Journal of Advances in Biology & Biotechnology

20(1): 1-6, 2018; Article no.JABB.14325
ISSN: 2394-1081

An Overview on the Processes Involved in the Production of Triploid Fish for Aquaculture

Iyiola, Adams Ovie[1,2*] and Umma, Samuel Bem[1,3]

[1]Department of Aquaculture and Fisheries Management, University of Ibadan, Nigeria.
[2]Department of Fisheries and Wildlife Management, Osun State University, Nigeria.
[3]Department of Fisheries and Aquaculture, Federal University, Wukari, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JABB/2018/14325
Editor(s):
(1) Dr. Cosmas Nathanailides, Professor, Department of Fisheries and Aquaculture Technology, Technological Educational Institute of West Greece, Greece.
Reviewers:
(1) Rosaria Meccariello, Università di Napoli Parthenope, Italy.
(2) Ghasem Askari, Gorgan University Agriculture and Natural Resources, Iran.
(3) Roberto Ferreira Artoni, Universidade Estadual de Ponta Grossa, Brazil.
Complete Peer review History: http://www.sdiarticle3.com/review-history/14325

Mini-review Article

Received 26 September 2014
Accepted 21 November 2014
Published 04 February 2019

ABSTRACT

Production of Triploid fish for aquaculture involves the manipulation of chromosome number of cultured fish to produce offspring with three sets of chromosomes. They have a large cell size and nucleus which contains 33% more alleles for growth thereby exhibiting fast growth which is a good culture characteristic. Triploid fish can be produced by applying shock either through temperature (cold shock- 2^{o}C to 6^{o}C and heat shock- 38 to 40^{o}C), pressure (7000 – 10000psi) or the use of chemicals (Cytochalasin B, Nitrous oxide) to fertilized eggs. The use of temperature shock is less expensive with pressure and heat shock giving the best results. The success of shock induction depends on the time and duration of shock, the temperature and pressure used. Sterility in triploids occurs as a result of genetic incompatibility of chromosome sets during meiosis to form two equal haploid sets thereby producing abnormal gametes and the sterility leads to increased growth. Triploids exhibit good carcass quality and can help to increase fish production and reduced the risk of genetic pollution of wild stocks when they are accidentally or intentionally released into aquatic ecosystems. The production of triploids for aquaculture can therefore be encouraged for increased production and the ethical aspects should be addressesed.

**Corresponding author: adamsovieiyiola@yahoo.com;*

Keywords: Triploid fish; shock induction; growth performance; environmental effects.

1. INTRODUCTION

In Aquaculture, production of triploids for aquaculture involves the manipulation of chromosome number of fish species to produce three sets (3n). These species possess a large cell size and nucleus which contains 33% more alleles for growth. They have aneuploid gametes thereby producing abnormal and sub-viable offsprings which do not live long; they have a fast growth characteristic and are generally sterile [1]. The success of this process depends on the proper optimization of shock duration and time of initiation after fertilization [2]. Fertile hybrids pose threats of interbreeding with wild stocks [3]; this can be resolved by the production of triploid fish and if such fish escape to the wild, fears of becoming established or contaminating local gene pools of established species are reduced thereby preserving the genetic viability and biodiversity of the environment.

Aquaculture is a way to meet up increasing demand of fish and attainment of self sufficiency, with the limitation of unreliable supply of fish seed of good quality (fast growing fishes). As a result of this, there have to be the development of improved seeds that can contribute to increased fish production to offset the deficit as well as protecting the biodiversity [4]. Production of Triploid fish for aquaculture can help to increase fish yield by improving their growth rate. It may raise issues about ethics, health, religious, and preservation of species etc. Some individuals believe that it is un-ethical to manipulate the form of fish as well as the side effects from consuming such fish species. Based on their characteristics of improved carcass quality and Amino acid profile and other benefits, the production of triploid species for aquaculture is advantageous, hence a study on the production of triploids for aquaculture is essential and its use for fisheries management purposes; although limitations may arise on the aspect of adequate funding by government for research purposes.

2. CHROMOSOME MANIPULATION AND PRODUCTION OF TRIPLOIDS

It is easy to manipulate the chromosome number of most species because fertilization occurs externally. The techniques used to alter chromosome number are similar and can be divided into three categories: temperature, pressure and chemical shocks. Triploids contain 3 sets of haploid chromosomes and are created by applying shock to newly fertilized eggs [2]. The shock is introduced shortly after fertilization in which the second polar body is retained in the nucleus [2]. The fertilized eggs contain three haploid nucleuses (3n); one from the egg, the other from the sperm and final one from the second polar body [5]. The three haploids fuse together to form a zygote and develops into a triploid fish [6,3].

