Research Journal of Animal Sciences 2 (5): 139-143, 2008
ISSN: 1993-5269

Influence of Broodstock Age on Reproductive Success in the African Catfish *Chrysichthys nigrodigitatus* (Claroteidae Lacépede, 1803)

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Abstract: The influence of female age and size on reproductive success and egg quality was investigated in *Chrysichthys nigrodigitatus*. Three confined groups were formed following fish age and size during spawning period. The results show that spawning rate increased with female age and size. Spawning rate was similar in 3+ and 4+ females (80 %). But only 50% of 2+ females have spawned. Absolute fecundity of *C. nigrodigitatus* was higher in 4+ females (9877±386) than in 2+ ones (6939±1024). The 3+ females had an intermediate absolute fecundity (8378±797). Nevertheless, relative fecundity decrease when the age of females increase. Moreover, egg size is positively strength correlated with female age. The 4+ females with a larger body size have produced large size eggs and larvae. Similarly, the hatching rate was higher in 4+ females intermediate in 3+ females and lower in the 2+ ones.

Key words: Broodstock age, reproductive success, African catfish, *Chrysichthys nigrodigitatus*

INTRODUCTION

In Ivory Coast and in other countries of West Africa, *Chrysichthys nigrodigitatus* is one of the African catfish that are of a commercial interest. The current knowledge indicates that this species spawn for the first time at 2-3 years (Dia, 1975). *C. nigrodigitatus* has a great aquaculture potentials (Erondu, 1997). Its reproduction takes place during rainy and flooding seasons (Laleye *et al*., 1995).

The rearing of this species in Ivory Coast, started in the years 80 (Hem and Nuñez-Rodriguez, 1995). These authors reported that the production of farmed *C. nigodigitatus* has jumped from 1981-1995 to attend 300 tonnes per year for a market value of 684, 932€. But, since 2000, the annual production of this fish is approximately 60 tonnes (FAO, 2005). Deficiency of larvae and fry remains one of the main obstacles limiting the expansion of intensive production of this species. This deficiency coincides with using of younger breeders for reproduction because of the scrapping of the previous breeding stock.

Previous studies in teleosts fish have reported that parental age seems to affect, fecundity (Abdoli *et al*., 2005; Poulet, 2004), egg size (Estay *et al*., 2004) and sperm quality (Schmidt-Baulain and Holtz, 1991). Wherever, the influence of breeder age on reproductive success is not even determined in *C. nigrodigitatus* both in natural and captivity populations.

The aim of this investigation was to study the influence of parental age on spawning rate, fecundity and egg quality in *C. nigrodigitatus* reared in lagoon enclosures.

MATERIALS AND METHODS

Reproduction: The broodstock used in this study was obtained from culture ponds of Layo Aquaculture Station (5°19' N, 4°19' W; Ivory Coast) and these fish were never used for reproduction. Three months before the reproduction season, three groups of males and females aged more than 2 (2+), 3 (3+) and 4 (4+) years were previously stocked in cages in the Ebrié Lagoon. This broodstock was fed at 7% of the biomass twice daily (8 00 and 17 00) with pelleted food containing 35% crude protein manufactured in Layo Aquaculture Station.

At the end of the period of fish dressing, an intra ovarian biopsy was realized for each female. The diameters (short and long) of 30 oocytes of each female were measured at the nearest half millimeter under a compound microscope using an ocular micrometer (10-fold magnification). Females selected for reproduction have mean oocytes diameter superior to 2.5 mm according to Atse *et al*. (2007). After selection, each female was

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measured (total length) and weighted to the nearest 0.5 mm and 0.01 g, respectively. The mature males were chosen according to Atse *et al.* (2007). The characteristics of fish in regard to the age are presented in Table 1.

Ten couples per group were constituted and enclosed in artificial PVC nests. These nests were put in concreted tanks supplied with water of the Ebrié lagoon via a water-tower. Daily water exchange in the tanks was 15 L min^{-1}. During the period of the confinement, the fish were not fed. The nests were controlled daily (7 and 17 h) to verify the state of fishes and to detect possible spawn. After spawning, the couple of fish was removed from the nest and transferred in lagoon enclosures. The eggs were collected, weighed and transferred in incubator system at 29-30°C during 4 or 5 days. Before the incubation, a sample of eggs was weighed and counted in order to determine the absolute fecundity (N) according to the formula:

$$N = n \times We/Ws$$

Ws = weight of the sample, n = number of eggs contained in the appropriated sample and We = total weight of the eggs.

