www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences DOI: 10.4194/1303-2712-v16_3_19

Are Pre Spawning Stressors Affect Reproductive Performance of African Catfish *Clarias gariepinus*?

Ramy M. Shourbela [1,*], Ashraf M. Abd El-latif [2], Eman A. Abd El-Gawad [2]

[1] Alexandria University, Faculty of Veterinary Medicine, Department of Animal Husbandry and Animal Wealth Development, Edfina, 22758, Rashid, Egypt.

[2] Benha University, Faculty of Veterinary Medicine, Department of Fish Diseases and Management, Moshtohor 13736, Egypt.

[*]Corresponding author: Ramy_aqua@yahoo.com Alternative e-mail: Ramy.abdelmegid@alexu.edu.eg
Phone: Mobile: 01097661554, Work: 045 296 03 06, Fax: 045 296 04 50

Abstract

The influence of administered pre spawning stressors on female African catfish, *Clarias gariepinus* was investigated throughout induced spawning. It was found that no significant difference ($P > 0.05$) in ovulation percentages among stressed and control groups. Significant differences were recorded for eggs weight and eggs numbers produced by stressed females and control one. Stressed females show low fertilization and hatching rate compared to the control group. Starved females progeny showed significantly higher deformity rate, dead larvae and low survival rates compared other groups. African catfish exposed to stressor have the ability to spawn successfully, but there appears to be a negative influence of this stress on their breeding output, particularly through the production of abnormal larvae. Thus, there is a limit to the ability of these fish to tolerate stressor as revealed. Proper feeding, handling and management of female African catfish is recommended for proper induced spawning.

Keywords: Stressors, African catfish, reproductive performance, induced spawning

Introduction

Clariid catfishes have a distinguished feature as one of the most important categories of farmed catfish in the world. C. gariepinus is the fundamental species cultured in Africa (Teugels, 1984). This species is known for its high growth rate, resistance to handling, stress, poor water quality, amenability to high stocking densities. It has also been known as the most suitable one for aquaculture throughout its distributional area (Hecht et al., 1996). In Europe, Clarias sp have been farmed in Germany, Netherlands and Belgium (Verreth et al., 1993). The Republic of Czech (Adamek and Sukop, 1995) has begun to culture this species on both an extensive and intensive basis. In South America, catfish is mainly farmed in Brazil (Hecht et al., 1996).

Effective fish reproduction under controlled conditions depends on high gamete quality and progeny performance (Bromage, 1995). Number of eggs spawned, egg mortality, size of larvae, and percent of larval mortality are considered attributes with high relative value when selecting brood fish (Leitritz and Lewis, 1980). Despite the need for high quality gametes, the environment under which the brood fish are maintained before reproduction is often stressful (Schreck et al., 2001; Gowaty et al., 2007; Schreck, 2010).

Although many studies on catfish have generated a body of information on spawning and hatching, and larval and juvenile rearing (Appelbaum and Mcgeer, 1998; Brzuska, 2002; Han et al., 2004; El Naggar et al., 2006;

Olumuji and Mustapha, 2012; Marimuthu et al., 2015). Studies on the influence of environmental and stress factors in African catfish reproduction are few (e.g., de Graaf and Janssen, 1996; Boeuf and LeBail, 1999; Adebayo, 2006; Okanlawon, 2010).

Common management applied in hatcheries such as transportation, rough handling, poor cleaning, overcrowding, use of chemicals, and problems with poor water quality are stressors that may negatively influence fish breeding (Bromage, 1995; Schreck et al., 2001; Adebayo, 2006; Okanlawon, 2010).

The hardly nature of C. gariepinus and its tolerance to adverse ecological condition make fish culturists believe that nothing can affect on C. gariepinus broodstocks and this persuasion bring them to ignore the effects of rough handling, poor feeding, hypoxia and crowding in their hatcheries. Research on the effect of stress such as starvation, handling, crowding on the reproduction of C. gariepinus may lead to the development of culture practices that minimize adverse effects of stress and enhance the production of high quality gametes and progeny with the subsequent commercial and ecological benefits. Therefore, the objective of this study was to determine if stresses applied to C. gariepinus broodstock during hormonal induction affect their reproduction performance or progeny outputs.

Materials and Methods

Broodstock care and selection

C. gariepinus broodfish females were stocked in concrete pond belonging to the department of Animal Husbandry and Animal Wealth Development, Faculty of Veterinary Medicine, Alexandria University. Study starting about mid-April 2015 fish fed on a diet of 25% protein at 3% total body weight every day. Towards the end of May 2015, when the climatic conditions were suitable for breeding (average daily water temperatures of 25 ± 1 °C), females were examined and their readiness to breed assessed on the basis of external appearance and release of eggs upon gentle pressure on the abdomen. Broodfish were selected using this process, weighed, and assigned randomly to one of the experimental treatments.

