quotient (QN) = $\frac{\text{Quantity of food served}}{\text{final weigth} - \text{initial weigth}}$
- Condition factor K = $100(W/LT^3)$ (W = Weight (g) LT = Total length (cm))
- Survival rate = $\frac{(\text{initial number of fishes} - \text{Mortality}) \text{ X } 100}{\text{initial number of fishes}}$

Statistical analysis

The data collected was subjected to the one-way analysis of variance. In case of significant differences, the Duncan's test at the 5% threshold permitted us to compare the means. Correlations were made in order to raise the level of association between the characteristics studied. SPSS version 21.0 software was used to perform these analyzes.

Results

Effect of the type of food on the evolution of the live weight and the total length of the post-larvae of *Labeobarbus batesii.*

The evolution of the live weight (2A) and the total length (2B) of post-larvae of *Labeobarbus batesii* according to the type of food is illustrated by the Figure 2. It follows that, regardless of the type of food considered, the live weight and the total length increased throughout the test with the highest significant values (p<0,05) obtained in the tanks fed with Artemia and the lowest values in the fertilized tanks.

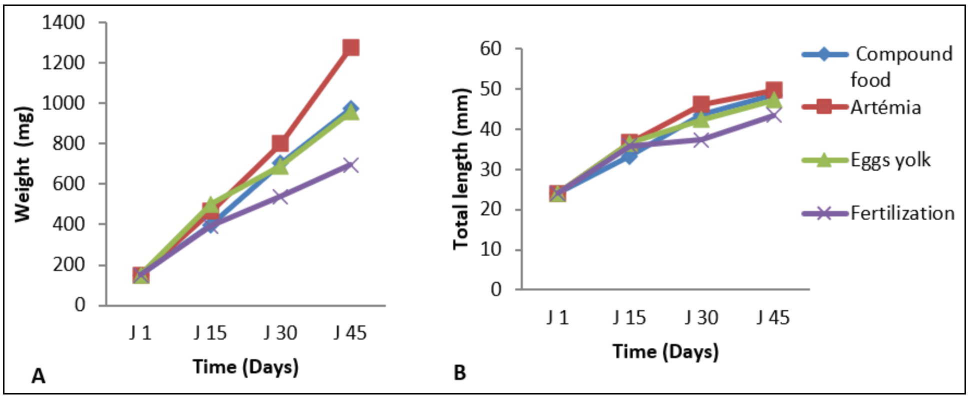

Fig 2: Evolution of live weight (A) and total length (B) of *Labeobarbus batesii* depending on the type of food

Growth performances of *Labeobarbus batesii* post-larvae according to the type of food

The variation of growth performances of post-larvae of *Labeobarbus batesii* according to the type of food is highlighted in Table 2. Thus, all the growth characteristics were significantly (p <0.05) influenced. Therefore, except the nutritive quotient, the highest significant values of the other growth characteristics were obtained in post-larvae fed with

Artemia while the lowest were recorded in individuals in the fertilized tanks

Table 2: Growth performances according to the type of food of *Labeobarbus batesii* post-larvae

Characteristics	Food types			
	Complete food	Artemia	Egg yolk	Fertilization
LT (mm)	48.43 ± 3.69^a	49.68 ± 4.03^a	47.17 ± 4.13^a	44.00 ± 1.63^b
LS (mm)	40.11 ± 3.06^a	41.59 ± 3.92^a	38.89 ± 3.38^{ab}	36.50 ± 1.00^b
PV (mg)	972.97 ± 202.28^b	1275.68 ± 220.36^a	957.14 ± 227.88^b	675.00 ± 95.74^c
GP (mg)	822.98 ± 202.28^b	1125.68 ± 220.36^a	957.14 ± 227.89^b	675.00 ± 95.74^c
GMQ (mg / d)	18.29 ± 4.50^b	25.02 ± 4.90^a	17.94 ± 5.06^b	11.67 ± 2.13^c
GL (mm)	23.43 ± 3.69^a	24.68 ± 4.03^a	22.17 ± 4.13^a	19.00 ± 1.63^b
TCS (%)	4.11 ± 0.43^b	4.72 ± 0.39^a	4.06 ± 0.53^b	3.33 ± 0.31^c
K factor	0.96 ± 0.12^b	1.15 ± 0.17^a	1.01 ± 0.15^b	0.89 ± 0.06^b
QN	2.30 ± 0.50^a	1.66 ± 0.33^b	2.41 ± 0.72^b	/

a, b and c: the means assigned the same letter on the same line show no significant difference (*P*> 0.05) between types of food. LT: total length; LS: standard length; PV: Live Weight; GP: Weight gain; GMQ: Average Daily Gain; GL: Length Gain; TCS: Specific Growth Rate; QN: Nutritive Quotient.

