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Effect of dietary energy level on the survival rate and growth performances of the african carp fry *Labeobarbus batesii* (Boulenger, 1903) in pre-fattening

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Abstract
With the aim of contributing to the domestication of *Labeobarbus batesii*, survival and growth performance in pre-fattening according to the dietary energy level were studied between July and December 2020, at the IRAD station in Foumban. For this, a total of 400 fingerlings with an average weight of 1.05 ± 0.15 g and an average total length of 4.86 ± 0.18 cm were divided into duplicates in four batches: R1, R2, R3 and R4, representing respectively the diets at 3600, 3700, 3800 and 3900 kcal of Metabolizable Energy (ME) per kg of food. The fish were fed twice a day (9 a.m. and 5 p.m.) at 5% of the fish biomass, for 180 days, during which the live weight and lengths were measured monthly. The main results are as follows: the highest survival rate (61.15%) was recorded in the batches receiving the diet at 3700 kcal/kg, while the lower rate (34.375%) in those receiving the diet at 3600 kcal/kg. Growth characteristics and food conversion rate varied between treatments. The highest values ($p<0.05$) were recorded with fishes fed the 3600 kcal/kg diet, compared to those receiving the 3800 kcal/kg one. The K factor was low and varied from 0.709 ± 0.037 (3700 kcal/kg) to 0.820 ± 0.032 (3800 kcal/kg). Whatever the dietary energy level, the fry showed a lower allometric growth. Thus, food containing 3600 kcal ME/kg is recommended to optimize the growth of *Labeobarbus batesii* in pre-fattening.

Keywords: *Labeobarbus batesii*; pre-fattening; metabolizable energy; survival rate; growth performances

Introduction

The Cyprinid family is the most produced in the world, representing 71% of aquaculture production (Gotesman *al.*, 2013; Burel and Médale, 2014) [9, 2]. The Asian continent is the largest producer and this production is based on the great diversity of endogenous species (3000 species). Despite the great diversity of species in this family within the African continent, which is 3,200 species (Tiogue and *al.*, 2013), comparable to that of Asia, no local cyprinid has so far been commonly used in aquaculture. However, several researches have already been carried out and others are in progress with a view of domesticating African carp in order to enhance the biodiversity in aquaculture. These include *Labeo parvus* in Benin (Montchowui and *al.*, 2010; Montchowui *et al.*, 2012) [19, 21], *Labeo coubie* (Ikpi and Okey, 2010) [11] in Nigeria, *Labeo senegalensis* in the Ouémé River in Benin (Montchowui and *al.*, 2010) [19] and *Labeobarbus batesii* in the rivers of the Mbô floodplain in Cameroon (Tiogue and *al.*, 2013; Tiogue and *al.*, 2010; Tiogue and *al.*, 2014; Tomedi and *al.*, 2014) [31].
Labeobarbus batesii (Boulenger, 1903) is an endogenous cyprinid in Cameroon, much appreciated by the local populations and always among the fish displayed and sold along the roads by local fishermen. In addition, researches carried out in its natural environment by (Tiogue and *al.*, 2013) made it possible to declare this carp as a good candidate for aquaculture. Its large size suggests a high growth rate (Tomedi and *al.*, 2014) [31] and its reproductive performances are appreciable (Tiogue and *al.*, 2013). Its broad food spectrum indicates flexibility and an ability to adapt to the food available in the environment in which it finds itself (Tiogue and *al.*, 2014). In a captive environment, the food preferences of this species at the post-larval stage (Tonfack and *al.*, 2020a) [32] and its pre-fattening protein requirements (Tonfack and *al.*, 2020b) [33] were studied. However, no study has yet been conducted on the energy requirements of this cyprinid. Nevertheless, the production of knowledge on its energy needs would certainly contribute to the continuity of its process of domestication. The objective of this work is therefore to contribute to the preservation and enhancement of the biodiversity of Cyprinids through a better knowledge of their nutritional needs. More specifically, the effect of the energy level of the diet on the survival rate and the growth characteristics of *Labeobarbus batesii* fry in pre-fattening will be evaluated.

Material and methods

Study period, area and site

The study took place between July and December 2020 at the fish farm of the Station of the Institute of Agricultural Research for Development (IRAD) at Foumban. This farm, located at Koupa Matapit (5°45.826' LN and 10°48.516' LE), is 9 km from the town of Foumban (Western Cameroon Highlands). The Sudano-Guinean type climate includes a rainy season (March – October) and a dry season (November – February). The average temperature and rainfall are 22ºC and 1800 mm/year respectively (Mikolasek and *al.*, 2006).

Animal material

A total of 400 *Labeobarbus batesii* fry with an average total length of 4.86 ± 0.18 cm and an average weight of 1.05 ± 0.15 g were collected in the wild by fishermen in the Nkam River and transported in oxygenated plastic bags to IRAD's fish farm. For their acclimatization, these fry were kept in happas at a density of 25 fry/m^2 and fed a standard diet containing 25% crude protein (Tonfack and *al.*, 2020b) [33] for two weeks.

Breeding structure

The test took place in 08 identical happas of rectangular shape, with dimensions of 1.80 × 0.80 × 1.60 m (length x width x height), made of mesh mosquito net of 1.5 mm. These happas were implanted in a rectangular pond of 400 m^2, previously cleaned and disinfected with quicklime two weeks before, then dried for 7 days before impoundment. Each happas was equipped with a floating frame below which was placed a basin used to collect food refusals. The pond was equipped with a water supply channel and an overflow pipe to control and maintain the water level in the happas at a height of 0.90 m throughout the experiment..

Experimental diets

Depending on the energy needs of Cyprinids, four experimental isoproteic diets were formulated. To do this, the ingredients used were purchased in local markets. The compositions and analyzed characteristics of these diets are presented in Table 1.