Experimental design

Forty_eight C. gariepinus females were randomly assigned among sixteen 200-liter indoor plastic tanks at a density of three fish per tank supplied with tap water provided with air through air stones distributed evenly in the tanks. Experimental groups consisted of two replicates each (i.e., 6 females per treatment). Each group was randomly assigned to a particular stressful condition allocated in the experimental design Table 1. Experimental fish were injected gonadotropin releasing hormone analogue GnRHa (Cystorelin®, 40µg kg-1 female-1) and dopamine antagonists Domperidone (Gastromotil®, 10mg kg-1 female-1) intramuscularly of the dorsal fin to artificially induce them for spawning (Shourbela et al., 2014).

Stripping and collection of eggs

Female fish were checked for ovulation by making gentle pressure to the abdomen starting ten hrs post injection

and continued at one-hour intervals. The fish that produced stream of transparent green brown eggs were rated as ovulated (Richter et al., 1987). Meanwhile, Non-ovulated fish were backed to the tanks and kept under the respective treatment design. Eggs were obtained by applying gentle pressure to abdomen of ovulated females.

Fertilization and incubation

Eggs from individual treated females were fertilized with pooled milt obtained from macerated testes of three killed males Rothbard (1981). Pooled milt was added and the gametes were gently mixed. Water was added to activate sperm and the mix was allowed to stand for two minutes, then rinsed and held for an additional 2 minutes. Eggs of each female were incubated in large trays, and kept separated from other females eggs.

Reproduction and performance parameters

Female body weights (gm) were recorded at the start of the experiment. Weight of the ovulated eggs was estimated also. The number of ovulated eggs were calculated by multiplying egg weight in grams by 700 (1 gm=700 eggs) (Viveen et al., 1985). The latency period (the time between treatment and ovulation) was recorded. The percentage of fertilized eggs was determined by sampling 100 eggs per female at 24 h after fertilization, using a dissecting microscope. Likewise, mean percentage of embryos hatched was calculated for each female by counting three replicates of random samples of hatchlings inside petri dish (Rothbard, 1981). At two days post-hatching fry survival rate, dead larvae percentage and deformity percentage were recorded per female according to De Leeuw et al. (1985).

Statistical analysis

A one way analysis of variance (ANOVA) was performed at the beginning of the experiment for fish weight to ensure randomization. Spawning percentage was analyzed with the Chi-square test, other reproductive parameters were analyzed by one-way analysis of variance (ANOVA), using the general linear models procedure using Statistical Analysis System software (SAS Institute Cary, North Carolina, USA, 2004).

Results

Chi-square test indicated no significant differences ($P > 0.05$) were found in ovulation percentage among stressed and control brood fish. Meanwhile, the brood fish females of different treatment groups did not spawn completely with the exception of those of T1 and T5 (Tab. 2). At stripping, the latency period was within the range of 11.3 to 13 hrs for the eight experimental groups (Tab. 2). Significant differences were found among the experimental groups. The longer latency period reported for T7 (13 hrs). In contrary, the lowest latency periods were recorded for T8 (11.3 hrs).

Weight of eggs produced per female showed no significant differences ($P > 0.05$) among all treated brood fish groups with the exception of T1 (77.2 gm) which showed significant difference ($P < 0.05$) from other experimental groups (Tab. 2). Likewise, Females of T1 had the highest mean number of ovulated eggs (54,935 eggs) with a

significant difference ($P < 0.05$) from other experimental groups (Tab. 2). T1 and T5 brood fish had the highest significant ($P < 0.05$) fertilization and hatching rate (Tab. 3).

On the other hand, T8 brood fish was of the lowest fertilization rate (66.5 %) and T3 brood fish was the lowest hatching rate (60.9 %) (Tab. 3). Additionally, T2 brood fish had significantly higher deformity, dead larvae and survival rate percentage ($P < 0.05$) compared to other brood fish groups (14.1%, 7.1%, 78.8%, respectively) (Tab. 3). Significant differences ($P < 0.05$) among treatments were found for survival rate in T1 (94.3 %) compared to other brood fish groups.

