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RELATIONSHIP BETWEEN BROODSTOCK WEIGHT COMBINATION AND SPAWNING SUCCESS IN AFRICAN CATFISH (*Clarias gariepinus)*

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ABSTRACT

Pearson's correlation and regression analysis were used in this study to test the relationship between broodstock weight combination and broodstock characteristics for African catfish (*Clarias gariepinus*) such as fecundity, weight of egg, weight of testis and their relationship with breeding parameters such as fertilization and hatchability. The result obtained reveals that broodstock size correlated positively with fecundity, weight of egg and weight of testis. Though the same strong relationship was observed for fertilization and hatchability, low r^2 values were obtained in regression analysis between these parameters, suggesting an insignificant regression. Fecundity also correlated positively with fertilization (0.764) and hatchability (0.494). The regression between fecundity and weight of female was significant (r^2 = 0.9558). Multiple regression showed significant regressions between % Fertilization and Fecundity, Egg Weight and Weight of Testis as a whole, between % Fertilization and Weight of Male and Weight of Female and between % Hatchability and Fecundity, Egg Weight, Weight of Testis and % Fertilization. The present study therefore advanced the thought that larger African catfish broodstocks are better for breeding activities.

INTRODUCTION

The demand for fish product is increasing yearly due to more enlightenment on the health benefits of fish consumption. Otubusin (1996) noted that the only means of meeting the projected demand for fish is through pragmatic options of intensive fish farming. To this effect, growth of aquaculture has been reported hinging on the ability of the hatcheries to be able to produce and supply fish seeds for stocking production ponds on a sustainable basis (Bamimore, 1994). Rearing culturable fish species under controlled environment has proved to be a successful method of enhancing fish supply. Among all, catfishes are important to the sustainability of the aquaculture industry of Africa, especially in Nigeria. Their method of propagation is well documented and understood but fingerlings and fish fry supply still outstrips fish farmers' demand. North african catfish (*Clarias gariepinus*, Burchell, 1822), which is presently the most widely cultured fish species in Nigeria, is facing problems of poor spawning and low hatchability rates (Ayinla, 1988), hence reduction in productivity.

To mitigate these problems, research has focused on the suitability of the environment as it affects breeding success; Oyelese (2006) demonstrated hatching success in relation to temperature, while Silva et al. (2003) reported effect of water hardness on breeding parameters of fish. Handling stress and health status of female brood fish as biological indices has been reported to be of great importance in the reproductive performance of fish, as reported by Muchlisin et al. (2006) and Aiyelari et al. (2007).

However, evaluation of biological phenomenon in terms of parental influence is not well understood in many species. Selection of broodstock in African catfish is largely through a disjointed, isolated and occasional effort, unlike in the case of Channel catfish (*Ictalurus punctatus*, Rafinesque, 1818) (Salami et al., 1993 and Nlewadim et al., 2004). Previous preliminary work by Ataguba et al. (2012) had reported tendency of increased hatching success with increasing broodstock size. The present study therefore was designed to evaluate the relationship between broodstock sizes and hatching success. The result presented in this study will guide fish farmers on brood fish selection for induced breeding to reduce breeding failure.

MATERIALS AND METHODS

Sixty-four broodstocks of the same breeding history raised for approximately fifteen months were obtained from the Fisheries research farm of the University of Agriculture, Makurdi. The broodstocks were separated by sex and weight and acclimatized for two weeks in concrete tanks at the Hatchery Unit of the Department of Fisheries and Aquaculture, Makurdi. Broodstocks were fed with 35% crude protein pelleted feed administered daily at 5% of their body weight.

Broodstock weight combination used in this study is shown in Table 1; each weight class had two broodstooks each for male and female.

