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Original Article

Improvement of fish production in Benin: Which strain of Tilapia *Oreochromis niloticus* is recommended to fish farmers?

Gangbé Luc[1,2], Achoh Mardochée Ephraim[*3], Aboudou Zouberou Aboudou[4], Hounhoedo Aimé[5], Agbohozo Buenas[5], Aizonou Romaric[3], Agadjihouèdé Hyppolite[1,3]

[1]Laboratory of Hydrobiology and Aquaculture (LHA), Faculty of Agronomic Sciences, University of Abomey-Calavi, 01 PO Box: 526 Cotonou, Benin.
[2]National Institute of Agricultural Research of Bénin, 01 PO Box 884 Cotonou, Benin.
[3]Laboratory of Research in Aquaculture, Biology and Aquatic Ecology (LaRABEA), the Valley's School of Aquaculture, National University of Agriculture, PO Box 43 Kétou, Benin.
[4]Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, 01 PO Box 2009 Cotonou, Benin.
[5]Department of Aquaculture and Fisheries Management, University of Ibadan, Ibadan, Nigeria.

Abstract: Controversies on the performance of the tilapia strain *Oreochromis niloticus* (S2 INRAB, SI), led us to be interested to the evaluating of that strain's growth in comparison with the strain commonly used by the fish farmers named Faizou's strain (SF). Fry of average weight 10.17±2.0663 g were stocked in concrete tank (density: 10 individuals/m^2). The experiment lasted 60 days where the temperature, oxygen-dissolved and pH parameters were measured morning and evening every 48 hours. The feed used was made from local products at protein level of 45%. The results revealed that physicochemical parameters have no negative influenced on fish growth even though they were significantly different from one strain to another. The gain in weight obtained was significantly higher for the strain SF (38.12±5.65 g) than the SI (37.15±4.99 g) despite it recorded 13.33% more mortality than the SI strain. Above of this, the average daily gain (ADG) of the SF strain was almost linear over the entire study period, unlike the SI strain whose has no linear ADG. It shows that the SF strain is more productive despite the recorded mortality. This confirms the fish farmers' claims on the lowest growth of the SI strain, which however is to be considered in selection and breeding programmes.

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Introduction

In West Africa especially in Benin Republic, agriculture is one of the essential components of the economy. It contributes 36% to Benin's gross domestic product (INSAE, 2008). It uses 48% of the active population with 60% of male workers and 40% of female workers. Among of the agricultural production sectors in Benin, aquaculture is one on which Benin is committed to increase its production of animal protein (PSRSA, 2011). The new government orientations for the 2016-2020 aim reaching 20,000 tons against 5,000 tons in 2015 as aquaculture production. These new orientations are aimed to reduce as far as possible the deficit in proteins from animal origin but also to ensure good employment, around 18 000 created for young people in aquaculture sector by 2021.

Beninese fish farming mainly exploits two species, including tilapia *Oreochromis niloticus* and African catfish, *Clarias gariepinus* (Imorou, 2007). *Oreochromis niloticus* is widely used in aquaculture in Benin with the support of several programmes and projects promoting industrial and family aquaculture (Achoh et al., 2018). However, fish farmers are faced with a collapse in the genetic aptitude on *O. niloticus* (Rurangwa et al. 2014). This is happened because, of a multitude strains which are present with uncontrolled crossings in aquaculture farms in Benin. It has been necessary to look at breeding and genetic improvement issues to obtain a good performance strain leading to a good production yield. It was in this perspective, Chikou et al. (2014) established and

[*]Correspondence: Mardochée Ephraim Achoh
E-mail: mardoachoh12345@gmail.com
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disseminated among important fish farmers' strains of *O. niloticus* named S2 INRAB strain (SI). In a logic of fish famers' appreciation on the performance of that strain, it is insisted that the strain S2 INRAB is less efficient and does not have the expectations of yield. To better understand the perception of fish farmers, it is better to conduct a comparative study on growth performance and to indicate new orientations in terms of research on the genetic improvement of tilapia in Benin Republic. This is the main objective of this study which aims to confirm or not the controversies of fish farmers on the zootechnical performance of the S2 INRAB strain under breeding conditions.

