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Effects of stocking density on growth, survival and feed utilization of Silver catfish *Schilbe intermedius* (Rüppel, 1832) fingerlings reared in circular concrete tanks

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Abstract
In order to realize the first breeding trials of the Silver catfish *Schilbe intermedius,* the effects of stocking density on growth, survival and feed utilization for this specie was examined. The experiment was conducted in circular concrete tanks during 42 days. Six stocking densities (40, 80,120, 160, 200 and 240 fish/m^3) represented respectively by D1, D2, D3, D4, D5 and D6 were tested in triplicate each on fingerlings (5.98±0.025 g body weight). Fishes were fed with the commercial food Coppens (protein 56%, diameter of 0.8 mm).
The results showed that, mean body weight, specific growth rate, feed conversion ratio and feed efficiency ratio were significantly affected by fish's densities (P<0.05). Except D6, the other densities showed the best growth performances and the higher were recorded with D4. Survival rates were not significantly (P>0.05) affected by stocking densities and ranged from 99.33 ± 0.66-100 ± 0.00%. Therefore, the most suitable stocking density for rearing of *S. intermedius* fingerlings in concrete tanks is 160fishes/m3 (D4).

Keywords: *Schilbe intermedius*, specific growth, feed conversion ratio, survival rate, aquaculture

1. Introduction

Schilbe intermedius (Rüppel, 1832) is a catfish widespread in almost all Africa. It is reported in many freshwater in Benin and can reach up to 500 mm in size [1, 2]. It has good economic value and is particularly prized for the quality and fineness of its flesh [3]. This causes the massive consumption of this fish and high pressure on the natural stocks. In order to improve fish production and to satisfy the demand for fish of the consumers, the domestication of new indigenous African freshwater species such as *S. intermedius* is increasingly recommended [4].
In view of this domestication of *S. intermedius*, recent studies were conducted to determine the transfer and storage modalities of fingerlings and begetter, but also to determine the optimum feeding rate of fingerlings of this species [5, 6]. The survival and growth performance reported by those studies, although encouraging, are not sufficient to conduct a captive breeding.
Stocking density is one of the main factors determining the growth and the final biomass harvested [7]. The relationship between stocking density and farmed fishes welfare were shown by many studies. Indeed, stocking density is identified and may affect fish growth performances, physiology and fish behavior [8, 9], influence feeding activities, metabolism distortion and digestive utility [10], feed utilization [11]. Fishes confined at high densities may present chronic stress, potentially resulting in lower growth rates, increased susceptibility to disease and increased mortality rates [12]. However, there are some species which growth rate is maximized at higher stocking densities [13]. Stocking density is seen as a crucial variable contributing to cultured fish growth performance. Moreover stocking density not only reportedly affects the fish productivity, but also affects water quality, land requirements and production costs [14].
In spite of this studies on stocking density were published, it is still difficult to obtain information on better densities for each species, because the best densities are affected by different culture systems, fish species and fish age [9].
A review of different research conducted on *S. intermedius* [1] was showed that the studies on the various stocking density of this species are nonexistent.

The studies on determining the optimum stocking densities of *S. intermedius* at different ontogenetic stages are therefore essential. This study will complement the previous determination of optimum feeding rates in order to allow the domestication of this species.
The aim of this investigation was to determine the optimum stocking density of *S. intermediu*s fingerlings reared in circular tanks conditions, in order to improve their growth performances and feed utilization.

2. Materials and Methods

2.1 Experimental fish preparation

S. intermedius fingerlings (used in this study) weighed 5.98 ± 0.025 g body weight were captured in the "Acadjas" installed on the Ouémé river in Agonlin-Lowé (N 0639' 378 ", E 00228' 571"). The average values of temperature, pH and dissolved oxygen of this environment are 27.2 ± 0.1 °C; 6.9 ± 0.2 and 5.8±0.1 $mg.l^{-1}$ respectively. Those fishes are acclimated in the experiment station of Research Laboratory on the Wetlands of the University of Abomey-Calavi for two weeks prior to experimentation. After the acclimatization, fishes were randomly stocked into tanks containing 250 liter total water volume (0.5 m radius, 0.32 m height) at 10, 20, 30, 40, 50 and 60 fish/tank. Fishes were feed four-time a day by the commercial catfish diet, Coppens (protein 56%, diameter of 0.8 mm).

2.2 Experimental design

The experimental facility was composed of 18 circular concrete tank (250 l each) supplied with well water; a water renewal and discharge system consisting of septic tank; an oxygenation system provided by a diffuser and a shading device to maintain the ambient temperature. The tanks water is renewed daily at 2/3 the evening. Before the experiment, the water parameters were adjusted on the values measured in the species naturel environment [15]. The various stocking densities [40fish/m3 (D1); 80fish/m3 (D2); 120fish/m3 (D3); 160fish/m3 (D4); 200fish/m3 (D5) and 240fish/m3 (D6)] were tested in triplicate on fingerlings during 42 days in order to estimate the optimum stocking density.