2.1 Pressure Shock

It involves the use of pressure chambers at pressure ranging from 7000 to 10,000 psi for several minutes shock to eggs [2]. The number of eggs that can be shocked is a function of the size of the cylinder. Safety measures must be taken because cylinders can rupture or blow up when the air in cylinder is not bled properly. Shocks for 2.5 – 9 minutes after fertilization at 7500 – 9000psi have been applied to Tilapia [1].

2.2 Temperature Shock

It involves altering the temperature of water baths to shock eggs and the duration of shock induction varies with species of fish [3]. Heat shock involves the use of a thermo-regulatory chamber at optimal temperature of 38 to 40°C for 4.5 - 6 minutes at 3-4minutes after fertilization to heat the water in bath [1,7]. Cold shock involves reducing the temperature for in water bath to between 2°C - 6°C for 30 – 40 minutes at 3 – 4 minutes after fertilization to shock eggs [3]. Cold shock produces better results for warm water fish species such as African catfish, Common carp. Channel catfish, *Tilapia aurea, T. mossambica, T. nilotica* and Heat shock for cold water species such as Chinook salmon and Channel catfish [3]. The temperatures needed to alter chromosome numbers are quite precise therefore it is important that both the volume and temperature control mechanisms are sufficient to prevent temperature fluctuations while eggs are shocked [5]. Heat shocks are the easiest for most fish culturist because only less expensive save equipments and materials are used [3].

2.3 Chemical Shock

It involves the use of chemicals to induce shock to fertilized eggs [2]. Chemicals such as Nitrous oxide and Cytochalasin B can be used. Chemical shocks are not often used because they seem to produce hybrids with large numbers of mosaics (fish having cells of various ploidy levels).

3. CHARACTERISTICS OF TRIPLOIDS

The following characteristics distinguish triploid fish species from other hybrids:

- Fast growth: Generally, they are larger than diploids because they have larger cell size and contain 33% more alleles for growth [3].
- Sterility: They have aneuploid gametes in that they contain unbalanced chromosomes which cannot pair and align properly to form equal haploid sets during meiosis [8,9].
- Improved carcass quality: Triploid hybrids contain more essential amino acids than their parents [10].
- Improved resistance to diseases: Triploid catfish have increased resistance to Infectious haematopoetic necrosis virus (IHN) that attacks diploids [11].
- They are less aggressive as compared with diploids [3].

4. CULTURE PERFORMANCE OF TRIPLOIDS

The culture performances of triploids have been compared with their normal counterparts by different authors [Table 1] with different conclusions but superiority of triploids in terms of growth was generally observed.

5. SUCCESSES IN TRIPLOD CULTURE

Triploids have been induced both in fin and shell fish using different methods and yielding different results.

- *Clarias gariepinus* triploids was induced by Oyebola [12] using cold shock of 5°C and 7°C for 30 minutes at 3-4 minutes after fertilization and it was observed that 5°C produced better result in terms of early survival and growth rate than 7°C.
- *C. gariepinus* triploids using heat shock at 40°C and 41°C at 4 - 6mins of fertilization and it was observed that there was 100% triploidy at 40°C at 3 minutes after fertilization for 4.5 minutes as observed by Ayinla et al. [7].
- *C. gariepinus* triploids produced by applying cold shock at 5°C for 40 minutes from 3-4 minutes after fertilization was observed that there was 100% triploidy as observed by Hammed et al. [4]; Olufeagba et al. [13] and Olufeagba and Yisa [14].
- *Heterobranchus longifilis* triploids produced by cold shocking of eggs at 5°C for 40 minutes at 3-4 minutes after fertilization, 100% triploidy was achieved as observed by Aluko et al. [15]; Dawley et al. [16] and Olufeagba [17].
- *Oerochromis niloticus* triploids produced by heat shock at 41°C at 3.5mins and 4.5 minutes, 70% percentage survival was observed at 3.5 minutes and no survival at 4.5 minutes [18].
- *O. niloticus* triploids produced by applying pressure shock at 8000psi for 2minutes at 9mins after fertilization, 85% hatchlings survival were observed [18].
- *O. niloticus* produced by applying cold shock at 9°C, 11°C and 13°C at 7, 0.5-5 and 5mins for 30, 60 and 45 minutes after fertilization, 67%, 41-50% and 6.1% hatchlings survival was observed respectively [18].
- Weigwo et al. [19] produced triploid oysters by application of chemical treatment with Cytochalasin B at 1mg/l and increased size and weight was observed.