Table 1: Experimental diets

Ingredients	Experimental diets (ME in kcal/kg)			
	R1: 3600	**R2: 3700**	**R3: 3800**	**R4: 3900**
Corn	29.00	38.00	32.00	36.00
Remolding	30.00	19.00	24.00	18.00
Cotton cake	15.00	9.00	8.00	4.00
Soybean meal	9.30	10.03	9.30	10.30
Blood meal	2.00	2.00	2.00	2.00
Fish meal	8.00	13.00	14.00	17.00
Shell	0.10	0.10	0.10	0.10
Bone meal	0.10	0.10	0.10	0.10
Palm oil	4.00	6.00	8.00	10.00
Iodized salt	0.50	0.50	0.50	0.50
Premix 2%	2.00	2.00	2.00	2.00
Total	100.00	100.00	100.00	100.00
Bromatological compositions analyzed				
Dry matter (%)	88.58	88.635	89.03	88.71
Ash (% DM)	6.385	5.835	6.41	5.675
OM (% DM) (kcal/kg)	81.7	82.8	82.535	83.035
CP (% DM)	19.36	19.43	19.92	20.215
Fat (% DM)	9.00	10.715	11.595	16.24
CC (% DM)	8.93	5.955	6.2	6.675
ME (kcal)	3588	3708	3820	3911

ME= Metabolizable Energy; DM = Dry Matter; OM = Organic Matter; CP= Crude Protein; CC= Crude Cellulose.

Experimental design

The 400 fry were randomly divided into eight comparable batches of 50 fishes each. These were placed in the eight happas described above at a density of 25 fry/m^2. Each happa received randomly and in duplicate one of the experimental diets R1, R2, R3 and R4, representing respectively the diets containing 3600, 3700, 3800 and 3900 kcal of ME/kg of food, according to a complete randomization design.

Conducting of the trial and data collection

During the 5 months of experimentation, the fry were fed twice a day (9 a.m. to 10 a.m. and 4 p.m. to 5 p.m.) at 5% of the fish biomass. A control fishery was carried out every month during which 20% of the population of each happa was sampled at random using a dip net, for body measurements as at the start of the trial. Thus, each fish was weighed individually using an electronic scale with a precision of 0.1g (Tomedi-Eyango and *al.*, 2008) [30] and measured using a millimetric ichthyometer. The monthly weight assessment allowed us to readjust the quantities of food to be distributed the following month. Food refusals were also collected from basins every week, dried under the sunlight and then weighed to estimate food characteristics. The physico-chemical characteristics of the water (pH, dissolved oxygen, temperature, conductivity, transparency and depth) were measured in-situ (in the pond) at the start of the test then every week between 6 and 8 am using appropriate devices. The monthly means of the values of these characteristics are presented in Table 2. At the end of the experiment, all the individuals were fished in each happa, counted and then measured (weight and height).

Table 2: Monthly averages of the physicochemical characteristics of the water in the pond.

Physicochemi-cals Features	July	August	September	October	November	December
Temperature (°C)	22.65±0.41	22.35±0.33	21.88±0.25	22.48 ± 0.38	23.29±0.17	24.57±0.15
pH	8.75±0.27	8.93±0.31	8.69±0.15	9.16 ± 0.28	9.02±0.37	9.40±0.22
Dissolved oxygen (mg/L)	9.58 ± 0.21	9.59 ± 0.18	9.45 ± 0.29	9.78 ± 0.26	9.27±0.14	9.31±0.35
Conductivity (µs/cm)	227.85±8.87	235.3±7.77	239.78±8.45	229.89±8.63	237.75±8.5	242.78±9.8
Transparency (cm)	33.43±1.60	34.75±1.29	33.93±1.18	29.86±1.06	25.14±1.64	22.97±1.56
Depth (cm)	85.73±1.32	89.27±1.41	90.79±1.72	88.93 ± 1.39	86.96±1.86	83.93±1.28

Studied characteristics

Survival rate

The survival rate was calculated using the formula:

$$Ts= \frac{(Initial\ number\ of\ fishes - Mortality)X100}{Initial\ number\ of\ fishes}$$

The live weight, the lengths (total and standard) collected allowed us to evaluate the following growth parameters:

Weight gain (WG) = $Final\ weight - Initial\ weight$

Average daily gain (ADG) = $\frac{Final\ weight\ - Initial\ weight}{Time\ (number\ of\ days)}$

Specific growth rate (SGR) = $\frac{(\ln final\ weight\ - \ln\ initial\ weight)\ X\ 100}{Time\ (number\ of\ days)}$

(ln = natural logarithm)

Length-weight relationship

It was established according to the equation: $W = a\ TL^b$ (Le Cren, 1951), with W = total fish weight (g), a = regression constant, b = regression coefficient, TL = total length (cm).

Condition factor K

This factor was calculated using the formula of (Ricker, 1975):

K = $100(W/TL^3)$, with W = total weight (g), TL = Total length (cm).

The food refusals collected allowed us to estimate the following food characteristics through the formulas below:

Food consumption (FC) = Quantity of food served – Refusal

Food conversion rate (FCR) = $\frac{CA}{GP}$

Statistical analysis

The data collected was subjected to one-way analysis of variance. When significant differences occured, Duncan's test at the 5% threshold was used to compare the means. Correlations were made to reveal the level of association between the studied characteristics. SPSS version 21.0 software was used to perform these analyses.

Results

The previous methodology allowed us to obtain the following main results:

Effect of dietary energy level on the survival rate of *Labeobarbus batesii* fry in pre-fattening

The analysis of variance showed that the level of energy in the diets significantly ($p<0.05$) influenced the survival rate of *L. batesii* fry. Thus, the means of the values of the survival rate according to the dietary energy level are illustrated in Fig. 1. The latter reveals that the highest value (61.15%) was recorded in the batches of fry fed with the diet at 3700 kcal ME/kg and the lowest (34.375%) with those fed with the diet with the lowest energy level. A significant difference ($p<0.05$) was observed between the individuals fed with the diet with the highest energy levels, 3800 and 3900 kcal/kg (comparable to each other) and those fed with the diet at low energy levels (3600 and 3700 kcal/kg).

