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First breeding trials of African catfish *Schilbe intermedius* (Rüppel, 1832): Effects of stocking density on growth and survival of larvae reared in circular tanks

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Abstract
Captive breeding of new species such as *Schilbe intermedius* appears today one of the solutions to reduce the overfishing. Successful aquaculture requires among other, appropriate stocking density of fish in breeding. The current study analysed the effect of stocking density on growth and survival of the larvae of the butter catfish *S. intermedius* in circular tanks. During 24 days, six stocking densities (5, 10, 15, 20, 25 and 30 larvae.l^{-1}) represented respectively by D1, D2, D3, D4, D5 and D6 were tested on larvae (0.152 ± 0.001g body weight) in triplicate each. The larvae were fed daily at 10% of body weight every hour from 08:00 am to 08:00 pm with the Coppens (56% protein).
The results of the final body weight (FBW), final specific growth rate (SGR), feed efficiency (FE), Survival rate (SR), daily weight gain (MDWG) and performance index showed lower values at higher stocking densities. Survival rate ranged from 29.66±0.25 to 66.33±1.2%, while specific growth rate ranged between 1.97±0.09 to 5.81±0.02% .day^{-1}. The best growth performances were recorded in D1 (5 larvae.l^{-1}) and D2 (10 larvae.l^{-1}). Hence, the optimum stocking density for rearing of *S. intermedius* larvae in tanks was 5 larvae.l^{-1} (D1) of water.

Keywords: *Schilbe intermedius*, larval rearing, aquaculture, specific growth rate, performance index

1. Introduction
Recently, the African catfish *Schilbe intermedius* is generally considered as one of the most important tropical freshwater fish species for aquaculture [1]. Moreover, it is highly appreciated by local consumers owing to the fineness of its meat [1]. In Benin, this fish is captured massively in aquatic ecosystems with various techniques and gear that violate fishing regulations [2]. Moreover, large specimens are becoming increasingly scarce [3], reflecting the strong pressure on natural reserves. Meanwhile, in this country, fish farming is interested in the breeding of the species belonging either to the family of Clariidae (*Clarias gariepinus*) or to that of cichlids (*Oreochromis niloticus*).
In order to reduce the fishing pressure and the gap between supply and demand, fisheries managers implement various options including the introduction of new species. The domestication of *S. intermedius* is therefore opportune.
The success of fish farming requires not only the selection of species, appropriate feeding and water quality management but also close attention to the stocking density of fishes in breeding [4]. Indeed, the stocking density is a key factor able to affect the growth and the harvested final biomass of wild and cultured fish [5-8]. The effects of stocking density on growth and survival have already been studied for some African catfishes such as *C. gariepinus* [9], *Heteropneustes fossilis* [10, 11], *Heterobranchus longifilis* [12], *Chrysichthys nigrodigitatus* [13] and *Parachanna obscura* [14]. The butter catfish, *S. intermedius* is a rheophilic fish and opportunistic carnivore which the diet varies with stage of development [15]. Several studies have been interested in this fish species [2, 3, 16-20] but there is little information about requisite conditions for its breeding in captivity. For instance, the breeding of its larvae including the stoking densities appropriate for obtaining optimum yield per unit of volume, have not been studied.

Yet, the control of larval rearing is very important for breeding in captivity of a new aquaculture species [21]. Therefore, the present investigation was carried out to assess the effects of stocking density on growth and survival of *S. intermedius* larvae.

2. Materials and Methods

2.1. Experimental procedure

The larvae (initial weight = 0.152 ± 0.001 g) were harvested from the spawning areas of the Ouémé River at Agonlin-Lowé (N 0639' 378 ", E 00228' 571"). In this environment, the average values of temperature, pH and dissolved oxygen are 27.2 ± 0.1 °C; 6.9 ± 0.2 and 5.8±0.1 $mg.l^{-1}$ respectively. After their collection, the larvae were immediately conveyed to the experimental station of the Laboratory of Research on Wetlands of the University of Abomey-Calavi. The first three days before the experiment, the larvae were fed only with live food (zooplankton and *Artemia* nauplii) which were gradually substituted by the commercial catfish diet (Coppens) after a week.