Discussion

Stress can affect breeding in many ways, depending on the severity and duration of the stressor. It can accelerate spawning or inhibit reproduction or may resulting in greater number of gametes to compensate for poor-quality of gametes (Schreck, 2000; Gowaty et al., 2007). Low effective stress may both hasten and enhance acclimation to a stressor (Emlen et al., 1998). Previous studies showed degenerative changes in the gonad, oocyte atresia and inhibition of spawning as a result of stress (Clearwater and Pankhurst, 1997; Schreck, 2000). Stress has been found to inhibit aspects of the fish endocrine system responsible for breeding (Pankhurst and Van der Kraak, 1997; Pankhurst and Van der Kraak, 2000). Our results indicated successful induction of spawning of C. gariepinus using the spawning agent (Ataguba et al., 2009; Ndimele and Owdeindi, 2012; Marimuthu et al., 2015). Meanwhile, stress caused cessation in reproduction (number of stressed females did not spawn after spawning induction, (Tab. 2). This result confirms previous findings in broodfish (Carragher et al., 1989; Campbell et al., 1992). Meanwhile, all stressed African catfish C. gariepinus were spawned completely (Adebayo, 2006; Okanlawon, 2010).

Concerning the latency period, all C. gariepinus brood fish spawning 11-13 h after hormones injection. These results were higher than those reported by Shinkafi and Ilesanmi (2014) for African catfish, but it was lower than those reported in previous studies on carp (Arabaci et al., 2004; Falahatkar et al., 2013). Furthermore, experimentally stressed females exhibited significant reduced egg weight and average number of ovulated eggs in comparison to control females.

A stressful reproductive environment negatively impacts reproductive performance in many ways (Jardine et al., 1996; Janz et al., 1997; Bowron et al., 2009). Similarly, stressed catfish spawn fewer eggs numbers (Ayinla, 1991; Adebayo, 2006). Additionally, in other fish e.g. Cichlid N. pulcher, stressed females showed longer intervals between spawning clutch, and produce fewer eggs of smaller mass than control females (Mileva et al., 2011). Also in mature jundia, (Soso et al., 2008), red gunard, Chelidonichthys kumu, (Clearwater and Pankhurst, 1997), silver carp (Akar, 2011). Subsequent studies have shown that stress does indeed have a negative effect on reproduction performance (Campbell et al., 1994; Contreras-Sanchez et al., 1998; Schreck et al., 2001). It often appeared that stressed broodfish ovulated more eggs than non-disturbed fish e.g. catfish (Okanlawon, 2010) and cod (Morgan et al., 1999).

Results based on rates of egg fertilization and hatching were the higher in control group than stressed one. The differences observed in the current study may suggest that well-handled unstressed females produced better quality

eggs than stressed. Similarly, eggs spawned by stressed Atlantic cod Gadus morhua females had lower fertilization and hatching rates than eggs from unstressed females (Lambert et al., 2000; Bogevik et al., 2012; Eriksen et al., 2015). Additionally, broodfish with bruises (T3) had the lowest hatching rate, spawner with bruises had adverse effect on their reproduction performance (Alatise, 1988).

Furthermore, low dissolved oxygen for five hrs group (T6) produced lower fertilization and hatching percentage than in control group. Hypoxia reduces overall reproductive success by disturbing endocrine functions, which in turn affect gametogenesis, gamete quality, fecundity, fertilization success, hatching, and viability of larvae (Wu, 2003; Thomas et al., 2015).

Starved brood fish (T2) had significantly higher percentages of deformity, dead larvae and the lowest survival rate ($P < 0.05$) compared to other brood fish groups (14.1 %, 7.1 %, 78.8%; respectively) (Tab. 3). Those results suggested that not only maternal fitness is influenced by stress, but also that maternal stress may have repercussions for progeny fitness increasing generation of deformed larvae (Jensen, 1996). Nutritional status is an important factor in gamete quality and has been shown to be related inversely to nutritional condition and cod fecundity is reduced markedly by poor nutritional condition (Kjesbu et al., 1990; 1991). Likewise, Cerda et al. (1994) reported in sea bass Dicentrarchus labrax L. that reducing the dietary protein rates decrease offspring quality resulting in large degree of larvae deformities.

Stressed groups show lower offspring survival rate than control. In line with this, previous studies reported that exposing fish females to various stressors can be deleterious to offspring survival (Campbell et al., 1992; Eriksen et al., 2008; Mingist et al., 2007). In contrast, several experiments demonstrate no effect of parental stress on survival rates of the progeny (Small, 2004; Tierney et al., 2009; Eriksen et al., 2015). High density group show poor fecundity. Similarly, prolonged culture stress and high stocking density had adversely effect on reproduction (Bayunova et al., 2002).

An interesting findings from this study were that the lowest percentages of deformity, dead larvae, highest fertilization percentage and survival percentage was found in low dissolved oxygen for one hr group (T5) and control group (T1). Suggested that short period of stress can positively affected gamete quality. A small amount of stress has a positive effect and more severe stressors have a negative effect on reproductive performance. For example, physical conditioning involving low levels of stress, yet sufficient to activate the HPI, can enhance a condition of stress-resistance in fishes (Schreck et al., 1997; Schreck, 2000). Increased fecundity associated with short-term, low severity stress has been shown previously in other fish, e.g. rainbow trout (Oncorhynchus mykiss) (Contreras-Sánchez et al., 1998) and zebrafish (Faught et al., 2016).