Table 1. Broodstock mating combination is in the following order (♀ × ♂)

Weight range	Short Code	♂			
	♀	A	B	C	D
200-300g	A	AA	AB	AC	AD
400-500g	B	BA	BB	BC	BD
600-700g	C	CA	CB	CC	CD
800-900g	D	DA	DB	DC	DD

Ovaprim was used to induce ovulation at a dosage of 0.5 $mlkg^{-1}$ of body weight. Hormone administration was carried out via intramuscular injection without anaesthesia. After a latency period of twelve hours, eggs were collected from each female according to the designated combinations by gently pressing the abdomen of the fish. These were collected into clean bowls labelled accordingly. The weights of the eggs were determined, as well as fecundity. The testes were obtained by sacrificing the males and the milt obtained was used to fertilize the eggs according to the combination. The stripped eggs were mixed with the milt gotten from the male of appropriate combination after which 5 ml of fresh water was added. After gentle and thorough stirring, the eggs were transferred and incubated in the plastic aquaria of 60 L capacity using nylon mosquito mesh netting as substrate suspended in 50 litres of fresh water according to the originally predetermined combination. Fertilization rates were calculated according to the method described by Ella (1987). Eggs were incubated in this static condition with aeration at an ambient temperature between 27 to 29 °C. Hatching was observed to be complete between 24 to 28 h after fertilization, and the hatching rates were evaluated about 32 hours post fertilization following methods described by Ella (1987).

Data collected were subjected to Pearson's correlation and regression analysis using Microsoft Excel 2007, Genstat Discovery Edition 4 and Minitab 14. Multiple regression analysis was performed to reveal the relationship between broodstock parameters and hatchability, as well as fertilization rate of African catfish eggs. The confounded equation with several inter-related parameters as predictors gives a better picture of their relationship with the response variable.

RESULTS AND DISCUSSION

The result of this study shows that weight of male had a strong positive correlation with testis weight. Ataguba et al. (2012) had rightly pointed out that fish generally need energy for growth and reproductive activity, however, less energy is available for weaklings (small fish compare to larger ones of the same reproductive age) to cater for growth and reproduction as more energy is spent in predation avoidance. Hence smaller fish carries smaller testis compared to bigger fish of the same age. The present study also observed that the weight of male and weight of testis did not correlate significantly with either fertilization or hatchability. This is because the ability of sperm to fertilize an egg is strongly linked to its motility. Though large milt volume translates to more numbers of sperm cells, the sperm cell may not be motile. Rurangwa et al. (2001) observed a high correlation between sperm fertility and spermatozoa motility and stated that a higher percentage of motile sperm is significantly related to fertilization capacity in catfish, African catfish, hence the reason for lower r^2 value of the regression of fertilization with testis weight (0.0639) and weight of male (0.0144).

On the other hand, the weight of females was strongly (positive) correlated with fecundity (0.900), egg weight (0.805), fertilization (0.821) and hatchability (0.450). Rideout et al. (2005) revealed that larger females often produce larger eggs in many fish species and this has been demonstrated earlier in many fish species, more so, Bromage and Roberts (1995) established that size is directly proportional to fecundity and egg size. Bromage and Cumaranatunga (1988) also reported that increase in egg number (fecundity) with age is due to increase in fish size, hence increase in size of fish leads to increased egg weight and fecundity, as depicted in Figure 1. Also, the relationship between fecundity and egg weight follows a similar pattern (Figure 2).

