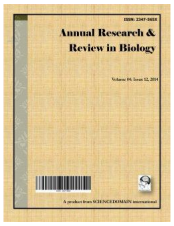

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Compensatory Responses of *Cyprinus carpio* (Linnaeus, 1758) fry under Different Feed-deprivation Regimes in Happas in the Westhern – Cameroon

Claudine Tekounegning Tiogué[1*], Simplice François Noumeu Kendi[2], Guegang Tekou[3] and Minette Eyango Tomedi –Tabi[2]

[1]Laboratory of Applied Ichthyology and Hydrobiology, Faculty of Agronomy and Agricultural Sciences, School of Wood, Water and Natural Resources, The University of Dschang, P.O.Box 786, Ebolowa, Cameroun.
[2]Institute of Fisheries and Aquatic Sciences of Yabassi, The University of Douala, P.O.Box 2701, Douala, Cameroon.
[3]Laboratory of Applied Ichthyology and Hydrobiology, Department of Animal Productions, Faculty of Agronomy and Agricultural Sciences, The University of Dschang, P.O.Box 222, Dschang, Cameroon.

Authors' contributions

This work was carried out in collaboration between all authors. Author CTT designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors SFNK and GT managed the analyses of the study. Authors GT and METT managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Compensatory growth in the fry of *Cyprinus carpio* was assessed to improve the aquaculture production
Place and Duration of Study: The trial was conducted between April 25 and June 19, 2015 in the Westhern Cameroon Highlands.

**Corresponding author: E-mail: tekou_claudine@yahoo.fr, tiogué.claudine@univ-dschang.org;*

Study Design: For this purpose, four (04) food restriction times (T0, T1, T2 and T3) corresponding respectively to 0, 1, 2 and 3 days in alternation; were tested in stochastic triplicate on fry of mean body weight 1.06 ± 0.19 g and of mean total length 4.1 ± 0.06 cm in 12 happas of 0.5 m^3 each, placed in a concrete tank of 2.2 m^3.
Methodology: Every 14 days in each control fishery and at the end of the test, fishes were harvested and the zootechnical parameters (individual standard and total lengths and individual weight of the fish as well as that of the food) were evaluated using an ichthyometer and electronic balance respectively. The total population was counted in each happa and the food was distributed manually in 3 meals per day. Every day, food refusal were harvested and dried in the sun.
Results: The survival rate was higher at T0 (90%) compared to restricted treatments. The fry subjected to two days of food restriction (T2) recorded significantly higher growth performances compared to other treatments. The feed conversion and feed efficiency have evolved respectively with a significant difference between treatments. The cost of producing a kilogram of fry was significantly lower in T2 compared to other treatments. Lot T2 showed a chemical composition of the carcass significantly better than other batches.
Conclusion: This study reveals that fry of *Cyprinus carpio* showed compensatory growth with a 65% reduction in production cost as a result of dietary restriction of two days.

Keywords: Compensatory growth; survival; food restriction; Cyprinus carpio; Cameroon.