Finally, it should be mentioned that African catfish offspring can be dramatically affected when their mothers have stressed during the induced spawning, revealed by lowered survival rates, increased frequency of morphological anomalies. These findings may be of interest both in conceptual and applied condition as they links the brood fish environment to subsequent viability of the progeny. In catfish hatcheries, brood fish are frequently disturbed during the breeding season and such practices may impact progeny quality. Thus, attempts to protect potential breeders from managemental disturbance during induced breeding would be secured because stressed fish

mothers are likely to create a less predictable and profitable product.

Acknowledgments

We would like to express our very sincere gratitude to Prof. Dr. Mohamed I. Sharaf, for his scientific support. The authors greatly appreciate the valuable assistance of Department of Animal Husbandry and Animal Wealth Development, (Fish breeding and production) Faculty of Veterinary Medicine, Alexandria University, Egypt.

References

Adamek, Z. and Sukop, I. 1995. Summer outdoor culture of African catfish (Clarias gariepinus) and tilapia (O. niloticus and O. aurea). Aquatic Living Resources, 8(4): 445-448. doi: http://dx.doi.org/10.1051/alr:1995053.

Adebayo, O.T. 2006. Repoductive performance of African clariid catfish clarias gariepinus broodstock on varying maternal stress. Journal of Fisheries International, 1(1-2): 17-20.

Akar, A.M. 2011. Effects of stress on Spawners reproductive performance in female grass carp (Ctenopharyngodon idella). Arabian Aquaculture Society 6(2): 171–180.

Appelbaum, S. a McGeer, J.C. 1998. Effect of diet and light regime growth and survival of African catfish (Clarias gariepinus) larvae and early juveniles. Aquaculture Nutrition, 4(3): 157–164. doi: 10.1046/j.1365-2095.1998.00064.x.

Arabaci, M., Cagirgan, H. and Sari, M., 2004. Induction of ovulation in ornamental common carp (Koi, Cyprinuscarpio L.) using LHRHa ([D-Ser (tBu)6 , Pro-Net]-LHRH) combined with haloperidol and carp pituitary extract. Aquaculture Research, 35(1): 10–14. doi: 10.1111/j.1365-2109.2004.00969.x.

Ataguba, G.A., Annune, P.A. and Ogbe, F.G. 2009. Induced breeding and Early Growth of Progeny from crosses between two African Clariid fishes, Clarias gariepinus (Burchell) and Heterobranchus longifilis under hatchery conditions. Journal of Applied Biosceiences, 14: 595-600.

Alatise, O. M. 1988. Fish breeding and fish seed multiplication. Proceeding of the National fish farmers workshop (A. M. Ajana ed):117-132.

Ayinla, O.A 1991. Feed Requirement and fattening of Broodstocks. Proceedings of the seed propagation course. (O.A.Ayinla,Ed) .Nigerian Institute of Oceanography and Marine Research, Lagos, Nigeria,PP.20-24.

Bayunova, L.V., Barannikova, I.A. and Semenkova, T.B. 2002. Sturgeon stress reactions in aquaculture. Journal of Applied Ichthyology, 18(4-6): 397–404. doi: 10.1046/j.1439-0426.2002.00410.x.

Bœuf, G. and Le Bail, P.Y. 1999. Does light have an influence on fish growth? Aquaculture, 177: 129-152. doi:10.1016/S0044-8486(99)00074-5.

Bogevik, A., Natário, S., Karlsen, Ø., Thorsen, A., Hamre, K., Rosenlund, G. and Norberg, B., 2012. The effect of dietary lipid content and stress on egg quality in farmed Atlantic cod Gadus morhua. Journal of Fish Biology, 81(4): 1391–1405. doi: 10.1111/j.1095-8649.2012.03425.x.

Bowron, L.K., Munkittrick, K.R., McMaster, M.E., Tetrault, G. and Hewitt, L.M., 2009. Responses of white sucker (Catostomus commersoni) to 20 years of process and water treatment changes at a bleached kraft pulp mill, and to mill shutdown. Aquatic Toxicology, 95(2): 117–132. doi: 10.1016/j.aquatox.2009.08.009.

Bromage, N. 1995. Broodstock management and seed quality - general considerations. In: N.R. Bromage and R.J. Roberts (Editors), Broodstock management and egg and larval quality. Blackwell Science, Oxford, pp. 1-24.

Brzuska, E. 2002. Artificial spawning of African catfish, Clarias gariepinus: stimulation of ovulation using carp pituitary or Ovopel. Journal of Applied Aquaculture, 12(4): 13–22. doi: 10.1300/J028v12n04_02.