2.3 Fish growth measurements

The parameters such as growth performances, feeding activities, survival rate and water quality were calculated based on the data collected during the experiment. Data on growth rate was recorded regularly every week by weighed individual fish from each tank. On each sampling day, each individual fish was caught from tank after emptying it. Then the fishes were quickly weighed and the tanks were completely cleaned. Immediately after measurements, the fish were carefully returned to its original tanks. Growth performances were calculated as following:
Specific Growth Rate (SGR, %/day) = 100 x [ln (final weight) – ln (initial weight)] / d
where: d is the number of days in the feeding periods.
Weight Gain (WG, %) = 100 x [(final weight (g) – initial weight (g)] / initial weight (g)
In experiment on survival rate, all treatments were observed daily and the data was calculated by the following formula:
Survival rate (SR, %) = (Final Number of fish / initial Number of fish) x 100

2.4 Feed utilization measurements

Fishes were manually fed every 4 hours from 8 AM - 8 PM at 5% of the biomass with commercial diet.
Feed Conversion Ratio (FCR) = dry feed intake (g) / [final body weight (g) – initial body weight (g)]
Feed Efficiency Ratio (FER) = [final body weight (g) + dead fish body weight (g) – initial body weight (g)] / dry feed intake (g).

2.5 Water quality measurements

Water quality parameters such as temperature, dissolved oxygen and pH were daily measured at 5 PM. pH was measured using pH meter (model WTW pH 330), dissolved oxygen with the Oxy meter (model WTW OXI 330) and temperature using a clinical thermometer. Water quality parameters as ammonium (NH_4^+), nitrite (NO_2^-) and nitrite-nitrogen (NO_2^- - N) were estimated weekly by the colorimetric method. Throughout the experiment, the water in the tanks was renewed at 2/3 of the total volume every evening.

2.6 Statistical analysis

Data were analyzed using one-way analysis of variance (ANOVA 1) after verifying the homogeneity of variance using "Hartley's test" for each experiment. When the differences were significant at $P<0.05$ level, Fisher's test was used to compare the means between individual treatments. Statistical analysis was performed using the Statview software.

3. Results

3.1 Fish growth performances

Fish growth was significantly affected by fish's densities. Growth performance and survival of fishes are presented in Table 1. Growth performances significantly increased with increasing of fish density up to 160fish/m3 (D4). Therefore, the best value the specific growth rate (1.23 ± 0.03) was recorded with this density and the fish's average final body weight was to 10.02 ± 0.15 g. While the lowest fish specific growth rate (0.53 ± 0.02) was observed in fish reared with high density (240fish/m^3).
In general, there is a gradual increase in fish biomass throughout the experiment. However, a biomass regression was observed in the third week (Figure 1). The weight gain in all the treatments was generally low. During the rearing period (6 weeks), fish survival rates (99.33 ± 0.66 to 100 ± 0.00) were not significantly ($P>0.05$) affect by the stocking densities.
Generally, the SGR decreases throughout the experiment, but this decrease is much more noticeable the first three weeks (Figure 2).

3.2 Feeding performances

Feeding parameters such as feed conversion ratio (FCR) and feed efficiency ratio (FER) were significantly affected by fish densities ($P<0.05$). The best feed utilizations parameters were obtained with D1, D2, D3, D4 and D5. The highest FER was found at D4 (1.80 ± 0.06), while the lowest was found with D6 (0.76 ± 0.02). This study found that, FER decreased and FCR ratio increased significantly with the treatment D6 compared to other treatments. Figure 3 shows that the FCR values have remained constant from the fourth week until the end of the experience for all treatments. These values were strongly varied the first three weeks.

3.3 Water quality parameters

The ranges and mean values (±SE) of water quality parameters monitored throughout the study are shown in

Table 2. There was no obvious effect of stocking density on water quality for all treatment. During the experiment, temperature in tank ranged between 25.7 - 30.4 °C, with the highest temperature found in higher density compare with lower density. In the tanks, pH values ranging from 5.68 - 7.72 and DO levels were between 3.50 - 4.3 mg.l^{-1}. Generally, ammonium (NH_4^+) and nitrite (NO_2^-) were relatively low values. The data also indicated that the higher stocking density tended to be lower in DO concentrations. The lowest DO and the highest pH were observed in all tanks during the third week. It was also during this period that the ammonium (NH_4^+) and nitrite (NO_2^-) has the highest values.

