Journal of Applied Biosciences 55: 3962– 3972

ISSN 1997–5902

Feeding rate requirements for *Parachanna obscura* fry reared under controlled environmental conditions.

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Original submitted in on 4th June 2012. Published online at www.m.elewa.org on July 27th 2012.

ABSTRACT

Objective: This work aims to estimate the optimal feeding rate for three stages of *Parachanna obscura* fry.
Methodology and results: Fish with initial body weights 0.9, 4.1 and 9.4 g, previously habituated to a dry diet (Crude protein 45%, Crude lipid 10%, Energy Brut 18.5 Kj/g) were used. Five feeding rate were tested in triplicate for 28 days in experiments 1 and 2 and for 42 days in experiment 3. Feeding rate 5, 10, 15, 20 and 25%; 2, 4, 6, 8 and 10% and 0.5, 2, 3, 4 and 5% of body weight were tested respectively in experiments 1, 2 and 3. In all experiments, growth, feed efficiency and body composition were significantly influenced by feeding rate. Survival rates were not affected by feeding rate. Second order polynomial regression analysis between food rations, specific growth rate and feed efficiency indicated that optimum food rations requirement for *P. obscura* is approximately 8.5%, 3.6% and 2.5% for fry with initial body weight 0.9, 4.1 and 9.4 g respectively.
Conclusion and Application: These results showed that feeding rates requirements decreased with increasing of body weight. *P. obscura* is a hardy carnivore which can be used successfully in aquaculture.
Keywords: Parachanna obscura, fry, feeding rate, requirement, growth, feed efficiency.

INTRODUCTION

Parachanna obscura is a favorite fish for food and constitutes an extremely important part of the staple food for African people because of its tasty flesh, few bones, remarkable growth and high economic value (O' Bryen & Lee, 2007). It represents a good potential for African aquaculture (Micha, 1974; Victor & Akpocha, 1992). Thus, *P. obscura* is overexploited and cannot meet local demands (O' Bryen & Lee, 2007). The culturing of this species is highly wished in other to stop it massive collection in the wild environment. In wild environment, fish growth correlates with food consumption and availability (Keckeis & Schiemer, 1992). On the other hand, in intensive aquaculture system or controlled environment, growth rate is largely influenced by food consumption (Andrews & Page, 1975; Condrey, 1982; El – Sayed, 2002). The quantity and quality of feed consumed by fish have a pronounced effect on its growth rate, efficiency of feed utilization and survival rate (Lovell, 1989; Pickering, 1993). Indeed, determination of appropriate rations for cultured fish is important to achieve optimum productivity. Several other factors including fish size also affects food requirement. The economic success of production control in aquaculture depends to a large extent on reasonable feeding costs because feed accounts for 70 % of the cost of the intensive fish culture (Pillay, 1990). One way of reducing feeding costs is to estimate the daily ration and formulate a feeding chart that will best suit local farming conditions (Imtiaz, 2007). Optimization of the amount of feeding may have the effect not only of reducing the cost of feeding but also the biological loading of recirculation systems and effluent production in flow – through systems (Woods, 2005). It is well established on many other teleosts that rations requirements decreased with increasing body weight (Hogendoorn *et al*., 1983; Hecht *et al*., 1988; Fiogbe & Kestemont, 2003). Although some aspects of biology and ecology of *P. obscura* have been studies, little attention was paid to the quantitative food requirements of this species during its growth in culture conditions. The objective of this study was, therefore, to determine optimum feeding rate for growth, feed efficiency and survival rate for three sizes of *P. obscura* fry rearing in controlled environment.

