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A Comparative Study of Morphology Between F_1 Hybrid Magur (*Clarias*) and their Parents

Md. Mukhlesur Rahman Khan, [1]Ann Cleveland and Md. Fazlul Awal Mollah
Department of Fisheries Biology and Genetics,
Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[1]Department of Biological Science, Northern Arizona University, USA

Abstract: Profound differences were detected in many characters between F_1 hybrids and their parents. Among the 17 morphometric characters, dorsal fin length and anal fin length of fishes were significantly shorter ($P_{DFL} = 0.03$, $P_{AFL} = 0.01$) in the F_1 hybrids than in their maternal parent. Other 15 morphometric characters were significantly longer in the F_1 hybrids than in their maternal parent. Among 7 meristic characters, for branchiostegal rays, dorsal fin rays and anal fin rays, all groups were differed significantly ($P<0.05$) from one another with the F_1 hybrid being intermediate in count for each character. The F_1 hybrids resembled *C. gariepinus* in three morphometric characters relating to the skull head length - (HL), $P_{HL} = 0.99$; head width- (HW), $P_{HW} = 0.92$; snout length-SNL, $P_{SNL} = 0.67$). So, F_1 hybrid demonstrated paternal inheritance. The occipital structure of hybrids was an intermediate form of the parents, which might represents phenotypic plasticity, or genetic factors might have influenced the developmental structure. All of these characters considered the F_1 hybrid an intermediate form which can be confirmed by the study of genetic characters.

Key words: Morphology, *Clarias batrachus*, *Clarias gariepinus*, magur, F_1 hybrid

Introduction

The catfish *Clarias batrachus* (L.), commonly known as magur, is widely used as a food fish. Many other African and Asian species of *Clarias* are commercially important. Recently, *Clarias* farming has begun development in Europe as well. The demand for and culture potential of *C. batrachus* is extensive in India, Thailand, Vietnam, Malaysia and Indonesia (Mollah and Karim, 1990; Mollah *et al*., 1991). The rapidly-growing congener, *C. gariepinus* (Burchell) is also propagated in Africa (mainly South Africa and Nigeria) and Europe (Netherlands, Germany, Belgium) (Verreth, 1993). *C. gariepinus* has an endemic geographic distribution from the Middle East in the north to the Orange river in South Africa in the south (Teugels, 1984). During the last decade, the intensive culture of African catfish *C. gariepinus* has propagated in South East Asian countries, including the production of many interspecific hybrids. Interspecific crossbreeding in fish may lead to hybrids with valuable characteristics such as sterility, monosex population and heterosis for disease resistance or growth rates. The morphological characters of F_1 clarid hybrids of *C. gariepinus* and *Heterobranchus longifilis* (Valenciennes) were compared to parental species (Legendre *et al*., 1992) and they found the hybrid morphology was found intermediate to that of the parents.

In Bangladesh, the exotic catfish *C. gariepinus* was introduced from Thailand in December 1989 and has been successfully bred since 1990 (Mollah and Karim, 1990). Since then, the popularity of this fish and the F_1 hybrids of indigenous female *C. batrachus* and male *C. gariepinus* have been increasing. The F_1 hybrids commands a high market price in Bangladesh (US$ 4 kg^{-1}).

In order to optimize hybrid quality and production, it is necessary to understand the early life history and growth rates of the hybrids in comparison with parental species. Khan *et al*. (2000) undertook a comparative study of embryonic development, hatching time and rate and survival rate up to first feeding of F_1 hybrids and parental *C. batrachus* and *C. gariepinus*. Other workers (Mollah and Karim, 1990) have examined gonadal characters (ovary and testes) of hybrids and their parental species. Comparative growth studies have indicated that the F_1 hybrids are phenotypically similar to *C. batrachus* but their growth rate is comparable to *C. gariepinus* (Mollah and Karim, 1990). Specimens were characterized by head shape, occipital structure and skin colour. The local Bangladeshi magur, *C. batrachus*, bears a conical shaped mouth; it is grey in colour on the dorsal side and has a brightly marbled colour on the lateral and ventral sides. *C. gariepinus* has a large mouth and a body shape different (deeper and longer) from that of *C. batrachus* and bears black spots in the skin. The F_1 hybrid has a smaller head than male *C. batrachus* parents and a longer, more robust body than female *C. gariepinus* parents. The body colour of the F_1 hybrids is similar to *C. batrachus*, showing a marked marble colouring (Khan *et al*., 2000). In this study, the morphology of F_1 hybrids and their parental species was compared to look for the differences in the hybrids that might favour their farming.

