Trakia Journal of Sciences, No 1, pp 60-66, 2017

Available online at:
http://www.uni-sz.bg

ISSN 1313-7050 (print)
ISSN 1313-3551 (online) doi:10.15547/tjs.2017.01.010

Original Contribution

SELECTION RESPONSE AND HERITABILITYESTIMATE FOR GROWTH IN THE GIANT AFRICAN CATFISH (*Heterobranchus bidorsalis* GEOFFROY SAINT-HILAIRE, 1809)

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ABSTRACT
Selection response and realized heritability estimate for growth were investigated in *Heterobranchus bidorsalis* using divergent selection for High (H) and Low (L) growth for a single generation. *H.bidorsalis* broodstocks from Dadinkowa dam was used to produce fingerlings in the hatchery of a commercial farm. High and low growth parents were selected in the 7th month of grow-out in earthen pond. Twelve weeks old hatchery produced juvenile progenies from H x H, L x L and reciprocally mated (H x L and L x H) parents were reared in grow-out earthen pond. Means (±SD) of the whole weight of offspring from each group after seven months of grow-out in earthen ponds were significantly different (P<0.05) with values of 279.36±13. 73g, 264.95±15.2 g and 252.29±18.65g for the H, L and reciprocally mated H and L group respectively. Direct response to one generation of selection for the H and L growth was 5.44% and 4.78% respectively which an average of 5.11% in both groups. The average realized heritability for weight at the end of the 7th month was 16.84%. The result indicates that the application of divergent selection for high and low growth to increase *H. bidorsalis* production is viable and promising.

Key word: Selection response, heritability, growth, *Heterobranchus bidorsalis*

INTRODUCTION

Heterobranchus bidorsalis belongs to the family *Clariidae* and is one of the commercially important fish species commonly cultured in Nigeria due to its high resistance to disease, efficient utilization of various types of locally formulated fish feed and simple propagation technique (1-2) and can grow to a very large size (3-4). Artificial propagation of *H. bidorsalis* using different hormones and management techniques has been successfully carried out (3, 5-6). Selective breeding program has been used to improve the growth rate of many cultured fish species (7) and the response to selection for growth rate in fish and shellfishes, is much higher compared to terrestrial farm animals. This is due to the higher genetic variance (20%-30%), higher fecundity which allows for higher selection intensity, less domestication and selection in fishes (8). Response to selection has been evaluated in several farmed aquatic species. About 12-18% response to selection for growth were obtained in three strains of the channel catfish (*Ictalurus punctatus*) after one generation of selection (9), 14.4% in *Salmon salar* (10), 7-9% in the Nile tilapia (11) and 7% in *Oncorhynchus mykiss* (12). In shellfishes, (13) obtained a 4% increase in growth rate in the Sydney-rock oyster (*Saccostrea commercalis*), while the Chilean oyster (*Ostrea chilesis*) showed 10-13% gain after one generation of selection (14). In shrimps, selection response in Kurama prawn (*Marsupenaeus japonicus*) was 10.7% (15), while in the Pacific White shrimp (*Litopenaeus vannamei*) a 21% increase in growth was observed after one generation of selection (16). In Nigeria, there is no documented report of any selection program in *H. bidorsalis*, hence the need to improve the growth potential of this catfish species. A selective breeding program could be carried out to develop *H. bidorsalis* with superior growth for aquaculture production, which necessitated this study. This present study was therefore undertaken to evaluate the response

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to selection and heritability estimate for growth after one generation of selection in *H. bidorsalis*.