6. ISSUES ASSOCIATED WITH TRIPLOIDS AND SOLUTIONS

Triploids are sterile and cannot be used for propagation because they contain uneven number of chromosomes which cannot align and pair equally during meiosis as compared with diploids that contains the same number of chromosomes and pair during meiosis [5]. Early survival of triploids is low and can be attributed to the shock used to prevent the extrusion of the second polar body.

The increased early mortality may be due to the adverse effect the shock has on the egg cytoplasm [3]. Tetraploids can mate with diploids to produce triploids [11,17]. Brodsky and Cohen [23] found out that this procedure improved early survival of triploids. Triploids produced in this manner are called interploid triploids so as to

Table 1. Culture performance of triploid fish species

Biotypes	Results	References
African catfish (*Clarias gariepinus*)	Triploids species grew faster and high survival rate at swim up fry than diploids	[5,20]
Heterobranchus longifilis	Triploids exhibited better survival than cultured diploids	[17]
Oerochromis aureus in hapas	Triploids grew better than diploids	[21]
Oerochromis niloticus in recirculatory systems	Triploids grew better	[22]
O. niloticus cultured in aquaria systems	Triploids grew faster than diploids	[21]
Bivalves	Triploids grew faster than diploids when observed until maturity.	[21]

differentiate them from triploids produced by the prevention of meiosis (shocking the fertilized eggs to prevent the extrusion of polar body). The misuse and inappropriate usage of chemicals during chemical shock have adverse effects on hormone balance, causes body developmental problems and interferes with the reproductive systems causing early puberty in girls and putting them at risk of development of breast cancer therefore chemicals used for shock induction must be at recommended dosages so as to avert these issues in humans [23].

7. ECONOMIC IMPORTANCE OF TRIPLOID PRODUCTION

Production of triploids for aquaculture on the long run has a lot of benefits to the farmers in terms of profit maximization. The initial production of triploids poses a huge financial burden in respect to method of shock induction; temperature shock among the methods of shock induction such as pressure and chemical is relatively cheaper. Also, the food conversion ratio of triploids are high thereby making fish available for market within a short period and attracts a high market value due to its increased size as compared to diploids. Its culture might double the production cycle of diploids in one production season thereby increase productivity.