Materials and Methods

Collection of fish specimens: *Clarias batrachus* adults were collected from natural canals, waterways and drainage ditches. The adults of *C. gariepinus* and F_1 hybrids (female *C. batrachus* X male *C. gariepinus*) were obtained from rearing ponds established in 1990 at the Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh, Bangladesh. The broods and F_1 hybrids were reared in ponds from April, 1994 to March, 1995 for this study. For the morphological study, 11 individuals of each species and 11 F_1 hybrids were used and it was needed for 15 days in April, 1995. All of the sample were approximately 1 year old individuals.

Preparation of samples: Morphometric measures were taken on whole animals (Fig. 1). After the measuring of morphometric characters, the samples of *C. batrachus*, *C. gariepinus* and F_1 hybrids were boiled in hot water to remove the muscle from the body. This process was done for easy counting of meristic characters and to allow for examination of occipital shape. Also the bone structures of lower and upper jaws, and gill rakers on the branchial arch, were studied.

Morphometric characters: The following 17 morphometric characters were measured by a conventional method described by Hubbs and Lagler (1958) with slight modification noted as below: total length (TL), standard length (SL), body depth at anus (BDA), caudal peduncle depth (CPD), pre- anal distance (PAD), pre- pelvic distance (PPLD), pre- pectoral distance (PPCD), dorsal fin length (DFL), pectoral fin length (PCFL), pectoral spine length (PCSL), pelvic fin length (PEFL), anal fin length (AFL), head length (HL, measured up to the edge of the opercular membrane), head depth (HD), snout length (SNL), nasal barbel length (NBL) and maxillary barbel length (MBL). In the head region more characteristics:

Corresponding Author: Dr. Md. Mukhlesur Rahman Khan, Assistant Professor, Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

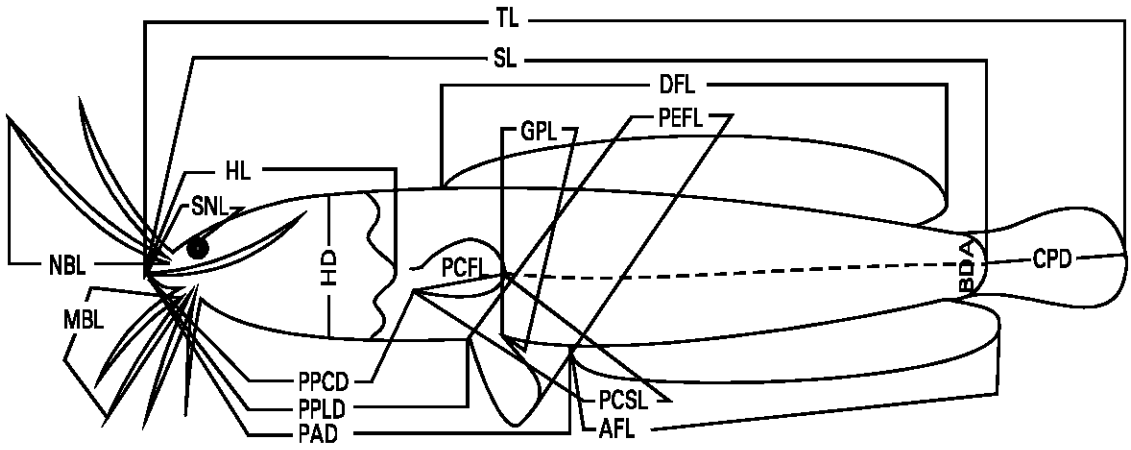

Fig. 1: Measurements taken on the F_1 hybrid with their parents: total length (TL), standard length (SL), body depth at anus (BDA), caudal peduncle depth (CPD), pre- anal distance (PAD), pre- pelvic distance (PPLD), pre- pectoral distance (PPCD), dorsal fin length (DFL), pectoral fin length (PCFL), pectoral spine length (PCSL), pelvic fin length (PEFL), anal fin length (AFL), head length (HL, measured up to the edge of the opercular membrane), head depth (HD), snout length (SNL), nasal barbel length (NBL), maxillary barbel length (MBL) and genital papillae length (GPL).