Materials and Methods

Experimental procedure: The experimental set-up was composed of six (6) concrete tanks (1 m^3) arranged by total randomization. Each strain was arranged in 3 replicates. The tanks were mid-filled with drilling water 72 hours before fish stocking with measurement of physicochemical parameters to monitor the stabilization of the water before starting the experiment. The comparative study was carried out with the Faizou's strain (SF) (Strain produced on the farm ''Johan Estève'' in Benin) which, according to the fish farmers, has proven zootechnical performance. The producer of this strain, Faizou has a good system of strain safety (with the support of the West African Agricultural Productivity Project WAAPP-Benin/ ProCAD), avoiding any kind of genetic pollution. The Faizou's strain was purchased and acclimatized for one week in the research station before the start of the experiment. The stocking density was 10 individuals per tank (10 individuals/m^2). Sixty (60) fingerlings of *O. niloticus* were used i.e. 30 S2 INRAB strain and 30 of Faizou's strain with average weight 10.17±2.0663 g.

Conduct of experimentation: After stocking, the fish were fed twice daily (8 A.M and 6 P.M), at the rate of 12% body weight. This rate was revised gradually downwards according to the growth of the specimens. Thus, the rate was revised firstly at a rate 10% body weight after the first control fishery, secondly at a rate of 6% body weight after the second control fishery and finally at a rate of 5% body weight after the third control fishery. The feed used contained a protein level of 45% and made from local ingredients whose incorporation rates are summarized in Table 1.

Table 1. Percentage of food composition.

Ingredients	Quantity of ingredients (%)
Bran	5
Wheat flour	14
Cotton	5
Soy	10
Fishmeal	60
CMV	1
Oyster shell	4
Iodized salt	0,5
Red oil of	0,5
Total	**100%**
Proteins	**40%**

During the experiment, pH, temperature and dissolved oxygen were measured every 48 hours in the morning at 7 o'clock and in the evening at 17 o'clock. The control fishery took place every fortnight and covered 50% of the total population of each experimental unit. During the fishing, water of each concrete tank was renewed. The experiment lasted 60 days.

Data analysis: The data collected were analyzed statistically with the STATISTICA software (2004, Version 6). Indeed, after verifications of the normality, the averages of the physicochemical parameters were compared between the plot using T Student test with *P*-value = 0.05. The curve of weight with the time was presented and the coefficients of variation were calculated and compared between the plots using Z bilateral test. The following zootechnical parameters were calculated and compared using T Student test.

Average Daily Gain (ADG) = (Pf - Pi)/T

Survival rate (SR %)= (NfX100)/Ni

Gain in Weight (GW) = Pf - Pi

Net Production Rate (%) (NPR) = (Pf - Pi) x 100 / Pf

Specific Growth Rate (SGR) = (LogPf-LogPi) x 100/T

Yield of harvest: (t / ha) = (GW) / Area Unit

Where Pi = Initial weight, Ni = Initial number, Pf = Final weight, Nf = Final number; T = duration of the experiment, Log = logarithm with base 10, SI = strain S2 Inrab, and SF = strain Faizou.

Table 2. Average of physicochemical parameters.

	Temperature (°C)		Disolved Oxygen (mg.L^{-1})		pH	
	Mean	SD	Mean	SD	Mean	SD
SF	29.19	1.871	3.33	1.306	7.88	0.715
SI	29.26	1.950	3.22	1.345	7.67	0.739
***P*-value**	0.013		0.013		0.000	

SD = Standard Deviation; $P>0.05$ = no significant difference; $P<0.05$ = significant difference

Table 3. Average initial weight and final weight.

	Initial weight		**Final weight**			
	Mean	**SD**	**Mean**	**SD**	**p-value**	**CV**
SF	9.62	2.178	47.74	7.836	< 0.05	16.41
SI	10.71	1.860	47.86	6.853	< 0.05	14.39
***P*-value**	>0.05		>0.05			>0.05

SD = Standard Deviation; $P>0.05$ = no significant difference; $P<0.05$ = significant difference

Results

Physico-chemical characterization of the water: The averages of the physico-chemical parameters for the duration of the trial are summarized in Table 2. According to the results, the physicochemical parameters (temperature, dissolved oxygen and pH) have significant difference between the two strains areas ($P<0.05$). Specifically, the temperature is significantly higher at the SI strain ($P=0.011$) while the dissolved oxygen and pH are significantly higher at the SF strain with a *P*-value 0.013 and 0.0000, respectively. The value of the temperature varied between 29 and 30°C, the dissolved oxygen between 3 and 4.5 mg.L^{-1} and the pH between 7 and 8.5 at the two strains. This, despite the significant difference noted, the values are within the tolerance range of the species.