Relative fecundity was defined as the number of oocytes or eggs per gram of female total body weight (Kraus *et al*., 2002).

A sub-sample of 30 eggs was taken, for individual weight and the diameters of each egg were measured at the nearest half millimeter under a compound microscope. The sampled eggs were preserved at -20°C for the biochemical analyses. Egg mean diameter (D) was calculated according to Coward and Bromage (1999): $D = (d_1 + d_2)/2$; with d_1 = long diameter and d_2 = short diameter.

At hatching, non hatched eggs of every couple were counted and hatching rate (Hr) was determined according to the formula:

$$Hr (\%) = 100 \times (Ni-Nn)/Ni$$

Table 1: Characteristics of *Chysichjthys nigrodigitatus* broodstock and reproductive success

	Broodstock		
Parameters	2+	3+	4+
Male body weight (g)	394.20 ± 38.40^a	521.64 ± 61.31^b	730.77 ± 171.59^c
Female body weight (g)	312.20 ± 36.45^a	500.92 ± 118.33^b	618.60 ± 85.74^c
Male total length (cm)	33.89 ± 2.52^a	36.97 ± 1.52^b	38.90 ± 3.18^c
Female total length (cm)	30.13 ± 1.37^a	33.77 ± 1.64^b	35.61 ± 1.95^c
Male condition factor	1.01±0.10	1.15±0.12	1.25±0.16
Female condition factor	1.08±0.12	1.19±0.14	1.28±0.17
Spawning rate (%)	50	80	80
Oocyte diameter (mm)	2.67 ± 0.24^b	2.73 ± 0.14^b	2.79 ± 0.14^c
Absolute fecundity (eggs)	6939 ± 1024^a	8378 ± 797^b	9877 ± 386^b
Relative fecundity (eggs/g of female)	20.67 ± 4.49^c	16.39 ± 1.31^b	14.39±0.74

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

with Ni = number of incubated eggs and Nn = number of the non hatched eggs. Thirty larvae by female were individually weighed, total length and the diameter of the yolk vesicle were measured under a compound microscope. These larvae were preserved at-20°C for biochemical analyses.

The other larvae were reared in circulars tanks and production was determined for each group after yolk vesicle resumption.

Biochemical analyses: The approximate compositions of the eggs and the larvae at hatching were analysed using standard methods (AOAC, 1990). Moisture content of each sample was determined through a hot-air oven set at 105°C for 24 h and ash was measured by incineration at 550°C in a muffle furnace for 24 h. Crude protein (Nitrogen × 6.25) was determined using micro-Kjeldahl method and crude fat was extracted (hexane extraction) using the Soxhlet method. Energy of samples was determined according to Beukema and De Bruin (1979) (17.9 kJ g^{-1} for protein) and Beninger and Lucas (1984) (33 kJ g^{-1} for lipids).

Statistical analyses: All group data were analysed using one-way ANOVA. The Tukey's HSD ranking test was used to compare the differences among means. Simple regression analysis was used to examine the relationships between fecundity-egg diameter and egg weight-larvae at hatching weight. Statistical analyses were carried out with Statistica 7.1 software.

RESULTS

Spawning rate and fecundity: Spawning rate and the absolute fecundity increased significantly ($p<0.05$) with female age (Table 1). Values of these parameters were lower for 2+ females, intermediate in 3+ females and higher for 4+ females. On the other hand, relative fecundity decreased significantly ($p<0.05$) with increasing female age (Table 1).

Characteristics of eggs and larvae at hatching: Egg diameter and weight were female age dependent (Table 2). The 4+ females produced larger eggs ($p<0.05$) than the other ones. The lowest values of egg weight (15.31±1.80) and diameter (3.09±0.25) were obtained in the youngest females (2+). Whereas, intermediate egg mean diameter (3.48±0.16) and weight (18.94±1.47) were recorded for 3+ females. Egg diameter was significantly and positively correlated with absolute fecundity (Fig. 1; $r = 0.90$; $n = 18$; $p<0.001$). Total lipids, proteins and energy contents of

Table 2: Characteristics of eggs and larvae at hatching *Chysichjthys nigrodigitatus* in regard to broodstock (mean ± SD)