occipital process length (OPL), occipital process width (OPW), frontal fontanel length (FFL) and frontal fontanel width (FFW) were also studied. All measures were taken with calipers and measured to the nearest 0.1 mm.

Meristic characters: The following 7 meristic characters were counted: branchiostegal rays (BR), dorsal fin rays (DFR), anal fin rays (AFR), pectoral fin rays (PCFR), pelvic fin rays (PEFR), ventral fin rays (VFR), and caudal fin rays (CFR). The methods of counting essentially followed by Hubbs and Lagler (1958). Each fin ray number was essentially derived from principal rays. A magnifying glass was used to count the ray numbers precisely.

Data analysis: Nonparametric statistical analysis were used in all comparisons due to limited number of fish in each group (Zar, 1996). Differences in morphometric characters and meristic counts between parental and F_1 hybrid fish were analyzed using the Kruskal-Wallis nonparametric analysis of variance (ANOVA) (Kruskal and Wallis, 1952). In instances where significant differences between groups were detected, a nonparametric post hoc test (Zar, 1996) was conducted. All data were analyzed using Statistica Ver. 4.0 software.

Results and Discussion

Mormphometric characters: In morphometric parameters, significant differences ($P<0.05$) appeared among parental and hybrid fishes for five characters (TL, SL, BAD, NBL and MBL). The average total length (TL) and standard length (SL) of F_1 hybrids were 378 and 331 mm, respectively, which were intermediate between parents (*C. batrachus*: TL = 268 mm, SL = 245 mm, *C. gariepinus*: TL = 430 mm, SL = 370 mm). The F_1 hybrids differed significantly from their *C. batrachus* (maternal) parent for each of the 1 morphometric characters (Table 1). Dorsal fin length (DFL) and anal fin length (AFL) were significantly shorter ($P_{DFL} = 0.03$, $P_{AFL} = 0.01$) in the F_1 hybrids than in their maternal parent. The F1 hybrids measured significantly longer than their maternal parent for the other 15 morphometric characters (Table 1).

There was no significant difference between F_1 hybrids and their *C. gariepinus* (paternal) parents in either CPD ($P_{CPD} = 0.96$) or PPLVD ($P_{PPLVD} = 0.83$). Additionally, the F_1 hybrids resembled *C. gariepinus* three of five morphometric characters relating to the skull (HL, $P_{HL} = 0.99$; HD, $P_{HD} = 0.92$; SNL, $P_{SNL} = 0.67$) (Table 3). For 9 of the characters, all three groups differed significantly from each other. For body length characters (TL, SL) and as well as characters relating to the pectoral (PPECD, PECFL, PECSL) and pelvic (PELFL) fins; the F_1 hybrid was intermediate between the two parental species (Table 1). For BAD, NBL and MBL, the F_1 hybrids were significantly greater than in length than either of the parental species.

For three characters (PAD, DFL, AFL), there was no significance difference between the parental species themselves (Table 3). The F_1 hybrids were significantly larger than both parents in PAD and significantly smaller than both parents for DFL and AFL (Table 3). These results suggest the F_1 hybrid demonstrated parental inheritance for above mentioned morphometric characters which was similar to that reported by Mollah and Khan (1997) for comparative growth studies.

In cases where significant differences in morphological characteristics appeared between parental and hybrid fishes, there was no consistent pattern of inheritance for the hybrid fish. In some instances, the hybrids demonstrated a blending of parental traits such that they were intermediate between parental fish (TL, SL). Second, hybrid vigour was demonstrated for NBL and MBL in that the length of these barbels was significantly greater in hybrid fish than in either parent. Lastly, hybrids showed resemblance with the paternal parent, *C. gariepinus*, in head length (HL = 27.6 mm).