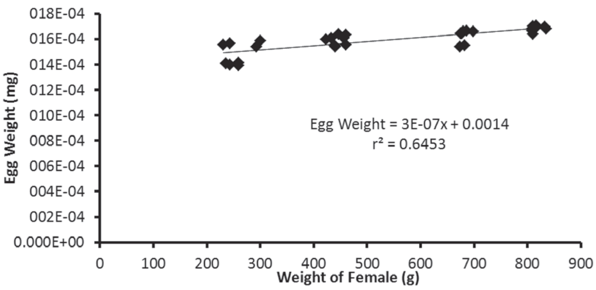

Fig 1. Linear relationship between weight of females and egg weight

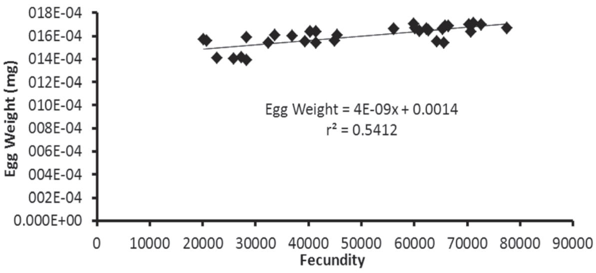

Fig 2. Linear relationship between fecundity and egg weight

Fertilization and hatchability (Table 2) in the present study also correlate positively with weight of female (Table 3), hence high values of the latter tends to be associated with higher values of the former. There is a direct relationship between fecundity and weight of females (Figure 3).

Table 2. Artificial spawning performance of broodstock combination of various weight ranges

Combination Number	Crosses	Weight. of Female (g)	Weight. of Male (g)	Egg Weight. (mg)	Weight of Testes (g)	Fecundity	Percentage Fertilization	Percentage Hatchability
1	A x A	296.55±3.55	259.19±3.06	1.072 E-03± 0.0103 E-03	0.9625±0.043	30368.0±93.5	53.45±0.85	72.10±0.30
2	A x B	239.40±4.00	427.78±5.04	0.997 E-03±0.0598 E-03	1.1250±0.015	24296.0±57.5	69.50±1.60	77.250±0.85
3	A x C	259.19±0.06	618.60±1.60	1.182 E-03±0.0340 E-03	1.7100±0.020	27834.0±62.0	67.70±1.20	77.85±1.55
4	A x D	237.00±6.00	822.70±0.97	0.731 E-03±0.0141 E-03	1.6050±0.015	20458.0±54.0	58.90±2.00	75.40±3.00
5	B x A	453.20±7.00	261.19±3.06	1.439 E-03±0.0184 E-03	0.9625±0.043	40842.0±31.0	67.95±2.15	69.750±0.35
6	B x B	458.1±2.10	439.73±3.39	1.011 E-03±0.0181 E-03	1.390±0.215	45145.0±47.0	67.20±1.30	65.60±1.80
7	B x C	427.78±5.04	616.60±1.60	1.527 E-03±0.00109 E-03	1.6250±0.035	35321.0±59.0	69.05±1.15	69.400±0.70
8	B x D	439.73±0.39	822.70±2.97	1.031 E-03±0.0181 E-03	1.6650±0.025	40405.0±48.0	66.50±0.70	65.750±0.35
9	C x A	677.45±2.95	261.19±3.06	1.482 E-03±0.00286 E-03	0.9625±0.043	59378.0±39.0	71.45±0.85	70.20±0.40
10	C x B	692.50±6.50	439.73±3.39	1.535 E-03±0.00826 E-03	1.390±0.215	62763.0±45.0	73.20±1.40	71.90±1.50
11	C x C	677.85±4.55	616.60±1.60	1.488 E-03±0.0383 E-03	1.6250±0.035	64954.0±48.0	72.85±1.05	78.25±3.35
12	C x D	678.85±1.55	822.70±2.97	1.463 E-03±0.0299 E-03	1.6650±0.025	61654.0±67.5	73.85±1.25	81.35±2.95
13	D x A	826.14±8.2	259.19±3.06	1.532 E-03±0.00500 E-03	0.9625±0.043	68374.0±95.5	77.33±2.67	74.35±3.15
14	D x B	809.84±0.62	427.78±5.04	1.584 E-03±0.00118 E-03	1.1250±0.015	62898.0±45.0	76.03±2.50	85.00±3.40
15	D x C	824.14±8.2	618.60±1.60	1.461 E-03±0.00228 E-03	1.7100±0.020	71961.0±39.5	83.70±1.20	83.70±1.20
16	D x D	809.34±1.12	822.70±0.975	1.512 E-03±0.0149 E-03	1.6050±0.015	74142.0±1.5	79.89±1.44	88.700±0.80