Relative growth of post-larvae of *Labeobarbus batesii* according to the type of food

The characteristics of the length-weight relationship summarized in Table 3 indicate that the weight of post-larvae is strongly associated with lengths (total and standard). This relation follows a power type equation and the coefficients of determination (R^2) are very strong. In addition, the allometric coefficient (b) varies from 2.03 (T1 with the standard length: LS) to 2.88 (T4 with the total length: LT). In short, the growth is of minorant allometric type independently of the type of food and the length considered.

Table 3: Weight length relationship in post-larvae of *Labeobarbus batesii* according to the type of food

Food types	Equations	R^2	a	b	Type of growth
Complete food	$Lw = 0.036LT^{2.41}$	0.757	0.036	2.41	Minorant
	$Lw = 0.057LS^{2.029}$	0.750	0.057	2,029	Minorant
Artemia	$Lw = 0.085LT^{2.681}$	0.763	0.085	2,681	Minorant
	$Lw = 0.224LS^{2.212}$	0.575	0.224	2,212	Minorant
Egg yolk	$Lw = 0.034LT^{2.12}$	0.754	0.034	2.12	Minorant
	$Lw = 0.045LS^{2.223}$	0.788	0.045	2,223	Minorant
Fertilization	$Lw = 0.01LT^{2.881}$	0.545	0.01	2,881	Minorant
	$Lw = 0.036LS^{2.277}$	0.461	0.036	2,277	Minorant

Lw: live weight; LT: total length; LS: standard length;

Effect of food type on the survival rate of *Labeobarbus batesii* post-larvae

The survival rate of *Labeobarbus batesii* post-larvae depending on the type of food is illustrated by Figure 3. It follows that the survival rate was significantly influenced (p <0.05) by the type of food with the highest values(55.61%) obtained in the tanks fed with Artemia and the lowest values (32.89) obtained in the fertilized tanks.

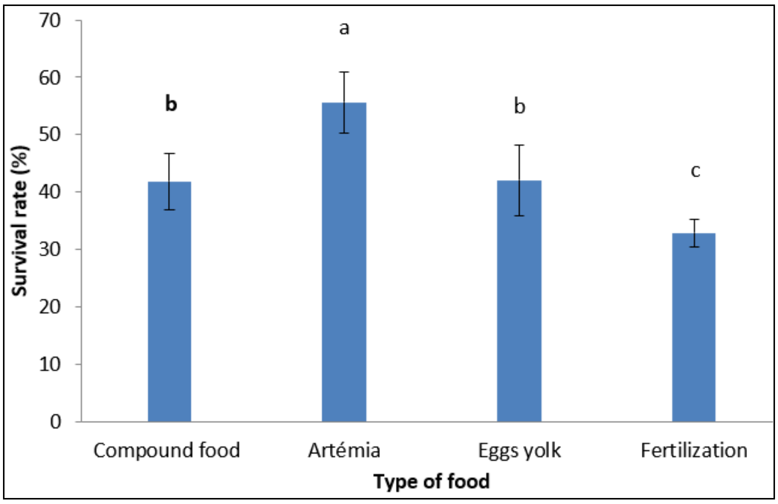

Fig 3: Survival rate of *Labeobarbus batesii* post-larvae according to the type of food

Correlations between different growth characteristics and survival rate depending on the type of food

The correlations between survival rates and different growth characteristics are presented in Table 4. It appears that all the growth characteristics showed a strong correlation between them. All these correlations were positive except for the condition factor K and the nutritive quotient (QN) which were rather negatively correlated with the other characteristics.

Concerning the survival rate, it rather showed a weak correlation with the other characteristics in the post-larvae fed with the complete compound food, while we observe a negative correlation between this characteristic and the growth characteristics of individuals from other treatment.