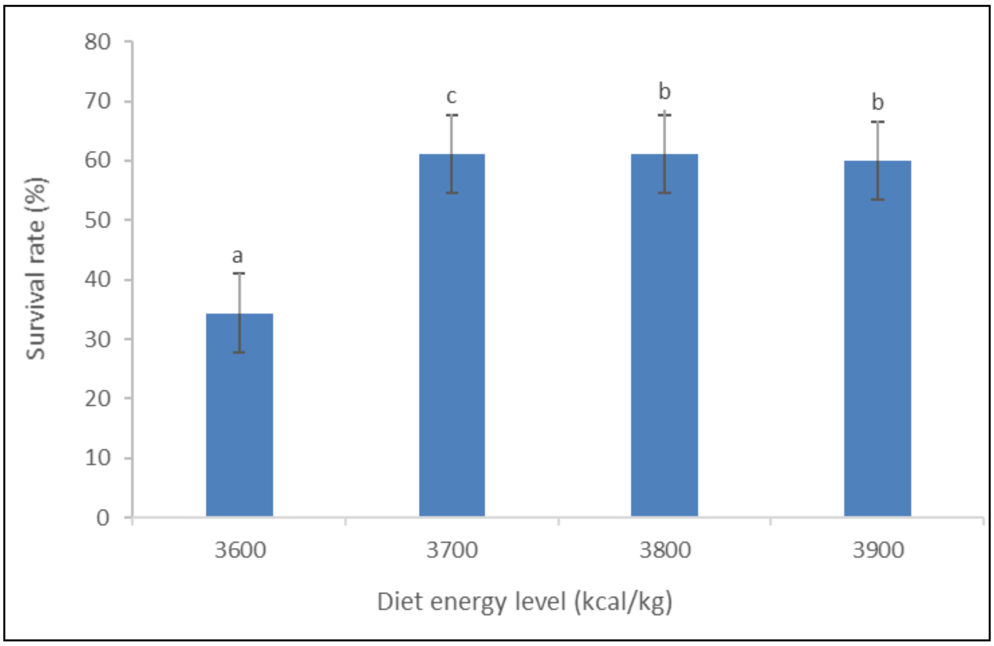

Fig 1: survival rate of *l. batesii* fry according to the dietary energy level in pre-fattening.

Effect of the energy level of the diet on the growth performances of *Labeobarbus batesii* fry

The analysis of variance showed that all the growth performances of *L. batesii* in pre-fattening were significantly affected by the dietary energy level.

Evolution of the total length of *L. batesii* fry according to the energy level of the diet

The monthly evolution of the total length of *L. batesii* fry according to the energy level of the diet (Fig. 2) indicates that, regardless the considered diet, this characteristic increased throughout the trial. Furthermore, regardless the considered period, the batches fed with the lowest dietary energy level presented the significantly ($p<0.05$) highest values. The lowest values were recorded in the batches receiving the diet containing 3800 kcal ME/kg.

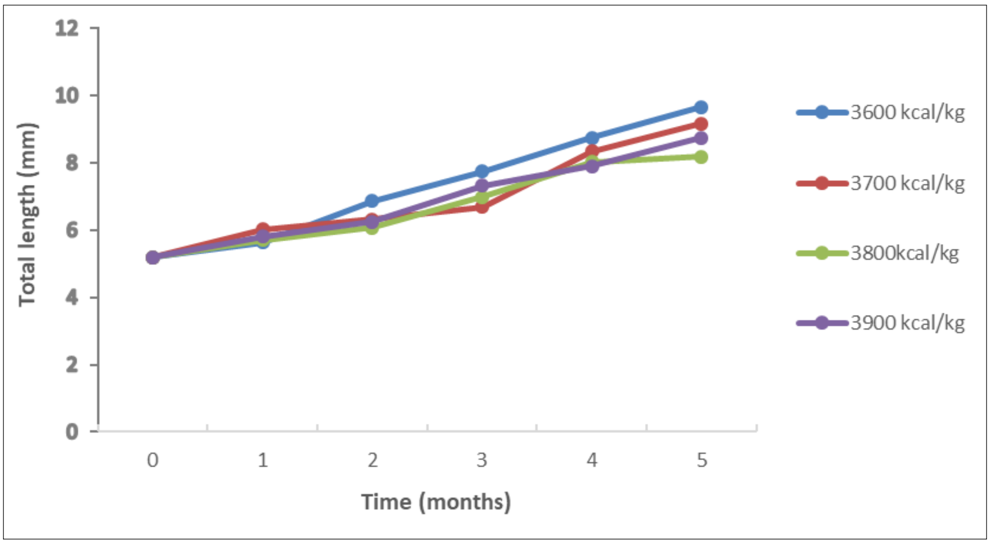

Fig 2: Effect of dietary energy level on the evolution of the total length of *Labeobarbus batesii* fry.

Means and standard deviations of growth performances of *L. batesii* fry according to the dietary energy level in pre-fattening

According to Table 3, the highest values of weight (5.72 ± 0,21 g), weight gain (4.68 ± 0,21 g) and average daily gain (0.03 ± 0,001 g/d) were recorded in the batches receiving the lowest dietary energy level. Furthermore, the lowest values (4.69 g, 3.65 g and 0.024 g/d, respectively) were obtained in those receiving the diet at 3800 kcal/kg.

Regarding the specific growth rate, the highest means (1.078 ± 0.028%) were recorded with the fry fed at the diet with the lowest energy level and the lowest values (0.949 ± 0.028 %) with those fed at 3800 kcal/kg in the diet.

Concerning the condition factor K, the fry receiving the diet at 3800 kcal/kg presented significantly ($p<0.05$) high values (0.082 ± 0.03) and the lowest values (0.71 ± 0.04) were obtained with those receiving 3700 kcal/kg in the diet.