MATERIALS AND METHODS

Establishment of foundation stock

The foundation stock of *H. bidorsalis* used in the present study were derived from wild broodstock populations using 4males (♂) and 8females (♀)) from the DadinKowa dam in the Sahel savannah of north-eastern Nigeria. Hypophysation, artificial fertilization and larvae rearing using the wild stocks were carried out in the hatchery of a commercial catfish farm (Jigna-Eco farm Bwari, Abuja) following the method of (17) in concrete tanks with continuous- water flow through system. Swim up fry were fed *ad-libitum* manually with shell free *Artemia* for, the first 21 days followed by 0.5mm-1.2mm commercial Coppen's floating feed (42% crude protein, 13%crude fat, 1.8% crude fibre, 7.7% crude ash, 1.1% phosphorus, 1.9% calcium and 0.2% magnesium) for another nine weeks. After twelve weeks, about 600 juveniles were stocked (5fish/m^2) in an earthen pond (10m x 12m x1m) and fed 40% crude protein pelleted diet (1mm-3mm size) twice daily at 5% biomass. The fishes were harvested at the end of the 7^{th} month and broodstocks which were used as the founder stock in this study were selected. The cut- off weight for selection was obtained by individually weighing 114 fishes sampled during the harvest. Due to limited grow-out and nursery facilities, 31.57% of the harvested fishes which serves as the parent broodstocks (n=36) were selected to initiate the High line (9H♂: 9H♀) and Low line (9L♂: 9L♀) parents, while additional 16 fishes were also randomly selected and used for artificial propagation between the reciprocal High and Low lines parents (4H♂ x 4L♀; 4L♂ x 4H♂). All the fishes were individually tagged and restocked in the earthen pond (4m x5m x 1m) for another 8 months when they have become sexually matured.

Experimental procedure and larval rearing

Hypophysation and artificial fertilization was carried out using 1♂ and 1♀ in each of the selected parent male and female broodstocks and a total of 8HH, 8LL, 4HL and 4LH families were produced in the F_1. Larval rearing was the same as previously described by (17). Swim up fry were fed *ad-libitum* manually, with shell free *Artemia* for the first 21 days followed by 0.5mm-1.2mm commercial Coppen's floating feed (42% crude protein, 13% crude fat, 1.8% crude fibre, 7.7% crude ash, 1.1% phosphorus, 1.9% calcium and 0.2% magnesium) for another nine weeks. At the 10^{th}week of larval rearing, fingerlings that appeared too large (>21g) or too small (<11g) based on average weight of the whole population (16.0±5g) were removed so that it does not introduce bias in the selection of progeny for grow-out. At 12weeks of age 60 juveniles from each family in the different groups were divided into triplicates and stocked in small net cages (2mx2mx1m) suspended in earthen pond (10m x 12m x 1m) with the bottom of the net touching the substratum. The sizes of the juveniles were carefully selected so as to match the size distribution of the overall population in the tank from which they were selected. The same stocking density of 5fish/m^2 used for the stocking of the parents in the grow-out pond as earlier mentioned was also applied. All the F_1 progenies from the different groups (genotypes) were raised in separate net cages for the first two months of culture, after which they were removed and individually tagged using PIT tag, and then directly stocked together in the same ponds, since communal stocking such as this will reduce the environmental component of variation.

Data collection

The F_1 progenies in each net cages for the different groups for the 7 months of grow-out were weighed monthly and recorded. Mortality was also recorded while dead fishes were not replaced. The monthly weight of the selected parental from the end of the 7^{th} month till the 15^{th} month in earthen pond when they were removed and used for production of the F_1 were also recorded and feed rations were adjusted monthly with the weight increase. Selection response for one generation of selection was calculated using the equation of (18) : $S.R(\%) = \frac{HH\ or\ LL - HL\ and\ LH \quad x\ 100}{HH\ and\ LH}$

Where HH and LL are mean growth of the selected High and Low progenies (F_1) respectively, HL and LH are the mean growth of the reciprocals mated High and Low progenies. Selection differential was calculated using the equation of (18): $S.D = X_F - X_{F0.}$

Where X_F is the mean body weight of the selected parents and $X_{F0}$is the parental population mean. Realized heritability was calculated based on (18) equation as: h^2 =S.R/S.D.

