A Brief Review of Growth Performance of Triploid Indian Catfish, *Heteropneustes fossilis* (Bloch) from the Perspective of Metabolism and Endocrinology

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ABSTRACT *Imposition of cold shock to the newly fertilized eggs of Indian catfish, Heteropneustes fossilis (Bloch), commonly known as Singi fish, produces triploids. These triploids showed about 150 % more body weight and size than the diploid fish but developed sterility. In the present article efforts have been made to understand metabolic and endocrine basis of this growth in this triploid catfish. Evaluation of some enzyme activities of metabolic importance in several vital organs demonstrated variations in these triploids. Efforts have been made to assess the thyroid hormone profile in triploid catfish. Growth hormones, Gonadotropin releasing hormone (GnRH), gonadotropin (GtH), Estradiol 17β, and subsequent expressions of estrogen receptors have been observed. All these observations indicate possible reasons of deficiency in the ovarian performance in triploids and probable diversion of metabolic energy towards growth promotion in such chromosomally altered catfish.*

Summary: *Growth promotion in cold shock induced triploid Indian catfish, Heteropneustes fossilis (Bloch) may be associated with their altered metabolic and endocrine performances.*

Key words: *Heteropneustes fossilis (Bloch), triploid, growth, metabolism, endocrinology*

Introduction

Triploids are organisms having three complete sets of chromosomes in their somatic cells instead of two sets found in diploids. Triploid fish are more useful to aquaculture owing to better survival and growth in comparison to rest of polyploids (Pandian & Koteeswaran, 1998). Natural triploid populations have evolved in eight genera representing three orders of fish; the viviparous poecilids), oviparous cyprinids and athernids (Benfey, 1999).

Propagation of fishes has been practiced from time immemorial in different parts of the world. Fish play an important role in the nutrition of people in India. To meet the increased demand for fisheries products by 2025, India must increase its current level of production to 7-8 million tons per year. However, paucity of basic information on the reproductive physiology of cultivated fishes has caused aquaculture to lag behind agriculture. In view of the importance and relevance of basic research on reproductive physiology of cultivated fishes for the expansion of aquaculture, work on many of these areas has been the subject of several reviews.

Air breathing fishes like *Heteropneustes fossilis* (Bloch) are major product of capture fisheries in our country. They thrive well at higher stock density in swamps and woody marshes and other derelict water bodies having poor oxygen content. Indian catfish or Singi fish, *Heteropneustes fossilis* (Bloch) is highly regarded for its high protein (22.8 %), low fat (0.6 %) and very high iron content (226 mg / 100 g tissue; Tiwary *et. al.*, 2004) in tissues. However, culture of this fish in a commercial basis is at a preliminary stage in India. Despite its potential advantages, culture of catfish is less lucrative to farmers due to its slower growth rate than Indian major carps. A remedy for overcoming the slower growth rate have been attempted by imposing triploidy in this species by subjecting freshly fertilized eggs to cold shock (4° C) for 30 minutes (Tiwary *et al*., 1997). Thereafter, from the hatched eggs triploid individuals are detected thorough flow cytometry (Biswas, 2016). These triploids showed better growth potential in comparison to their diploid siblings under controlled laboratory conditions and were sterile (Tiwary *et al*., 1997).

Indian catfish, *Heteropneustes fossilis* Bloch, is a seasonal breeder. The annual reproductive cycle of Indian catfish *Heteropneustes fossilis* (Bloch) can be divided into (a) resting phase [Sept-Jan] (b) preparatory phase [Feb-Apr] (c) pre-spawning phase [May-Jun] (d) spawning phase [Jul-Aug]. In seasonal breeders like fishes, generally majority of the metabolic activities revolve around their reproductive performances. Vital organs take part in the processes that lead to ovarian maturation in the female fish. Thus a number of metabolic alterations are found in different organs like liver, kidney, brain, muscles, gonads, etc., in normal diploid fish when it passes through the different phases of the reproductive cycle having the only destination of gonadal maturation.

Growth performance of triploid fishes:

Triploid cell nuclei contain, by definition, 50 % more DNA than diploid cell nuclei. Nuclear volume and corresponding cellular volume are increased in triploids. Despite increased cell size, triploid individuals are not, as a rule, larger than the diploids. This appears to be due to a reduction of cell numbers in those tissues and organs containing larger cells. Apart from that triploids are expected to have a higher growth potential due to sterility and reduced gonadal development. Growth rates in triploid mud loach, *Misgurus mizolepis*, Atlantic salmon, and in two species of tilapia (*Oreochromis niloticus* and *O. aureus*) are similar to their diploid counterpart. Growth performances are poorer in triploids of species such as rainbow trout (*Oncorynchus mykiss*) sunshine bass, coho salmon (*Oncorynchus kisutch*), Atlantic salmon (*Salmo salar*) (Benfey, 1999). However, triploids have a better growth rate than diploids at maturation in tilapia (Benfey, 1999). No weight gain was noted in female triploid brook trout even after long-term treatment with anabolic steroid 17β-estradiol (E2) (Schafhauser-Smith and Benfey, 2003a). Probably, shocks suffered by a triploid individual may modify its rate and pattern of growth. Thermal shock also triggers the production of a heat-shock specific protein, which affects growth (Pandian and Koteeswaran, 1998). However, both sexes of triploid *Heteropneutes fossilis* (Bloch) shows increase in growth performances.