1. INTRODUCTION

Feed is the most expensive component in aquaculture production. In intensive aquaculture, it represents nearly 50 to 60% of the production cost [1]; hence the need to control optimal feeding techniques to ensure the best growth rate and feed efficiency of animals; as well as the profitability of fish farms [2]. Efforts have been made to reduce food costs, while increasing growth rate and maximizing the use of foods by including digestive enzymes in the diet of *O. niloticus* [3]. Other methods have been tested, such as the composition of foods at different levels of protein incorporation [4,5], optimization of the feed rate [6] and reduced protein feed costs by various means such as the replacement of fishmeal, the main source of fish feed with vegetable proteins [7]. However, the poor fish farmers find these methods expensive and difficult to implement. They prefer to subject fish to food deprivation for a few days before re-feed them [8]. During re-feeding, animals ingest a large amount of food that they effectively convert into flesh and therefore can display faster growth called compensatory growth as opposed to those fed continuously [8]. Compensatory growth, known as catch-up growth and compensatory gain, is an accelerated growth of an organism following a period of slowed development, particularly as a result of nutrient deprivation [9]. The feeding of animals by restriction and re-feeding strategies has been demonstrated in other species as simple, easy, applicable, practicable and above all reduces the cost of production [10,11]. Under a restricted diet, some fish convert most of the food to body weight with no adverse effects on their growth; they use the nutrients more than they do under an unrestricted daily diet [8]. Feed restriction and re-feeding have been described in many groups of fish [12,13,14,15,16,5,17,18,19,20,21,22,23,24, 25,26,27]. Common carp *Cyprinus carpio*, is one of the most produced species in the world [28]. However, the use of feed-deprivation regimes in its breeding is still very limited. Intensive production of fry of this species requires permanent feeding, which further increases its feeding cost [29]. Unfortunately, many common carp fish farmers in developing countries do not have enough income and knowledge for their food [1]. This situation rarefies the appearance of the common carp in the markets, consequently increases its inaccessibility to all consumers. Depending to Langer et al. [29], irregular feeding and especially of long duration, would lead to stunting which cannot be caught up with later reduced yields. However, .a relatively short period of fasting likes that of two days made it possible to compensate for this slow growth in *Atlantic halibut* [30], *Clarias gariepinus* [24] and *Oreochromis niloticus* [17]. It is indeed in this objective that this study aims to evaluate the compensatory growth in the fry of *Cyprinus carpio* with a reduced duration of restriction. More specifically, it is to evaluate the survival and growth performances, food efficiency; and to determine the production cost and the bromatological composition of *Cyprinus carpio* at 0, 1, 2 and 3 day (s) of food restriction in happas.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted between April 25 and June 19, 2015 at the Common Initiative Group (CIG) - Aquaculture Integrated of Westhern Cameroon located in the Sudano-Guinean zone between 5°17'31''- 5°20' NL et 10°10'-10°17'44'' EL, average altitude of 1700 m [31]. The climate is of tropical type modified by altitude. It is characterized by a dry season from mid-November to mid-March with temperatures ranging from 20 to 27°C and a rainy season from mid-March to mid-November with temperatures from 17 to 23°C. The average annual rainfall is 1621 mm; and relative humidity between the two seasons is between 45.5 and 98.7% [31].

2.2 Biological Material

600 fry of *Cyprinus carpio* of mean body weight 1.06 ± 0.19 g and mean total length 4.1 ± 0.06 cm from in-situ spawners in the Bambui aquaculture station in North-West Region of Cameroon, were used during this test.

2.3 Experimental Food

1.6 kg of powdered artificial food containing 38.05% crude protein, 86, 83 dry matter, 10,84 raw Lipids, 22,7 crude fiber, 34,38 ash and 3939,0 gross energy (kcal / kg) was used to feed the animals. The food was manufactured locally based on agro-industrial products and was bought at the rate of 700 FCFA per kilogram. Its chemical composition was obtained at the Faculty of Agronomy and Agricultural Sciences (FAAS), Animal Nutrition Laboratory of the University of Dschang.

2.4 Experimental Disign and Assay Conduct

Four (4) times T0, T1, T2 and T3 corresponding respectively to 0, 1, 2 and 3 alternating food restriction day (s) were tested in stochastic triplicate on *Cyprinus carpio* fry in 12 happas of 0.5 m^3 each placed in a concrete tank of 2.2 m^3. The tank was supplied with water from a borehole and operated in a closed circuit by means of a pump (flow rate: 3 l / min) and a biophysical filter installed there. The average height of the water in the tank was 26.5 ± 3.5 cm throughout the test. The tank was cleaned beforehand and filled with water after installation of the happas. Thereafter, the fry were introduced and fed ad libitum for acclimatization. After 10 days, 50 fry of individual average weight 1.06 ± 0.19 g and of mean total length 4.1 ± 0.35 cm were put into each happas and fed alternately at the 6% daily rate of ichtyobiomass for 56 days.

2.5 Data Collection

Every 14 days in each control fishery and at the end of the test, fishes were harvested using a landing net (<1 mm mesh) and the zootechnical parameters were evaluated: In a sample of 15 individuals by happa (30% of the population) taken randomly, the individual standard and total lengths of the fry were measured using a 50 cm ichthyometer and of precision 1 cm. The individual weight of the fish as well as that of the food was obtained on an electronic scale of mark Digital Started and of precision 0,01g. The total population was counted in each happa at the end of the test to determine the survival rate.