Statistical analysis

A One- way analysis of variance (ANOVA) was used to analyse difference in weight among the three groups of the High (H), Low (L) and reciprocally mated H and L groups and then followed Duncan multiple range test to determine significant differences among means using SPSS version 11.0. The accepted level of significance was P<0.05. Response to selection and selection differentials were standardized by converting to standard deviation units before estimation of heritability because of the variance between the offspring and parental generation. A regression of offspring mean performance on the mid - parent mean was further used to validate the estimate for realizing heritability.

RESULTS

The average weight of *H. bidorsalis* population in the earthen pond at the time of selection, coefficient of variations for the highlines, lowlines of the males and females are shown in **Figure 1A, 1B** and **1C** respectively. The monthly mean weight increase for 7months of grow out in offspring from the selected parents is shown in **Figure 2**. Offspring of the selected HH parent had a higher weight increase than those of the selected LL parent with a weight difference of 27.07g (9.69%) at the end of the 7months of growth studies while those of the reciprocal (H x L, L x H) lines were intermediate.

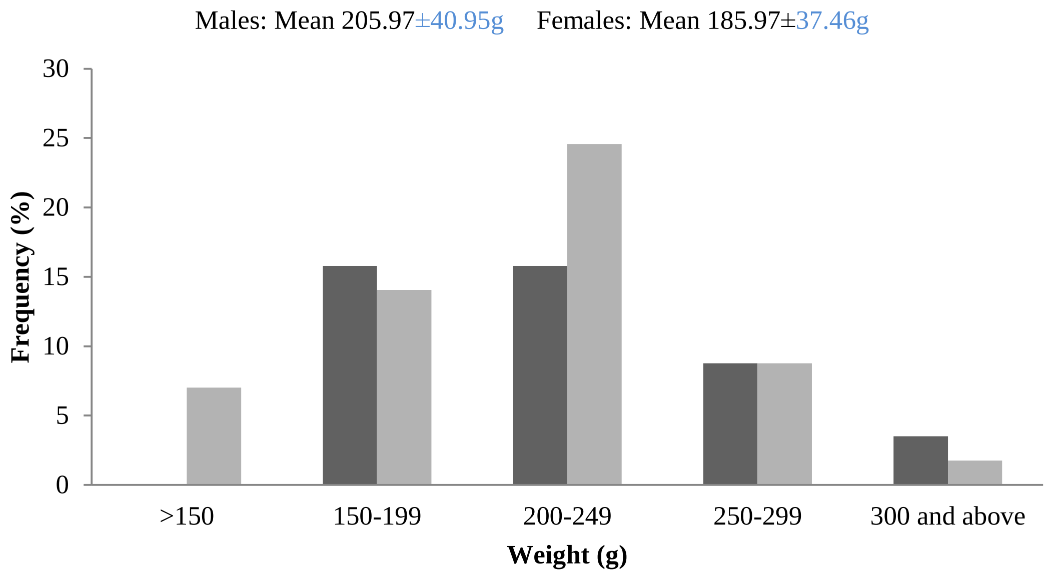

Figure 1A. Size distribution of pond population of *H. bidorsalis*

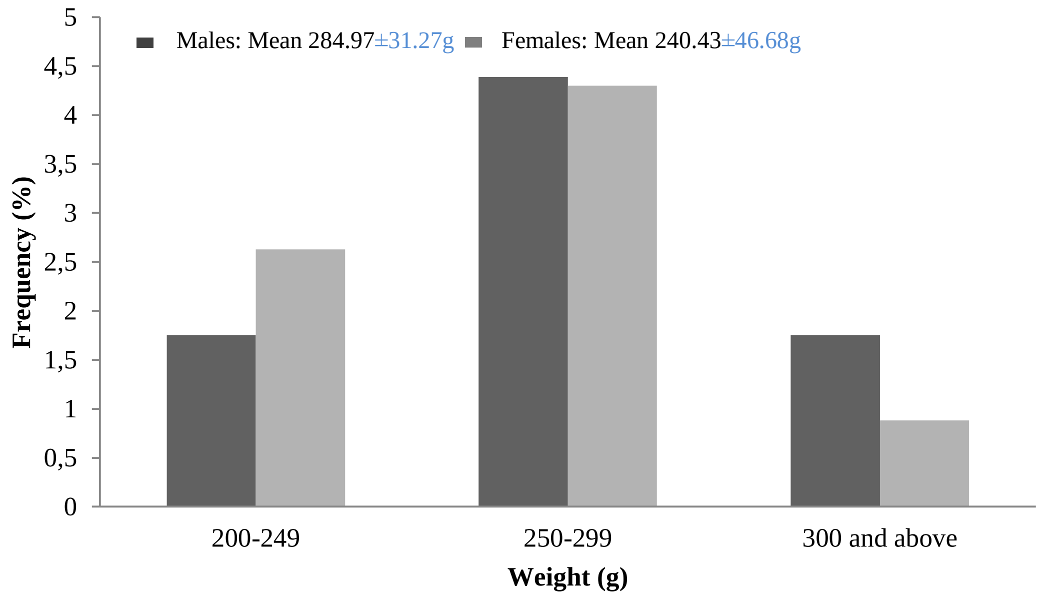

Figure 1B. Size distribution of selected High Line of *H. bidorsalis*

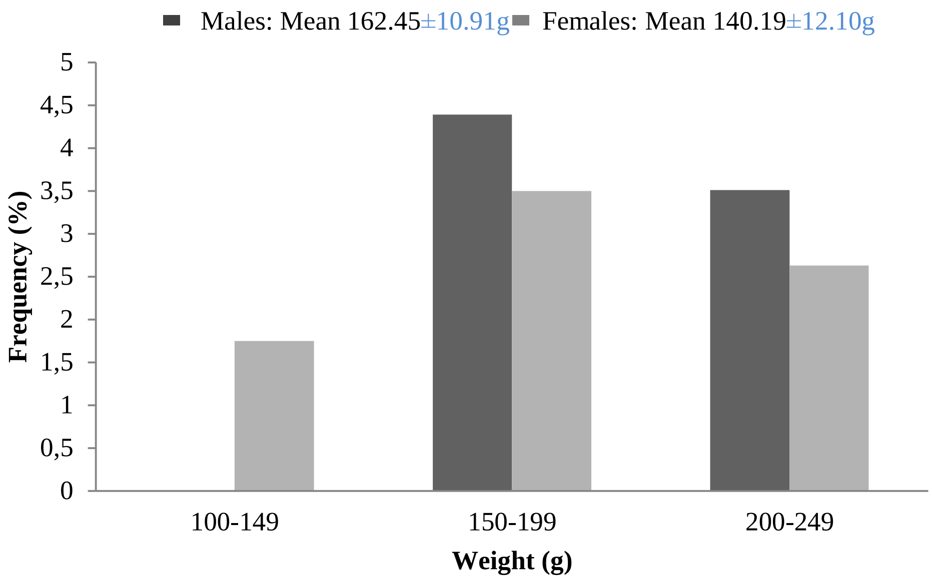

Figure 1C. Size distribution of selected Low lines of *H. bidorsalis*

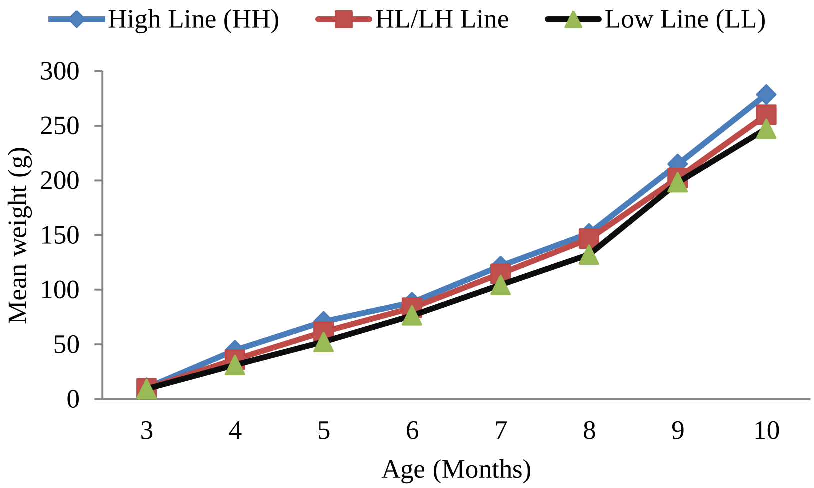

Figure 2. Selection response for weight in *H. bidorsalis* raised in earthen pond for seven months

