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FACTORS AFFECTING EARLY GROWTH OF NILE TILAPIA FRY IN HAPA-IN-POND ENVIRONMENTS

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Introduction

Hapas, usually suspended in fertilized ponds, have long been used for tilapia fry production (Santiago et al., 1985; Bhujel, 1997) and recently for fry rearing (Little et al., 2003). In fish breeding programs, members of a full-sib family usually share a common tank or hapa prior to tagging and communal testing. This tends to increase resemblance between family members which may reduce the efficiency of breeding programs. For convenience of monitoring and identification of families, hapas are often arranged in rows over the pond. If ponds are heterogeneous, for example with respect to nutrient availability, the spatial arrangement of hapas may create an environmental correlation among neighbouring units. The aim of this study was to quantify the common environmental and genetic effects on early rearing stages of tilapia in hapa-in-pond nursing conditions.

Materials and methods

25 full-sib families of Nile tilapia, *Oreochromis niloticus,* were produced by single-pair mating. Fry were produced and reared from hatching to swim-up in separate 6-m^2 hapas suspended in fertilized ponds. At swim-up, four groups of 30 fry each were obtained from each family. A total of 54 hapas (2m × 1m × 1m) were installed in each of two 4500-m^2 ponds, in two columns of 27 hapas. Ponds were fertilized with chicken manure at a rate of 50kg dry matter $ha.day^{-1}$. The fry groups were randomly stocked into the inner 25 hapas at a stocking density of 15 $fry.m^{-2}$. The remaining two hapas at either end of each row were controls (not stocked). Two treatments were assigned to either column: 40% protein

commercial formulated feed twice daily or no supplementary feed. Temperature, dissolved oxygen (DO), and pH were measured twice weekly with a portable DO meter (WTW® model multi 340i meter at a depth of 30cm inside each hapa. On days 14, 21, 28, and 35 fry were counted, bulk weighed, and average weight recorded. On day 42 fish were removed from the hapas, and individual body weight (BW) and standard length measurements taken.

Survival rate (S_t %) was calculated as $S_t = (N_t/N_0) \times 100$, where N_t is the number of fry at day t and N_0 is the number of fry at stocking. Due to heterogeneity of variances of fish among ponds in the main experiment, BW data was log-transformed. Genetic, environmental, and spatial variability effects were analysed with the following model (ASReml; Gilmour et al., 2002):

$$Y_{ijkl} = \mu + p_i + t_j + \beta_l \log(INWT_{ijkl}) + \beta_2 d_{ijkl} + u_{ijkl} + h_k + e_{ijkl} \qquad \text{(Model 1)}$$

where Y_{ijkl} = logarithm of the 42-day body weight of an individual; μ is overall mean; p_i is fixed effect of pond (i = 1, 2); t_j is fixed effect of dietary treatment (j = 1,2); β_l is regression coefficient of logarithm of initial body weight; $log(INWT_{ijkl})$ is a co-variable of the logarithm of initial body weight of an individual; β_2 is regression coefficient of number of fry in the kth hapa at the end of the experiment; d_{ijkl} is the effect of number of fry on individual l; u_{ijkl} is random additive genetic effect of the lth individual; h_k is a random effect of the kth hapa; and e_{ijkl} is a random residual effect associated with an individual.

Heritabilities (h^2) and common environmental/hapa effects (c^2) for BW were obtained from the complete data set. A bivariate setting of Model 1 in which BW in pond A and BW in pond B were considered separate traits was used to obtain h^2, c^2 in each pond, and genetic correlation (r_g) between traits. The r_g was used to evaluate the presence of genotype by environment (GXE) interaction. The mean performance of few full-sib families in each pond was plotted to illustrate the GXE interactions. The effects of water quality, pond, treatment and week of sampling on BW were determined by the GLM procedure of SAS (1989).