Meristic characters: A total of seven meristic characters were counted (Table 2). For branchiostegal rays (BR), dorsal fin rays (DFR) and anal fin rays (AFR), all groups differed significantly ($P<0.05$) from one another with the F_1 hybrid being intermediate in count for each character (Table 2). Hybrid fish resembled the male, *C. gariepinus* parent for CFR while they resembled the female, *C. batrachus* parent for VFR. In the case of BR, DFR and AFR, the hybrid was intermediate between the two parental species. In case of PCFR, the hybrid was inferior than both parents whereas in the PEFR hybrids showed vigour (Table 2).

For pelvic fin rays (PEFR), there was no significant difference between the parental species while the F_1 hybrid had a significantly higher count. For pectoral fin rays (PCFR), *C. batrachus* was intermediate between the other two groups; *C. batrachus* was not significantly different in count from either the F_1 hybrid or *C. gariepinus* while these two groups differed significantly from each other. No striking differences were found between *C. gariepinus* cultured in Bangladesh and *C. gariepinus*

Table 1: Mean ± SE of 17 morphometric characters from *C. batrachus*, *C. gariepinus* and F_1 hybrids

Characters	*C. batrachus* $\bar{x}$ ± SE	F_1 hybrid $\bar{x}$ ± SE	*C. gariepinus* $\bar{x}$ ± SE	P- value
Total length (mm) (TL)	268.8 ± 1.8a	378.6 ± 2.8b	430.0 ± 2.2c	< 0.0001
Standard length(mm) (SL)	244.9 ± 0.8a	331.8 ± 2.6b	370.3 ± 1.8c	< 0.0001
Body depth at anus[1] (BAD)	11.0 ± 0.1a	19.8 ± 0.4b	18.0 ± 0.3c	< 0.0001
Caudal peduncle depth (CPD)	5.4 ± 0.1a	8.0 ± 0.3b	7.9 ± 0.3b	< 0.0001
Pre anal distance[1] (PAD)	53.9 ± 0.5a	59.8 ± 1.2b	56.3 ± 0.4a	< 0.0008
Pre pelvic distancce[1] (PPLVD)	43.0 ± 0.6a	49.5 ± 0.8b	50.1 ± 0.7b	< 0.0001
Pre pectoral distance[1] (PPECD)	16.7 ± 0.2a	18.9 ± 0.4b	24.7 ± 0.5c	< 0.0001
Dorsal fin length[1] (DFL)	69.2 ± 1.0a	64.8 ± 1.4b	69.9 ± 0.9a	< 0.0305
Pectoral fin length[1] (PECFL)	9.5 ± 0.2a	11.5 ± 0.2b	12.9 ± 0.4c	< 0.0001
Pectoral spine length[1] (PECSL)	7.5 ± 0.2a	8.8 ± 0.3b	9.8 ± 0.4c	< 0.0006
Pelvic fin length[1] (PELFL)	7.6 ± 0.2a	10.1 ± 0.2b	10.8 ± 0.4c	< 0.0001
Anal fin length[1] (AFL)	46.2 ± 0.8a	43.2 ± 0.5b	44.8 ± 0.6a	< 0.0197
Head length (HL)	24.9 ± 0.4a	27.6 ± 0.4b	27.6 ± 0.4b	< 0.0007
Head depth[2] (HD)	17.7 ± 0.4a	22.2 ± 0.8b	22.5 ± 0.6b	< 0.0001
Snout length[2] (SNL)	8.3 ± 0.2a	10.5 ± 0.4b	10.9 ± 0.4b	< 0.0001
Nasal barbel length[2] (NBL)	57.0 ± 0.6a	61.0 ± 0.7b	44.4 ± 0.5c	< 0.0001
Maxillary barbel length[2](MBL)	68.6 ± 0.9a	92.6 ± 0.6b	76.8 ± 01.0c	< 0.0001

[1]Percentage of standard length [2]Percentage of head length

Table 2: Mean ± SE of 7 meristic characters from *C. batrachus*, *C. gariepinus* and F_1 hybrids