	Broodstock		
Parameters	2+	3+	4+
Eggs			
Weight (mg)	15.31±1.80[a]	18.94±1.47[b]	20.64±1.74[c]
Diameter (mm)	3.09±0.25[a]	3.48±0.16[b]	3.67±0.12[c]
Incubation times (Days)	4.50±0.50[a]	5.50±0.25[b]	5.25±0.75[b]
Hatching rate (%)	75.67±6.12[a]	89.40±4.00[b]	96.50 ± 3.27[c]
Dry matter (%)	33.85±0.88[a]	34.48±0.76[a]	35.84±0.68[b]
Ash (%)	3.38±0.03	3.44±0.05	3.50±0.05
Total lipids (mg/g of dry matter)	317.42±2.20[a]	326.95±2.54[b]	332.36±2.00[c]
Crude protein (mg/g of dry matter)	652.46±3.44[a]	663.14±3.85[b]	665.71±2.79[b]
Energy contents (kJ/g of dry matter)	22.14±0.11[a]	23.66±0.06[b]	23.88±0.06[b]
Larvae			
Larvae weight (mg)	12.82±0.93[a]	15.28±0.81[b]	17.14±0.64[c]
Larvae total length (mm)	9.30±0.39[a]	9.75±0.20[b]	11.47±0.16[c]
Yolk vesicle diameter (mm)	3.01±0.22[a]	3.43±0.18[b]	3.60±0.18[c]
Dry matter (%)	33.06±0.97[a]	33.61±0.48[a]	34.86±0.71[b]
Ash (%)	2.31±0.03	2.39±0.04	2.40±0.03
Total lipids (mg/g of dry matter)	212.67±2.34[a]	239.73±2.05[b]	260.45±1.72[c]
Crude protein (mg/g of dry matter)	643.92±2.94[a]	658.51±2.08[b]	662.47±4.45[b]
Energy contents (kJ/g of dry matter)	18.54±0.66[a]	19.71±0.26[b]	20.45±0.22[b]

[abc] Mean values with different superscript letters within a row are significantly different ($p<0.05$)

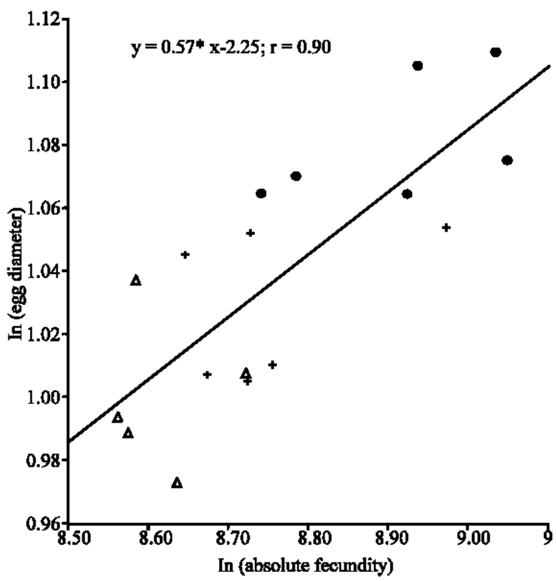

Fig. 1: The linear regression relationship between egg diameter and absolute fecundity in female of *Chrysichthys nigrodigitatus* (2+ (△), 3+ (+) and 4+ (●); n = 18, $p<0.05$)

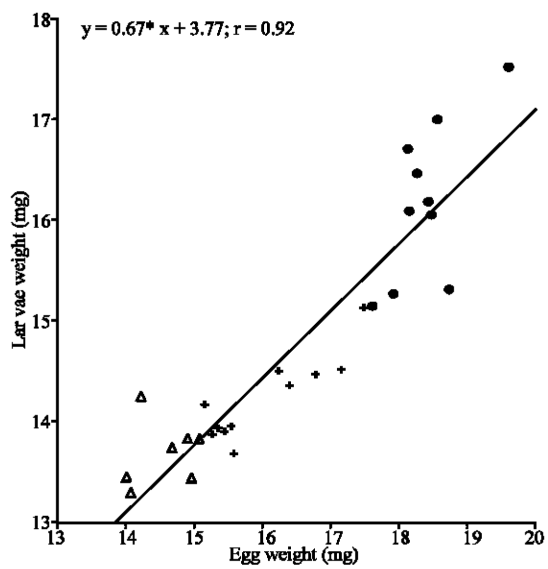

Fig. 2: The linear regression relationship between larvae weight and egg weight in *Chrysichthys nigrodigitatus* (2+ (△), 3+ (+) and 4+ (●); n = 18, $p<0.05$)

egg at spawning and the incubation times were also affected by the age of the broodstock even if proteins and incubation duration were the same for eggs produced by 3+ and 4+ fish. The lower values of these parameters were obtained in 2+ fish (Table 2).