MATERIALS AND METHODS

Fish and experimental design: *Parachanna obscura* fry weighing less than 0.5 g were caught in swamp "Dra" in Takon (South – East Benin). Water temperature, pH and dissolved oxygen in the swamp were 27.7°C, 6.1 and 2.1 mg.L $^{-1}$ respectively. Once collected, fry were transported to the experimental Station to the Research Unit of Wet Land of the Department of Zoology of the Faculty of Sciences and Technology (University of Abomey-Calavi) and put in circular tank. Before the beginning of each experiment, fish were selected to obtain homogenous body weights and were habituated to the artificial food (Coppens – International, Helmond, Netherlands, Crude protein 45%, Crude lipid 10%, Energy brut 18.5 KJ.g^{-1}). Particles sizes 0.8, 1.2 and 2 mm for fish with initial body weight 0.9, 4.1 and 9.4 g respectively were used. The experiments were conducted consecutively in 15 circular cement tanks containing 225 L of water each under atmospheric conditions during 28 days for fish of 0.9 and 4.1 g and 42 days for fish of 9.4 g. Water in all tanks was renewed continuously 1L/min. In each experiment, five feeding levels were tested in triplicate at density of 40 fishes/ tank. The daily food rations were fixed according to the initial body weight of fish in such a way that optimum and maximum rations for *P. obscura* fry at those different stages could be determined. In experiment 1, feeding rates (5%, 10%, 15%, 20%, and 25%) of body weight were tested on *P. obscura* fry with initial body weight 0.9 g. In experiment 2, *P. obscura* fry with initial body weight 4.1 g were fed with feeding rates 2%, 4%, 6%, 8% and 10% of body weight. In experiment 3, feeding rates 0.5%, 2%, 3%, 4% and 5% of body weight were tested on *P. obscura* fry with initial body weight 9.4 g .In each experiment, food was distributed daily by hand every 2 hours from 08: 00 AM to 06: 00 PM. Water quality parameters such as dissolved oxygen, temperature and pH using temperature and dissolved oxygen meter (WTW oxi 197i, WTW, weilheim, Germany, precision: ± 0.01°C and 0.01 mg. L^{-1}) and pH meter (WTW pH 330i precision: ± 0.01) respectively were measured daily in each tank throughout the experimental period. The water parameters were respectively 28.15 ± 0.45°C, 6.51 ± 0.12 mg.L^{-1}and 6.75 ± 0.33 in experiment 1, 28.43 ± 0.25°C, 5.61 ± 0.24 mg.L^{-1}and 6.02 ± 0.25 in experiment 2 and 28.58 ± 0.05°C, 4.91 ± 0.08 mg.L^{-1}and 6.25 ± 0.12 in experiment 3 for temperature, dissolved oxygen and pH respectively. At the beginning of each experiment, 40 fishes were weighed individually. All fish were counted and weighed every 7 days before being released into their corresponding tank and food ration was adjusted. No feed was offered to the fish on the day the measurements were taken. At the end of each experiment, all fish were counted and fish body weights per tank as well as individual weight were taken. Fish samples were analyzed by standard methods for dry matter (oven drying) at 105° C for 24 h, crude protein (N- Kjeldahl x 6.25) and ash (oven incineration at 550° C). Total lipids were extracted according to Bligh and Dyer (1959). The Specific Growth Rate (SGR), the Feed Efficiency (FE) and survival rate were calculated on the basis of the initial and final body weight, according to the duration of the experiment (number of days = d) as followed : SGR (%/d) = 100 x [ln(final weight) – ln(initial weight)]/d. FE was calculated on the basis of the total food distributed (FD, g), the Initial and Final Biomasses [IB and FB, respectively (g)], and Biomass of Dead fish (DB, g) as followed: (FB+DB-IB)/FD. Survival rate (%) = 100 x

FN/IN (IN, FN = Initial and Final Number of fish respectively).

Analysis of data: The mean values of final weight, SGR, FE, survival rate and body composition were compared between treatments by one way analysis of variance (ANOVA 1) after verifying the homogeneity of variance using "Hartley' s test" for each experiment. Significant differences between treatments means ($P < 0.05$) were determined using a Fisher's test (Saville, 1990). Results are given as means ± standard deviation. Two mathematical (dose – response) models were used to assess the effect of feeding rate on specific growth rate of *P. obscura* fry. The general equation of the broken line model (Robbins *et al.*, 1979) is $y = L+U(R-X_{LR})$

where L is the ordinate and R, the abscissa of the breakpoint. R is taken as the estimated requirement (feeding rate that guarantees the maximum specific growth rate).

X_{LR} means X less than R and U is the slope of the line for X_{LR}. By definition, $R-X_{LR}$ is zero when $X > R$.

The model of Brett & Grove (1979) was applied to the second order polynomial regression between feeding rate and specific growth rate. This model allows determination of:

The maximum feeding rate (corresponding to the maximum specific growth rate and calculated by taking the first derivative of the second order polynomial equation). The optimum feeding rate (obtained graphically and corresponding to the best feed efficiency).

RESULTS

Effects of feeding rate on growth, feed efficiency and survival rate of *P. obscura* fry are presented in table 1, 2 & 3. In *P. obscura* fry (initial weight ≈ 0.9 g), survival rate were not significantly affected by the feeding rate ($P > 0.05$) and varied from 91.67 ± 2.89% to 95.00 ± 2.50% (table 1). Final body weight and Specific Growth Rate (SGR) were significantly influenced by feeding rate ($P < 0.05$). The increase of feeding rate leads to an increase of growth performance up to the ration 15% of body weight and decrease later on. Final body weight and SGR of fish fed the feeding rates from 10% to 15% were the highest ($P > 0.05$). There were no significant differences ($P > 0.05$) between growth performances (final body weight and SGR) for fish fed rations 5% and 25% on the one hand and 20% and 25% of body weight on the other hand (table 1).