The experiment was conducted for 24 days in a re-circulated system including 18 plastic tanks containing 20 l of water each. Water was recirculated through mechanical and biological filter system. The renewal of the water in the tanks was 0.5 $l.min^{-1}$. The larvae were stocked at six various densities: 5 $larvae.l^{-1}$ (D1), 10 $larvae.l^{-1}$ (D2), 15 $larvae.l^{-1}$ (D3), 20 $larvae.l^{-1}$ (D4), 25 $larvae.l^{-1}$ (D5) and 30 $larvae.l^{-1}$ (D6). The densities were selected on the basis of preliminary experiments on densities of this species and results for other catfish [9, 13, 14]. Each stocking density was experimented in three tanks. Every day, larvae were fed manually every hour from 08:00 AM to 08:00 PM with the Coppens (diameter of 0.5-0.8 mm, 56% protein and 15% lipid) at 10% of body weight.

During the experiment, leftovers of feed and wastes were siphoned twice daily, in the morning (7.30 AM) and in the evening (6.30 PM). After siphoning, the water volume was adjusted in each tank and dead fish were counted and weighed.

Every three days, water quality parameters such as temperature, pH and dissolved oxygen (DO) were measured every two hours from 7.30 am to 5.30 pm with clinical thermometer, pH meter (Model WTW Ph 330) and DO meter (Model WTW OXI 330), respectively. Every four days, 10 larvae randomly sampled in each tank, were weighed individually in order to adjust dietary ration. After 24 days of rearing, all the surviving larvae of each tank were collected and weighed. The specific growth rate (SGR), survival rate (SR), mean daily weight gain (MDWG), and feed efficiency (FE) were calculated as follows:

$$SGR\ (\%.day-1) = 100 \times \frac{Ln(Final\ mean\ body\ weight) - Ln(Initial\ mean\ body\ weight)}{Duration\ of\ rearing\ period\ (days)}$$

$$SR\ (\%) = 100 \times \frac{Final\ number\ of\ larvae}{Initial\ number\ of\ larvae}$$

$$MDWG\ (g.day-1) = \frac{Final\ mean\ body\ weight\ (g) - Initial\ mean\ body\ weight\ (g)}{Duration\ of\ rearing\ period\ (days)}$$

$$FE = \frac{Final\ body\ weight\ (g) + Dead\ fishes\ body\ weight\ (g) - Initial\ body\ weight\ (g)}{Total\ feed\ given\ (g)}$$

The performance index (PI) was calculated by combining two responses such as growth and survival in order to evaluate the effect of stocking density on production performance with more precision [22, 23].

$$PI = \frac{Survival\ rate\ (SR) \times [Final\ mean\ body\ weight(g) - Initial\ mean\ body\ weight\ (g)]}{Duration\ of\ rearing\ period\ (days)}$$

2.2. Statistical analysis

A completely randomized design was used for the experiment. Analysis of variance (ANOVA 1) was carried out to find out the effect of stocking densities on growth and survival rate of *S. intermedius* larvae. Significant difference between parameters means values of the experimented stocking densities were determined using the least significant difference (LSD) with significant level of 5%. Regression analysis was performed to determine the relationships between the stocking density and survival rate. These statistical analyses were performed with Stat View (version 5.0.1.0) software.

3. Results

The ranges and mean values (±SE) of water quality parameters monitored throughout the study, are shown in table 1. Water temperature mean values ranged between 26.92±0.06 °C and 27.10±0.05 °C and that recorded with treatment D_1 is significantly lower ($p<0.05$) to those of other treatments. The pH mean values in all tanks ranged from 6.19±0.03 to 6.82±0.07 and decreased with increasing stocking density. However, there is no significant difference between D1 and D2. Dissolved oxygen values were comparatively lower ($p<0.05$) in the highest density (D3, D4, D5 and D6).

The first four days of the rearing period, there was no much variation in the body weight of larvae stocked at different densities (Figure 1). Thereafter, larvae stocked at D1 and D2 attained the significantly higher ($p<0.05$) mean body weight (Table 2, Figure 1). On the other hand, the lowest values were obtained in the highest stocking densities (D3 to D6). The larval growth was therefore influenced by the stocking density.

The larvae bred with high stocking densities (D5 and D6) which SGR increased throughout the experience while that on the least stocking densities (D1, D2, D3 and D4) showed a progressive decrease (Figure 3).