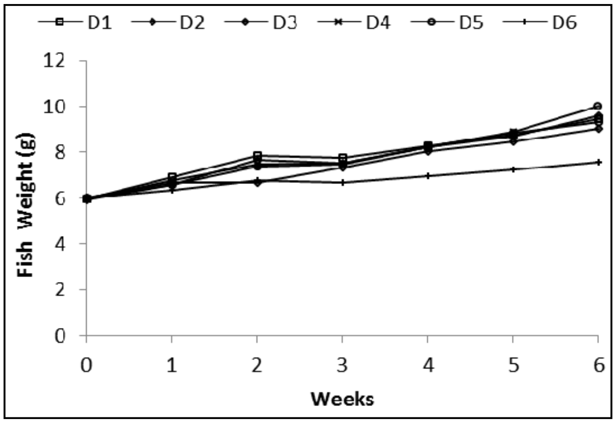

Fig 1: Comparative of *Schilbe intermedius* body weight reared at different stocking density in circular concrete tanks during 6 weeks of culture.

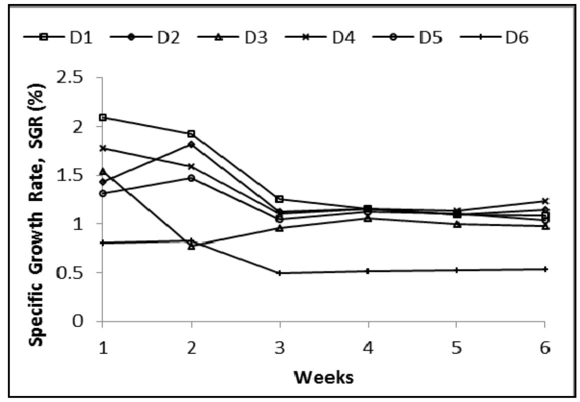

Fig 2: Mean specific growth rate (SGR) of *Schilbe intermedius* reared at different stocking density in circular concrete tanks during 6 weeks of culture.

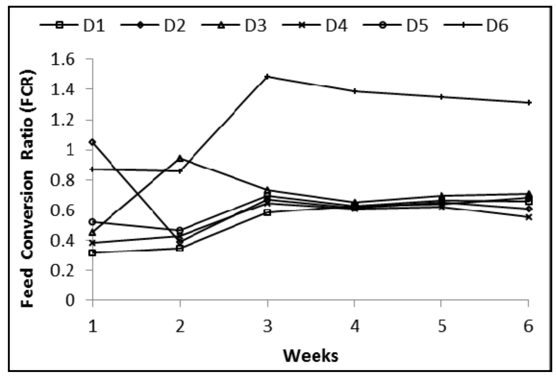

Fig 3: Mean feed conversion ratio (FCR) of *Schilbe intermedius* reared at different stocking density in circular concrete tanks during 6 weeks of culture.

Table 1: Effect of different stocking densities on the growth performance of *Schilbe intermedius* fingerlings reared in circular concrete tanks during 42 days of culture.

Density	D1 (40 fish/m^3)	D2 (80 fish/m^3)	D3 (120 fish/m^3)	D4 (160 fish/m^3)	D5 (200 fish/m^3)	D6 (240 fish/m^3)
AIW (g)	5.98±0.03a	5.94±0.01a	6.00±0.04a	5.97±0.05a	6.02±0.05a	6.02±0.05a
AFW (g)	9.44±0.10a	9.62±0.13a	9.04±0.04b	10.02±0.15c	9.30±0.10ab	7.55±0.04d
SGR (%/day)	1.08±0.02a	1.14±0.02a	0.97±0.02b	1.23±0.03c	1.01±0.04ab	0.53±0.02d
FER	1.51±0.02a	1.64±0.03b	1.41±0.04a	1.80±0.06c	1.46±0.04a	0.76±0.02d
FCR	0.79±0.01ab	0.73±0.01ac	0.85±0.02b	0.68±0.02c	0.82±0.02ab	1.55±0.05d
SR (%)	100.00±0.00a	100.00±0.00a	100.00±0.00a	100.00±0.00a	99.33±0.66a	100.00±0.00a

AIW = average initial weight, AFW = average final weight; SGR = specific growth rate, SR = survival rate; FCR: feed conversion ratio; FER: feed efficiency ratio and % = percent. Values are means of triplicate groups' ± S.D. Within a row, means with different letters are significantly different (P<0.05). Means with the same letters indicate not significantly different between treatments.

Table 2: Physicochemical parameters monitored during 42 days of experiment.