Table 3. Correlation matrix of broodstock parameters and spawning performance

	Weight ♀	Fecundity	Egg Weight	Weight ♂	% Fertilization	% Hatchability
Fecundity	0.900*** (0.000)					
Egg Wt	0.805*** (0.000)	0.693*** (0.000)				
Wt ♂	-0.035 (0.851)	0.065 (0.992)	-0.204 (0.448)			
% Fertilization	0.821*** (0.000)	0.764*** (0.000)	0.711*** (0.005)	0.120 (0.513)		
% Hatchability	0.450** (0.01)	0.494** (0.013)	0.337 (0.366)	0.332 (0.064)	0.525** (0.002)	
Wt Testis	-0.019 (0.919)	0.075 (0.879)	-0.096 (0.322)	0.869*** (0.000)	0.208 (0.253)	0.253 (0.163)

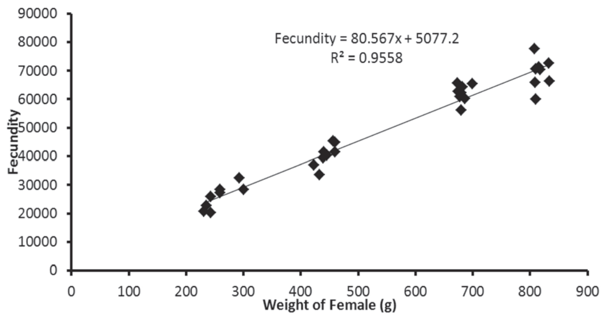

Fig 3. Linear relationship between fecundity and weight of females

De Graaf et al. (1995) stated that variations in the size of broodstock can lead to differences in hatching rates. Egg size has also been reported to be positively correlated with many larval traits including larval length and hatchling survival (Buckley et al., 1991 and Rideout et al., 2005). Hempel (1979) reported that larger eggs provide more energy for larvae development which is explained by a larger yolksac, hence the high correlation between female size and hatching success recorded in this study. The result of the present study is different from the observation of Changadeya et al. (2003) on vendace (*Coregonus albula*) which reveals that small fish had increased hatchability compared to larger ones. Fertilization rate was significantly correlated (P = 0.000) with fecundity, egg weight and weight of testis as predictors (Equation 1) with adjusted r^2 = 0.6670. Also, there was a significant regression between the weight of broodstock and % fertilization (P = 0.000). The regression equation (Equation 2) gives the coefficients of these predictors with the adjusted r^2 value of 0.6750. Fecundity, egg weight and weight of testis were confounded as predictors in a multiple regression to predict hatchability. The regression was significant (P = 0.032) but r^2 = 0.2120 (Equation 3). The low r^2 value can be explained by the fact that hatchability is affected by other parameters such as water temperature and other water quality parameters which were not confounded in the current investigation.

- % Fert = 68.1 + 0.000384 Fecundity - 13543 Egg Wt + 3.64 Wt Testes …(Equation 1)

  r^2 = 0.6670 (P = 0.000)
- % Fert = 52.2 + 0.00524 Wt M + 0.0283 Wt F …(Equation 2)

  r^2 = 0.6750 (P = 0.000)
- % Hatch = 64.6 + 0.000103 Fecundity - 14479 Egg Wt + 2.97 Wt Testes + 0.351 % Fert … (Equation 3)

  r^2 = 0.2120 (P = 0.032)

According to Eyo and Mgbenka (1992) and Ezenwaji (1998), fecundity encompasses all available eggs in the ovary of the broodstock, however Bagenal (1978) described fecundity as the number of ripe spawnable eggs (>1.0 mm vitellogenic oocytes in mature females) in the ovary of the fish prior to the next spawning season. The aim of synthetic hormone administration for induced breeding is to ripen the egg for release, hence the ease of stripping out eggs when the abdomen is gently pressed. Oyelese (2006) observed that the total weight of eggs stripped from a female is dependent on the number of eggs ovulated at the time of stripping, which is actually not the total quantity of eggs produced by the female spawner. The total number of ovulated eggs considered as fecundity in the present study is a true representation of ripe and ready to be fertilized eggs, hence the more fecund eggs (ripe eggs), the more the fertilization and by extension hatchability.