8. CONCLUSION

It can be noted that the production of triploid fish for aquaculture has a lot of benefits to the the immune, neurological, hematological and reproductive system in humans [23]. Scientsts in the European Union discovered that residual effects from the misuse of chemicals have adverse effects on humans as it disrupts farmers in terms of profit maximization and fish species are available for market within the shortest time of production period, thereby, increasing productivity because its culture might double the production cycle of diploids in one production season. The fast growth characteristic makes triploid fish a good culture determinant because they are sterile and the energy required for gamete production is converted for growth. Due to their sterility, the fear of environmental impacts or contaminating local gene pools if they escape to the wild are prevented therefore preserving the genetic diversity of local wild species. Based on all these, Government and stakeholders can intervene in respect of providing triploid fish seed production centers or hatcheries so that fish farmers can get triploid seeds and at affordable price, thereby eliminating any form of initial cost investments on the part of the farmer. This can go a long way in increasing productivity and profit margin and can attract more farmers into the aquaculture venture trade. The Government and stakeholders should provide funding to procure facilities for genetic improvement in this field to support research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Aluko PO. Effects of cold and warm shocks on the ploidy of *Clarias gariepinus*. Nig. J. Biotech. 2001;10(1):197-199.
2. Olufeagba SO, Aluko P, Omotosho JS, Oyewole SO, Raji A. Preliminary report on the growth performance of triploid *Heterobranchus longifilis*. Paper presented at FISON Conference; 1996.
3. Fast AW. Triploid Chinese catfish. Center for tropical and subtropical aquaculture publication. 1998;134:1-4.
4. Hammed A, Fashina-Bombata H, Osinaike A. The use of cold shock in inducing triploidy in African mud cat fish *Clarias gariepinus.* African Journal of Biotechnology. 2010;9(12):1844-1847.
5. Olufeagba SO, Aluko PO, Omotosho JS, Oyewole SO, Raji A. Triploidy production in *Heterobranchus longifilis* (Family: Clariidae) by old shock. In: 13th Annual Conference of the Fisheries Society of Nigeria (FISON), 3-8 November, New Bussa, Nigeria; 2005.
6. Aluko PO. Growth and survival of triploid *Heterobranchus longifilis.* National Institute for Fresh Water Fisheries Research, Annul Report, New Bussa. 1998;102-109.
7. Ayinla OA, Adeogun OA, Oguntade OR, Ajao EA. The payoffs of Aquaculture research: An assessment of hybrid catfish. proceedings of the 20th annual conference of FISON, Nov 14th – 18th; 2009.
8. Food and Agriculture Organization of the United Nations. FAO yearbook; 2009 Fishery and Aquaculture Statistics.
9. Mair B. Production of second-generation triploid and tetraploid rainbow trout by matingtetraploid males and diploid females potential of tetraploid fish. Theor. Appl. Genet. 2003;72:193-206.
10. Effiong BN, Tafa JL. Proximate composition of nutrients in adult *Clarias gariepinus*, *Heterobranchus longifilis* and their hybrid (Heteroclarias). Department of Fish Processing and Storage. Federal College of Freshwater Fisheries Technology, P.M.B 1500, New Bussa, Niger state; 2005.
11. Dorson D, Nlewadim AA, Onuoha GC. Studies on the growth and survival of fry and fingerlings of clariid catfish species: *Clarias gariepinus* (Burchell, 1822), *Heterobranchus bidorsalis* (Geoffroy, 1809) and *Heterobranchus longifilis* (Valenciennes, 1840). Journal of Aquaculture in the Tropics. 2001;19(1):1–14.
12. Oyebola O. Comparative study of genetically improved triploid *Clarias gariepinus* induced by cold shocking. An M.Sc dissertation submitted to Department of Aquaculture and Fisheries Management, University of Ibadan; 2001.
13. Olufeagba SO. Induced triploid *Heterobranchus longifilis* (Val. 1840) (family Clariidae) and its aquacultural potentials. Ph.D. thesis, Dept. Biological Science, Univ. of Ilorin (Nigeria). 2008;161.
14. Olufeagba SO, Yisa Moses. Monosex production of African catfish, *Heterobranchus longifilis*, through gynogenesis and androgenesis. International Journal of Fisheries and Aquaculture. 2010;3(4)64-69.

    © April 2011 Academic Journals.
15. Aluko PO, Aluko JF, Aremu A. Induced Tetraploidy in the African Catfish *Clarias anguillaris*. National Institute for Fresh Water Fisheries Research, Annul Report, New Bussa. 1999;94-100.
16. Dawley, et al. Effects on stress on reproductive, gamete quality and progeny. Aquaculture 197. 1987;303–320.
17. Olufeagba SO. Induced triploid *Heterobranchus longifilis*, Valenciennnes, 1840 (Family Clariidae) and its aquacultural potentials. Ph.D Thesis, University of Ilorin; 1999.
18. Hussain MG, Chatterji A, McAndrew BJ, ohnstone R. Triploidy induction in Nile tilapia, *Oreochromis niloticus* L. using pressure, heat and cold shocks. Theor. Appl. Genet. 2010;81:6-12.
19. Weigno Jiang, Gang Li, Gougiang Xu, Yueguang Lin, Ning Qing. Growth of induced triploid pearl oyster. *Pinctada martensii* (1) Aquaculture III. 1993;245–253.
20. Olufeagba SO, Aluko PO, Omotosho JS, Oyewole SO, Raji A. Triploidy induction in Heterobranchus longifilis (Family: Clariidae) by cold shock. In: 13th Annual Conference of the Fisheries Society of Nigeria (FISON), New Bussa, Nigeria. 1999;3-7.
21. Arai K. Reproductive performance of African Clariid Catfish *Clarias gariepinus* broodstock on varying maternal stress.

Journal of Fisheries International. 2006;1(1-2):17-20.

22. Penman DJ, Skibinski DOF, Beardmore JA. Survival, growth rate and maturity in triploid tilapia. In: Tiews K. (Ed.) Proceedings of the World Symposium on Selection, Hybridization, and Genetic Engineering in Aquaculture. Bordeaux, France. Heinemann, Berlin, 1999;II(27-30): 277-287.
23. Brodsky F, Cohen J. Controlling aquatic vegetation with triploid grasscarp. World Aquaculture. 1996;23:36–37.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/14325