Significant negative exponential correlation ($R^2 = 0.9834$) was noticed between average survival rate and larvae densities (Figure 2). The increase larvae density involved decreasing of survival rate.

Likewise, at the end of the rearing period, studied parameters (SGR, FE, SR, MDWG and PI) showed the highest values with the least larvae stocking density (D1). These parameters values decreased significantly ($P<0.05$) as the larvae stocking density increased (Table 2).

Table 1: Ranges and mean ± SD of in-tank water temperature (T), pH and dissolved oxygen (DO) recorded during larval rearing in plastic tanks. Each mean represents samples collected at daily (every two hours) intervals during the 24 days rearing period.

Stocking density (larvae.l^{-1})	Temperature (°C)		pH		DO (mg.l^{-1})	
	Range	Mean	Range	Mean	Range	Mean
D1	24.8-28.3	26.922±0.063^a	6.38-7.29	6.821±0.070^a	6.18-6.21	6.198±0.009^a
D2	25.4-28.1	27.106±0.056^b	6.23-7.10	6.727±0.008^a	5.95-6.15	6.073±0.05^a
D3	25.4-28.3	27.050±0.067^b	6.20-7.00	6.508±0.012^b	5.60-5.80	5.654±0.053^b
D4	25.2-28.1	27.011±0.006^b	6.10-6.55	6.339±0.006^c	4.80-4.90	4.876±0.028^c
D5	24.8-28.2	26.967±0.035^b	5.88-6.44	6.199±0.032^d	4.24-4.36	4.299±0.023^d
D6	24.7-28.1	26.961±0.045^b	6.10-6.49	6.209±0.004^d	3.90-4.25	4.151±0.057^e

Mean values with different superscript letters within a column are significantly different (p<0.05)

Table 2: Mean ± SD of final body weight (FBW), final specific growth rate (SGR), feed efficiency (FE), Survival rate (SR), daily weight gained (MDWG) and performance index of *Schilbe intermedius* reared in plastic tanks at six densities during the 24 days rearing experiments.

Parameters	D1	D2	D3	D4	D5	D6
IBW	0.152±0.001^a	0.153±0.002^a	0.152±0.001^a	0.152±0.001^a	0.152±0.001^a	0.152±0.001^a
FBW	0.614± 0.004^a	0.594±0.004^b	0.446±0.004^c	0.351±0.001^d	0.313 ±0.005^e	0.245±0.006^f
SGR (%.day^{-1})	5.816±0.029^a	5.664±0.049^a	4.498±0.016^b	3.478±0.017^c	3.008±0.070^d	1.977±0.099^e
FE	2.059±0.021^a	1.969±0.044^b	1.701±0.022^c	1.309±0.003^d	1.057±0.015^e	0.588±0.045^f
SR (%)	66.333±1.202^a	59.000±0.289^b	49.667±0.882^c	39.333±0.882^d	33.000±0.577^e	29.667±0.255^f
MDWG (g.day^{-1})	0.019±1.521^a	0.018±1.882^b	0.012 ±8.619^c	0.008±4.400^d	0.007±2.113^e	0.004±2.450^f
PI	1.276±0.014^a	1.085±0.011^b	0.610±0.010^c	0.325 ±0.007^d	0.221±0.007^e	0.114±0.006^f

Mean values with different superscript letters within a same row are significantly different (p<0.05)