The food was distributed manually in 3 meals per day (¼ between 06:30 and 07:30 AM, ¼ between 12:30 and 13:30 PM and ½ between 18:30 and 19:30 PM) in a square bamboo feeder of 30 cm by side which was installed and floating in each happa. Each was placed on top of a plastic dish 13 cm in diameter located at the bottom of the happa and intended to collect food refusals. Every day, food refusal were harvested and dried in the sun. Also, the water of the tank was renewed to two-thirds in addition to that of the rains every 7 days to limit pollution by fish droppings and dissolved feed.

The physico-chemical characteristics of the water were collected 3 times a day (between 06:30 and 07:30 AM, 12:30 to 13:30 and 18:30 to 19:30 PM): The temperature was obtained using a maxi-minima thermometer by reading the position of the mercury in the thermometer after plunging it for 5 mn in water. For pH, it was obtained using a pH-meter paper (JBL - Eosy Test): The strip was released for 2 to 3 seconds and the coloration obtained was compared with the standard. As for dissolved oxygen, it was measured using an oxygen kit (JBL Test O_2): The test tube was filled to the brim with water from the tank; and successively 6 drops of reagent 1 and 2 were added before homogenizing the mixture; 2 minutes later, the color of the water was compared to the standard color scale. Transparency was measured daily with a Secchi disc.

For the bromatological analysis, four (4) fish from each lot (T0, T1, T2 and T3) selected randomly were transported to the Laboratory of Animal Nutrition of the FAAS (the University of Dschang) at the end of the trial.

2.6 Studied Parameters

The following parameters were studied:

- Survival rate (SR): it was determined according to the formula :

  SR (%) = (Nf/Ni) $\times$ 100 With Nf = final number of fry and Ni = initial number of fry.

- Mean weight (mW): it translates the average individual weight.

  mW (g) = tB / Nf Where tB = Total biomass (g)

- Mean Weight Gain (MWG): It was determined by the formula:

  MWG(g) = (fmW – imW) Where fmW and imW are the final and initial average weights of fry (g)
  Respectively

- Average daily growth (ADG): Calculated by the formula:

  ADG (g/d) = (fmW – imW) / Δt Where Δt = Duration of the test (j)

- Relative growth rate (RGR): calculate by the formula used by Lugert et al. [32]:

  RGR (%)= [(fmW – imW)/ imW] X 100

- Specific growth rate (SGR): it was determined by the formula:

  SGR (%/d) = (In(fmW) – In(imW)) $\times$ 100 / Δt where In = Natural logarithm

- Length-weight relationship: It was established according to the formula:

  TW= a(TL) ^{b} [33] Where TW = Total fish weight (g), TL = Total fish length (cm), a = originally ordered and b = Allometric coefficient.

- K condition Factor: It was determined by the formula used by Tiogué *et al.* [34]:

  K (%) = TW / (TL) ^{b} $\times$ 100 Where b is the allometric coefficient of the length-weight relationship

- Size heterogeneity (SH)

  SH (%) = SD / Xw avec Xw = Average weight (g) and SD = Standard deviation

- Consumption Index (CI) : It was determined by the formula:

  CI = Q_f / (fmW – imW) Where Q_f = Quantity of feed distributed (g)

- Food Efficiency (FE) : This is the inverse of the consumption index.

- Protein Efficacy Factor (PEF) : It was determined by the formula:

  PEF = (fmW – imW) / (Q_f ×t) With t = Protein content in food

- Production cost (PC): It was determined by the relationship:

  PC = IC × Price / kg of feed used

- Bromatological composition of fry at the end of the study

2.7 Statistical Analysis

The descriptive statistics (mean, standard deviation, percentage ...) were used. The parameters studied were subjected to one-way analysis of variance (ANOVA I). Duncan mean separation test were used to determine the differences among the means. For this purpose, the analysis model was as follows:

yij = μ + αi + eij where μ: Mean of the parameter considered; αi: Effect of periods of food restriction; eij: Residual Error

Correlations and regressions were established between the parameters. The LWR equation was not transformed into a linear form, the equation was maintained as power, so in a curved line. The statistical significance of R^2 (determination coefficient) was estimated and the b value tested using the t-test to verify if it was significantly different from the isometric (b = 3.0).The probability threshold was 5%. All statistical analyses were performed using statistical software SPSS 20.0 for Windows (SPSS Inc.