Campbell, P.M., Pottinger, T.G. and Sumpter, J.P. 1992. Stress reduces the quality of gametes produced by rainbow trout. Biology of Reproduction, 47(6): 1140-1150. doi: 10.1095/biolreprod47.6.1140.

Campbell, P.M., Pottinger, T.G. and Sumpter, J.P. 1994. Preliminary evidence that chronic confinement stress reduces the quality of gametes produced by brown and rainbow trout. Aquaculture, 120(1-2): 151-169. doi:10.1016/0044-8486(94)90230-5.

Carragher, J.F., Sumpter, J.P., Pottinger, T.G. and Pickering, A.D. 1989. The deleterious effects of cortisol implantation on reproductive function in 2 species of trout, Salmo trutta L. and Salmo gairdneri Richardson. General and Comparative Endocrinology, 76(2): 310-321. doi :10.1016/0016-6480(89)90163-9.

Cerda, J., Carrillo, M., Zanuy, S., Ramos, J. and de la Higuera, M. 1994. Influence of nutritional composition of diet on sea bass, Dicentrarchus labrax L., reproductive performance and egg and larval quality. Aquaculture, 128(3-4): 345–361. doi:10.1016/0044-8486(94)90322-0.

Clearwater, S.J. and Pankhurst, N.W. 1997. The response to capture and confinement stress of plasma cortisol, plasma sex steroids and vitellogenic oocytes in the marine teleost, red gunard. J. Fish Biology, 50(2): 429–441. doi: 10.1111/j.1095-8649.1997.tb01370.x.

Contreras-Sánchez, W.M., Schreck, C.B., Fitzpatrick, M.S. and Pereira, C.B. 1998. Effects of stress on the reproductive performance of rainbow trout (Oncorhynchus mykiss). Biology of Reproduction, 58: 439–447. doi:10.1095/boil reprod58.2.439.

De Graaf, G. and Janssen, H. 1996. Artificial reproduction and pond rearing of the African catfish Clarias gariepinus in sub-Saharan Africa. FAO Fisheries Technical Paper, 362(73). Food and Agriculture Organization of the United Nations, Rome, Italy.

De Leeuw, R., Goos, H.J., Richter, C.J. and Eding, E.H. 1985. Pimozide-LHRHa induced breeding of the African catfish, Clarias gariepinus. Aquaculture, 44(4): 295–302. doi:10.1016/0044-8486(85)90228-5.

El Nagger, G.O, John, G., Rezk, M.A., Elwan, W. and Yehia, M. 2006. Effect of varying density and water level on the spawning response of African catfish Clarias gariepinus: implications for seed production. Aquaculture, 261:904-907. doi:10.1016/j.aquaculture.2006.07.043.

Emlen, J.M., Freeman, D.C., Mills, A. and Graham, J.H. 1998. How organisms do the right thing: the attractor hypothesis. Chaos, 8(3): 717–726. doi: 10.1063/1.166355.

Eriksen, M.S., Espmark, A.M., Poppe, T., Braastad, B.O., Salte, R. and Bakken, M. 2008. Fluctuating asymmetry in farmed Atlantic salmon (Salmo salar) juveniles: also a maternal matter? Environmental Biology of Fishes, 81(1):87–99. doi: 10.1007/s10641-006-9174-5.

Eriksen, M.S., Poppe, T.T., McCormick, M., Damsgard, B., Salte, R., Braastad, B. and Bakken, M. 2015. Simulated maternal pre-spawning stress affects offspring's attributes in farmed Atlantic salmon Salmo salar (Linnaeus, 1758). Aquaculture Research, 46(6): 1480–1489. doi 10.1111/are.12301.

Faught, E., Best, C. and Vijayan, M. M. 2016. Maternal stress-associated cortisol stimulation may protect embryos from cortisol excess in zebrafish. Royal Society open science, 3(2): 160032. doi:10.1098/rsos.160032.

Falahatkar, B., Poursaeid, S., Langroudi, H., Efatpanah, I., Meknatkhah, B. and Rahmati, M. 2013. Spawning induction in Kutum, Rutilus frisii kutum (Kamensky), with different hormones: Analysis of hormone profiles and induced spawning success. Archives of Polish Fisheries, 21: 271-281. DOI 10.2478/aopf-2013-0028.

Gowaty, P.A., Anderson, W.W., Bluhm, C.K., Drickamer, L.C., Kim, Y.K. and Moore, A.J. 2007. The hypothesis of reproductive compensation and its assumptions about mate preferences and offspring viability. Proceedings of the National Academy Science, 104: 15023–15027.