Growth in weight and length of fish: The evolution of the growth in weight of the specimens for the two strains is shown in Figure 1. The trend of evolution of the growth is almost similar for the two strains except that the strain SI seems to have presented a more accelerated growth at the first month before matching the same growth rate with the SF strain. In this way, the growth of the strain SI has no linear evolution while the SF strain has linear evolution over the time.

The Table 3 shows the initial weights, final weights, the coefficient of variation, and the probabilities associated with the analysis. It appears

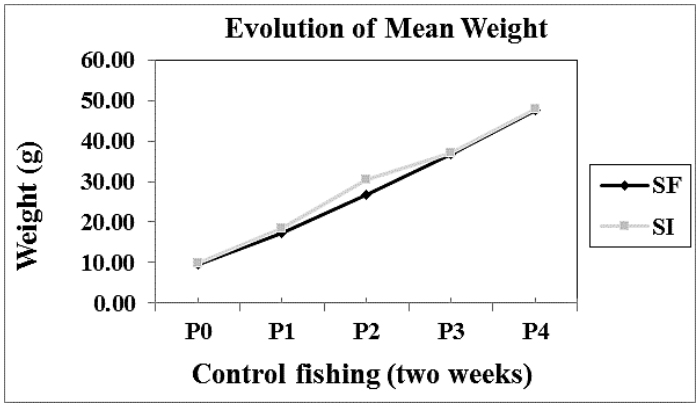

Figure 1. Weight curve evolution for control fishery.

that the averages obtained for the final weights are respectively 47.74±7.836 and 47.86±6.853 g against initial weights of 9.62±2.178 and 10.71±1.860 g for the SF and the SI strains. At the end of trial, the growth in weight of that two strains is significant and the average values are significantly higher than the initial values with $P<0.05$. On the other hand, the final average weights are no significant different between the strains ($P>0.05$). Thus, the two strains have the same weight gain after 60 days of experimentation. Regarding the homogeneity of the batches, no significant difference was recorded between the two strains ($P>0.05$).

Evolution of average daily gain: The variation in daily average after control fishery for both strains is presented in Figure 2. The average daily gain is roughly equal for both strains at the first control

Table 4. Total initial length and final length of fish.

	Initial length		Final length			
	Mean	**SD**	**Mean**	**SD**	**p-value**	**CV (%)**
SF	7.94	0.698	14.37	1.174	<0.05	8.17
SI	8.49	0.539	14.61	0.593	<0.05	4.06
***P*-value**	>0.05		>0.05			<0.05

SD = Standard Deviation; $P>0.05$ = no significant difference; $P<0.05$ = significant difference

Table 5. Evaluation of the Zootechnical Parameters.

	SF		SI	
	Mean	**SD**	**Mean**	**SD**
WG (g)	38.12^{a}	5.657	37.15^{b}	4.992
SR (%)	86.67^{c}	5.7735	100.0^{d}	0.0
NPR (%)	79.84^{e}	72.198	79.65^{e}	72.853
SGR	1.16^{f}	0.927	1.15^{f}	0.944
Yield (g/m^2)	12.71^{g}	1.886	12.38^{h}	1.664

SD= Standard Deviation; Means bearing the same letters are not significantly different from other while those wearing the different letters are significantly different

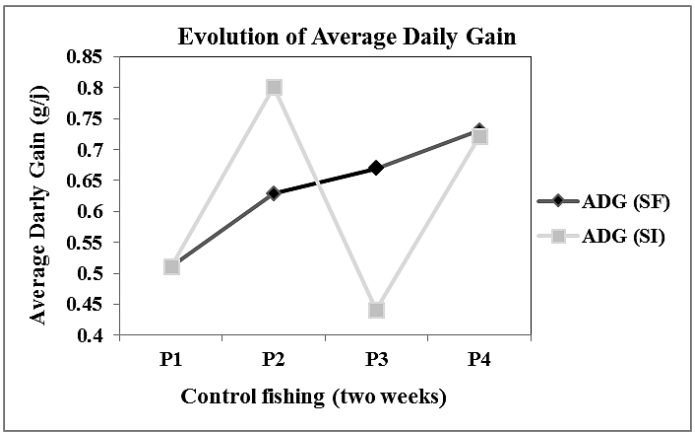

Figure 2. Curve evolution of the average daily gain according to control fisheries.

fishery (0.51 g/day). Growth acceleration is noted at the end of the second fortnight of the SI strain (0.80 g/day); and felt down considerably in the third fortnight till recorded the lowest gain in fifteen days for the whole experimentation period (0.44 g/day). The average daily gain of the SI strain evolved no linear during the experiment, while the SF strain showed an almost linear weight gain over the entire period. At the end, the means of daily gain obtained for the entire trial period are no significant different ($P>0.05$) and are 0.635±0.09 and 0.619±0.17 g/day for SF and SI strains, respectively. However, strain SF recorded a numerically higher value than strain SI.