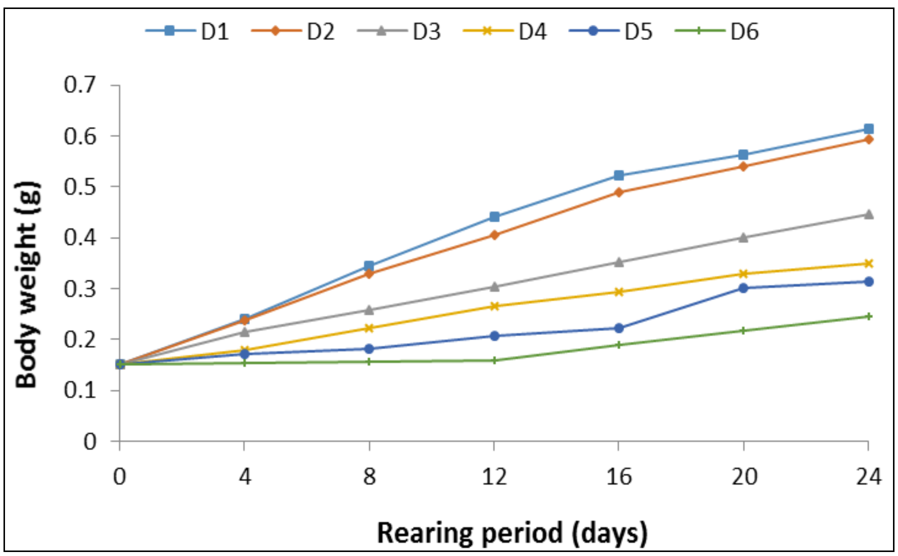

Fig 1: Total body weight of *Schilbe intermedius* larvae cultured at six densities in tanks for 24 days.

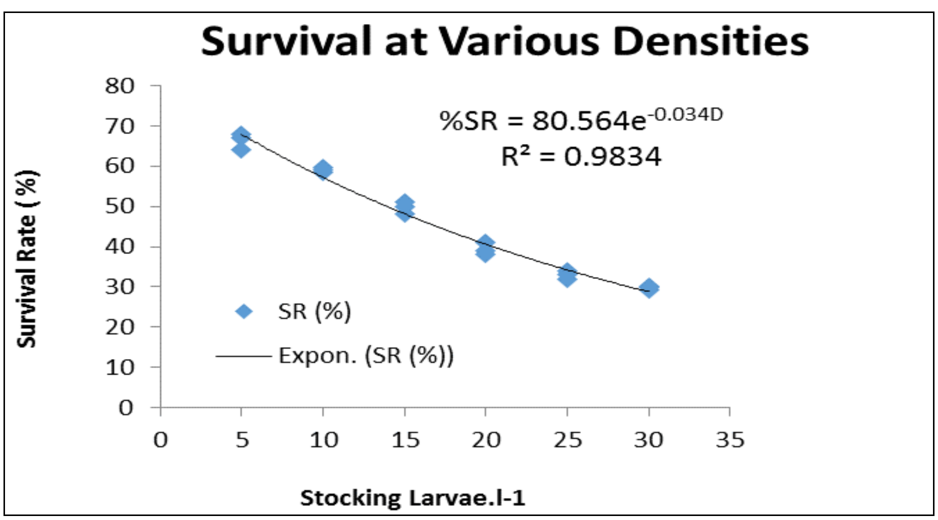

Fig 2: Relationship between larval stocking density (D) and survival rate (SR) in plastic tanks

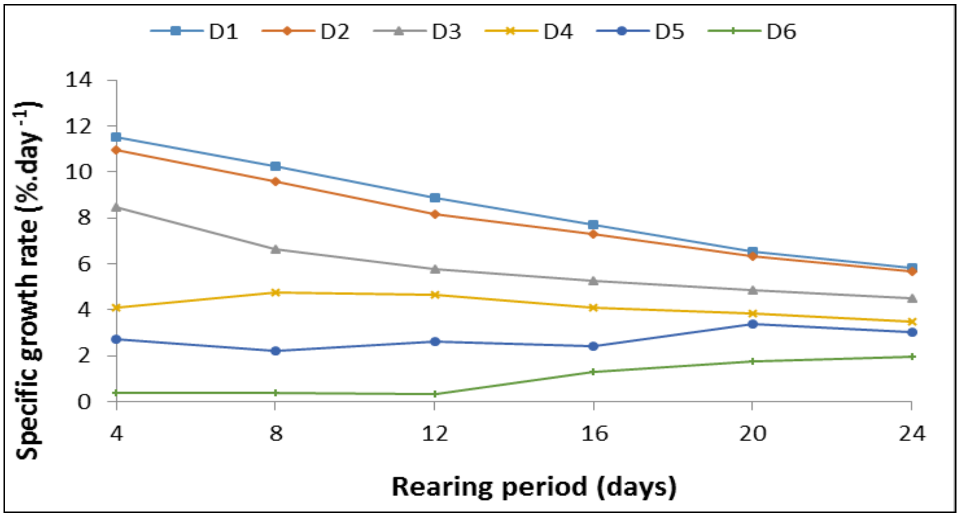

Fig 3: Specific growth rate of *Schilbe intermedius* larvae cultured at six stocking densities in tanks for 24 days.