Han, D., Xie, S., Lei, W., Zhu, X. and Yang, Y. 2004. Effect of ration on the growth and energy budget of Chinese longsnout catfish, Leiocassis longirostris Günther. Aquaculture Research, 35(9):866-873. doi: 10.1111/j.1365-2109.2004.01078.x.

Hecht, T., Oellermann, L. and Verheust, L. 1996. Perspective on clariid catfish culture in Africa. Aquatic Living Resources 9: 197-206.

Janz, D.M., McMaster, M.E., Munkittrick, K.R. and Van Der Kraak, G. 1997. Elevated ovarian follicular apoptosis and heat shock protein-70 expression in white sucker exposed to bleached kraft pulp mill effluent. Toxicology and Applied Pharmacology, 147(2): 391–398. doi:10.1006/taap.1997.8283.

Jardine, J.J., Van Der Kraak, G.J. and Munkittrick, K.R. 1996. Capture and confinement stress in white sucker exposed to kraft pulp mill effluent. Ecotoxicology and Environmental Safety, 33(3): 287–298. doi:10.1006/eesa.1996.0037.

Jensen, A.L. 1996. Berverton and Holt life history invariants results from optimal trade-off of reproduction and survival. Canadian Journal of Fisheries and Aquatic Sciences, 53(4): 820-822. doi: 10.1139/f95-233

Kjesbu, O.S., Klungsoeyr, J., Kryvi, H., Witthames, P.R. and Greer Walker, M. 1991. Fecundity, atresia, and egg size of captive Atlantic cod (Gadus morhua) in relation to proximate body composition. Canadian Journal of Fisheries and Aquatic Sciences, 48(12): 2333–2343. doi: 10.1139/f91-274.

Kjesbu, O.S., Witthames, P.R., Solemdal, P. and Greer Walker, M. 1990. Ovulatory rhythm and a method to determine the stage of spawning in Atlantic cod (Gadus morhua). Canadian Journal of Fisheries and Aquatic Sciences, 47(6): 1185–1193. Doi: 10.1139/f90-138.

Lambert, Y., Dutil, J.D. and Ouellet, P. 2000. Nutritional condition and reproductive success in wild fish populations. In: Norberg, B., Kjesbu, O.S., Taranger, G.L., Andersson, E., Stefansson, S.O. (Eds.), Proc. 6th International Symposium Reproductive Physiology of Fish. Bergen, pp: 77–84.

Leitritz, E. and Lewis, R.C. 1980. Trout and Salmon culture. University of California. California fish bulletin 164, 197 pp.

Marimuthu, K., Satthiyasilan, N., Rahman, M., Arshad, A., Raj, M., and Arockiaraj, J. 2015. Induced ovulation and spawning of African catfish Clarias gariepinus (Bloch) using ovaprim: Journal of Environment and Biotechnology Research, 1(1): 2-9. doi.org/10.4172/2155-9546.1000133.

Mileva, R., Gilmour, K.M. and Balshine, S. 2011. Effects of maternal stress on egg characteristics in a cooperatively breeding fish. Comparative Biochemistry and Physiology, 158: 22–29. doi:10.1016/j.cbpa.2010.08.017.

Mingist, M., Kitani, T., Koide, N. and Ueda, H. 2007. Relationship between eyed-egg percantage and levels of cortisol and thyroid hormone in masu salmon Oncorhynchus masou. Journal of Fish Biology, 70: 1045–1056. doi: 10.1111/j.1095-8649.2007.01362.x.

Morgan, M.J., Wilson, C.E. and Crim, L.W. 1999. The effects of stress on reproduction in Atlantic cod. Journal of Fish Biology, 54(3): 477–488. doi: 10.1111/j.1095-8649.1999.tb00629.x.

Ndimele, P.E. and Owodeinde, F.G. 2012. Comparative Reproductive and Growth Performance of Clarias gariepinus (Burchell, 1822) and Its Hybrid Induced with Synthetic Hormone and Pituitary Gland of Clarias gariepinus. Turkish Journal of Fisheries and Aquatic Sciences, 12(3): 619-626. doi: 10.4194/1303-2712-v12_3_09.

Okanlawon, S. S. 2010. Reproductive fitness of stressed female catfish broodstock of clarias gariepinus (Burchell, 1822). PAT. 6(1):77-83.

Olumuji, O. K. and Mustapha, M.K. 2012. Induced Breeding of African Mud Catfish, Clarias gariepinus (Burchell 1822), using Different Doses of Normal Saline Diluted Ovaprim. Journal of Aquaculture Research and Development, 3(4):133. doi: 10.4172/2155-9546.1000133.

Pankhurst, N.W. and Van Der Kraak, G. 1997. Effects of stress on growth and reproduction. In: Iwama, G.K., Pickering, A.D., Sumpter, J.P., Schreck, C.B. (Eds.), Fish Stress and Health in Aquaculture. Cambridge University Press, Cambridge, pp: 73–93.