Table 1: Growth performance, Feed Efficiency and survival rate of *P. obscura* fry (0.9 g) fed with different feeding rates

Rations	Initial body weight (g)	Final body weight (g)	SGR (%/d)	Feed Efficiency	Survival rate (%)
5%	0.94±0.09	1.62±0.09 a	2.59±0.81 a	0.41 ± 0.03 a	92.51±6.61
10%	0.90±0.00	2.15±0.06 b	3.94±1.14 b	0.67± 0.28 b	94.17±1.44
15%	0.90±0.00	2.17±0.04 b	4.00±0.07 b	0.37± 0.00 ac	95.00±2.50
20%	0.86±0.01	1.96±0.10 c	3.73±0.24 c	0.26 ± 0.03 c	91.67±5.77
25%	0.87±0.01	1.76±0.07 ac	3.17±0.19 ac	0.18 ± 0.01 d	91.67±2.89

Means on the same line followed by different superscripts are significantly different (P<0.05).

Feed Efficiency (FE) was significantly influenced by feeding rate. Feed Efficiency increase with feeding rate up to food ration 10% of body weight and decrease ($P < 0.05$) afterwards. The highest Feed Efficiency was found with feeding rate of 10% and the lowest, with 25% of body weight ($P < 0.05$). As far as fry (initial weight ≈ 4.1 g) is concerned, survival rate were not affected by the feeding rate and were 100% with all food ration (table 2).

Table 2: Growth performance, Feed Efficiency and survival rate of *P. obscura* fry (4.1 g) fed with different feeding rates

Rations	Initial body weight (g)	Final body weight (g)	SGR (%/d)	Feed Efficiency	Survival rate (%)
2%	4.25±0.12	6.52±0.08 a	1.71±0.09 a	0.51± 0.04 b	100
4%	4.11±0.10	9.17±0.31 b	3.27±0.09 b	0.73 ± 0.04 a	100
6%	4.07±0.06	9.30±0.50 b	3.30±0.27 b	0.52± 0.08 b	100
8%	4.14±0.20	8.17±0.21 c	2.72±0.23 c	0.33± 0.04 c	100
10%	4.01±0.18	7.57±0.25 ac	2.54±0.09 ac	0.26 ± 0.01 cd	100

Means on the same line followed by different superscripts are significantly different (P<0.05).

Feeding rate influenced significantly final body weight and Specific Growth Rate (SGR) (P < 0.05). Growth performances increased significantly with feeding rate. Best final body weight and SGR were obtained with rations 4% and 6% (P < 0.05). Growth (final body weight and SGR) of fish fed the 10% ration was not significantly different (P > 0.05) from that of fish fed the food rations 2% and 8% of body weight. Feed Efficiency (FE) increased with increasing food ration up to 4% and decreased later on. Feed Efficiency of fish fed 4% ration was significantly higher (P < 0.05) than for fish fed other rations. The lowest FE was found with 10% food ration but was not significantly different (P > 0.05) from that of fish fed the 8% feeding rate. Survival rate were not affected by the feeding rate and were 100% with all food ration for fry with initial body weight ≈ 9.4 g (table 3).

Table 3: Growth performance, Feed Efficiency and survival rate of *P. obscura* fry (9.4 g) fed with different feeding rate

Rations	Initial body wt (g)	Final body wt (g)	SGR (%/d)	Feed Efficiency	Survival rate (%)
0.5%	9.58±0.16	12.93±0.30 a	0.83±0.03 a	1.00±0.06 a	100
2%	9.37±0.03	20.70±1.04 b	2.20±0.15 b	1.06±0.07 a	100
3%	9.17±0.40	26.17±1.90 c	2.91±0.19 c	1.34±0.20 b	100
4%	9.38±0.39	24.37±1.50 b	2.65±0.22 b	1.01±0.01 a	100
6%	9.71±0.08	23.33±1.20 b	2.43±0.13 b	0.84±0.18 c	100

Means on the same line followed by different superscripts are significantly different (P<0.05).