Table 4: Correlation between the different characteristics studied according to the type of food

Food type	Characteristics	LT	LS	PV	GP	GMQ	GL	TCS	K	TS	QN
Complete compound feed	LT	1									
	LS	, 968 **	1								
	PV	, 810 **	, 785 **	1							
	GP	, 810 **	, 785 **	1,000 **	1						
	GMQ	, 810 **	, 785 **	1,000 **	1,000 **	1					
	GL	1,000 **	, 968 **	, 810 **	, 810 **	, 810 **	1				
	TCS	, 817 **	, 797 **	, 994 **	, 994 **	, 994 **	, 817 **	1			
	K	-, 513 **	-, 480 **	. 076	. 076	. 076	-, 513 **	, 066	1		
	TS	.025	.003	, 125	, 125	, 125	.025	, 126	, 170	1	
	QN	-, 816 **	-, 802 **	- .967 **	- .967 **	- .967 **	-, 816 **	- .989 **	-, 043	-, 125	1
Artemia	LT	1									
	LS	, 887 **	1								
	PV	, 809 **	, 696 **	1							
	GP	, 809 **	, 696 **	1,000 **	1						
	GMQ	, 809 **	, 696 **	1,000 **	1,000 **	1					
	GL	1,000 **	, 887 **	, 809 **	, 809 **	, 809 **	1				
	TCS	, 823 **	, 706 **	, 997 **	, 997 **	, 997 **	, 823 **	1			
	K	-, 740 **	-, 669 **	-, 215	-, 215	-, 215	-, 740 **	-, 241	1		
	TS	-, 299	-, 275	- .078	- .078	- .078	-, 299	-, 102	, 399 *	1	
	QN	-, 834 **	-, 713 **	- .983 **	- .983 **	- .983 **	-, 834 **	- .995 **	, 273	, 131	1
Egg yolk	LT	1									
	LS	, 966 **	1								
	PV	.790 **	, 808 **	1							
	GP	.790 **	, 808 **	1,000 **	1						
	GMQ	.790 **	, 808 **	1,000 **	1,000 **	1					
	GL	1,000 **	, 966 **	.790 **	.790 **	.790 **	1				
	TCS	, 815 **	, 832 **	, 989 **	, 989 **	, 989 **	, 815 **	1			
	K	-, 511 **	-, 428 *	, 111	, 111	, 111	-, 511 **	. 071	1		
	TS	-, 069	- .070	-, 145	-, 145	-, 145	-, 069	-, 146	-, 119	1	
	QN	-, 821 **	-, 834 **	- .942 **	- .942 **	- .942 **	-, 821 **	- .981 **	- .015	. 158	1
Fertilization (freshwater zooplankton)	LT	1									
	LS	.905 **	1								
	PV	, 655 **	, 585 **	1					,		
	GP	, 655 **	, 585 **	1,000 **	1						
	GMQ	, 655 **	, 585 **	1,000 **	1,000 **	1					
	GL	1,000 **	.905 **	, 655 **	, 655 **	, 655 **	1				
	TCS	.670 **	, 600 **	, 994 **	, 994 **	, 994 **	.670 **	1			
	K	- .020	-, 023	, 737 **	, 737 **	, 737 **	- .020	, 728 **	1		
	TS	-, 365	-, 383	-, 114	-, 114	-, 114	-, 365	-, 146	, 163	1	

LT: Total length; LS: Standard length; PV: Live Weight; GP: Weight gain; GMQ: Average Daily Gain; GL: Length gain; TCS: Specific Growth Rate; K: condition factor; TS: Survival rate; QN: Nutritive Quotient ;**; *. : Correlation is significant at level 0.01and 0.05 respectively

Discussion

Total length and length gain

During this test, the values of total length (LT) and length gain (GL), varying respectively from 44 to 50 and from 19 to 25 mm, were much higher than the respective values of 30; 25 and 36.2 mm reported respectively by [26] in the Clariidae, [27] in *Cirrhius mrigala* post-larvae (20 days old) and by [28] in Common carp post-larvae (at 30 days of age). The high value of this result would be explained not only by the species used but also by the longer duration of the nursery which was 45 days in this test. Concerning the length gain, the values remain well above the 4.59 mm reported by [29] in the larvae of *Channa striatus*. They are comparable to the values of 20.69 mm obtained by [30] after 60 days of washing with *Osteochilus vittatus*. This value is still lower than that obtained with *Puntius Vitattus* (33.1 - 45.2 mm) by [31] after 75 days of breeding. These results would suggest high length growth in this species at this stage of development.