As for feeding characteristics, feed consumption and feed conversion rate showed significantly high values (17.47 ± 0.11 and 5.06 ± 0.23, respectively) with the fry fed 3800 kcal/kg in the diet. The lowest values were obtained in batches receiving the highest energy level in the diet for food consumption (16.6 ± 0.11 g) and in those receiving the lowest dietary energy for food conversion rate (3.88 ± 0.23).

Table 3: Growth characteristics of *Labeobarbus batesii* fry according to the energy level of the diet.

Features	Metabolizable Energy Levels (kcal/kg of food)			
	R1: 3600	**R2: 3700**	**R3: 3800**	**R4: 3900**
TL (mm)	9.19±0.19^{b}	9.16±0.22^{b}	8.330± 0.19^{a}	8.82±0.19^{a,b}
SL (mm)	8.11±0.161^{b}	7.93±0.18^{b}	7.27±0.16^{a}	7.63±0.16^{a,b}
Weight (g)	5.72±0.21^{c}	5.44±0.24^{b,c}	4.69±0.21^{a}	4.93±0.21^{a,b}
WG (g)	4.68±0.21^{c}	4.4±0.24^{b,c}	3.65±0.21^{a}	3.89±0.21^{a,b}
ADG (g/d)	0.03±0.001^{c}	0.029 ±0.002^{b,c}	0.024±0.001^{a}	0.026 ± 0.001^{a,b}
LG (mm)	4.33±0.19^{b}	4.3±0.22^{b}	3.47±0.19^{a}	3.96±0.19^{a,b}
SGR (%)	1.078±0.028^{c}	1.055 ±0.033^{b,c}	0.949±0.028^{a}	0.983±0.028^{a,b}
K-factor	0.76±0.03^{a,b}	0.71±0.04^{a}	0.82±0.03^{b}	0.72±0.03^{a}
FC (g)	17.01±0.11^{b}	17.24±0.13^{b,c}	17.47±0.11^{c}	16.6±0.11^{a}
FCR	3.88±0.23^{a}	4.01±0.26^{a}	5.06±0.23^{b}	4.49±0.22^{a,b}

a, b and c: means with the same letter on the same row show no significant difference (P>0.05) between different energy levels. TL: total length; SL: standard length; WG: weight gain; ADG: average daily gain; LG: length gain; SGR: specific growth rate; FC: food consumption; FCR: food conversion rate.

Length-weight relationship of *Labeobarbus batesii* fry in pre-fattening according to the dietary energy level

The length-weight relationship of *L. batesii* fry according to the dietary energy level is presented in Table 4. It can be deduced that the weight of the fry of this African carp is associated with the lengths (total and standard). This relationship follows a power-type equation and the coefficients of determination (R^2) are very strong in all treatments, except those fed with the diet containing the lowest energy level. Furthermore, the allometric coefficient (b) varies from 1.34 (diet at 3600 kcal/kg with the standard length) to 1.98 (diet at 3900 kcal/kg with the standard length). In short, the growth of this species at this development stage is of the minorant allometric type whatever the energy level of the diet and the length considered.

Table 4: Length-weight relationship of *Labeobarbus batesii* fry according to the dietary energy level.

Diet energy level (kcal/kg)	Relationships				
	Equations	**R^2**	**a**	**b**	**Type of growth**
3600	$LW = 0.25TL^{1.40}$	0.56	0.25	1.40	Minorant
	$LW = 0.34SL^{1.34}$	0.52	0.34	1.34	Minorant
3700	$LW = 0.09TL^{1.87}$	0.93	0.09	1.87	Minorant
	$LW = 0.10SL^{1.94}$	0.92	0.10	1.94	Minorant
3800	$LW = 0.13TL^{1.69}$	0.91	0.13	1.69	Minorant
	$LW = 0.11SL^{1.88}$	0.95	0.11	1.88	Minorant
3900	$LW = 0.10TL^{1.80}$	0.91	0.10	1.80	Minorant
	$LW = 0.09SL^{1.98}$	0.93	0.09	1.98	Minorant

LW: live weight; TL: total length; SL: standard length.

Correlations between the different growth characteristics and the survival rate according to the dietary energy level

The correlations between the survival rate and the different growth characteristics are presented in Table 5. It appears that the lengths (total and standard) presented a significant, strong and positive correlation with all the characteristics except the condition factor k, the survival rate, the feed consumption and the feed conversion rate, with which they showed a weak and negative correlation, precisely in the batches fed with the diets at 3700 and 3800 kcal ME/kg. Correlations were positive and weak between length and survival rate and also with food consumption in batches receiving diets at 3600 and 3900 kcal ME/kg.

Live weight, weight gain, average daily gain and specific growth rate were significantly and positively correlated with all traits except the K-factor and the feed conversion ratio (where the correlation was strong and negative), as well as the survival rate and the food consumption (where the correlation was weak). Regarding feed consumption and feed conversion rate, they were low and negatively correlated with all the characteristics in all the treatments, except for the groups fed at 3600 and 3900 kcal ME/kg in the diets, where the correlation of the food consumption, although weak, is positive.

Table 5: correlations between different growth characteristics and survival rate according to the dietary energy level.