Food ration influenced significantly growth performances (final body weight and Specific Growth Rate) (P < 0.05). Final body weight and SGR increased significantly with increasing of food ration. Best final body weight and SGR were obtained with food ration 3% of body weight (P < 0.05). Final body weight and SGR of fish fed food ration 6% of body weight are not significantly different (P > 0.05) from that of fish fed the food rations 2% and 4% of body weight. Feed Efficiency increased significantly with increasing of food ration up to 3% and decreased later on. The highest Feed Efficiency was obtained with food ration 3% (P < 0.05). The lowest Feed Efficiency was obtained with the food ration 6% of body weight (P < 0.05). Final body protein increased significantly (P < 0.05) with increasing feeding rate and the lowest body protein content were found in fish fed food ration 5% in experiment 1 (table 4) and 2% in experiment 2 (table 5). In experiment 3 (table 6), body protein content increased with increasing of food rations up to 3%; thereafter a significant fall of body protein was noticed (P < 0.05). In all experiments, the fat content in fish increased with the increasing of food rations.

Table 4: Whole body composition of *P. obscura* fry (0.9 g) fed with different feeding rates

Rations	Initial protein (%)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
5%	52.69±0.08	71.71±1.30 b	53.71±0.01 a	12.75±0.11 a	12.31 ± 0.09
10%	52.69±0.08	71.24±0.91 b	55.54±0.04 b	13.01±0.02 a	12.75± 0.11
15%	52.69±0.08	70.12±0.89 b	55.13±0.11 b	13.22±0.07 a	12.81± 0.03
20%	52.69±0.08	70.63±0.01 b	54.58±0.09 b	13.62±0.15 ab	12.79 ± 0.01
25%	52.69±0.08	69.82±0.53 a	54.28±0.18 b	14.13±0.23 b	13.02 ± 0.07

Means on the same line followed by different superscripts are significantly different (P<0.05).

Table 5: Whole body composition of *P. obscura* fry (4.1 g) fed with different feeding rates

Rations	Initial protein (%)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
2%	57.51±0.13	69.24±0.33 b	59.21±0.05 a	16.62±0.31 a	11.11 ± 0.19
4%	57.51±0.13	67.41±0.05 a	61.32±0.03 b	17.45±0.42 b	11.58± 0.14
6%	57.51±0.13	70.19±0.08 b	61.17±0.15 b	17.56±0.53 b	12.84± 0.10
8%	57.51±0.13	70.69±0.63 b	60.59±0.32 b	17.71±0.27 b	11.86 ± 0.04
10%	57.51±0.13	71.32±0.02 b	60.12±0.09 b	17.73±0.73 b	12.57 ± 0.23

Means on the same line followed by different superscripts are significantly different (P<0.05).

Table 6: Whole body composition of *P. obscura* fry (9.4 g) fed with different feeding rates

Rations	Initial protein (%)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
0.5%	60.12±0.01	78.22±0.02	61.06±0.01 a	19.95±0.10 a	16.19 ± 0.04
2%	60.12±0.01	78.36±0.06	64.42±0.04 b	21.60±0.21 a	17.91± 0.37
3%	60.12±0.01	78.51±0.33	67.16±0.05 c	21.57±0.27 a	17.93± 0.22
4%	60.12±0.01	78.86±0.08	65.82±0.08 b	22.80±0.21 a	18.86 ± 0.26
5%	60.12±0.01	78.88±0.15	62.95±0.01 a	25.74±0.35 b	18.70 ± 0.15

Means on the same line followed by different superscripts are significantly different (P<0.05).

Relationships between rations, Specific Growth Rate and Feed Efficiency were used to estimate the optimum and maximum feeding rate requirements for the three sizes of *P. obscura* fry studied. A second degree polynomial regression analysis (Brett & Grove, 1979) was used to interpolate the data (figures 1, 2 & 3). Thus, optimum feeding rate requirements were 8.5, 3.6 and 2.5% of body weight/ day for *P. obscura* fry with 0.9, 4.1 and 9.4 g of initial body weight respectively. By applying the broken line model of Robbins *et al* (1979) on the Specific Growth Rate data (figures 4, 5 & 6), the maximum feeding rate requirements were estimated to be 15%, 6% and 3.1% of body weight.day^{-1} for fish with initial body weight 0.9, 4.1 and 9.4 g respectively. Values of optimum and maximum feeding rates requirements for the different sizes of fry of *P. obscura* are shown in table 7.