Parameter	Unit of mea surement	Range	Mean ± standard error
Ammonium (NH_4^+)	mg.l^{-1}	0.5 - 1	0.75±0.25
Nitrite (NO_2^-)	mg.l^{-1}	0.02 – 0.05	0.03±0.01
Nitrite-nitrogen (NO_2^--N)	mg.l^{-1}	0.006 – 0.015	0.01±0.00
pH	-	5.68 – 7.72	6.88±0.72
Dissolved oxygen (DO)	mg.l^{-1}	3.50 – 4.3	3.75±0.26
Temperature (T)	ºC	25.7 – 30.4	28.01±1.12

4. Discussion

The present study indicated that, fish growth performances and feed utilization were significantly affected by the stocking density. Other studies reported also that the catfish growth performances were affected by space and number [7, 16-18]. The low weight gain recorded in all the treatments could be due to the effect of age on the fish since the fishes were advanced in age. The lowest growth performance was recorded with the highest density (240 per m^3). Similar trends were obtained by Narejo *et al.* [21] and Sirakov and Ivancheva [22] which reported a negative effect when fishes are cultivated at higher density. However, the previous studies of Ajani *et al.* [13] on *Clarias gariepinus*; Samad *et al.* [14] on *Epinephelus coioides*; North *et al.* [19] on Rainbow trout *Oncorhynchus mykiss*; Howell [20] on turbot (*Scophthalmus maximus*) showed an increment on growth when the stocking density increase.

Indeed, the negative effect associate to higher density for *S. intermedius* could be explained by its oxygen requirement. *S. intermedius* although it is a catfish, have a high dissolved oxygen (≥ 5 mg/L) need [6]. Boyd [23] and Samad *et al.* [14] have also mentioned that in high stocking density, the problems such as oxygen deficiency are frequently occurring. Furthermore social interactions through competition for food and/or space can negatively affect fish growth, hence higher stocking densities leads increasing stress. Therefore, energy requirements were increased and causing a reduction in growth and food utilization [24, 25].

The specific growth rate (SGR) obtained in this study (0.53 - 1.23%) are higher than the values of 0.3 - 0.48% which Narejo *et al.* [21] recorded with the catfish, *Heteropneustes fossilis* fingerlings. The significant (P<0.05) differences among the treatments suggest that higher stocking densities of *S. intermedius* fingerlings affected the growth of the fish. The results of SGR in this study are lower than those obtained on other studies. For instance, Malik *et al.* [18] reported the SGR of range 1.2 - 1.4%/day and Kpogue [17] with SGR range 1.66 - 2.08%/day in a study on the effects of stocking density on growth of respectively *Pangasius hypophthalmus* and *Parachanna obscura* fingerlings. The specific growth rate is based on the ratio need growth / need maintenance [26]. Lower SGR recorded for this study could be explained by a high need for maintenance of *S. intermedius* compared to other catfish.

In this study, fish's survival rate ranged from 99.33 - 100.00% and was not significantly (P>0.05) affect by stocking density. Similar results were obtained by Kpogue [17] and recorded 100% survival rate for *P. obscura* fingerlings. Nevertheless, this trend is contrary to the observations of Osofero *et al.* [27]. Higher survival rate could be attributed to the favorable environmental conditions throughout the experimental period. This is in agreement with the findings of El-Sherif and El-Feky [28] who indicate that higher (100%) survival rates could be linked to favorable ecological conditions.

On the other hand, stocking density could explain the differences in feed utilization performance obtained. These results show similar FER (0.76 - 1.80) with those (0.75 - 1.13) obtained by Kpogue [17] on *P. obscura*. FCR recorded in this study ranged from 0.68 - 1.55. The best FCR obtained with the treatment D4 is explained by the best feed utilization resulting in the growth obtained. In general, high FCR were recorded and this may be due to food losses, low conversion of food into muscle and environmental factors [29, 25].

Oxygen is a determining factor for the metabolism necessary to the increase in body mass of fish [30]. In aquaculture systems, APHA [31] recommends dissolved oxygen levels of 5 - 8 mg / L. The levels of 3.5 - 4.3 mg / l recorded for this study is lower than the recommendations of APHA [31] which explain the slow growth of our fish. For aquaculture pond waters, Boyd [23] recommends the values of 7 -9; 0.2 - 2 mg.l^{-1}; and <0.3 mg.l^{-1} respectively for pH, ammonium (NH_4^+) and nitrite (NO_2^-). For this study, the values of NH_4^+ (0.5 - 1 mg.l^{-1}) and NO_2^- (0.02 – 0.05 mg.l^{-1}) recorded are well below the recommendations of Boyd [23] and do not hinder fish growth performance unlike that of pH (5.68 – 7.72) recorded. However, the acidic pH associated with low DO recorded during the third week did not make better use of the food and explain the drop in growth during this week. This corroborates the results of Samad *et al.* [14] for which the studies on stocking density involve many interrelated parameters including water quality and food availability.

5. Conclusion

This study shows that, stocking density had a significant effect growth and food conversion. Therefore, the optimum stocking density for *S. intermedius* fingerlings is 160/m^3 (D4). However, stocking density in this study had no significant effect on the survival of the fish. Water quality parameters recorded in this study affect the growth of *S. intermedius*. However, other water quality parameters may need to be investigated to ascertain their influence on fish growth.

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