Pankhurst, N.W. and Van Der Kraak, G. 2000. Evidence that acute stress inhibits ovarian steroidogenesis in rainbow trout in vivo, through the action of cortisol. General and Comparative Endocrinology, 117(2): 225–237. doi:10.1006/gcen.1999.7401.

Rothbard, S. 1981. Induced reproduction in cultivated cyprinids - the common carp and the group of Chinese carps. I. The technique of induction, spawning and hatching. Bamidgeh, 33: 103-121.

Richter, C.J., Eding, E.H., Goose, H.J., De Leeuw, R., Scott, A.P. and Van Oordt P.G. 1987. The effect of pimozide/LHRHa and 17 alpha-hydroxyprogesterone on plasma steroid levels and ovulation in the African catfish, Clarias garpienus, Aquaculture, 63, 157 – 168. doi:10.1016/0044-8486(87)90068-8.

SAS (2004): SAS institute / STAT Guide for personal computers, 6th ed. Cary, NC.

Schreck, C.B. 2000. Accumulation and long-term effects of stress in fish. In: Moberg, G.P., Mench, J.A. (Eds.), The biology of animal stress. CAB International, Wallingford, pp. 147–158.

Schreck, C.B. 2010. Stress and fish reproduction: the roles of allostasis and hormesis. General Comparative Endocrinology, 165: 549–556. doi:10.1016/j.ygcen.2009.07.004.

Schreck, C.B., Contreras-Sanchez, W. and Fitzpatrick, M.S. 2001. Effects of stress on fish reproduction, gamete quality and progeny. Aquaculture, 197: 3–24. doi:10.1016/S0044-8486(01)00580-4.

Schreck, C.B., Olla, B.L. and Davis, M.W. 1997. Behavioral responses to stress. In: Iwama, G.W., Sumpter, J., Pickering, A.D., Schreck, C.B. (Eds.), Fish Stress and Health in Aquaculture. Cambridge University Press, Cambridge, pp. 745–770.

Shourbela, R., Abd El-latif, A. and Abd-El-Azem .M.A. 2014. Induced spawning of African catfish, clarias gariepinus using GnRha combined with dopamine antagonists. Benha Veterinary Medical Journal, 27(2): 25-35.

Shinkafi, B.A. and Ilesanmi, B.D. 2014. Effect of Varying Doses of Ovatide on the Breeding Performance of African Catfish (Clarias gariepinus Burchell, 1822) in Sokoto, North-western Nigeria. Asian Journal of Animal Sciences, 8: 56-64. doi: 10.3923/ajas.2014.56.64.

Small, B.C. 2004. Effect of dietary cortisol administration on growth and reproductive success of channel catfish. Journal of Fish Biology, 64(3): 589–596. doi: 10.1111/j.1095-8649.2004.00322.x.

Soso, A.B., Barcellos, L.G. and Ranzani-Paiva, M.J. 2008. The effectsof stressful broodstock handling on hormonal profiles and reproductive performance of Rhamdia quelen (Quoy and Gaimard) females. Journal of the World Aquaculture Society, 39(6): 835–841. doi: 10.1111/j.1749-7345.2008.00221.x.

Teugels, G.G. 1984. The nomenclature of African Clarias speciesused in aquaculture. Aquaculture 38(4): 373–374. doi:10.1016/0044-8486(84)90342-9.

Thomas, P., Rahman, M. S., Picha, M.E. and Tan, W. 2015. Impaired gamete production and viability in Atlantic croaker collected throughout the 20,000km2 hypoxic region in the northern Gulf of Mexico. Marine Pollution Bulletin, 101(1): 182-192. doi:10.1016/j.marpolbul.2015.11.001.

Tierney, K.B., Patterson, D.A. and Kennedy, C.J. 2009. The influence of maternal condition on offspring performance in sockeye salmon Oncorhynchus nerka. Journal of Fish Biology, 75(6): 1244–1257. doi: 10.1111/j.1095-8649.2009.02360.x.

Verreth, J., Eding, E.H., Rao, G.M., Huskens, F. and Segner, H. 1993. A review of feeding practices, growth and nutrition physiology in larvae of the catfishes Clarias gariepinus and Clarias batrachus. Journal of World Aquaculture Society, 24(2): 135–144. doi: 10.1111/j.1749-7345.1993.tb00002.x.

Viveen, W.R., Richter, C.J., Van-Oordt, P.G.W., Janssen, J.A.L. and Huisman, E.A. 1985. Practical manual of the culture of African catfish, Clarias gariepinus: Directorate General International Cooperation for the Ministry of Foreign. 129 p.