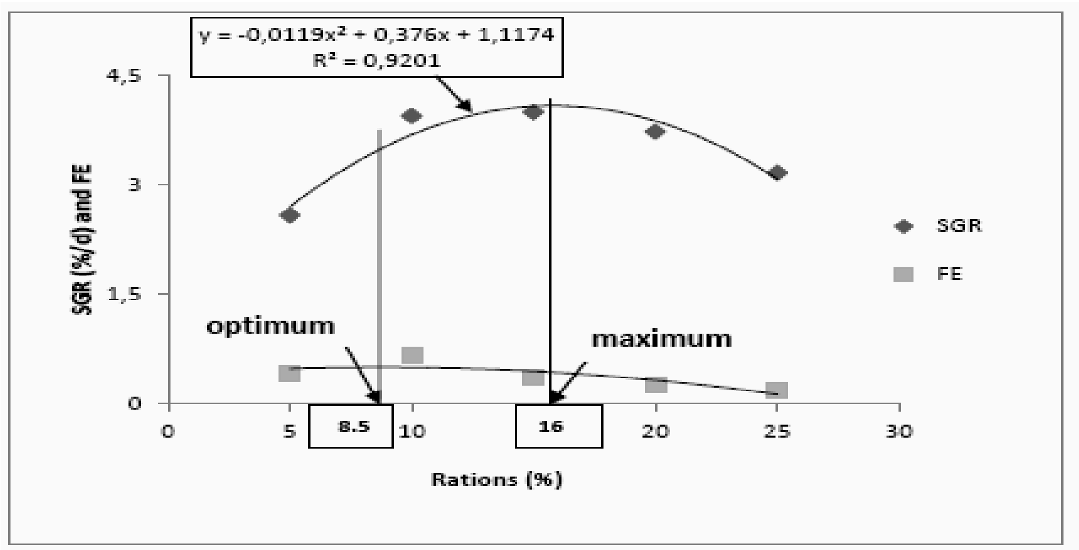

Figure 1: Variation in the SGR and the FE of *P. obscura* fry (0.9 g) fed different rations according to the model of Brett

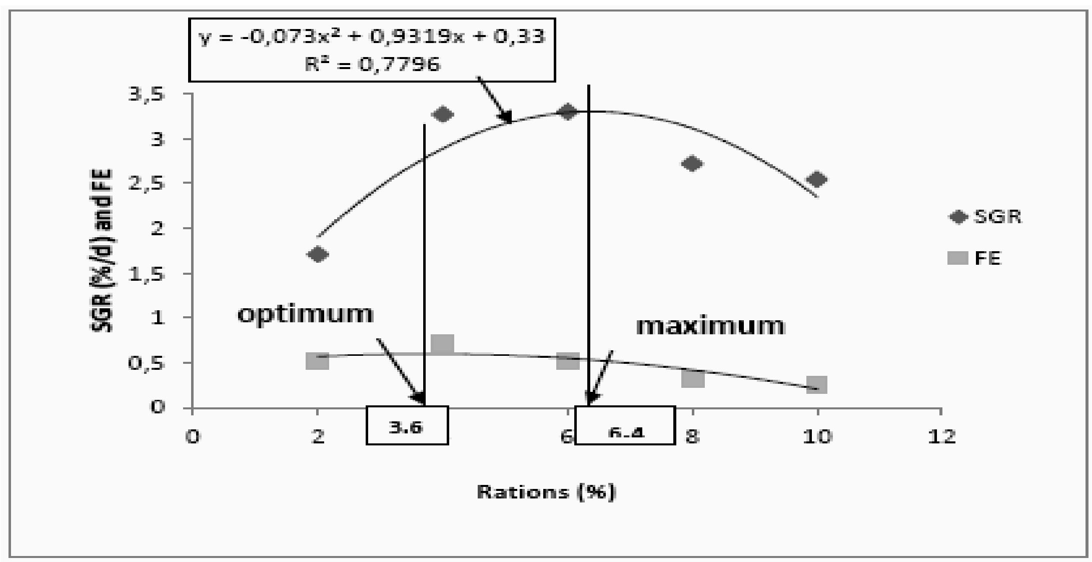

Figure 2: Variation in the SGR and the FE of *P. obscura* fry (4.1 g) fed different rations according to the model of Brett