Chicago, IL USA). Graphs were generated using Excell software version 2007.

3. RESULTS

3.1 Survival Rate, Growth Performances and Characteristics of the Use of the Feed by the Fry of *Cyprinus carpio*, at the End of the Test at Different Durations of Food Restriction

Survival rate, growth performance, size heterogeneity (SH) and characteristics of the use of the feed by the fry of *Cyprinus carpio*, at the end of the test at different durations of food restriction are presented in Table 1. It shows that: Regardless of the duration of food restriction, the survival rate was significantly (*P* = *.05*) high (> 80%). It was higher in control (T0) compared to those with food restriction. However, this difference was not significant (*P* = *.05*).

The fry subjected to two days of food restriction (T2) recorded significantly higher growth performances (*P* = *.05*) compared to other treatments. However, at the end of the trial, the coefficients of variation were comparable (*P* = *.05*) between the different durations of feeding restrictions.

The consumption index (CI) in fish subjected to food restriction was significantly (*P* = *.05*) lower, at least 40% compared to unrestricted ones. On contrary, food efficiency (FE) and protein efficacy factor (PEF) were significantly (*P* = *.05*) higher in restricted fish than in the control group.

3.2 Evolution of the Average Body Weight of the Fry at Different Durations of Food Restriction During the Period of the Test

Fig. 1 illustrates the evolution of the mean body weight of the fry at different durations of restriction based on the trial period. The analysis shows that the average weight increases similarly whatever food restriction period considered. Fish subjected to 2 days of food restriction (T2 treatment) had a higher body weight than those of other batches during 56 days of rearing. However, no significant difference (*P* = *.05*) was observed between batches.

3.3 Length-weight Relationship, Growth Type and Condition Factor K of Fry of *Cyprinus carpio* at the End of the Trial at Different Durations of Food Restriction in Happas

Table 2 shows the parameters of the weight-length relationship, the type of growth and the condition factor K of the fry of *Cyprinus carpio* subjected to different durations of food restriction during 56 days of rearing. It appears that, regardless of the restriction period considered,

Table 1. Survival rate, growth performances and characteristics of the use of the feed by the fry of *Cyprinus carpio* depending on the feed restriction period in happas

Characteristics	Food restriction period				
Survival	**T0**	**T1**	**T2**	**T3**	**Average**
SR (%)	90±3.651	86±6.831	88±5.508	83.5±9.147	86.50±6.429
Growth performances					
imW (g)	1.06±0.19	1.06±0.19	1.06±0.19	1.06±0.19	1.06±0.19
fmW (g)	3.00±1.35^{ab}	2.79±1.17^{ab}	3.26±1.16^{b}	2.60±1.03^{a}	2.92±1.20
MWG (g)	1.94±1.35^{ab}	1.73±1.7^{ab}	2.20±1.16^{b}	1.54±1.03^{a}	1.85±1.20
ADG (g/d)	0.03±0.02^{ab}	0.03±0.02^{ab}	0.04±0.02^{b}	0.02±0.01^{a}	0.03±0.02
RGR (%)	183.02^{ab}	163.25^{a}	207.55^{b}	145.28^{a}	174.33
SGR (%/d)	1.71±0.71^{ab}	1.6±0.66^{a}	1.89±0.63^{b}	1.48±0.65^{a}	1.67±0.68
SH (%)	37.70±6.98^{a}	33.37±6.18^{a}	32.31±4.94^{a}	29.91±7.60^{a}	33.31±6.50
Food's use characteristics					
CI	2.92±2.56^{b}	1.75±2.37^{a}	1.13±0.80^{a}	1.80±1.25^{a}	1.60±1.66
FE	0.54±0.38^{a}	0.97±0.65^{b}	1.23±0.65^{c}	0.86±0.58^{b}	1.09±0.75
PEF	1.36±0.95^{a}	2.43±1.64^{b}	3.09±1.62^{c}	2.16±1.45^{b}	2.72±1.88

T0, T1, T2 and T3 = respectively 0, 1, 2 and 3 day (s) food restriction; a, b, c: The values of the same row affected different letters are significantly differents (p =.05); SH = size heterogeneity; CI= Consumption Index; FE = Food Efficiency; PEF = Protein Efficacy Factor