4. Discussion

During the rearing period, larvae stocking density influenced environmental conditions in culture tanks. In all treatments, temperature values were within the favorable range (27.1-31.9 °C) for the catfish [24-26]. The pH and DO registered in this study are similar to those recorded by Nwipie *et al.* (2015) [27] for *C. gariepinus*. However, starting treatment D4, values of pH (6.20 - 6.33) and DO (4.15 - 4.87) are respectively below the standards of 6.5 [28] and 5 [29] recommended for good growth in aquaculture fish. Therefore, tanks with high stocking densities exhibit pH and DO values below the standard. The low dissolved oxygen recorded in tanks with high stocking densities can be attributed to the high oxygen consumption of the larvae as reported for other catfishes such as *C. gariepinus* [30] and *C. nigrodigitatus* [13]. This high oxygen consumption could also explain the low pH in these tanks, where densities are high [31, 32].

Growth is the manifestation of the net outcome of energy gains and losses within a framework of abiotic and biotic conditions. The current study results clearly shows that growth performances of *S. intermedius* larvae were influenced by stocking density. High stocking density of *S. intermedius* larvae, reduce growth parameters. Similar results have been obtained for *H. longifilis* larvae [33] which SGR and MDWG were nevertheless higher than current study findings. Growth lateness observed for high densities could be due on the one hand, to fish stress induced by aggressive food interaction owing to the crowded conditions [27, 33, 34] and, on the other hand, for space competition [14].

The current experiment indicates that the growth performances of *S. intermedius* larvae stored at densities above 5 individuals.l^{-1} (D1) have been compromised. This optimum stocking density is lower than those reported for the larvae of other catfishes as for instance, *Clarias batrachus* (15larvae.l^{-1}, [35]), *C. gariepinus* (10-25larvae.l^{-1}, [36]) and *P. obscura* (20larvae.l^{-1}, [14]). This low optimum stocking density recorded for *S. intermedius* is the consequence of its high oxygen requirement (≥5mg.l^{-1}, [20]) comparatively to other catfishes which generally tolerate some dissolved oxygen rates around 3 mg.l^{-1} [30]. This can be also explained by the absence of accessory breathing organs in *S. intermedius*, since according to Bonou and Teugels (1984) [37], this organ allows *P. obscura* and *C. gariepinus* to live in water with low dissolved oxygen and high ammonia levels.

The best Feed Efficiency (FE) was obtained for larvae stocked at 5.l^{-1} (D1) while for instance for *P. obscura* larvae, a density of 20.l^{-1} produced the best results [14]. However, our results show a negative correlation between the FE and fish stocking density. The high stocking densities reduced significantly feed efficiency. This report is in agreement with the findings of Pangni *et al.* (2008) [13] on *C. nigrodigitatus* larvae.

The effect of stocking density on larvae survival depends on the species [13]. In this study, the survival rates of *S. intermedius* decreases as stocking density increases. Similar results were recorded with larvae of *Clarias batrachus* [35], *Solea solea* [38] and *C. nigrodigitatus* [13] also reared in tanks. In return, it has been reported that the stocking density did not affect survival of *P. obscura* larvae reared in tanks [14] and *C. gariepinus* larvae reared in floating cages [9]. This can be due to the difference among the experimental conditions [33] and the high vulnerability of *S. intermedius* compared to most catfish. The same reasons can explain also the fact that the survival rates registered in this study (29.66±0.25 - 66.33±1.2 %) are lower than those obtained for *C. nigrodigitatus* [13] and *C. gariepinus* [30]. However, the survival rates noticed for *S. intermedius* larvae were higher than those (29.7 ± 7.4 - 56.6 ± 33.3%) reported by Nwipie *et al.* (2015) [27] for *C. gariepinus* larvae reared at the same stocking densities. Indeed, *S. intermedius* larvae reared in the current trial were not developed the cannibalism contrary to *C. gariepinus* larvae reared by Nwipie *et al.* (2015) [27].

5. Conclusions

This study shows that, stocking density has significant effect on the growth, feed efficiency and survival rates of *S. intermedius* larvae reared in tanks. Therefore, for an optimum food conversion and good biological conditions (growth and survival), *S. intermedius* larvae should be reared with stocking density of 5 individuals.l^{-1} in tanks.

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