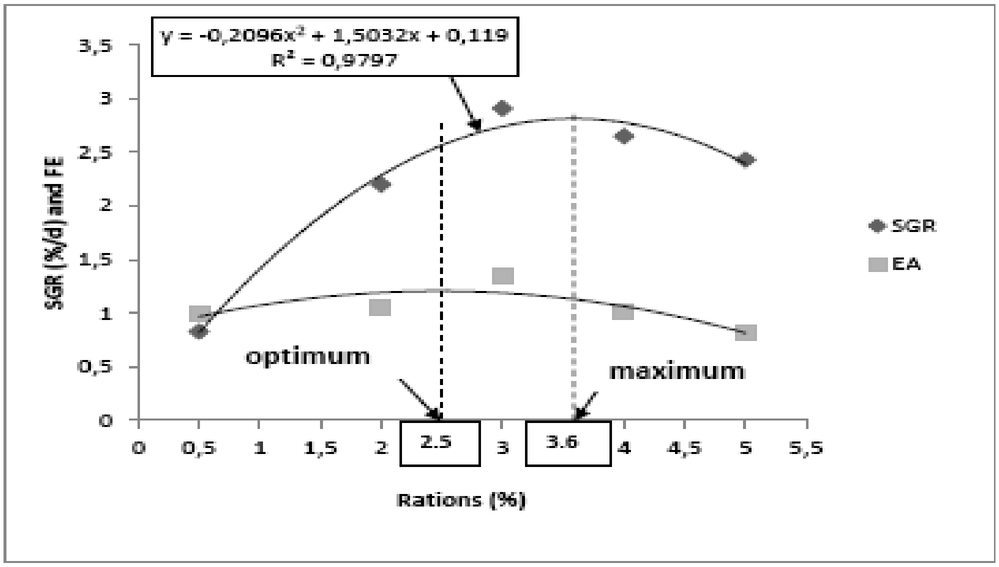

Figure 3: Variation in the SGR and the FE of *P. obscura* fry (9.4 g) fed different rations according to the model of Brett

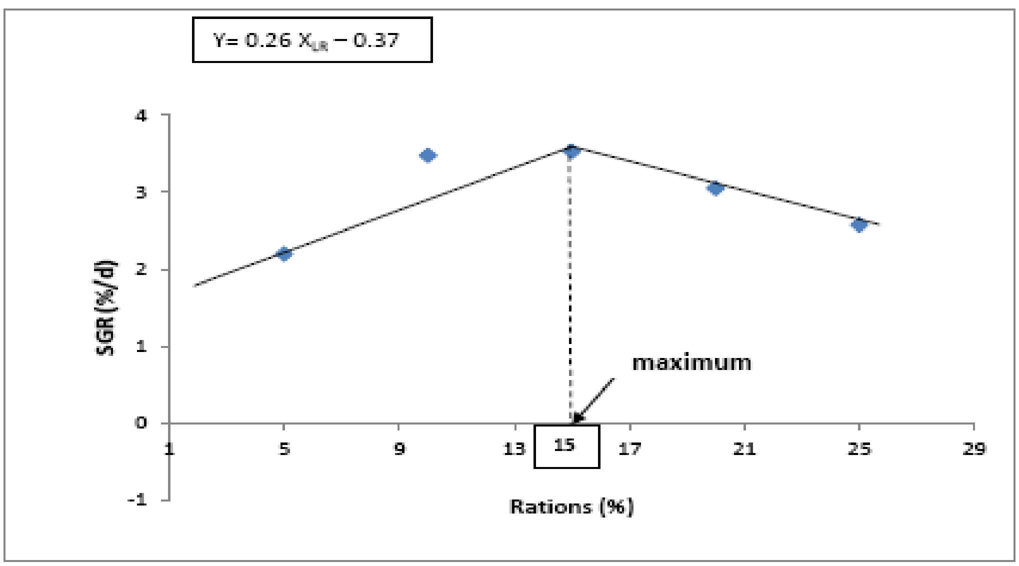

Figure 4: Variation in the SGR of *P. obscura* fry (0.9 g) fed different rations according to the broken line model