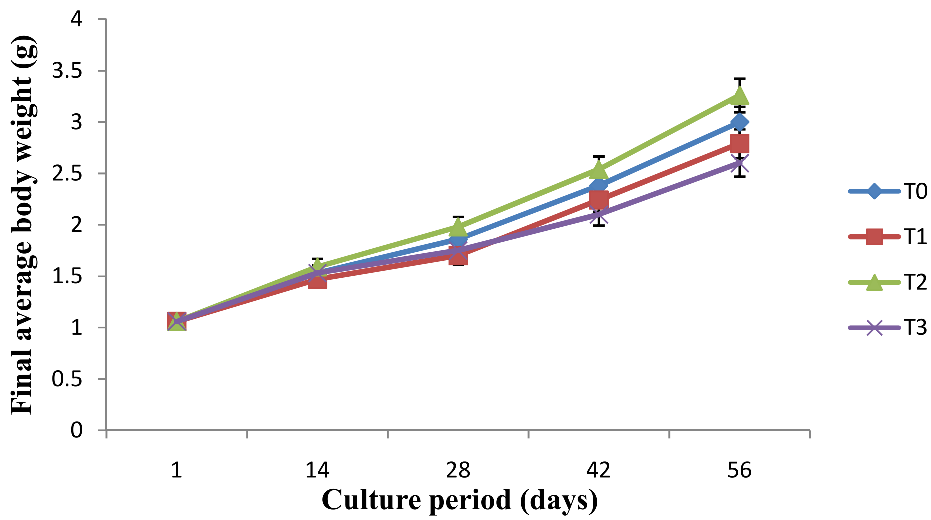

Fig. 1. Weekly evolution of the average body weight of *Cyprynus carpio* fry at different durations of food restriction during 56 days of breeding in happas

T0, T1, T2, T3 = respectively 0, 1, 2 and 3 day (s) of food restriction

Table 2. Length-weight relationship, growth type and condition factor K of the fry of *Cyprinus carpio* as a function of the duration of food restriction at the end of trial

Treatments	N	Length-Weight relationship parameters					Growth type	K Factor
		Equation	R^2	a	b	ts		
T0	225	$TW=0.038TL^{2.441}$	0.8362	0.0385^a	2.441^b	0.420	A^-	4.80±3.12a
T1	225	$TW=0.043TL^{2.347}$	0.8078	0.0435^b	2.347^a	0.037	A^-	5.62±3.38a
T2	225	$TW=0.037TL^{2.4697}$	0.8738	0.0371^a	2.450^b	0.365	A^-	4.49±2.43a
T3	225	$TW=0.043TL^{2.358}$	0.7987	0.0433^b	2.358^a	0.045	A^-	5.17±2.25a
Average	900	$TW=0.0425TL^{2.059}$	0.8256	0.0425	2.059	0.334	A^-	5.02±2.57

N = number of fry; A^- = negative allometric growth; a = intercept; b= Allometric coefficient; TW= total body weight; TL= Total Length; R^2= coefficient of determination; T0, T1, T2 and T3 = respectively, 0, 1, 2, 3 restriction day (s). ts: students t-test ; a: The values of the same column assigned by the same letter are not significantly different (p = .05).

the parameters of the weight-length relationship were comparable (*P* = *.05*) and all animals showed negative allometric growth with the coefficient b < 3. Otherwise, at the end of the trial the fish of treatment T1 recorded the highest value of the condition factor K while the lowest value was obtained in T2. However, this difference was not significant (*P* = *.05*).

3.4 Evolution of the Condition Factor K of the fry of *Cyprinus carpio* During the Trial Period in Happas

The evolution of the condition factor K of the fry of *Cyprinus carpio* during the study period on the duration of food restriction as presented by Fig. 2 shows that, whatever food restriction period under review, the K condition factor was increasing during the first 14 days of testing before decreasing until day 42.

3.5 Estimation of the Cost of Production and Bromatological Composition of *Cyprinus carpio* at the End of the Food Restriction Test in Happas

Table 3 shows the estimated cost of production and nutritive composition of *Cyprinus carpio*'s fry after testing on food restriction period in happas. It appears that the production cost was lower (*P* = *.05*) in fish subjected to dietary restriction compared to the control group. However, it was lower (*P* = *.05*) with a decrease of at least 65% in fish restricted by T2 treatment compared to other batches. Furthermore, the batch T2 showed a chemical composition of the carcass significantly (*P* = *.05*) better compared with the control batch and other batches restricted.