Characters (total count)	*C. batrachus* $\bar{x}$ ± SE	F_1 hybrid $\bar{x}$ ± SE	*C. gariepinus* $\bar{x}$ ± SE	P-value
Branchiostegal rays (BR)	7.1 ± 0.3a	8.9 ± 0.3b	9.1 ± 0.2c	= 0.0002
Dorsal fin rays (DFR)	63.1 ± 0.4a	68.3 ± 0.8b	70.4 ± 0.3c	< 0.0001
Anal fin rays (AFR)	46.8 ± 0.6a	52.2 ± 0.5b	57.8 ± 0.6c	< 0.0001
Pectoral fin rays (PCFR)	8.8 ± 0.3ab	8.4 ± 0.3b	9.5 ± 0.2a	= 0.0225
Pelvic fin rays (PEFR)	6.9 ± 0.3a	8.4 ± 0.5b	7.1 ± 0.3a	= 0.0408
Ventral fin rays (VFR)	6.8 ± 0.3a	6.8 ± 0.3s	7.5 ± 0.3a	= 0.1513
Caudal fin rays (CFR)	17.2 ± 0.3a	19.2 ± 0.3b	19.5 ± 0.4b	= 0.0002

n = 11 for each group. Values within a character sharing the same letters are not significantly different from each other (non parametric post hoc test, $P < 0.05$)

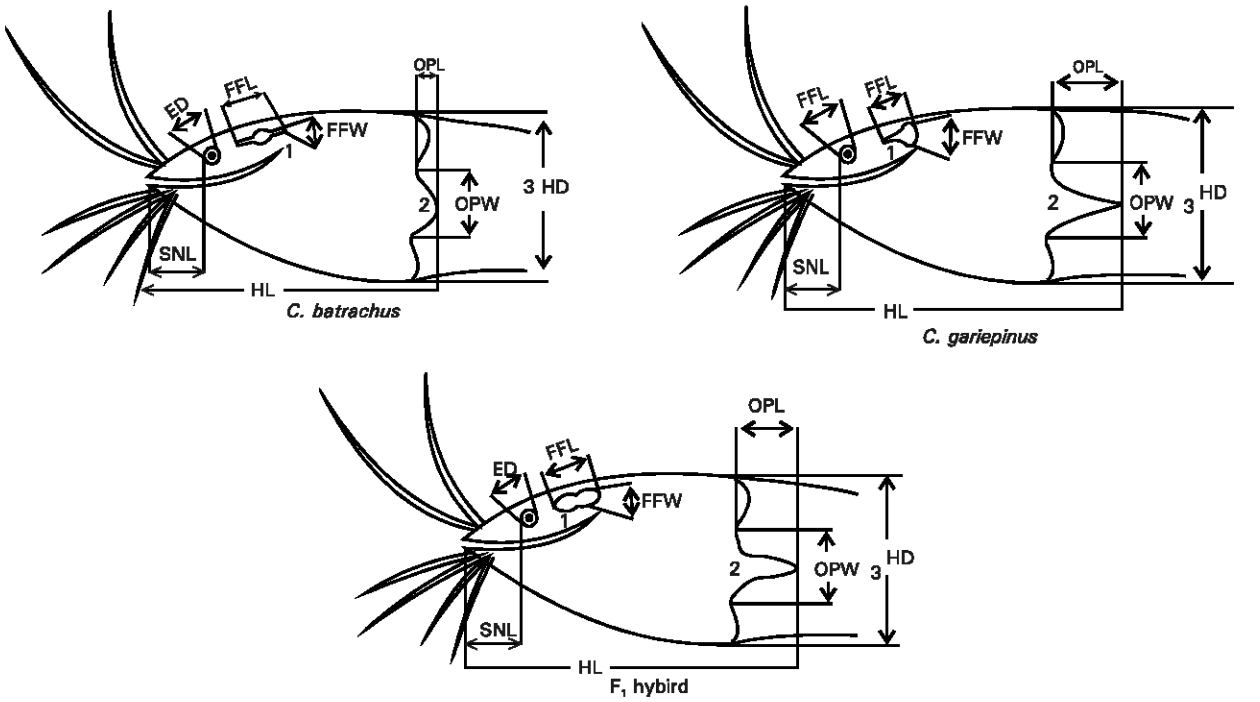

Fig. 2: Most striking external morphological differences of hybrid with their parents. 1. Frontal fontanel shape; 2. Occipital process shape; and 3. Distance between occipital process and dorsal fin origin. Other characters: head depth (HD), eye diameter (ED), occipital process length (OPL), occipital process width (OPW), frontal fontanel length (FFL) and frontal fontanel width (FFW)