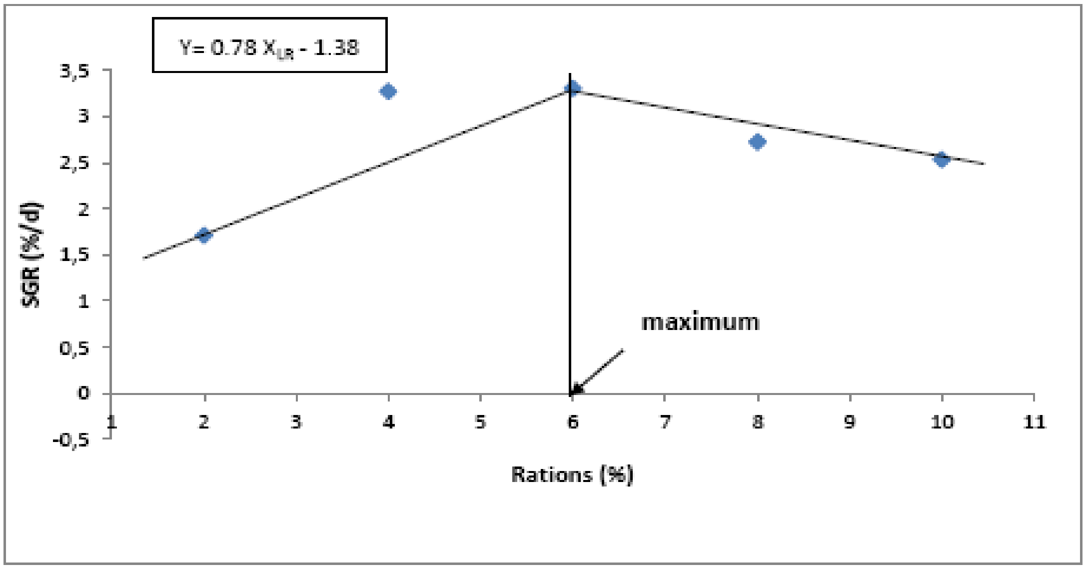

Figure 5: Variation in the SGR of *P. obscura* fry (4.1 g) fed different rations according to the broken line model

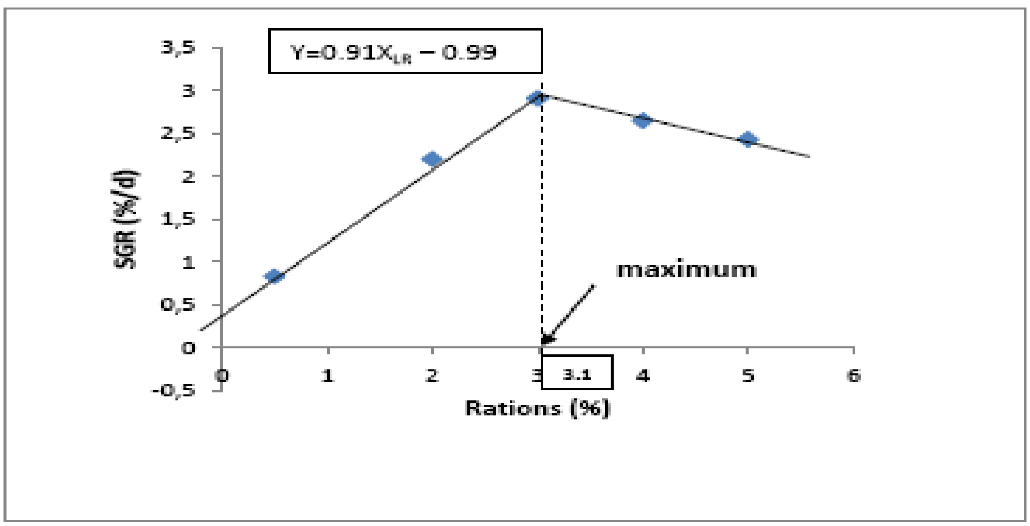

Figure 6: Variation in the SGR of *P. obscura* fry (9.4 g) fed different rations according to the broken line model

Table 7: Values of optimum and maximum feeding levels for different sizes of *P. obscura* fry

Body weight (g)	Optimum	Maximum (Brett & Grove, 1979)	Maximum (Robbins *et al.*,1979)
0.9	8.5	16	15
4.1	3.6	6.4	6
9.4	2.5	3.6	3.1

DISCUSSION

Survival rate were not significantly affected by the food ration. In *P. obscura* fry with initial body weight ≈ 4.1 and 9.4 g, survival rates were 100% with all rations and were higher than those obtained with 0.9 g. This result agrees with the findings of Hecht & Appelbaum (1988); Durville *et al* (2003) who indicated that in young fish predators species, the habituation of artificial food affected the survival and the survival rate increase with increasing of initial body weight. Growth of *P. obscura* fry varied significantly with food ration. Growth (final body weight and SGR) for the different sizes of fry increased significantly with rations up to the maximum point and decreased later on. Similar observations were made by Brett & Grove (1979), Pickering (1993), Al – Hafedh & Ali (2004), Peres & Oliva – Teles (2005). The quantity and quality of feed consumed have a pronounced effect on growth rate and efficiency of feed utilization Lovell (1989), Pickering (1993). Indeed, as food availability increases, the quantity consumed by the fish will also increase, giving a linear increase in SGR up to the point of maximum voluntary food intake (Peres & Oliva – Teles, 2005). Overfeeding does not necessarily result in higher growth. When food intake levels are higher than the optimum, growth increase is negligible (Tsevis *et al*., 1992) whereas sub – optimum rations may result in reduced growth (Tyler & Dunn, 1976; Johnston *et al*., 2003). When the feeding rate moves towards the maximum daily consumption, the digestion efficiency decreases and limits the supply of energy destined to growth (Brett & Grove, 1979). Moreover, these authors mentioned that, although any food ration between the maintenance rate and the maximum one causes weight gain, the highest weight gain per unit of added ration is obtained before the maximum feeding rate, at a rate considered as optimum in terms of biological conversion. This study indicated that feeding fish in the range of 5 to 10%, 2 to 4% and 0.5 to 3% of body weight for *P. obscura* fry with initial body weight ≈ 0.9, 4.1 and 9.4 g respectively, results in optimum utilization of food for growth.