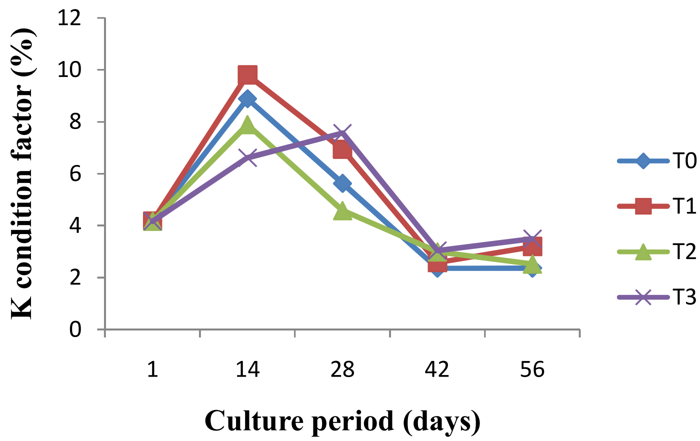

Fig. 2. Evolution of K condition factor of the fry of *Cyprinus carpio* at different durations of food restriction during 56 days of breeding in happas

0, 1, 2 and 3 day (s) = respectively T0, T1, T2, T3 food restriction treatment

Table 3. Cost of production and chemical composition of the fry of *Cyprinus carpio* at the end of the test on the duration of food restriction in happas

Treatments	Estimated cost of production (FCFA)			Chemical composition of fingerlings			
	CI	P/Kg A	PC (FCFA)	MS (g)	CP (%DM)	Lipids (%DM)	Ashes (%DM)
T0	2.92	700	2045.25^{c}	87.18^{a}	46.81^{a}	20.25^{ab}	15.20^{b}
T1	1.75	700	1230.47^{b}	88.77^{ab}	58.84^{b}	13.85^{a}	10.76^{a}
T2	1.13	700	794.18^{a}	90.15^{b}	62.03^{c}	22.06^{b}	19.34^{c}
T3	1.80	700	1264.95^{b}	86.98^{a}	48.34^{a}	15.10^{a}	17.25^{b}

T0, T1, T2 and T3 = respectively at 0, 1, 2 and 3 days of food restriction; CI = Food consumption index; P / Kg A = price per Kg of food in CFA Franc; PC= production Cost; CP = Crude protein, DM = Dry matter
(a,b, c) = The values of the same column assigned by the same letter are not significantly different (P = .05).

4. DISCUSSION

Survival rates observed are less than 100 and 97.5% obtained by Bignumba [24] and Limbu and Jumanne [17] respectively in *Clarias gariepinus* in aquariums and *Oreochromis niloticus* in ponds. The phenomenon of apnea and predation of ichthyophagous birds during breeding has not been observed. Mortalities recorded would therefore be related to the stress experienced during the various manipulations during the control fisheries. Nevertheless, they remained higher than previous results in the same species: 80% [1] and 65% [35].

Results obtained on the growth characteristics (absolute growth (mean weight, mean daily gain), relative growth rate, specific growth rate (SGR)) show significantly higher growth in restricted animals than from non-restrained animals. The refeeding leads to a resumption of fish growth. Animals subjected to a 2-day food restriction gained approximately 207.55% of their initial weight in 56 days [32]; and recorded specific growth rates higher than controls thus demonstrating a phenomenon of compensatory growth [22]. These results are contrary to those reported by Langer et al. [29] in the same species. However, these results corroborate those recorded by Lefevre et al. [22], Bignumba [24], Limbu and Jumanne [17] respectively in rainbow trout (*Oncorhynchus mykiss*) female mono-sexe, *Clarias gariepinus* and in *Oreochromis niloticus*.