Table 3: Mean ± SE of some morphometric and meristic characters of *C. batrachus*, *C. gariepinus* and F_1 hybrids (n = 11 for each group)

Characters	F_1 hybrid	*C. gariepinus*	P-values
Characters with the P-values among F_1 hybrids and *C. gariepinus* parent			
CPD	8.0 ± 0.3	7.9 ± 0.3	= 0.96
PPLVD	49.5 ± 0.8	50.1 ± 0.7	= 0.83
HL	27.6 ± 0.4	27.6 ± 0.4	= 0.93
HW	22.2 ± 0.8	22.5 ± 0.6	= 0.92
SNL	10.5 ± 0.4	10.9 ± 0.4	= 0.67
DFL	64.8 ± 1.4	69.9 ± 0.9	< 0.01
		C. batrachus	*C. gariepinus*	P-values
Characters with the P-values between parents				
PAD		53.9 ± 0.5	56.3 ± 0.4	< 0.08
DFL		69.2 ± 1.0	69.9 ± 0.9	= 0.90
AFL		46.2 ± 0.8	44.2 ± 0.6	= 0.26
	F_1 hybrids	*C. batrachus*	*C. gariepinus*	P-values
Characters with the P-values of F_1 hybrids and parents				
PAD	59.8 ± 1.2	53.9 ± 0.5	56.3 ± 0.4	< 0.01
DFL	64.8 ± 1.4	69.2 ± 1.0	69.9 ± 0.9	< 0.01
AFL	43.2 ± 0.8	46.2 ± 0.8	44.2 ± 0.6	< 0.01

naturally occurring in Africa. Teugels *et al.* (1998) reported that the hybrid between *C. gariepinus* x *C. macrocephalus* showed an external morphology which was intermediate between that of parental species.

For caudal fin rays (CFR), the F_1 hybrid resembled *C. gariepinus* and both groups were significantly greater than *C. batrachus* for this character. There was no significant difference among the three groups for ventral fin rays (VFR). The meristic counts of fishes can be considered phenotypically plastic and can be affected by environmental factors such as water temperature in fresh water and salinity in marine water; these factor can induce changes in the larval stages of fish development (Schreck and Moyle, 1990; Kurata, 1975). Since the hybrid form examined here were artificially cultured in Bangladesh, some of their meristic counts might have been influenced by the breeding condition.

Occipital structure and colouration: The occipital structure of F_1 hybrid was merely defined as second factor which was an intermediate form of the parents (Fig. 2). The second factor is simply defined by the length of occipital process, the distance between occipital process and dorsal fin origin and length of the frontal fontanel. These characteristics easily enable to distinguish the F_1 hybrid and their parents (Fig. 2). It is quite difficult to consider that environment might be caused such large differences. The difference might be phenotypic only, or genetic factors might have influenced the developmental structure of occipital. The body colour of F_1 hybrid is similar to *C. batrachus*, showing a marked marbled colour. About 80 % of F_1 hybrid specimens offered a uniform marbled colour, while remaining 20 % showed a slightly grayish colour. Similar maternal inheritance of colour pattern were observed for reciprocal hybrid of *C. gariepinus* and *H. longifilis* (Legendre *et al.*, 1992).

The hybrid form exhibits higher morphological variability in both morphometric and meristic characters resulting from the paternal dominating characteristics, which may have been completely fixed in each individual and remain constant after the juvenile stage. The characteristics of hybrid with their parents were studied in the present work need to justify whether they will be favourable for farming in the aquaculture potential.

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