In conclusion, the present study has shown that larger size of broodstock correlated positively with all the breeding parameters measured in the present study. More research should therefore be performed to test their commercialization under different culture facilities and systems.

Sažetak

ODNOS IZMEĐU KOMBINACIJE MASE MATIČNOG STOKA I USPJEŠNOSTI MRIJESTA AFRIČKOG SOMA (*Clarias gariepinus*)

U ovom istraživanju korištena je Pearsonova korelacijska i regresijska analiza za ispitivanje odnosa kombinacije mase matičnog stoka i osobina matičnog stoka afričkog soma (*Clarias gariepinus*) kao što su: plodnost, masa jaja, masa testisa i njihov odnos s uzgojnim parametrima, oplodnjom i valjenjem. Dobiveni rezultat otkriva pozitivnu korelaciju matičnog stoka s plodnošću, masom jaja i masom testisa. Iako je podjednako jak odnos zabilježen za oplodnju i valjenje, dobivene su niske r^2 vrijednosti u regresijskoj analizi navedenih parametara, označavajući neznatnu regresiju. Plodnost je također u pozitivnoj korelaciji s oplodnjom (0,764) i valjenjem (0,494). Regresija između plodnosti i mase ženke je značajna (r^2 = 0,9558). Višestruka regresija pokazala je značajne regresije između postotka oplodnje i plodnosti, mase jajeta i mase testisa kao cjeline, zatim između postotka oplodnje i mase mužjaka te mase ženke, a također i između postotka valjenja i plodnosti, mase jajeta, mase testisa i postotka oplodnje. Ovo istraživanje dokazalo je da

veći matični stok afričkog soma pozitivno utječe na uzgojne aktivnosti.

Ključne riječi: uzgojni parametri, afrički som, korelacijska analiza

REFERENCES

Aiyelari, T. A., Adebayo, I. A., Osiyemi, A. S. (2007): Reporting fitness of stressed and steroids. Fish Physiol. Biochem. 14, 237–246. Animal Biology, 1, 5, 78-81.

Ataguba, G. A., Solomon, S. G., Onwuka, M. C. (2012): Broodstock size combination in artificial spawning of cultured *Clarias gariepinus*. Livestock Research for Rural Development, Volume 24, Article #223. Retrieved: December 3, 2012. Available from: http://www.lrrd.org/lrrd24/12/atag24223.htm

Ayinla, O. A. (1988): Nutrition and reproductive performance of *Clarias gariepinus* (Burchell 1822). PhD thesis, University of Ibadan, Nigeria, 433 pp.

Bamimore, M. A. (1994): Performance of *Clarias gariepinus* fingerlings raised under varying culture conditions. PhD thesis, University of Ibadan, Nigeria. 226 pp.

Bagenal, T. B. (1978): Aspects of fish Fecundity. In: Gerting, S. D. (ed.), Ecology of freshwater fish production. Blackwell Scientific, Oxford, 75-101.

Bromage, N. R. and Cumaranatunga, R. (1988): Egg production in the rainbow trout. In: Muir, J. F. and Roberts, R. J. (eds), Recent Advance: in Aquaculture, Vol. IV, Pl'. 03-13X. Croom Helm/Timber Press, London and Sydney/Portland. Oregon.

Bromage, N. R. and Roberts, R. J. (1995): Broods tock Management and Egg and Larval Quality. Blackwell Science, Oxford OX2 OEL, 424 pp.