Diet energy level (kcal/kg)	Correlations											
	Features	**TL**	**SL**	**LW**	**WG**	**ADG**	**LG**	**SGR**	**K**	**Survival**	**FC**	**FCR**
3600	TL	1										
	SL	.920**	1									
	LW	.759**	.741**	1								
	WG	.759**	.741**	1.00**	1							
	ADG	.759**	.741**	1.00**	1.00**	1						
	LG	1.00**	.920**	.759**	.759**	.759**	1					
	SGR	.761**	.729**	.995**	.995**	.995**	.761**	1				
	K	-.837**	-.768**	-.309	-.309	-.309	-.837**	-.325	1			
	Survival	.477*	.196	-.381	-.381	-.381	-.477*	-.395	-.360	1		
	FC	.463*	.401	.622*	.622*	.622*	.463*	.685**	-.308	.268	1	
	FCR	-.765**	-.726**	-.989**	-.989**	-.989**	-.765**	-.993**	.317	-.407	-.625**	1
3700	TL	1										
	SL	.994**	1									
	LW	.951**	.948**	1								
	WG	.951**	.948**	1.00**	1							
	ADG	.951**	.948**	1.00**	1.00**	1						
	LG	1.00**	.994**	.951**	.951**	.951**	1					
	SGR	.961**	.957**	.998**	.998**	.998**	.961**	1				
	K	-.926**	-.916**	-.764**	-.764**	-.764**	-.926**	-.790**	1			
	Survival	-.005	-.10	.005	.005	.005	-.005	.001	.019	1		
	FC	-.056	.071	-.110	-.110	-.110	-.056	-.100	-.022	-.875**	1	
	FCR	-969**	-.962**	-.990**	-.990**	.990**	-969**	-.997**	.819**	-.017	,111	1
3800	TL	1										
	SL	.962**	1									
	LW	.961**	.975**	1								
	WG	.961**	.975**	1.00**	1							
	ADG	.961**	.975**	1.00**	1.00**	1						
	LG	1.00**	.962**	.961**	.961**	.961**	1					
	SGR	.962**	.979**	.999**	.999**	.999**	.962**	1				
	K	-.884**	-.751**	-.724**	-.724**	-.724**	-.884**	-.727**	1			
	Survival	-.265	-.247	-.266	-.266	-.266	-.265	-.271	.230	1		
	FC	-.149	-.086	-.079	-.079	-.079	-.149	-.076	.243	-.655**	1	
	FCR	-.961**	-.982**	-.992**	-.992**	-.992**	-.961**	-.997**	.735**	.264	.095	1
3900	TL	1										
	SL	.996**	1									
	LW	.948**	.957**	1								
	WG	.948**	.957**	1.00**	1							
	ADG	.948**	.957**	1.00**	1.00**	1						
	LG	1.00**	.996**	.948**	.948**	.948**	1					
	SGR	.959**	.967**	.998**	.998**	.998**	.959**	1				
	K	-.914**	-.896**	-.741**	-.741**	-.741**	-.914**	-.767**	1			
	Survi-val	.202	.193	.158	.158	.158	.202	.141	-.217	1		
	FC	.290	.295	.263	.263	.263	.290	.254	-.273	-.462*	1	
	FCR	-.956**	-.962**	-.977**	-.977**	-.977**	-.956**	-.988**	.789**	-.148	-.153	1

**: The correlation is significant at the 0.01 level (two-sided); *: The correlation is significant at the 0.05 level (two-sided).

TL: total length; SL: Standard length; LW: live weight; WG: weight gain; ADG: average daily gain; LG: length gain; SGR: specific growth rate; FC: food consumption; FCR: food conversion rate.

Discussion

The survival rate of *Labeobarbus batesii* fry varied significantly ($p<0.05$) depending on the energy level in the diet. This result is not in agreement with that of Marammazi and Kahkesh (2011) [16] who reported a non-significant variation of this parameter in juvenile *Barbus grypus*, fed at different energy levels (from 2500 to 3500 kcal/ kg), although their values (97.8 - 100%) are high to those obtained during this work. This difference would be essentially due to the size and stage of development of this species; the juvenile would have been less sensible to the dietary variations compared to the fry. However, the values obtained are similar to those (57 - 67%) revealed by Tonfack and *al.* (2020b) [33] in the fry of the same specie fed with diets at different levels of crude protein and those (60 – 70%) reported by FAO (2009) [8] in *Cirrhius mrigala* during 2 to 3 months of pre-fattening. Moreover, these values are higher than those (29.67 - 37%) reported in *Cyprinus carpio* post-larvae (Djikengoue and *al.*, 2020) exposed to different levels and frequency of fertilization with chicken droppings, for 30 days. On the other hand, they remain weak compared to those (79 – 92% and 78 – 93%) revealed in *Poecilia reticulata* fry (Paliitha and *al.*, 2010) [22] and *Pethia reval* (Rathnayake and *al.*, 2016), respectively, fed with different types of food. This fluctuation in the values of the survival rate would be essentially due to the wild character of this specie, which would have not yet adapt to the new farm fishing conditions.

The total length as well as the length gain have been significantly ($p<0.05$) influenced by the energy level of the food. This result is not in agreement with that of Tsoupou and *al*. (2018) [34] in *Clarias jaensis* fingerlings, which showed that the total length was not significantly ($p<0.05$) affected by the energy level of the diets. The values of these parameters showed a tendency to decrease with increasing level of energy in the diet. This trend is contrary to that reported by Mishra and Samantaray (2004) [18] in *Labeo rohita* whose lengths increased (from 9.4 to 10.04 cm TL and from 3.6 to 4.24 cm LG) at the same time as the dietary energy level (from 2891 to 3794 kcal/kg of dry matter). In view of this difference in trend, it would be obvious that high-energy diets have little or no effect on the growth in length of *L. batesii*. Indeed, energy-rich diets reduce the digestion and assimilation of lipids by fish, resulting in poor growth (Sargent and *al.*, 1989) [25]. According to Le Gouvello *et al.* (2017) [14], in common carp and Chinese carp, a diminution of the fat digestive utilization is observed beyond 10-15% of fat in the diet.

Moreover, FAO (2009) [8] recorded values (8-10 cm TL) comparable to those obtained in this work in juvenile *Cirrhius mrigala* after 90 days of rearing. Similar values (6.4-6.9 cm TL and 1.9-2.42 cm GL) were reported by Tonfack and *al.* (2020b) [33] in post-larvae of this same specie fed with diets at different levels of crude protein (25 to 40%) for 4 months. According to these same authors, these results would suggest an average growth in length in this specie at this stage of development. The differences noted between the values would be essentially due to the genetic determinism of the species.