The higher growth characteristics of restrained fish reveal a greater mobilization of body reserves in *Cyprinus carpio.* Hoch et al. [36] explain this phenomenon by the fact that the basal energy metabolism of the animal remains low and increases slowly thereafter, when adapting to the new regime. Limbu and Jumanne [17] obtained similar results in juveniles of 37.5 g of *Oreochromis niloticus* respectively over a period and a restitution rate of two days and 5% feeding rate (17.92 g for restricted fish versus 13.44 g for unrestricted fish after 56 days of testing). These results are similar to those of Bignumba [24] in *Clarias gariepinus* of 6.37 g with the same period of restriction to a feeding rate of 7% (13.93 g for restricted fish versus 11.91 g for unrestricted fish after 8 weeks of testing).

As for the mean daily gain and the specific growth rate recorded, they remained low compared to the previous results: 3 to 6 g / day [1] and 1 to 4% / day [37], and 0.13 and 0.32 g / day; 1.3 and 3.71% / day respectively reported by Bignumba [24] and Limbu and Jumanne [17] in the same species. These results, however, are greater than 0.238 g and 0.07% / day obtained by Langer et al. [29] in *Cyprinus carpio*.

The low weight growth observed was mainly due to the species, the quality of the food (powdered versus pelleted), the feeding rate (6 versus 7%), and to the physico-chemical characteristics of the water (temperature, pH, dissolved oxygen) relatively below the optimum values reported by FAO [37] and Schlumberger and Girard [38] in the same species. Also, the fry used for the test would be derived from the repeated inbreeding crosses of the different strains obtained at the GIC since its creation. This could be in the same direction with the results of Tiogué et al. [39] which stipulate that repeated use of the same strain for several years results in genetic degeneration and therefore poor growth performance. Similarly, a reduction in the consumption index of more than 60% was also observed and the increase in feed efficiency and protein coefficient obtained corroborate with the results obtained by Ali et al. [8,19], Bignumba [24], Limbu and Jumanne [17]. This confirms that improved metabolic transformation of nutrients, another characteristic of compensatory growth [40] was also expressed; and in conjunction with hyperphagia contributed to inducing compensatory growth in *Cyprinus carpio*. Then, a maximum food restriction period of 2 days as recommended by Bignumba [24], Limbu and Jumanne [17] is necessary to induce a sufficient decrease in catabolism and thus allow compensatory growth in *Cyprinus carpio*.

Moreover, the reduced allometry obtained remained close to 2.762 reported by Attal and Arab [33] in the same species in the Grib dam in Algeria. These results show that fish grow faster in length than in weight. The condition factor K was significantly hight than 1, thus showing that fish were in good healt during breeding. This superiority would be related to the nature of the livestock. The decrease in the K factor observed in the last few weeks of breeding should be due to the stress of control fisheries which was more pronounced.

The cost of producing one kilogram of fry was lower in restricted fish. These results corroborate those reported by Limbu and Jumanne [17]. This decrease is attributed to improved feed intake of restricted animals during feeding.

Lot T2 showed a significantly better carcass chemical composition compared to the control and other restricted lots. In addition, changes in the body composition of animals in this treatment during the deprivation and refeeding periods could lead to a better body fat deposits [8]; confirm in this study by the higher value of lipids. According to Lefevre et al. [21] and Won and Borski [41], the application of a prolonged fast, followed by a re-feeding period, significantly affects the structure of muscle tissue, with both a very large recruitment of small neoformed fibers and hypertrophic growth, associated with the re-feeding. Furthermore according to Lefevre et al. [22], a prolonged fasting to period leads a halt in overall and muscle growth in fish. After a re-feeding phase, the recovery of muscle growth (Hypertrophic but also hyperplasic in fish) significantly affects the biochemical and structural characteristics of the muscle tissue resulting in a modification of the quality parameters and in particular of the texture [22,42,41,18,43].

5. CONCLUSION

At the end of the study on the assessment of the compensatory growth in *Cyprinus carpio* fry in happas in Cameroon's altitude area, it appears that: the survival rate was better in non-restricted *Cyprinus carpio* alevins compared to those subjected to food restriction. The mean body weight and other growth parameters studied were higher in restricted fish (T2). The condition factor K was high, thus showing a good health status of the fry during the test. Consumption index and feed efficiency were significantly better in restricted fish compared to control fish. The production cost was also better in restricted fish with a 40-65% reduction compared to unrestricted fish. Fish of the T2 treatment recorded the best chemical composition at the end of the test. Then fry of *Cyprinus carpio* showed compensatory growth with a 2-day restriction period.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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