Buckley, L. J., Smigielski, A. S., Halavik, T. A., Caldarone, E. M., Burns, B. R., Laurence, G. C. (1991): Winter flounder Pseudopleuronectes americanus reproductive success. II. Effects of spawning time and female size on size, composition and viability of eggs and larvae. Marine Ecology Progress Series, 74, 125–135.

Changadeya, W., Malekano, L. B., Ambali, A. J. D. (2003): Potential of genetics for aquaculture development in Africa. NAGA, 26, 3, 31-35. Available from: http://www.worldfishcenter.org/naga/Naga26-3/pdf/naga_26no3_feature8.pdf

de Graaf, G. J., Galemoni, F., Banzoussi, B. (1995): The artificial reproduction and fingerling production of the African catfish *Clarias gariepinus* (Burchell 1822) in protected and unprotected ponds. Aqua. Res., 26, 233-242.

Ella, M. O. (1987): Simple Calculations in Fish Farming. Wusen Press Ltd. Calabar, Nigeria. 1-64.

Eyo, J. E., Mgbenka, B. O. (1992): Aspects of the biology of *Clarias gariepinus* in Anambra River basin I: oocyte diameter, fecundity and sex ratio. Journal of Agriculture Science and Technology, 2, 1, 47-51.

Ezenwaji, H. M. G. (1998): The breeding biology of *Clarias albopunctatus* Nicholas and La Monte, 1953 in semi intensively managed ponds in the flood plain of the River Anambra, Nigeria. Ecology of Freshwater Fish, 1, 101-107.

Hempel, G. (1979): Early life history of marine fish. The Egg Stage. University of Washington Press, Seattle, 70 pp.

Muchlisin, Z. A., Hashim, R., Chong, A. S. C. (2006): Influence of dietary protein levels on growth and egg quality in broodstock female Bagrid catfish (*Mystus nemurus Cuv. & Val.*). Aquaculture Research, 37, 416-418.

Nlewadim, A. A., Onuoha, G. C., Aluko, P. O. (2004): Studies on the growth and survival of fry and fingerlings of clariid catfish species: Clarias gariepinus (Burchell, 1822), *Heterobranchus bidorsalis* (Geoffroy, 1809) and *H. longifilis* (Valenciennes, 1840). Journal of Aquaculture in the Tropics, 19, 1, 1-14.

Otubusin, S. O. (1996): Intensive small scale cage pen and enclosure fish production systems: Towards 2010 proceedings of the 13th Annual Conference of the Fisheries Society of Nigeria (FISON). New Bussa 3rd – 8th Nov 1996., 181-184.

Oyelese, O. A. (2006): Water Temperature a determinant of Fertilization and Hatchability Rates in Artificially induced Breeding of *Clarias gariepinus* (Teleostei: Clariidae). Research Journal of Biological Sciences, 1, 1-4, 83-87.

Rideout, R. M., Trippel, E. A., Litvak, M. K. (2005): Effects of egg size, food supply and spawning time on early life history of haddock *Melanogrammus aeglefinus*. Marine Ecology Progress Series, 285, 169-180.

Rurangwa, E., Volckaert, F. A. M., Huyskens, G., Kime, D. E., Ollevier, F. (2001): Quality control of refrigerated and cry preserved semen using computer assisted sperm analysis (CASA), viable staining and standardized fertilization in African catfish (*Clarias gariepinus*). Theriogenology, 55, 3.

Salami, A. A., Fagbenro, O. A., Syndeham, D. H. J. (1993): The production and growth of clariid catfish hybrids in concrete tanks. Israeli Journal of Aquaculture, Bamidgeh, 45, 18-25.

Silva, L. V. F., Golombieski, J. I., Baldisserotto, B. (2003): Incubation of silver catfish, *Rhamdia quelen* (Pimelodidae), eggs at different calcium and magnesium concentrations Aquaculture, 172, 3-4, 279–287.