The direct response to selection for weight at the end of a 7month of grow-out, measured as a divergence between the HH lines(5.11%) in the upward direction and the LL lines (4.87%) in the downward direction was 9.98% **(Table 1).** The realized heritability for weight was estimated to be 14.24% in HH line and 20.18% in the LL lines while a value of 16.8% was obtained from the divergence of two lines which was close and not significantly different (P>0.05) from the value of 21.10% **(Figure 3)** obtained from the regression of the offspring mean on the mid parents mean.

Table 1. *Response to selection, selection differentials and realized heritability for growth in H. bidorsalis*

	Direction of selection		
	High	**Low**	**Divergence**
Selection response (g)	14.41	12.66	27.07
%	5.11	4.87	9.98
Selection differential (g)			
Female	54.0	45.78	99.78
Male	79.	43.5	122.5
Average	66.5	44.64	111.14
Realized heritability (%)	14.24	20.18	16.84

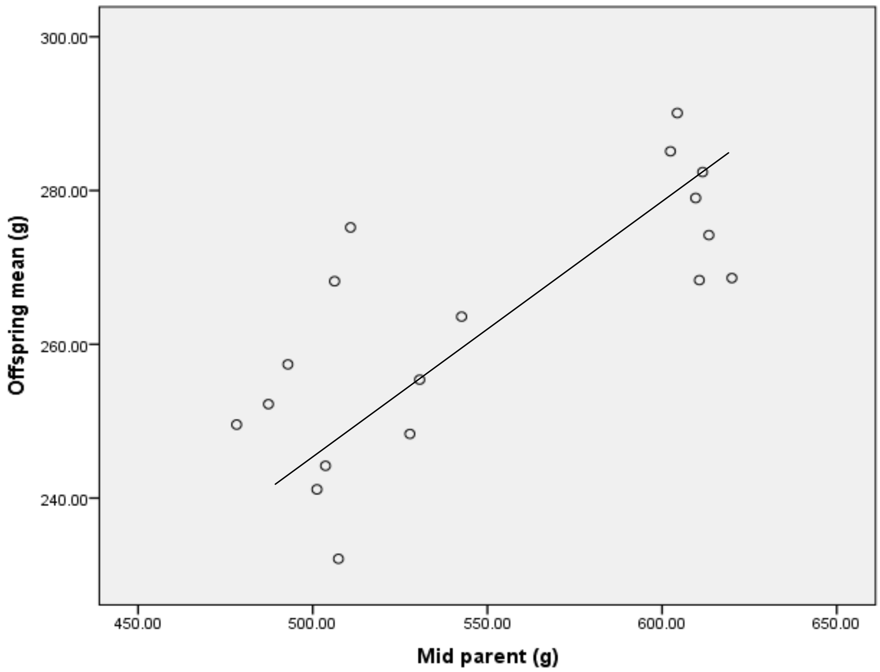

Figure 3. A regression (slope = 0.211 ± 0.054) of offspring mean on mid-parent mean for growth of *H. bidorsalis.*