Body weight, weight gain and average daily gain

The values obtained during this work, between 675-1275mg; 525-1126mg and 12-26 mg/Day respectively for bodyweight, weight gain and average daily gain, were very high compared to those obtained after 30 days of nursery by [28] in post-larvae of common carp (420-620mg; 180-431 mg and 12-29 mg/Day respectively). The same observations were made by [31] in the ornamental fish *Puntus vittatus* (370-840 mg and 5-11.2 mg/Day respectively for weight gain and average daily gain) after 75 days of nursery. These values are still much lower than those reported by [32] in *Cyprinus carpio* fingerlings (7680mg- 13410mg; 170-300 mg/Day respectively for weight gain and average daily gain) after 45 days of breeding and by [30] in juveniles of *Osteochilus vittatus* (13740-20690 mg and 2560-3110 mg/Day) for the same parameters. The same is true by the work of [33] in the *Aspikutum* hybrid with respective values of weight gain and average daily gain of 5190-8620 mg and 280-460 mg/Day. These differences could be explained by the species used, the duration of production and the stage of breeding.

Specific growth rate, condition factor K and nutrient quotient

The specific growth rate range between 3.33 and 4.72% obtained during this work is high compared to that (1.4-2.04%) reported by [34] in the post-larvae of the keurelian fish *Tor tamba*. The same trend was observed by [35] in post-larvae of *Pethia reval* (1.3-1.49%). However, this rate remains low compared to the values of 3.33-10.85% obtained by [28] in the post-larvae of *Cyprinus carpio*. These differences are essentially linked to the genetic determinism of the species.

The values of the condition factor K ranged during this test between 0.90 and 1.50 were comparable to the values (0.89-1.096) obtained by [17] in the natural milieu in the same species, and those of 0.93-1.23 reported by [28] in the post-larvae of *Cyprinus carpio*. This value remains relatively high compared to that (0.73-0.77) obtained in the *Aspikutum* hybrid by [33]. This factor remains very low compared to the values of 0.87-3.14 obtained by [36] with *Garra ruffa*. The low observed values of K would be explained by the high density used in this test, which were 250 individuals /m^3. In short, regardless of the type of food used, post larvae show a good nutritional and sanitary state since all the K values remained superior to 1 ($K \geq 1$)

Survival rate

The values of this parameter during the test varied significantly between 32 and 56%. This result is similar to that observed with *Cirrhius mrigala* by [27], which reports survival rates varying from 30-50% during the first 20 days of nursery and 60-70% during 2-3 months of pre-growth with this species. Furthermore, our rates are higher than those obtained by [28] with the post-larvae of *Cyprinus carpio* (29.67-37%). However, it remains very low compared to those (79-92% and 78-93%) obtained from the fry of *Poecilia reticulata* and *Pethia reval* respectively by [37] and [35]. This variation can be explained by the difference in the development stage considered and therefore, because of the fragility and the difficulty of nutrition of the post-larva used in breeding.

Length-weight relationship

The relative growth coefficient b indicates the type of growth. Indeed, when b is equal to 3, growth is said to be isometric, and when it is different from 3, growth is said to be allometric, hence the concepts of negative or minorant allometry if $b < 3$ and positive or majorant allometry for $b > 3$ [38]. In our study, b ranges from 2.029 to 2.881, indicating a minorant allometry. This result is close to the observations of [39], who, comparing 03 strains of Nile Tilapia in hatchery, obtained the values of b varying between 2.28 and 3. However, it remains far from that of [17] who reported values of this parameter ranged between 2.785 and 3.088 with adults *Labeobarbus batesii*.

Conclusion

At the end of this study on the effect of the type of food on survival and growth performances of post-larvae of *Labeobarbus batesii* in captivity, it appears that the type of food significantly influenced both the survival rate and the set of growth characteristics. The best growth performances and survival rates were obtained with batches fed with Artemia (brackish water zooplankton) unlike batches fed with freshwater zooplankton. The use of Artemia is therefore recommended for the nursery of *Labeobarbus batesii*. However, for better domestication of this species, it would be necessary to assess its nutrients requirements (protein and energy needs).

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