Best Feed Efficiency (FE) were obtained with food ration from 5 to 10% for fish with 0.9 g of initial body weight, 2 and 4% for fish with 4.1 g of initial body weight and 0.5% to 3% for fish 9.4 g of initial body weight. Significantly low FE for higher rations could be resulted from loss of nutrients and wastage of food because fish took longer time to consume food to reach satiation (Tvenning & Giskegjerde, 1997; Hassan & Jafri, 1994). Hassan & Jafri (1994) reported a gradual decline in conversion efficiency for Asian catfish (*Clarias batrachus*) fed higher rations. Growth rate and ration interact to determine Feed Efficiency and are used to estimate the feeding rates requirement for fish (Imtiaz, 2007). Optimum ration estimated were 8.5, 3.6 and 2.5% of body weight respectively for fish with body weight 0.9, 4.1 and 9.4 g. Optimum and maximum feeding rates requirements estimated (table 4) decreased when body weight increased. This results showed that food ration requirements decreased when body weight increase and agreed with Hogendoorn *et al*. (1983); Hecht *et al*. (1988) and Fiogbe & Kestemont (2003) observations. In a second hand, optimum feeding level requirement for the different stages are inferior to the maximum one and is in agreement to what was observed by Brett & Grove (1972), Smith (1989) and De Silva & Anderson (1995) who observed that the highest weight gain per unit of added ration is obtained before the maximum feeding rate, at a level considered as optimum in terms of biological conversion. Maximum Specific Growth Rate of *P. obscura* fry decreased with increasing of body weight from 4.00%/d for fish with 0.9 g of body weight to 2.91%/d for fish with 9.4 g of body weight. This coincided with the findings of Brett *et al* (1969) and Fiogbe & kestemont (2003) who observed respectively that maximum Specific Growth Rate of *Oncorhynchus nerka* and *Perca fluviatilis* decrease with increasing of body weight.

Optimum feeding rate requirement estimated (8.25% of body weight) for fish with body weight 0.9 g is near to 5 - 10% and 6.6 - 13.1% of body weight recommended respectively by Basimi & Grove (1985) and Godin (1981) as optimum for maximum growth of *C. gariepinus* and *O. gorbuscha* with final body weight 2.03 g. For *P. obscura* with body weight 4.1 and 9.4 g, optimum feeding rate requirement estimated (3.6 % and 2.5% of body weight respectively) agrees with results of Calbert & Huh (1976), Qin & Fast (1996) and Fiogbe & Kestemont (2003) who observed that optimum feeding rate requirement for carnivorous species with initial body weight superior to 1 g can vary from 1 to 5% of body weight. Kpogue *et al* (2011) reported that ration of approximately 5% of body weight per day is optimum for maximum growth rate for fry of *P. obscura* with body weight 2.42 g. Comparison of the optimum rations recommended in this study with the results obtained by Kpogue *et al* (2011) reveals that optimum food rations requirements decreased with increasing of initial body weight. This agrees with the findings of Fiogbe & Kestemont (2003) who observed similar trend with fry of *P. fluviatilis*. Several factors including growth and diet are known to affect the body composition of fish (Imtiaz, 2007). The fat content of fish increased with the increasing of food rations. This corresponds with the findings of Hassan & Jafri (1994) and Adebayo *et al* (2000) who observed that when rations were lower the amount of fat was slightly lower, although at the same time the fish managed to maintain relatively higher and constant amounts of protein in their body tissue over the initial value. In this fish, body fat is preferred to protein as an energy source.

CONCLUSION

This study showed that *P. obscura* fry can be successfully reared in controlled environment and feed with dry food. The results of the present study indicated that optimum feeding rate requirements are approximately 8.25, 3.6 and 2.5% of body weight per day for *P. obscura* fry with initial body weight 0.9, 4.1 and 9.4 g respectively.

ACKNOWLEDGEMENTS

This study was supported by the Ministry of Higher Education and Scientific Research of Republic of Benin which provided a PhD grant to Diane KPOGUE.

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