Hatching rates also depend on fish age. Values increased with increasing the age of fish (Table 2). At hatching, larvae weight, total length and yolk vesicle diameter for 4+ females were higher ($p<0.05$) than those of the females of the 2 other groups. Body weight of larvae was positively correlated with egg at spawning weight; larger egg did produce larger larvae at hatching (Fig. 2). Total lipids, proteins and energy contents of the larvae at hatching were affected by female age. Values of these parameters were significantly higher ($p<0.05$) in the oldest females (4+) than the youngest ones (2+) (Table 2).

Production of larvae increased with fish age. The values were 22929, 59023 and 74364, for 2+, 3+ and 4+ fish, respectively.

DISCUSSION

Spawning rates were higher in 3+ and 4+ females than in the youngest females (2+). Ovulation and spawning in fish depend on hormonal secretion; thus, our results reveal that fish of 3 years old and more were in the best condition to spawn. This could explain the fact that the sexual maturity and the first spawning period take place about 3 years in this species in natural habitat (Dia, 1975). In female catfish *Ictalarus punctatus*, the 3+ females would have the best reproductive performances because their plasma sex hormone concentrations were higher than the 2+ females (Davis *et al*., 2005).

Absolute fecundity and relative fecundity evolved inversely in relation to female age. Absolute fecundity increased with age of the females whereas relative fecundity drops in aged females. The increase of absolute fecundity with age would indicate that in the 4+ females, the amount of energy available for egg production is sufficient to produce many eggs. This increase of fecundity would also show that the 4+ fish were able to increase the quantity of reserve attributed to egg development proportionally to the number of eggs and the egg quality increased. The body cavity of these females would also be accommodating for stocking great ovaries (Kennedy *et al*., 2008). Whereas, the effect of female age on fecundity is variable. Among teleost fishes, trade-offs between number and size of eggs has been demonstrated both within freshwater and marine fishes (Elgar, 1990; Einum *et al*., 2004; Abdoli *et al*., 2005). Therefore, egg size is depends on selective pressures and egg number. The relative fecundity decreased in the 4+ females because of the high body weight of these females. The reduction of the relative fecundity with age indicates that the potential reproductive of the population would especially be founded on the young females (Poulet, 2004). Similar, observations were reported in the same species in natural population (Ekanem, 2000) and in other species such as *Gadus morhua* (Kraus *et al*., 2002) and *Salmo trutta* (Estay *et al*., 2004).

The relative fecundity obtained in all female groups was ranged from 14.39-20.67 eggs/g of female total body weight. Those values were similar to that reported by Oteme (1993), for the same species. However, the values obtained in this study were higher than those reported in natural population in Porto Novo lagoon (Laleye *et al*., 1995) and in Cross River (Ekanem, 2000) for the same species.

Egg at spawning diameter and weight, in *C. nigrodigitatus* were dependent on parental age. Female spawning for the first time produced small eggs, whereas eggs produced during the second year are larger and old fish (4+) produced largest and heaviest eggs. A positive parental effect (age in the present study) on egg size has been observed in *Salveinus alpinus* L. (Atse, 1997). Furthermore, the parameters of regression of egg at spawning diameter on the absolute fecundity showed that in *C. nigrodigitatus*, there is a positive correlation between these two parameters. The high size of the egg produced by 4+ females would be due to their lipids and proteins contents resulting of the important mobilization of energetic reserves during oocyte maturation. Thus, for 2+ females, the capacity to transfer protein and lipids from the somatic body to the oocytes in maturation would be limited. In teleosts fishes, egg size and egg energy content were shown to be largely dependent on the females' nutritional status (Brooks *et al*., 1997) and abiotic factors (Atse *et al*., 2002). In the present study, feeding rate, diet and environmental conditions were similar among groups. Therefore, the results show that the oldest broodstock invest relatively more energy into offspring than the youngest ones (Estay *et al*., 2004). On the other hand, Paugy (2002) have reported that in *C. maurus* in Baoule River, fecundity is low when oocyte size is large. Therefore, relationship between egg size and absolute fecundity would depend on species and environment conditions of broodstock.

Otherwise, ours results indicate that in *C. nigrodigitatus*, egg at spawning size influenced the larva at hatching. The larger eggs produced larger larvae with a better hatching rate. Similar, results were reported in other species by Bromage *et al*. (1992). Hatching rates and egg energy contents were higher in 4+ females than in other ones. This would indicate that the 4+ females produced eggs which have the best quality.

CONCLUSION

The results of this study showed that the reproductive success and the egg quality in *C. nigrodigitatus* were influenced by age of the parents. The 4+ fish produced better eggs with high quality. Furthermore the production of larvae was best when the fish were age.

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