During this study, the energy level of the diet significantly ($p<0.05$) affected live weight, weight gain and average daily gain. This result is in agreement with that of Al Dilaimi (2010) [1] in Nile tilapia fry (*Oreochromis niloticus*) fed diets with different lipid levels (6, 9, 12, 15 and 18%) for 28 days. On the other hand, El-Dakar and *al.* (2010) [7] reported that diets containing different energy levels (3882 - 4360 kcal/kg food) do not significantly influence these parameters in *Siganus rivulatus* fingerlings. This difference could be explained by the omnivorous, detritivorous and benthopelagic character of African carp (Tiogue and *al.*, 2013) and tilapia, which allows them an efficient digestion of lipids.

The highest live weight, weight gain and average daily gain were obtained in fry fed with the diet containing the lowest energy level. Similar results were reported by some authors with high values compared to those obtained in this study. Thus, Du and *al.* (2005) [5] reported in juvenile *Ctenopharyngodon idella* a decreasing WG from 117.85 ± 9.39 to 81.64 ± 5.06 g as the lipid level of the diet increases from 60 to 120 g/kg of dry matter. Similarly, Marais and Kissil (1979) [15] observed a decrease in ADG from 0.505 to 0.389 g/d in *Sparus aurata* sea bream at the same time as the energy level in the diet increased from 4687 to 5053 kcal/kg. It is the same for Marammazi and Kakesh (2011) [16] and Yilmaz and *al.* (20126) [35] who found a decrease in WG (from 294.2 to 233.4 g and from 14.55 to 4.10 g, respectively) correlated with the increase in energy level (from 2500 to 3500 kcal/kg and from 2600 to 3600 kcal/kg, respectively) in diets in juvenile *Barbus grypus* and *Cyprinus carpio*, respectively, during 60 days of rearing. Mishra and Samantaray (2004) [18] also reported that GP decreases (from 17.06 ± 0.5 to 12.06 ± 0.38 g) with increasing rate of diet energy (from 2900 to 3800 kcal/ kg of dry matter) in *Labeo rohita* fed for 56 days.

However, the values obtained in this present work are higher than those reported by Imtiaz (2007) [12] in the Indian major carp *Labeo rohita*, whose WG has varied from 0.43 to 1.5 g when the energy level in the diets increases from 72.3 kcal/kg to 289.2 kcal/kg after 8 weeks. Beyond the species, the relatively low values of these parameters could be explained by the weak adaptation of this African carp to the compound food regularly served, rather than to the richly varied natural food found in the wild..

The specific growth rate and the condition factor K varied significantly ($p<0.05$) according to the energy level of the diet during this experiment. This observation is not in agreement with that of Shalaby (1998) [26] in *Siganus rivulatus* fingerlings whose growth performances were not affected by the increasing rate of energy in the diet.

The SGR values obtained showed a tendency to decrease with the rate of increasing energy level in the diet. These results corroborate those of Du and *al.* (2005) [5] who reported values (0.85 - 1.30%) comparable which decrease with the increasing rate of lipid (from 40 to 120 g/kg) in the diet of juvenile carp *C. idella*. Moreover, with a similar trend, Marammazi and Kakesh (2011) [16] recorded in *B. grypus* reared for 60 days low values (0.7 - 0.9%) compared to those obtained in this study. These results support the observation of Sargent and *al*. (1989) [25], that the excess of lipids in the diets reduce the fish's ability to digest and assimilate them, which results in reduced growth rate. On the other hand, the values obtained are low and the trend opposite to the results reported by Imtiaz (2007) [12] in *Labeo rohita*, whose values (1.05 - 2.41%) increase when the energy level in the diet increases from 72.3 to 289.2 kcal/kg. These differences in SGR values and trends could be attributed to the quality of the food used during the different experiments.

The condition coefficient k or condition factor is a good indicator of the physiological and nutritional state of the fish. During this study, *L. batesii* fry showed a poor physiological state regardless of the energy level in the diet.

This observation is comparable to that (0.73 - 0.77) obtained by Haghparast and *al.* (2016) [10] in the Aspikutum hybrid fed with diets at different protein/lipid ratios for 60 days. On the other hand, with higher values of k (0.89 - 1.5), *L. batesii* presented a good physiological state in the natural environment (Tiogue *et al.*, 2010); the same was true in captivity, in post-larvae of the same species fed on different types of food (Tonfack and *al.*, 2020a) [32] and in pre-fattening, receiving food rations at different protein levels (Tonfack and *al.*, 2020b) [33]. The differences in k values would probably be due to the poor adaptation of this endogenous carp to the conditions of captivity and to the food served during the experiment.

These two parameters were significantly ($p<0.05$) affected by the energy level of the food. Food consumption values showed a tendency to decrease with increasing rate of energy in the ration. This trend is similar to that observed by Tsoupou and *al.* (2018) [34] in juvenile *Clarias jaensis* fed with diets at different energy levels (3000 to 3300 kcal ME/kg), although the values obtained are low compared to the 137.25 – 153.83 g recorded. It is the same for the sea bream *Sparus aurata* which showed a decrease in FC of 88.46 - 71.76g when the energy level of the diet increases from 4700 to 5000 kcal/kg Marais and Kissil (1979) [15]. In addition, the work of Du and *al.* (2009) [5] carried out in juvenile grass carp *Ctenopharyngodon idella* also revealed that increasing energy levels (2670 to 3480 kcal/kg) in the diet lead to a decrease in FC from 8.59 to 6.44g. On the other hand, for an opposite trend, the values obtained remained lower than those (56.80 - 61.47 g) recorded by El-Dakar and *al.* (2010) [7] in the fingerlings of *Siganus rivulatus* when the energy level increased from 3882 to 4360 kcal/kg in the food. However, the values obtained are high compared to those (7.92 - 11.84 g) reported by Tonfack and *al.* (2020b) [33] in *L. batesii* when the protein level increases from 25 to 40% in the diet. Fluctuations in values and trends would be related to size, species and type of food served. And, according to Al Dilaimi (2010) [1], the amount of energy contained in the diet is a factor that controls the food consumption of fish. Indeed, high levels of lipids would affect the smell and taste of food which decrease the appetite of fish, thus resulting in low food consumption and weight gain of fish.