Diet utilization and metabolism

The feed conversion efficiency has been well studied in triploid African catfish, *Clarias gariepinus* (Henken et al., 1987). No significant differences were observed for a variety of measures reflecting energy utilization like protein efficiency ratio, net protein utilization, efficiency of energy gain, total energy intake and nitrogen balance in this species. Differences have been observed when fat and energy utilization was considered in maturing fishes. Diploid females have been shown to reduce fat and energy deposition as they mature, presumably due to the high-energy requirements of oogenesis. As a result, triploid females have larger fat deposits around the viscera compared to maturing diploid females (Benfey, 1999). Triploid Chinese catfish had a lower feed conversion ratio (FCR) than diploid fish, while both diploid and triploids indicated a lower FCR at higher temperature than at low temperature. Triploid Chinese catfish consume about 24 % less feed than diploids (Benfey, 1999).

Activities of some metabolic enzymes such as cytosolic NADP-malate dehydrogenase (NADP-MDH), mitochondrial NAD malate dehydrogenase (NAD-MDH), glutamate pyruvate dehydrogenase (GPT) and glucose-6-phosphate dehydrogenase (G-6-P D) were evaluated in liver, brain, kidney and ovary of *Heteropneustes fossilis*. Activities of those enzymes showed distinct seasonal periodicity, mostly with highest activities in prespawning and spawning periods. In triploid liver, GPT showed higher activity than the diploid counterpart, on the contrary G-6-P D, NAD-MDH and NADP-MDH activities showed consistent lower activities throughout the year (Biswas et. al. 2006a). Difference of expression of these metabolic enzyme activities probably indicate the utilization of dietary carbohydrate towards increased fat and protein deposition in triploid *H. fossilis*.

Endocrinology

Plasma growth hormone levels in triploid rainbow trout were similar to diploids of the same sex and similar stage of sexual maturity (Sumpter et al., 1991). Earlier investigation indicated higher plasma growth hormone levels in diploid females than triploid counterparts, presumably due to the obligation of diploids to mobilize energy stores and resume somatic growth after spawning (Sumpter et al., 1991). Triploid and diploids remained unresponsive to changes in growth rate, when recombinant growth hormone was delivered via intraperitonial injection (McLean et al., 1991) or by feeding (McLean et al., 1993). Growth hormone administration caused a reduction in the ratio of weight to length in diploids but not in triploids but it depleted lipid energy stores in triploids more rapidly than the diploids (McLean et al., 1991).

Gonadotropin releasing hormone (GnRH) has central role in vertebrates by regulating the release of gonadal steroids mediated through gonadotropin (GtH) (Tiwary et al., 2004). A positive correlation has been observed between GnRH and gonadal maturity in teleosts. Reduced level of GnRH in triploid rainbow trout has been reported (Benfey, 1999). Decrease in size and number of immunoreactive GnRH cells in preoptic area (POA) and low immunoreactivity in pituitary of triploid Indian catfish have been observed (Tiwary et al., 2000). The low activity of GnRH in triploid fish could be due to absence of positive feedback stimulation by sex steroids and/or reduced responsiveness of sensory cells to environmental cues required for gonadal maturation in teleosts (Tiwary et al., 2004).

Female triploid fish exhibited low levels of gonadotropin and sex steroids like E2, testosterone (T) in various species (Benfey et al., 1989 b). Concentrations of hepatic Estradiol-17β (E2) receptors in

cytosolic and nuclear fractions were evaluated in tripoid *Heteropneustes fossilis* (Bloch) during four different reproductive periods of complete annual cycle. Lower E2 binding capacity and lower amount of E2 receptors of triploids represent one of the several causes of sterility and subsequent growth of these organisms (Biswas et. al., 2007).

A significant increase in the total thyroid hormones, T4 and T3 was noticed in plasma of triploids during spawning period. However, during the same period, accumulation of THs was significantly higher in the oocytes of diploids. Thyroid gland also showed a higher state of activity in the diploids. Lower activity of thyroid tissue, higher levels of THs in plasma and lower accumulation of maternally derived hormones in the oocytes of triploid females may be associated with sterility of triploids (Biswas et. al., 2006b).

Discussion

It is already known that triploid fish have a great potential for commercial exploitation in aquaculture. Apart from that, they serve as an attractive model for basic research. Although, various studies on impact of triploidy on growth, behavior, endocrinology, gonadal development, haematology, energetics of different fish species have been made, there are still appreciable lacunae to be filled in. Protein, fat and carbohydrate contents of different organs of triploid fish have not yet been studied, as redistribution of lipid and protein molecules, besides their biosynthesis in different organs is also an important factor for gonadal maturation in teleosts. As triploid fish are with abnormal physiological features, they provide a unique potential for discovery of new biochemical and molecular mechanisms in basic cytogenetics vis-à-vis fish physiology. Future study needs data on various field performances of triploid fish before their commercial exploitation. There are ample scopes to venture through other physiological changes in neuroendocrine organs, central nervous system, circulatory system, and muscular system. Investigation on magnitude of responsiveness of the Vitellogenin gene expression in triploid *H. fossilis* to estrogen in comparison to that of diploid fish may be carried out. Developmental biology of triploid catfish may be an important area of research. Detailed study on metabolism and energetics in muscular tissue with assessment of micronutrient contents is a separate subject that needs to be ventured. The nutritional properties and public health aspects of triploid fish production must be evaluated before their introduction for commercial exploitation.

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