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Use of Hormonal Steroids for Artificial Sex Reversal of *Tilapia*

RAFAEL D GUERRERO III
College of Inland Fisheries, Central Luzon State University, Nueva, Ecija, Philippines

A review of the androgens and estrogens used for artificial sex reversal of tilapia is presented. Genotypic females of four species, *Tilapia mossambica. T. nilotica, T. aurea* and *T. zillii* have been sex-reversed with methyltestosterone and ethynyltestosterone administered *per os* with varying dosages and durations of treatment. Sex reversal of genotypic males of *T. mossambica* using ethynylestradiol and estrone, and of *T. aurea* and *T. nilotica* using ethynylestradiol and diethylstilbestrol have been tested

Introduction

Tilapias are among the most widely cultured foodfishes in the world, probably next only to the common carp, *Cyprinus carpio* (Bardach et al. 1972). The major constraint in the culture of tilapias is their excessive reproduction which reduces yield of table-size fish (Hickling 1960).

Various methods have been applied to control unwanted reproduction of tilapias. One technique that has promise for practical application is the use of hormones for the production of monosex populations (Guerrero 1975, Shelton et al. 1978).

This paper is a review of the work that has been done on the use of hormonal steroids for inducing sex reversal in tilapias. A discussion of the methodologies applied for artificial sex reversal in the species is also presented.

Artificial sex reversal of genotypic female Tilapia

Monosex male tilapia is preferred to the all-female population because of superior growth (van Someren & White-head 1960). Masculinization of genotypic females of four species of tilapias has been achieved (table 1).

Two synthetic androgens, methyltestosterone and ethynyltestosterone, have been used for masculinizing genotypic female tilapia. Treatment is by oral administration for varying periods (18–60 days) in tanks or aquaria. The dosages for effective sex reversal range from 10–60 mg/kg diet.

Sex reversal in the species is ascertained by comparing the sex ratios of the treated fish with that of the controls (untreated fish) and/or by progeny-testing. If treated fish have a significantly higher percentage of males in the population than the usual 1 : 1 ratio of sexes, sex reversal of genotypic females is assumed to have occurred (Jalabert et al. 1974, Sanico 1975, Guerrero 1976a, Tayamen 1977, Valera 1977, Woiwode 1977). Sex reversal is further verified by mating suspect "sex-reversed females" (genotypic females with male phenotype) with untreated females and sexing the offspring (Clemens & Inslee 1968, Guerrero 1975, Guerrero & Abella 1976, Liu 1977).

Table 1 Tilapia *species treated with androgens for sex reversal*

Species	Androgen	Dosage (mg/kg diet)	Duration (days)	References
Tilapia mossambica [a]	methyltestosterone	10-30	60	Clemens and Inslee (1968)
	ethynyltestosterone	50	40	Guerrero (1976a)
	methyltestosterone	30	21-28	Guerrero (1976b)
Tilapia nilotica [b]	,,	30	60	Jalabert et al. (1974)
	,,	15–50	42	Guerrero and Abella (1976)
	,,	30–60	21	Tayamen (1977); Tayamen and Shelton (1978)
	ethynyltestosterone	30–60	21	Tayamen (1977); Tayamen and Shelton (1978)
Tilapia aurea [c]	methyltestosterone	15–60	18	Guerrero (1975)
	ethynyltestosterone	15–60	18	,,
	,,	30	22	Sanico (1975)
Tilapia zillii	methyltestosterone	50	45	Woiwode (1977)
	,,	30	56	Valera (1977)

[a], [b], [c] Renamed as *Sarotherodon mossambicus*, *S. niloticus* and *S. aureus*, respectively, by Trewavas (1973)

Effectiveness of the sex reversal treatment depends on the kind and dosage of steroid used, the method of administration, time and duration of treatment, and on the species to be treated (Yamamoto 1969). Shelton et al. (1978) recommend oral treatment of 9–11 mm *T. aurea* fry at a density of 2600/m² or less with ethynyltestosterone dosage of 60 mg/kg diet for six weeks at 25-29°C for production of all-male populations.

Artificial Sex Reversal of Genotypic Male *Tilapia*

Production of monosex female tilapia populations has been tested with the use of three estrogenic steroids, ethynylestradiol, estrone and diethylstilbestrol (table 2). An all-female tilapia population is said to be desirable because it eliminates nest-building activity (Bardach et al. 1972). Sex reversal of homogametic male tilapia may also result in the production of all-male populations through breeding (Guerrero 1975, Shelton et al. 1978).

Table 2 *Tilapia species treated with estrogens for sex reversal*

Species	Estrogen	Dosage (mg/kg diet)	Duration (days)	Reference
Tilapia mossambica [a]	ethynylestradiol	50	25	Nakamura and Takahashi (1973)
	estrone	200	56	Guerrero and Guerrero unpublished data
Tilapia aurea [b]	ethynylestradiol (with cypropterone acetate)	100	35	Hopkins (1977)
	diethylstilbestrol	100	56	Hopkins (1977)
Tilapia inlotica	,,	25-100	25–59	Tayamen and Shelton (1978)
	Estrone	100-200	25–59	,, ,,

[a],[b] Renamed as *Sarotherodon mossambicus* and *S. aureus*, respectively, by Trewavas (1973)

Estrogens effective for feminizing sexually undifferentiated tilapia fry are administered *per os*. Dosages applied range from 25–200

mg/kg diet. The duration of treatment has varied from 25–59 days (table 2). Evaluation of the success in sex reversal of genotypic males is also based on sex ratios of the treated fish (Nakamura & Takahashi 1973, Guerrero & Guerrero; unpublished data) or progeny-testing (Hopkins 1977).

General Considerations

Much work on the artificial sex reversal of tilapias in both directions has been done in recent years. Although the methods of application still have to be standardized to attain consistent results, the technique offers a practical and economical approach for the control of tilapia reproduction (Guerrero 1976b, Shelton et al. 1978).

Two questions, however, remain open and have to be considered before large scale application of the sex reversal technique can be adopted. One is the question of the acceptance of hormone-treated fish for human consumption. The other is the feasibility of producing monosex tilapia through breeding of hormone-treated fish (Shelton et al. 1978).

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