Regarding the feed conversion rate, the values increased with the increasing level of energy in the ration. This result corroborates that of Tsoupou and *al.* (2018) [34] who reported that the increasing level of energy (from 3000 to 3300 kcal/kg) in the food induces the increase of the FCR from 3.86 to 4.36 in *C. jaensis*. The values recorded in this work remain high compared to those (1.28 - 1.30 and 2.66 - 3.10, respectively) reported in *Dicentrachus labrax* larvae El-Abed and *al.* (2013) [6] whose the FCR increases with the increasing rates (2500 to 3000 Kcal/kg) of energy in the diets and in the fingerlings of *Siganus rivulatus* (El-Dakar and *al.*, 2010) [7] whose FCR decreases besides with the increase of the diet energy level (from 3882 to 4360 Kcal/kg). The difference between the FCR values recorded in these different studies would depend on the species and the quality of the food. In fish generally, the degree of nutrient uptake and utilization by the body depends on the energy level of the food. Thus, once the energy requirements are met, the fish decreases its consumption even if the needs for other nutrients are not satisfied. It is therefore important to determine the optimum level of energy for efficient use and recovery of food, while avoiding waste.

During this experiment, the fry of *L. batesii* presented a minorant allometric growth whatever the energy level considered. This result corroborates those of (Tonfack and *al.*, 2020a and 2020b) [32,33] who suggest that *L. batesii* in captivity tend to grow more in length than in body mass, at the fry stage. However, the result obtained in this study is opposite to that of Tiogue and *al.* (2010) who find that the same species in the natural environment has a majorant allometric growth (b between 2.785 and 3.088).

Conclusion

At the end of this study on the effect of the dietary energy level on the survival and growth performances of *Labeobarbus batesii*, it appears that the energy level of the diet has significantly influenced both the survival rate than all growth characteristics. The best growth performances and survival rate were obtained in fry receiving the lowest energy level diet, unlikely those receiving the highest level diet. The level of metabolizable energy 3600kcal/kg is therefore recommended for diets in pre-fattening of the African carp *Labeobarbus batesii*. However, for a better control of the nutritional needs of this species, it would be necessary not only to continue this work until adulthood, but also to evaluate the effect of the dietary energy level on its reproductive performances.

References

1. Al Dilaimi, A. Détermination de la ration lipidique alimentaire optimale chez les alevins de Tilapia du Nil (*Oreochromis niloticus*). Mémoire présentée pour l'obtention du diplôme de Magister en Gestion des ressources aquatiques (Ge.Re.Aq), Département de Biotechnologies; Université d'Oran, 2010, 78.
2. Burel C, Médale F. Protein sources in animal feed, Les sources de protéines dans l'alimentation du bétail. Quid de l'utilisation des protéines d'origine végétale en aquaculture ? Oilseeds & fats Crops and Lipids D406,2014:21(4):15.
3. Djikengoue KPL, Mambe TF, Kpoumie NA, Tonfack AP. Effects of the Level and Frequency of Fertilization with hen Droppings on Zooplanktonic Density and Growth Performance of Common Carp Post-Larvae (*Cyprinus Carpio*). International Journal of Aquaculture Research and Development, 2020:1(2):14.

