The potentials of phytoestrogenic plants in tilapia production – mini review

The potentials of phytoestrogenic plants in tilapia production – mini review

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Abstract

Tilapias are one of the best global aquaculture candidates given their desirable qualities. However, their paradox reproductive nature has led to adoption of several methods to curb the subsequent menace. The existing ways of tackling the problems associated with excessive recruitments in farmed tilapia have some technical limitations. Reports have it that numerous plants possess phytoestrogenic properties capable of controlling early maturity and precocious breeding in farmed tilapia production.

Keywords: Tilapia, Paradox, Phytoestrogenic, Monosex, Reproduction

Introduction

The aptitude for all living organisms to generate offspring (sexually or asexually) is a pre-requisite for their existence. The physiology and reproductive behaviors of tilapia is well documented. Sexuality of fish is of great importance in aquaculture due to dimorphism exhibited by different species i.e. differences in growth rates, survival rate, size, behavior pattern and breeding time (Manosroi, *et al*. 2004; Dauda *et al.*, 2014). Tilapia shows sexual dimorphism in which the males are preferred to the females hence the demand for “all-male” tilapias.

The easy and rapid propagation abilities of tilapias in various tropical and sub-tropical environments is one of the features that makes them an ideal aquaculture species, but, this attribute is impaired by their reproductive efficiency combined with precocious sexual maturation - as early as 2 - 3 months (Pullin and McConnell, 1982; Phelps and Popma, 2000). According to Fortes (2005), under favorable conditions, tilapia will continue to reproduce therefore the offspring compete with the initial stock for food thereby resulting in stunted growth and unmarketable fish sizes. The existing methods to produce monosex (all-male) tilapia population encompass technical limitations that make them inappropriate for small aquaculture farms hence the need to explore affordable, environmentally friendly and appropriate alternative technology.

Ways of curbing paradox reproduction in tilapia (mono-sex populations):

The negative effect of unrestrained spawns in tilapia culture ponds has led to the development of several methods to check the precocious maturity and prolific reproduction in farmed tilapia. According to reports, the early predominant methods used to control reproduction in tilapia culture (Table 1) are – manual separation of sexes, interspecific hybridization, hormone augmentation and genetic manipulations (androgenesis, polyploidy and transgenesis) (Eckstein and Spira, 1965; Guerrero, 1975; Mires, 1977; Lovshin *et al.*, 1990; Mair and Little, 1991; Fortes, 2005). Other methods include; intermittent harvest, high stocking density culture, use of predatory fishes, sterilization, culture in cages and using organic toxicants and/ or other chemicals (Fortes, 2005).

Novel techniques – potentials of phytoestrogenic plants:

Due to the limitations associated with the aforementioned methods of controlling tilapia reproduction, the use of natural products as inhibitory agents is being advocated (Ekanem and Okoronkwo, 2003; Ugoala *et al.*, 2014). Phytoestrogenic plants with anti-fertility properties have also been thought of as a solution since they can be easily obtained and incorporated in tilapia feed (Gupta and Sharma, 2006; Dauda *et al.*, 2014).

Table 1: Existing methods of controlling paradox tilapia reproduction and their limitations

Existing Methods	Limitations
Manual Separation of Sexes	Tedious and the reliability of sexing depends on the skill of the workers, the species to be sorted and its size. Breeding and reproduction is rarely completely controlled.
Hybridization	Unsustainable – limited fecundity of parent fish restricts fry production, insufficient number of hybrid fry due to spawning incompatibility between parent species, sometimes the hybrids may still be subjected to manual separation of sexes or hormone augmentation. Risk of introgression of tilapia species with deleterious implications for the conservation of tilapia genetic resources.
Hormone augmentation	Public concerns and consumer perceptions on use of synthetic steroids in production of human foods. Hormones are expensive, restricted in some countries and skilled labors are required. Widespread use of hormones in hatchery may pose a health risk to workers, consumers and environment.
Genetic Manipulation	*YY Super-male Technology* Complex, time consuming, tedious, still require sex hormones at the initial stage, and only suitable for homogametic species (XX/XY) *Chromosome set and* sex *manipulation / Polyploidy (Triploids and Tetraploids)* Complex and offsprings hardly survive due to the processes involved thus has not gone beyond experimental levels to commercial application. *Androgenesis* Deleterious impact of the shock and expression of deleterious recessive genes *Transgenesis* Organisms resulting from successful transgenesis are classed as genetically modified or living modified organisms (GMO or LMO) and are thus subject to societal and regulatory concerns as regards ethics, risks to human health and environmental impacts