DISCUSSION

Selective breeding can increase the growth rate and survival of aquaculture species and thus optimize the aquaculture productivity of cultured species. Divergent selection is quite effective for measuring response to selection and heritability estimate where limited number of animals has been measured since the expected variance in response and heritability is minimized (18) and this has been applied to increase the response to selection for body weight in several aquatic organisms (9, 12,15). The average mean weight of *H. bidorsalis* obtained from base population from which selection was made in this study, was lower than the average weight (850g) obtained in *H. bidorsalis* raised in semi intensive pond culture system as reported (19) at 7months of culture. This could be due to the lower stocking density (>1fish/m^2) applied, initial fertilization of the pond which boosted primary productivity, higher dietary crude protein level (45%) of feed used in that study. Furthermore, the fingerlings used in that study were produced from broodstocks that are several generations away from the wild and which possibly have undergone domestication that further enhanced the growth rate, unlike the wild stocks used in this study. In this present study, an average selection response of 5.11% was obtained in *H. bidorsalis* in a single generation which is higher than the value of 3% obtained in *O. niloticus* (20) and comparable with those of 6% - 7% and 7-9% obtained in *Salmon salar* (12, 21), *O. niloticus* (11) respectively. Higher values of about 12%-20%, 11.8% and 14.4% were however reported in the channel catfish, *Ictalurus punctatus(*9, 22-24), *Clarias macrocephalus* (25) and the Atlantic Salmon (10) respectively over one to three generations of selection. Both the highline and low lines of *H. bidorsalis* showed positive response to divergent selection in this study unlike in another *Clariid* catfish; *Clarias macrocephalus,* in which the Highline shows positive response, while there was no response in the low line to bidirectional selections after one generation (26). The selection response obtained in *H. bidorsalis* in this present study was also higher than the values of 4.16% and 3.4% obtained in divergent selection in *C. macrocephalus* at 29 and 33weeks of age even with the large number of families(75each) used in the study (27). The realized average heritability (16.8%) for weight in at 7month of grow-out (10months old) in this study is higher than those reported in some fish species. (28) Obtained an estimate of 4.8% in *Aristichthys nobilis* while 9.3% was reported in *Labeo rohita* (29) with the same culture durations. Higher heritability values of 31%, 24%-50%, and 23% has however been obtained in *C. macrocephalus* (26), *Ictalurus punctatus* (24), while the value of 16% reported in *O. niloticus* (20) was close to that obtained in this present study. A larger number of families could not be used in this study and may have resulted in the moderately high intensity of selection (1.18) applied to estimate the selected response and heritability estimate based on sub analysis due to the limited hatchery facilities. The F_1 progenies of the selected parents were also raised in net cages though it was suspended in the same earthen pond with the same stocking density as the select parents that were stocked directly into the pond. The difference in culture enclosure could also cause possible potential bias in response to selection and the heritability estimate obtained in this study. The moderate selection response and heritability estimate obtained in this present study after one generation shows the possibly of improving the bodyweight of *H. Bidorsalis* through divergent selection. Selection of the parents was based on phenotypic measurements for growth. The selection response and heritability estimate reported in this study is for only a single generation and this is the first published report of its kind for the giant African *Clariid* catfish *H. bidorsalis*. The use of larger family size and marker - assisted selection, such as the quantitative trait loci (QTL) for growth in *H. bidorsalis* can further enhance the efficiency of selective breeding in this fish.

CONCLUSIONS

This study shows that growth will respond rapidly to selection in *H. bidorsalis* and the use of divergent selection for growth in selective breeding for *H. bidorsalis* will provide remarkable benefit to the fish farming industry in Nigeria. This is because of the faster growth rate, which reduces production cost due to faster turnover rate. With this, the productivity of *H. bidorsalis* will be increased to meet the increasing fish demand of the growing population. It is possible that if selection is carried out using larger families, response to selection and heritability estimates for growth may be higher in *H. bidorsalis* than what is presently obtained in this study. The parameters obtained may be used to predict selection response and heritability for more sucessive generations over a medium term.

ACKNOWLEDGEMENTS

The authors wish to appreciate Mr Ada Obe of Jigna Eco-farm for the use of his catfish hatchery facilities and the staff for their invaluable assistance in the early spawning of the base population and the data collections during the grow-out studies.

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