Averages of total length: The body length gain of the two strains was evaluated and is summarized in Table 4. The length growth was significant at the end of the experiment ($P<0.05$) for the both strains. The final averages obtained are 14.37±1.174 and 14.61±0.593 cm against 7.94±0.698 and 8.49±0.539 cm, respectively for the SF and SI strains. The coefficient of variation revealed that the plot of SI strain (4.06%) is significantly more homogeneous than SF strain (8.17%) ($P<0.05$).

The Table 5 shows the average zootechnical parameters (WG, SR, NPR, SGR and Yield) of two strains. The zootechnical parameters reveals that the weight gain is significantly higher at the SF strain than the SI strain ($P=0.4841$). Although it had the highest gain in weight, the SF strain had the lowest survival rate (86.67%) against 100% for the SI strain ($P<0.05$). In the same way, the yield is significantly higher with the SF strain (12.71 g.m^{-2} or 127.1 tons. ha^{-1}) against 12.38 g.m^{-2} or 123.8 tons.ha^{-1} for the strain SI. It should be noted that no significant difference is recorded between the strains for the other parameters, especially the net production rate (NPR) and the specific growth rate.

Discussions

Physicochemical parameters are the characteristics of the ecological conditions that determine aquatic life.

The values obtained for these parameters into the water of the two strains (29-30°C for the temperature, 3-4.5 mg.L^{-1} for the dissolved oxygen and 7 to 8.5 for pH) are within the range required for good growth of *O. niloticus* (Lacroix, 2004; Lazard, 2009; Amoussou et al., 2016) For that, the values obtained for the parameters could not negatively influence the zootechnical performances during the trial.

The both strains have final average weights that are no significant different. The weight gain compared to the initial weight of the two strains is significant and shows the quality of the feed, but also the physicochemical conditions recorded which did not influence the growth of the fish whatever the strain (Toguyeni, 1996). The average daily gain is no significant different between the two strains during the entire study period, but remains numerically higher in the SF strain. However, the variations obtained for the average daily gain of the SF strain express an almost linear growth, unlike the SI strain, which show the best quality of the SF strain. Besides, considering the survival rate, it is obvious that the SF strain, although it recorded a mortality rate of 13.33%, achieved the highest gain in weight. Mortalities recorded from SF strain relieve an adaptation to the environment since this strain was purchased from producers while the SI strain is in stock at the fish station. This adaptive behavior is supported by the work of Lan et al. (2008), which states that stoking, environmental and handling stress influence the survival and growth of fisheries resources. The weight gain, although different between the two strains, indicates the zootechnical quality of the two strains to express a good growth performance especially in SF strain. This corroborates the observations Bamba et al. (2008), which, with a density of 10 individuals/m^2, had obtained a similar result in four months of breeding on *O. niloticus* against two months of rearing in the present study. Avit et al. (2012) reported having the weight gain of 11.04±0.05 g in four months of rearing. The average daily gains for SF and SI strains (0.635±0.09 and 0.619±0.17 g/day) are lower than those obtained by Chakrabortry and Banerje (2010) and Githukia et al. (2015) in fertilized pond that are respectively 1.74 and 0.6677 g/day (all sexes combined). On the other hand, the average daily gain obtained in this study for both strains is higher than that obtained by Olufagla et al. (2017) in aquarium (0.013 g/day) for 24 weeks of rearing. Bamba et al. (2008) obtained less, using the same stocking density as in this study. These results imply the both strains express some growth performance that should be considered in future genetic selection and breeding programmes. However, the SF strain, in terms of its almost linear growth throughout the study period, would result in a significantly higher average final weight, especially if the technical management favours a better survival rate than the one obtained in this study (86.67%).

As conclusion, it should be noted that the SF strain is the one which has the most growth. This strain had an almost linear average daily gain and a higher weight gain than the SI strain. Nevertheless, the both strains showed reasonably acceptable growth in tilapia culture. It would be advisable to consider them in future selection and genetic improvement programmes and projects, especially to try to combine the growth capacity of the SF strain with the resistance capacity of the SI strain for having expressed a survival rate of 100%.

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