Asian Fisheries Science 1(1988):215-219.
Asian Fisheries Society, Manila,
Philippines

https://doi.org/10.33997/j.afs.1987.1.2.012

Female Homogamety in Tilapia (*Oreochromis niloticus*) Revealed by Gynogenesis

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Abstract - Gynogenetic experiments were conducted on 14 female *Oreochromis niloticus* of which fertilization occurred in 13 cases involving eight different females. Successful hatching obtained in seven different cases involving five different females. Levels of hatching ranged from 2 to 40 per cent and the number of fry obtained was 291. Total number of fish that survived in different broods after 20 to 28 weeks of age was 89, which were all female indicating that females in *O. niloticus* are homogametic.

Gynogenesis is an aberrant type of reproduction rarely found in nature, where the populations are exclusively females (Hubbs and Hubbs 1946; Schultz 1967). In nature for diploidization in the eggs, two events are required: 1) an event leading to the inactivation of the sperm nucleus in the fertilized eggs; 2) an event leading to an abortive reduction division in the eggs during the process of egg formation.

Depending upon the sex-determining mechanism in the species concerned, the gynogenetic fish can be all female if the female is homogametic (XX) or else, in the case of female heterogamety (WZ), one can expect the appearance of ZZ males; WW females are

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apparently non-viable and normal WZ females can appear entirely as a result of crossing over between the sex chromosomes (Kirpichnikov 1979). All-female gynogenetic broods have been produced in the grass carp (Stanley 1976) and in common carp (Golovinskaya 1969). Both male and female gynogenetic offspring were obtained in the plaice *(Pleuronectes platissa)* which indicates either female heterogamety or polygenic determination of sex (Purdom and Lincoln 1973).

All-male hybrid production in tilapia according to Hickling (1960) was due to female heterogamety and the mechanism was thought to be similar to the four-chromosome model discovered by Gordon (1947) in platyfish. The platyfish model later could not satisfy the results of many different studies that produced males in inconsistent proportions (Chen 1969; Pruginin et al. 1975). Avtalion and Hammerman (1978) proposed that there was autosomal gene influence in the determination of sexes in tilapia with a model of three sex chromosomes. This model still could not explain the enormous array of data on sex ratios obtained in different interspecific crosses. Majumdar and McAndrews (1983) performed some interspecific crosses and came up with sex ratios which neither supported the four-chromosome model of Gordon (1947) nor the model of Avtalion and Hammerman (1978) and felt that the variable results obtained could indicate polygenic and/or multi-allelic mechanisms in tilapia. However, much of the scatter of the results so far published and also of their own could be explained by contamination of the tilapia stock.

Fourteen different mature *O. niloticus* females were involved in the experiment. The stock of fish used was obtained from the Institute of Aquaculture, University of Stirling, originally from Bangkok, Thailand. Eggs were obtained by abdominal squeezing. Sperm were taken from any ripe males available. A sample of 0.2 ml fresh sperm was diluted 10 times with Cortland salt solution in a 50-mm Triple Vent Sterilin petridish resulting in a sperm sample 0.02-mm thick. Sperm were irradiated under a short-wave UVG-11 ultraviolet lamp with an output capacity of 580 $\mu W\ cm^{-2}$ for 20-80 seconds at distances of 1.8 to 10 cm from the lamp filter. The eggs were fertilized with this sperm and exposed to heat shock in a hot water bath at 42°C for 3.5 minutes, 5 minutes after fertilization. Incubation of the eggs was performed in a glass funnel connected to a flow of water from a biological power filter. Fry were fed with finely ground trout pellets for 3-4 weeks and then on larger pellets. Sex was identified at 20-28 weeks both by inspection of dissected gonads and

Table 1. Observations on the production of gynogenetic offspring in female *O. niloticus*.

Duration of irradiation (seconds)	Distance of irradiation (cm)	Duration of heat shock (seconds)	Temperature (°C)	"Control" Haploid (n)			Gynogenetic offspring				
				No. of eggs used	Fertilization rate (%)	Hatching rate (%)	No. of eggs used	Fertilization rate (%)	Hatching rate (%)	% female	Code no. female
60	1.8	210	42	150	?	6.67	120	0	0		054
60	1.8	210	42	90	0	0	95	0	0		048
60	1.8	210	42	150	0	0	200	0	0		049
60	4.6	210	42	250	?	6.0	250	0	0		038
60	6.0	210	42	200	0	0	250	0	0		043
50	5.0	210	42	300	0	0	300	0	0		036
30	5.0	210	42	200	12.5	0	250	20.0	0		085
20	5.0	210	42	—	—	—	350	40.0	0		085
20	5.0	210	42	150	0	0	250	13.33	2.0	100	095
30	10.0	210	42	—	—	—	320	56.25	15.31	100	036
40	10.0	210	42	—	—	—	240	66.67	19.59	100	036
60	10.0	210	42	—	—	—	180	47.62	13.33	100	036
60	10.0	210	42	—	—	—	336	45.0	10.12	100	035
60	10.0	210	42	200	6.0	0	200	14.0	2.0	100	097
60	10.0	210	42	76	0	0	44	10.0	0		101
60	10.0	210	42	208	40.0	0	270	79.0	47.41	100	081
60	10.0	210	42	231	6.41	0	282	9.21	0		086
80	10.0	210	42	220	1.82	0	312	33.76	0		035
80	10.0	210	42	200	—	—	232	12.0	0		045

by the Acetocarmine squash of gonad method (Guerrero and Shelton 1974).

In Table 1 it is seen that in three trials of 60-second UV exposure at a distance of 1.8 cm and one trial each at distances of 4.6 cm and 6.0 cm, no fertilization was produced, though in the haploid control at distances of 1.8 cm and 4.6 cm, hatching rates of 6.2 and 6.0 per cent, respectively, were seen. Since haploids do not survive the post-hatching period, these individuals were most certainly normal diploids produced due to presumed improper UV treatment. At 5.0 cm distance, although reasonable rates of fertilization, from 13 to 40 per cent, were obtained in three of the trials for 20 and 30 seconds involving two different females, there was hardly any success in hatching rates - only two per cent in one female.

Taking into consideration the suspect purity of tilapia stocks used in the crossing experiments by different authors, the female homogamety in *O. niloticus* might be thought to be proven by the sporadic incidences of all-male production of hybrid broods in different studies (Pruginin et al. 1975; Majumdar and McAndrew 1983). Jalabert et al. (1974) demonstrated female homogamety in *O. niloticus* by crossing sex-reversed males with normal females. The findings of the present study confirm this hypothesis.

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