4. Du ZY, Liu YJ, Tian LX, Wang JT, Wang Y, Liang GY. Effect of dietary lipid level on growth, feed utilization and body composition by juvenile grass carp (*Ctenopharyngodon idella*). Aquaculture Nutrition,2005:11:179-88.
5. Du YZ, Tian LX, Liang GY, Liu YJ. Effect of Dietary Energy to Protein Ratios on Growth Performance and Feed Efficiency of Juvenile Grass Carp (*Ctenopharyngodon idella*). Open fish Science journal,2009:2:25-31.
6. El-Abed FH, Mohamed S, Alaa A, El-Dahhar AA. Effect of Dietary Protein and Metabolizable Energy Levels on Growth and Feed Utilization of Sea Bass (*Decentrarshus laborax*) Larvae. Journal of the Arabian Aquaculture Society,2013:8:11-23.
7. El-Dakar A, Hassanen G, Shalaby S, Ghoniem S, and Zenhom O. Survival Growth Feed Efficiency and Carcass Composition of Rabbit fish, *Siganus Rivulatus*, Fed Different Dietary Energy and Feeding Levels. Mediterranean Aquaculture Journal,2010:1(1):18-27.
8. FAO. The state of Food insecurity in the world: Economic crisis-impacts and lessons learned, Rome., 2009, 218.
9. Gotesman M, Kattlun J, Bergmann SM, El-Matbouli M. CyHV-3: the third cyprinid herpes virus. Diseases of Aquatic Organisms (Dis Aquat Org),2013:105:163-174.
10. Haghparast P, Falahatkar B, Khoshkholgh MR, Meknatkhah B. Influence of dietary protein/lipid ratio on growth performance and body composition of Aspikutum, a new hybrid of *Leuciscus aspius* ♀ × *Rutilus frisii* ♂ (Teleostei: Cyprinidae). Iranian Journal of Ichthyology,2016:3(4):304-315.
11. Ikpi UG, Okey BI. Estimation of Dietary Composition and Fecundity of African Carp, *Labeo Coubie*, Cross River, Nigeria. Journal of Applied Science and Environmental Management,2010:14(4):19-24.
12. Imtiaz A. Effect of ration size on growth, body composition, and energy and protein maintenance requirement of fingerlings Indian major carp, *Labeo rohita* (Hamilton). Fish Physiolology and Biochemistry,2007:33:203-212.
13. Le Cren ED. The length-weight relationships and seasonal cycle in gonad weight and condition factor in perch (*Perca fluviatilis*). Journal of Animal Ecology,1951:20(2):201-219.
14. Le Gouvello R, Simard F. Durabilité des aliments pour le poisson en aquaculture: Réflexions et recommandations sur les aspects technologiques, économiques, sociaux et environnementaux. Gland, Suisse: UICN, et Paris, France: Comité français de l'UICN, 2017, 296.
15. Marais JFK, Kissil GW. The influence of energy level on the feed intake, growth, food conversion and body composition of *Sparus aurata*. Aquaculture,1979:17:203-219.
16. Marammazi JG, Kahkesh F. Effects of dietary protein and energy levels on growth performance, feed utilization and body composition of juvenile shirbot *Barbus grypus* (Heckle, 1843). Iranian Journal of Fisheries Sciences,2011:10(3):461-474.
17. Mikolasek O, Guérin G, Lopez A, Khuyen TD, Huy PT, Dien NT. Local fish farming practices and a typology of farms based on organic matter intake management, In: Orphyre, V. and Coi, N. Q. (Eds.), Pig Production Development, Animal Waste Management and Environment Protection: A Case Study in Thai Binh Province, Northern Vietnam. PRISE Publications, France, 2006, 107-125.
18. Mishra K, Samantaray K. Interacting effects of dietary lipid level and temperature on growth, body composition and fatty acid profile of rohu, *Labeo rohita* (Hamilton). Aquaculture Nutrition,2004:10:359-369.
19. Montchowui E, Lalèyè P, Poncin P, Philippart J-C. Reproductive strategy of *Labeo senegalensis*, Valenciennes 1842 (Teleostei: Cyprinidae) in the Ouémé basin, Benin. African Journal of Aquatic Science,2010:35(1):81-85.
20. Montchowui E, Bonou CA, Lalèyè P, Philippart JC, Poncin P. Successful artificial reproduction of the African carp: *Labeo parvus* Boulenger, 1902 (Pisces: Cyprinidae). International Journal of Fishery and Aquaculture,2011:3:35-40.
21. Montchowui E, Agadjihouede H, N'tcha E, Laleye P. Effets de milieux d'élevage sur la survie et la croissance des juvéniles de la carpe africaine, *Labeo parvus* (Boulenger, 1902). International Journal of Biology and Chemistry Science,2012:6(5):2131-2138.
22. Paliitha KHM, Prakash S, Syeddian ZSG, Pal AK, Venkateshwarlu G. Growth and reproductive performance of female guppy, *Poecilia reticulata* (Peters) fed diets with different nutrient levels. Indian Journal of fisheries,2010:57(1):65-71.
23. Rathnayake RMLW, Shirantha RRAR, Rupuka GRH, Kithsiri HMP, Nayananjali WAD. Evaluation of growth and breeding performances of *Pethia reval* (red fin barb), with different feed under aquarium condition. International Journal of Scientific and Research Publications,2016:10(6):191-195.
24. Ricker WE. Computation and interpretation of biological statistics of fish populations. *Bulletin of Fishery Resources and Board of Canada*,1975:191:382.
25. Sargent J, Henderson RJ, Tocher DR. The lipids. In: Fish Nutrition (Halver J. E.ed.). Academic Press, London, 1989, 154-209.
26. Shalaby SM. Nutrients requirements of Rabbitfish fingerlings, Siganus rivulatus. PhD, Alexandria University, Egypt, 1998, 224.

27. Tiogué TC, Tomedi MTE, Nguenga D, Tchoumboué J. Caractéristiques de morphologie générale et de croissance du Cyprinidae africain *Labeobarbus batesii* dans la plaine inondable des Mbô, Cameroun. International Journal of Biology and Chemistry Sciences,2010:4(6):1988-2000.
28. Tiogué TC, Tomedi MTE, Tchoumboué J. Reproductive Strategy of *Labeobarbus batesii* (Boulenger, 1903) (Teleostei: Cyprinidae) in the Mbô Floodplain Rivers of Cameroon. Hindawi Publishing Corporation, International Journal of Zoology, 2013, 8.
29. Tiogué TC, Tomedi MTE, Nguenga D, Tekou G, Tchoumboué J. Feeding Habits of the African Carp *Labeobarbus batesii* (Pisces: Cyprinidae) from the Mbô Floodplain Rivers. Advances in Research, 2014:2(12):757-765.
30. Tomedi-Eyango M, Tchoumboue J, Jamtade O. Effet du poids de mise en charge sur la survie et la croissance des fingerlings du poisson chat africain (*Clarias gariepinus* Burchell, 1822). Science Agronomique Developpement,2008:4(1):41-47.
31. Tomedi TEM, Tiogué CT, Efole TE, Kenfack M, Tchoumboué J. Population Structure, Condition Factor, Length-weight and Length-age Relationships of *Labeobarbus batesii* (Boulenger, 1903) in Mbô Flood Plain in Western Region of Cameroon. International Journal of Aquaculture,2014:4(19):113-117.
32. Tonfack AP, Kpoumie NA, Ngoula F, Djikengoue KPL, Tiogué TC, Njouokou S, *et al*. Survival rate and growth performances of post-larvae of the African Cyprinidae *Labeobarbus batesii* (Boulenger, 1903) with different type of food. International Journal of Fisheries and Aquatic Studies,2020a:8(3):128-134.
33. Tonfack AP, Tiogué TC, Kpoumie NA, Ngoula F, Djikengoue KPL, Mambe TF, *et al*. Survival Rate and Growth Performances on Pre-Grossing of the African Cyprinidae *Labeobarbus Batesii* (Boulenger, 1903) According to the Level of Dietary Protein. International Journal of Aquaculture Research and Development,2020b:1:(2):22.
34. Tsoupou KSG, Efole ET, Moussala OJ, Tchoumboué J. Effect of various levels of metabolize energy on growth performance of *Clarias jaensis* fingerlings (Boulenger, 1909), International Journal of Research - Granthaalayah,2018:6(5):65-72.
35. Yilmaz E, Şahin A, Duru M, Akyurt İ. The effect of varying dietary energy on growth and feeding behaviour of common carp, *Cyprinus carpio*, under experimental conditions. Applied Animal Behaviour Science, Volume 92, Issue (1-2), 2005, 85-92.