Table 2: Some studied phytoestrogenic plants for control of paradox tilapia reproduction

Botanical Name	Family	Phytoestrogenic compounds	Investigators
Quillaja saponaria	Quillajaceae	Saponnin	Angeles *et al*., 2015
Azadirachta indica	Meliaceae	Flavonoids, Phenol, Saponin, Alkaloids	Jegede and Fagbenro, 2008
Hibiscus rosa-sinesis	Malvaceae	Flavonoids, Tannin, Sterol	Jegede, 2010
Carica papaya	Cariceae	Alkaloids, Flavonoids, Saponins, Phenols, Anthraquinone	Jegede, 2011; Abdelhak *et al*., 2013; Ampofo-Yeboah, 2013
Aloe vera	Liliaceae	Flavonoids, Saponins, Anthraquinone	Jegede, 2011
Moringa oleifera	Moringaceae	Flavonoids, Phenol	Ampofo-Yeboah, 2013
Basella alba	Basellaceae	Flavonoids, Phenol, Saponins	Ghosal and Chakraborty, 2014
Tribulus terrestris	Zygophyllaceae	Saponins, Tannins, Steroids, Alkaloids	Omitoyin *et al*., 2013

The concept of harnessing the potentials of phytoestrogenic plants to produce monosex tilapia population in aquaculture is novel and is operating on same principles as synthetic sex reversal hormones in fish culture. Several plants contain phytochemicals (phytoestrogens) that are structurally and/ or functionally similar to the steroid hormones and are capable of producing estrogenic effects in animals (Price and Fenwick, 1985; Fowler, 1983; Lehtinen and Tana, 2001; Gabriel *et al*., 2015). Furthermore, the reported potential of phytochemical/phytoestrogens to control reproduction in tilapia, have a wide range of consequences on various physiological processes in fishes such as: anti-stress, growth promotion, appetite, stimulation, tonic and immune-stimulation, and antimicrobial properties (Citarasu, 2010; Chakraborty and Hanz, 2011; Chakraborty *et al*., 2012).

Table 2. Some phytoestrogenic plants with potentials in control of paradox tilapia reproduction

Botanical Name	Family	Anti-fertility action(s)
Jatropha Curcas	Euphorbiaeceae	Abortifacient
Albizzia lebbec	Mimosacaeae	Anti-fertility
Allium cepa	Liliaceae	Antiimplantation activity
Aspilia africana	Asteraceae	Antiovulatory activity
Cassia fistula	Caesalpinaceae	Anti-fertility
Gossypium hirsutum	Malvaceae	Abortifacient
Acalypha indica	Euphorbiaceae	Antiimplantation
Trigonella foenum graecum	Fabaceae	Anti estrogenic
Nelumbo nucifera	Nelumbonaceae	Anti-estrogenic
Nelumbo nucifera	Nelumbonaceae	Anti-estrogenic
Melia azedarach	Meliaceae	Antiimplantation
Afromosia laxiflora	Fabaceae	Antigonadotropic activity, block oestrous cycle

Conclusion

Amidst other technical limitations associated with existing methods of monosex tilapia production, the main concerns about the methods (especially synthetic sex hormone application) in tilapia production include; potential health risks caused by malpractice of this system by farm workers, detrimental impacts on the environment and social constraints. Mlalila *et al*. (2015) emphasized that the quantity of MT used for conventional practice is large compared to the actual dose required for the target organism and may lead to accumulation of this chemical in tilapia production systems. This is in concurrence with the previous study which reported that oral administration of MT to fish resulted in detectable levels of steroid in recirculating system (Hulak *et al*., 2008). If this water is released into natural waters, it may have a far-reaching consequence of possibly sex reversing some natural population, thus altering the sex dynamics of the stock, producing more males which on the long run may lead to recruitment failure (Megbowon, 2011). This is perhaps part of the reasons why Kavitha and Subramanian (2011) had suggested the use of natural substances while addressing the concerns about hormone treated fish. Therefore more research into the use of phytoestrogenic plants in farmed tilapia culture is recommended so as to develop a technology that is sustainable, human and environmental friendly in curbing the paradox reproductive nature of the species.

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