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Heritability estimates and response to selection for growth of Nile tilapia (*Oreochromis niloticus*) in low-input earthen ponds

Harrison Charo-Karisa [a,b,c,1], Hans Komen [b,*], Mahmoud A. Rezk [c], Raul W. Ponzoni [d], Johan A.M. van Arendonk [b], Henk Bovenhuis [b]

[a] *Fish Culture and Fisheries Group, Wageningen Institute of Animal Sciences (WIAS), Wageningen University, P.O. Box 338, 6700 AH, Wageningen, The Netherlands*
[b] *Animal Breeding and Genetics Group, Wageningen Institute of Animal Sciences (WIAS), Wageningen University, P.O. Box 338, 6700 AH, Wageningen, The Netherlands*
[c] *Regional Center for Africa and West Asia, The World Fish Center, Abbassa, Abou Hammad, Egypt*
[d] *WorldFish Center, Jalan Batu Maung, 11960 Batu Maung, Penang, Malaysia*

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Abstract

This study presents results of two generations of selection (G_1 and G_2) for growth of Nile tilapia. The selection environment consisted of earthen ponds which were fertilized daily with 50 kg dry matter (dm)/ha chicken manure. No supplementary feeds were provided. In total, 6429 fully pedigreed experimental fish were included in the analysis. Survival till harvest was highly variable ranging from 35% to 77% and was affected by initial weight, pond, and age effects. Body weight at harvest (BW) increased from a mean of 67.4 g in the grandparental (unselected) population (G_0) to 129.5 g in G_2 was affected by initial weight, pond, sex and age effects. Generations were discrete and therefore genetic parameters were estimated separately for each year. Heritability estimates for BW ranged from 0.38 to 0.60, and the heritability for survival ranged from 0.03 to 0.14. The estimated selection response was 23.4 g (34.7%) between G_0 and G_1 and 13.0 g (14.9%) between G_1 and G_2. These results demonstrate the feasibility of selection for growth of Nile tilapia in low-input environments.

Keywords: Nile tilapia; *Oreochromis niloticus*; Selection response; Body weight; Heritability; Breeding value

1. Introduction

Tilapias are, after carp, the second most important group of farm raised fish in the world. They are the mainstay of many resource-poor fish farmers (Eknath et al., 1993). Among the tilapiines, the Nile tilapia (*Oreochromis niloticus* L.), is the most important cultured fish species. Although *O. niloticus* is farmed in a wide range of aquaculture systems (Pullin, 1985), majority of its culturing is carried out in the tropics in semi-intensive environments such as fertilized earthen ponds. Nile tilapia is herbivorous by nature, consuming mainly phytoplankton (Moriarty, 1973; Moriarty and Moriarty, 1973), but can as well consume a variety of other natural food organisms found in ponds (Bowen, 1982). To increase fish production,

* Corresponding author. Tel.: +31 317 48265; fax: +31 317 483937.
E-mail address: Hans.Komen@wur.nl (H. Komen).
[1] Permanent address: Kenya Marine and Fisheries Research Institute, P.O. Box 136, Pap-Onditi, Kenya.

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supplementary or artificial feeds may be added. However, supplementary feeds can take up to 60% of fish production costs (Green, 1992) making them unaffordable for most farmers in developing countries (Nguenga et al., 1997; Liti et al., 2005). Due to the high cost of supplementary feeds, poor farmers either grow Nile tilapia with organic fertilization alone or with a variety of locally available farm resources. This leads to reduced yields and small fish sizes at harvest.

A number of selective breeding programs have been initiated to improve the growth of *O. niloticus* in ponds and cages (e.g. Hulata et al., 1986; Eknath et al., 1993; Bentsen et al., 1998). Initial trials at selective breeding, which were based on mass selection for growth, indicated low response to selection for growth (Tave and Smitherman, 1980; Hulata et al., 1986; Teichert-Coddington and Smitherman, 1988; Huang and Liao, 1990). Recently, considerable improvement of response to growth has been achieved using family selective breeding schemes and tilapia germplasm assembled from several wild stocks in Africa (Eknath et al., 1998). These selection programs have typically been carried out in relatively favorable environments receiving supplementary feed. However, there are reports that the gains of selection in Nile tilapia were lost when selected breeds were tested in less favorable environments (Macaranas et al., 1997). This could indicate that the expression of body weight in different environments, i.e. low- and high-input culture conditions, is influenced by a different set of genes.

Here we report on the analysis of a Nile tilapia selection experiment carried out in ponds receiving chicken manure as the only external nutrient source. The aim was to estimate heritability for growth and survival and to investigate the potential of selecting for growth in low-input environments (i.e. manure fertilized ponds without supplementary feeding).

2. Materials and methods

The experiment was carried out at the Regional Center for Africa and West Asia of the World Fish Center, Abbassa, Egypt. Fish used for this study were the G_0 population produced in 2002, the first generation of selection (G_1) produced in 2003, and the second generation of selection (G_2) produced in 2004.

2.1. The founder population and production of G_0

The founder population (i.e. parents of the G_0 population) was produced in spring of 2000 in a full diallel mating design among local Egyptian strains namely Maryout, Zawia, Abbasa and Aswan (Rezk et al., 2002, 2004). 80 sires and 105 dams, selected at random from among the founder stock, were subsequently used to produce the G_0. Each sire was mated to two dams and each dam mated to only one sire, thus generating full and half sib groups. Fry were raised in $2 \times 1 \times 1$ m hapas suspended in concrete tanks and were fed twice daily with 40% protein supplements, initially in the form of powder and later as pellets. Initial feeding rate was 20% of body weight, which was gradually reduced to 5% body weight at tagging size (i.e. mean wet weight of 2 g).

2.2. Production of G_1 and G_2

The first and second generations of selection, G_1 and G_2, were produced in $2 \times 3 \times 1$ m hapas suspended in fertilized ponds. Each sire was mated to two dams as in G_0. 50 sires and 87 dams were used to produce generation G_1, while for generation G_2, 54 sires and 104 dams were used. At first, each sire was kept in a single hapa with two dams. Twice a week, hapas were checked for occurrence of spawning. Spawning was assumed to have occurred when the dam had eggs or yolk-sac fry in her mouth. The un-spawned dam and the sire were both transferred to an adjacent hapa thus producing the paternal half sibs. To prevent multiple spawning, the male was removed immediately after spawning occurred. When swim-up fry were sighted in both hapas, the females were also removed. 2 to 3 weeks later, the number of swim-up fry in each hapa was reduced to 80 individuals. In contrast to the G_0, the G_1 and G_2 fry were given no supplementary feeds and were reared in hapas suspended in the earthen ponds. Each full-sib family was reared separately in hapas until tagging. To boost natural pond productivity, ponds with hapas containing fry were fertilized daily with chicken manure at the rate of 50 kg dry matter, dm/ha.

2.3. Grow-out and pond management (G_0, G_1 and G_2)

As soon as a family reached suitable tagging size, 24 randomly chosen fry from each full-sib family were individually tagged with Floy® tags and returned into the respective hapas until stocking. Each family of fry was removed from the hapas and randomly divided into two groups, which were then stocked in two 1000 m^2 fertilized earthen ponds for grow-out. Fry were between 31–96 days old at stocking. Ponds were supplied daily with dry chicken manure from layer and broiler farms at the rate of 50 kg dm/ha. This fertilization rate corresponds to 0.3 kg nitrogen ha^{-1} day^{-1} which is enough to support yields of 4.3 kg fish BW ha^{-1} day^{-1}