Wu, R.S., Zhou, B.S., Randall, D.J., Woo, N.Y. and Lam, P.K. 2003. Aquatic hypoxia is an endocrine disrupter and impairs fish reproduction. Environmental Science and Technology, 37(6): 1137-1141. doi: 10.1021/es0258327.

Table 1. The experimental design.

Treatments	Stressors
T1	Good condition without any stress (Control).
T2	Starvation for ten days before hormonal injection.
T3	Harvesting stress (bruises due to poor handling before hormonal injection).
T4	Netting (fish chased with a dip net in the tank every one hour for 2 minutes after hormonal injection).
T5	Oxygen stress (one hour out of water before hormonal injection).
T6	Oxygen stress (five hours out of water before hormonal injection).
T7	Crowding stress (two-fold increase in density after hormonal injection)
T8	Crowding stress, (four-fold increase in density after hormonal injection).

Table 2. Female weights (gm), ovulation %, latency period (hrs), egg weight (gm) as well as number of ovulated eggs of African catfish (C. gariepinus) as influenced by various Treatments (LSM ± SD).

Treatments	Number	Fish weight (g)	Ovulation %	Latency period (hrs)	Egg weight (g)	Egg number
T1	6	714.2 ± 36.0	100.0	11.5 ± 0.5^{c}	77.2 ± 7.8^{a}	$54{,}935 \pm 4{,}735^{a}$
T2	6	704.3 ± 63.2	66.67	12.7 ± 0.5^{ab}	50.5 ± 6.5^{b}	$36{,}002 \pm 4{,}262^{b}$
T3	6	671.1 ± 54.9	66.67	12.2 ± 0.9^{abc}	51.7 ± 8.9^{b}	$34{,}955 \pm 5{,}054^{b}$
T4	6	647.2 ± 67.2	66.67	11.5 ± 0.5^{c}	55.8 ± 5.1^{b}	$39{,}975 \pm 3{,}234^{b}$
T5	6	692.1 ± 66.3	100.0	11.8 ± 0.7^{c}	53.2 ± 7.3^{b}	$37{,}071 \pm 4{,}855^{b}$
T6	6	625.7 ± 45.5	83.33	12.8 ± 0.8^{ab}	50.9 ± 5.3^{b}	$35{,}184 \pm 3{,}527^{b}$
T7	6	685.9 ± 69.5	66.67	13.0 ± 0.8^{a}	55.6 ± 7.5^{b}	$37{,}498 \pm 4{,}623^{b}$
T8	6	657.3 ± 68.2	50.00	11.3 ± 0.6^{c}	47.5 ± 6.5b	$32{,}730 \pm 3{,}943^{b}$

Means in the same column with similar letters are not significantly different (P> 0.05).

Table 3. Percentage of fertilization (%) at 24 hrs of incubation, hatching rate (%), deformity (%), dead larvae (%) as well Survival rate (%) of African catfish (C. gariepinus) as influenced by various Treatments (LSM ± SD).

Treatments	Fertilization (%)	Hatching (%)	Deformity (%)	Dead larvae (%)	Survival rate (%)
T1	81.1 ± 5.7^{a}	83.7 ± 5.7^{a}	2.70 ± 1.5^{ef}	2.8 ± 1.4^{cd}	94.3 ± 2.1^{a}
T2	70.0 ± 7.0^{bc}	64.1 ± 3.6^{d}	14.1 ± 4.9^{a}	7.1 ± 2.5^{a}	78.8 ± 4.8^{c}
T3	74.6 ± 6.6^{abc}	60.9 ± 6.6^{d}	5.60 ± 1.6^{bcd}	5.2 ± 2.7^{b}	89.1 ± 3.6^{b}
T4	75.1 ± 6.5^{ab}	76.7 ± 7.2^{ab}	4.40 ± 2.2^{de}	5.9 ± 1.8^{ab}	89.6 ± 3.8^{b}
T5	80.2 ± 7.5^{a}	80.1 ± 8.3^{a}	2.40 ± 1.6^{f}	1.5 ± 1.1^{d}	96.0 ± 1.7^{a}
T6	71.2 ± 5.8^{bc}	71.9 ± 9.3^{bc}	5.10 ± 2.0^{d}	4.3 ± 2.3^{bc}	90.5 ± 3.8^{b}
T7	70.1 ± 7.3^{bc}	65.1 ± 8.3^{cd}	7.55 ± 1.1^{b}	4.2 ± 2.3^{bc}	88.2 ± 2.0^{b}
T8	66.5 ± 8.4^{c}	71.8 ± 5.1^{bc}	7.00 ± 1.5^{bc}	5.1 ± 2.2^{b}	87.9 ± 2.8^{b}

Means in the same column with similar letters are not significantly different (P> 0.05).