Results and discussion

The h^2 estimates for 42-day BW from the whole data set was 0.01 with high c^2 effects (Table II). The h^2 estimate for BW in pond B was 0.05. The h^2 estimates in pond B were consistent with those obtained for 45-day BW (Tave and Smitherman, 1980). Heritability in pond A was higher (0.59) but there were lower c^2 effects for pond A than pond B. This indicates that h^2 estimates in Nile tilapia are environmentally dependent. Common environmental/hapa effects should be reduced to improve heritability of BW in Nile tilapia. The r_g estimates for the two traits (BW in pond A and pond B) was -0.27, which is well below unity, suggesting GXE interaction. GXE interactions of the crossover type are also implied by Fig. 1. However, given the high standard errors, the existence of GXE interaction is not conclusive. We found significant spatial autocorrelations (χ_2^2 = 7.6; p = 0.0224) across rows and hapa columns (Table I), indicating that ponds were heterogeneous with respect to environmental factors affecting fry growth. Lower h^2 estimates were associated with higher pond heterogeneity (Table I). Since patterns of spatial variability are not known before hand, spatial autocorrelation should be included in breeding programs using hapa-in-ponds systems, to determine underlying environmental patterns. However, spatial autocorrelations are more important in environments with poor water quality.

Table I. Heritability (h^2), common environmental effect (c^2) and genetic correlation (r_g) estimates for body weights in pond A and B and the spatial autocorrelations across rows (ρ_r) and columns (ρ_c) within ponds. Body weight in each pond was considered as a distinct trait and was used for estimation of (r_g).

Trait	h^2	c^2	r_G	ρ_r	ρ_c
BW in both ponds	0.01 (0.06)	0.36 (0.05)	-	0.29	0.22
BW pond A	0.59 (0.19)	0.14 (0.06)	-0.27(0.69)	0.16	-0.06
BW pond B	0.05 (0.11)	0.29 (0.07)		0.26	0.33

Morning and afternoon DO and afternoon pH significantly affected fry BW (Table II). This indicates that differences in BW had to do with the amount of DO available in the hapas. Extended periods of hypoxia may reduce growth (Chervinski, 1982) and cause mortality (Coche, 1982) in Nile tilapia. We did not find any differences in survival between ponds or treatments in this study. The observed GXE interaction may be a response to the differences in DO levels in the two ponds.

Table II. Marginal (Type III) mean square values of water quality, pond, fish survival, sampling week and treatment effects on body weight of Nile tilapia fry reared in a hapa-in pond system

Source	df	Type III SS	F value	P-value
Pond	1	31.17	167.08	<0.0001
Week	5	544.91	584.13	<0.0001
Treatment	1	0.19	1.03	0.3108
Fish survival	1	1.17	6.29	0.0124
Morning DO (mg l^{-1})	1	1.11	5.95	0.0151
Afternoon DO (mg l^{-1})	1	1.00	5.38	0.0207
Morning Temperature (°C)	1	0.04	0.23	0.6307
Afternoon Temperature (°C)	1	0.16	0.88	0.3478
Morning pH	1	0.13	0.69	0.4061
Afternoon pH	1	0.85	4.57	0.0330
R-Square	0.88			

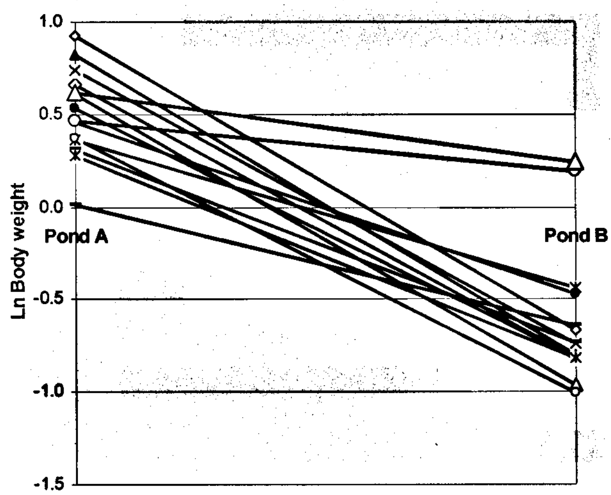

Fig.1. Mean body weights of full-sib families reared under two different ponds and dietary environments. Fry were given supplementary artificial protein diet or fed naturally on pond food.

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