RESPONSE TO SELECTION IN TWO PRODUCTION ENVIRONMENTS IN THE GIFT STRAIN OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*)

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SUMMARY
Progeny were generated in two spawning seasons (2002 and 2003) in a fully pedigreed population based on the sixth generation of GIFT (Genetically Improved Farmed Tilapia) established in Malaysia. Two lines were created (Selection and Control), and two production environments (cages and ponds) were used to grow out the fish. Live weight at harvest (LW) was the trait under selection, treating the production environments as a fixed effect in the model. In the analysis presented here LW in cages and in ponds was treated as two different traits (LWC and LWP, respectively). Response to selection was estimated for LWC and LWP by three methods by comparing: (i) The least squares means of LW for the Selection and Control lines in the progeny of the 2003 spawning season, (ii) The estimated breeding values for LW between the progeny of the 2002 spawning season and those of the Selected line in the 2003 spawning season, and (iii) The estimated breeding values of the Selection and Control lines in progeny of the 2003 spawning season. For LWC, expressed as a percentage of the overall least squares mean in the population, the estimates were 9.2, 9.6 and 12.7 for methods (i), (ii) and (iii), whereas for LWP they were 8.2, 7.9 and 10.4, respectively. It was concluded that selection response was being achieved in both environments and that there was not enough evidence to justify the conduct of separate genetic improvement programs for cage and pond environments.
Key words: Nile Tilapia, Selection response, Genotype by environment interaction

INTRODUCTION
Bentsen et al. (1998), Gunnes and Gjedrem (1978) and Gunnes and Gjedrem (1981) report that genotype by environment issues are of relatively low importance in Tilapia, Atlantic Salmon and Rainbow Trout, respectively. However, there are no equivalent studies for any species in the prevailing production systems in Malaysia. Tilapia farming in Malaysia is conducted in two main production systems, namely, cages and ponds (Annual Fisheries Statistics 1996). In a selection line described by Ponzoni *et al.* (2005a, these Proceedings) selection was carried out for live weight at harvest (LW), after growing out the fish in cages and ponds, and treating the production environment as a fixed effect in the model. The fish belonged to the GIFT (Genetically Improved Farmed Tilapia) strain (Bentsen *et al.* 1998). In this paper we estimate the response to selection for live weight at harvest expressed in cage and pond environments, and we discuss the genotype (individual's genetic merit) by grow-out environment interaction.

MATERIALS AND METHODS
General. The physical environment, the fish involved, the grow-out system, the records taken, and the statistical procedures used are described by Ponzoni *et al.* (2005a, these Proceedings).

Response to selection. The progeny resulting from the 2002 spawning season were selected as parents of the next generation in two different ways, to create the Selection line, and to continue the Base Population as the Control line. Animal model breeding values were calculated for all individuals. The parents for the Selection line were selected from among those with the greatest breeding values for LW, imposing some restrictions with the aim of controlling inbreeding and maintaining a high effective population size (use of at least 30 sires and avoiding the mating of close relatives). By contrast, the parents of the Control line were selected among those with breeding values for LW as close to the average as possible, and imposing the same restrictions regarding inbreeding and population size as for the Selection line.

We estimated the genetic change in LWC and LWP in three ways: (i) Comparing the least squares means for the Selection and Control lines in the progeny of the 2003 spawning season; (ii) Comparing the estimated breeding values for body weight (LWC and LWP) between the progeny of the 2002 spawning season and those of the Selected line in the 2003 spawning season, and (iii) Comparing the estimated breeding values of the Selection and Control lines in progeny of the 2003 spawning season. The model fitted in each case is specified in Table 1. The square root transformation of LWC and LWP improved the distribution of residuals and was used throughout in all analyses.

RESULTS

The results are shown in Table 1. Overall, there was good agreement among the methods and between the environments, although the estimate from method (iii) was greater than for the other two methods. In all cases the response was large enough to suggest that genetic change was being achieved in both the cage and pond environments, and in the intended direction.

DISCUSSION

The genetic gains estimated in both environments (Table 1) were of similar magnitude and consistent across the three methods used. The latter finding is in agreement with the results reported by Chen and Boichard (2003) and Piles and Blasco (2003), for poultry and rabbit data, respectively. Furthermore, the gains in cages and ponds, resulting from a bivariate analysis, were in good agreement with those resulting from a univariate analysis (treating the expression in both environments as a single trait) earlier reported (Ponzoni *et al.* 2005b, in press Aquaculture). Note that for selection purposes we estimated breeding values in a univariate analysis, and treated cage and pond as a fixed effect in the model, fitting 'spawning season, environment, sex' sub-classes. Selection based on such estimated breeding values appears to have resulted in response to selection in both environments. Consistent with the suggestion made based on the genetic correlation between LWC and LWP (Ponzoni *et al.* 2005a, these Proceedings), we conclude that there is no evidence to justify the conduct of separate genetic improvement programs for cage and pond environments in Tilapia.

Table 1 Response to selection estimated by different methods and expressed in actual units and as a percentage (%) (SS=spawning season; L=line; S=sex; E=environment)

Method (comparison of)	Model (effects)	Environment	Selection Response ($LW^{0.5}$) [A]	
			Actual units ($g^{0.5}$)	%
(i) Least squares means for the Selection and Control lines in the progeny of the 2003 spawning season	Fixed: SS, L, S, E, SSxS, LxS Covariate: age (SS, S, E)	Cage	1.21	9.2
		Pond	1.23	8.2
(ii) Estimated breeding values for LW between the progeny of the 2002 spawning season and those of the Selected line in the 2003 spawning season	Fixed: SSxSxE Covariate: Age (SS, S, E) Random: animal, dam	Cage	1.25	9.6
		Pond	1.19	7.9
(iii) Estimated breeding values of the Selection and Control lines in progeny of the 2003 spawning season.	Fixed: SxE Covariate: Age (S, E) Random: animal, dam	Cage	1.67	12.7
		Pond	1.56	10.4

[A] Actual units are $LW^{0.5}$ difference in mean values for method (i) and difference in mean breeding values for methods (ii) and (iii); Percentage is the least squares mean relative to mean of $LW^{0.5}$ for the whole population (for cage = 13.1 $g^{0.5}$, for pond =15.0 $g^{0.5}$); Genetic standard deviation equals the square root of the additive genetic variance in Table 3 of Ponzoni *et al.* (2005a) ($\sigma_{A(cage)}$ = 1.64 $g^{0.5}$, $\sigma_{A(pond)}$ = 1.89 $g^{0.5}$)

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