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ESTIMATION OF GENETIC CHANGE IN THE GIFT STRAIN BY COMPARING CONTEMPORARY PROGENY PRODUCED BY MALES BORN IN 1991 OR 2003

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SUMMARY
During the development of the GIFT (Genetically Improved Farmed Tilapia) strain in Philippines sperm was frozen from a sample of males from founder stocks and subsequent generations. In this paper a comparison of progeny performance produced from cryopreserved sperm from the base population of the GIFT strain, with progeny from freshly colleted sperm from the ninth generation produced in Malaysia was conducted. Differences in performance were used to estimate the genetic change over these nine generations. GIFT proved to be a highly improved strain that had at least a 63 per cent advantage in growth rate accumulated over nine generations of non-continuous selection.

INTRODUCTION
Tilapia is a popular tropical finfish widely cultured in the world by more than 100 countries (Romana-Eguia *et al.* 2004). The popularity of tilapia is due to its easiness to breed and its hardiness. Also, it is highly marketable and affordable by the lower income community (Pullin 1985; Shelton 2002).

Asian countries are the major tilapia producers. Their production accounted for 80 per cent of the total farmed tilapia production in 2004 (FAO fishplus 2006). The principal species cultivated in Asia is Nile tilapia (*Oreochromis niloticus*).

The Genetically Improved Farmed Tilapia, known as GIFT, is a superior strain created by a selective breeding program conducted from 1988 to 1997 in Philippines. Across five generations of selection, GIFT achieved between 12 and 17 per cent genetic gain in growth rate per generation (Eknath and Acosta 1998; Eknath *et al.* 1998). However, Eknath *et al.* (1998) comment that the accumulated response based on these estimates did not agree with the results obtained when the comparison was made with the progeny of founder stock.

The sixth generation of GIFT was introduced to Malaysia only in 2002. During the phase of selection in Malaysia, GIFT experienced 10 to 15 per cent gain per generation over five generations (Unpublished data). Details about GIFT in Malaysia were reported by Ponzoni *et al*. (2005).

In this paper, we compare the performance of the progeny produced from cryopreserved spermatozoa from the base population (generation zero produced in Philippines) with progeny from freshly collected spermatozoa from the ninth generation produced in Malaysia (three generations after it was received from Philippines). Several characteristics were recorded during the experiment, but only live weight at harvesting is reported here.

MATERIALS AND METHODS
The work was carried out at the Bureau of Fisheries and Aquatic Resources (BFAR), Philippines. Thirteen males from each male parent generation (i.e. base population or ninth generation) were involved in the mating with a random sample of female brood stock available at BFAR to produce

progeny for comparison. The mating procedure resulted in the creation of full and half sib families. The live parents were identified with Passive Integrated Transponders (PIT tags).

The females were checked for signs of pre-spawning behaviour every morning. When a female was ready, the eggs were extruded by stripping and collected in a Petri-dish. Sperm from the base population had been cryopreserved in liquid nitrogen, and it was thawed for use in this experiment. For males from the ninth generation, in order to collect good quality sperm, a 100 µl capillary tube was used and held at the tip of the genital papilla to draw the sperm into the tube by capillary attraction. The collected sperm was transferred into labelled microcap vials and stored in a refrigerator at 4^{o}C. Sperm from each male (from each population, base or ninth generation) was used to fertilize eggs from two different females. The fertilized eggs were rinsed with clear water for several times before transfer to an incubator.

The fingerlings were reared in hapas (net cages) by full sib family until they reached tagging size (3-5g). After being identified with Floy® tags, the fish were sent to communal rearing in two ponds (labelled pond 1 and pond 2). All full sib families were represented in each pond. One month after stocking, the Floy® tags were replaced with PIT tags to avoid loss of data as the fish grew bigger. The fish were harvested after 120 days of communal rearing.

We analyzed records for harvest weight using PROC MIXED in SAS software (SAS Institute Inc. 1997). The statistical model for harvest weight included sex, environment (pond 1 or 2) and sire generation (base population or ninth generation) as fixed effects, and the two-way interaction between sex and the other two fixed effects. Sire (nested within sire generation), dam, and the interaction between sire and dam were fitted as random effects. Age at harvest was fitted as a covariate.

Genetic change was estimated by what is commonly known as the 'repeat mating' method. It consists of a comparison of contemporary of progeny produced by sires of different generations and it provides a means of estimating genetic change without use of a control population (Dickerson 1969; Rye and Gjedrem 2005), but a random sample of dams needs to be assigned to the sires of each of the different generations. In the resulting progeny only half of the genes is contributed by the sires, hence the total genetic change can be measured, as (Dickerson 1969; James 1987; Rye and Gjedrem 2005):

$$\Delta g = 2\left(\overline{X}_{new} - \overline{X}_{old}\right)$$

where, $\overline{X}$ is the mean of performance for progeny produced by the new and by the old sires.

RESULTS

The number of observations, simple mean, minimum and maximum, standard deviation and coefficient of variation for harvest weight and age at harvesting are presented in Table 1.

Table 1 Descriptive statistics for harvest weight (g) and age (days) at harvesting

Variable	N	Mean	Min	Max	Standard deviation	Coefficient variation (%)
Harvest Weight	1928	163	37	385	55.7	34
Age at harvest	1928	212	200	227	7.3	3

Table 2 shows the statistical significance for the fixed effects and the covariate fitted to harvest weight. The genetic change estimated from the difference in least squares means of harvest weight (Table 3) between the progeny of base population and ninth generation sires was 63 per cent.

Table 2 Analysis of variance of harvest weight: Tests of fixed effects using PROC MIXED

Effect	F Value	Prob. > F
Sex (S)	666.2	< 0.0001
Environment (E)	59.4	< 0.0001
Sire Generation (G)	37.4	< 0.0001
S*E	1.6	0.2124
S*G	7.2	0.0075
Age at harvest	1.6	0.2103
Residual variance	1566.54	

Table 3 Harvest weight least square means (g) for sire generation

Sire generation	Least squares means (s.e.)
Base population	140.9 (5.8)
Ninth generation	185.5 (5.8)

DISCUSSION

The total genetic change in harvest weight for GIFT between the base population and the ninth generation was 89.2 g (i.e. twice 44.6 g), or 63 per cent. If we compute the genetic change per generation from this latter figure, for nine generations, it is only 7.03 per cent, considerably lower than the estimate reported by Eknath *et al.* (1998). However, for the reasons we detail below, ours may be an underestimate of the true genetic gain, whereas Eknath's may be an overestimate.

The base population of GIFT was established following three rounds of matings. Details about the GIFT history were documented by ICLARM (1993). Eknath *et al.* (1998) reported an annual genetic gain of 12-17 per cent over five generations of selection, which is considerably higher than our annual estimate for nine generations. Eknath *et al.* (1998) did not establish a separate control population and maintained it throughout these five generations, but rather, they recreated a new control in each generation by mating a sample of average individuals for that generation. Sampling problems accumulated during the selection could have caused an over estimation of the genetic gain that reported by Eknath *et al.* (1998).

By contrast, our estimate of genetic gain may actually be biased downwards. Firstly, the frozen sperm was collected from the best males among the base population, whereas the sires used from the ninth generation were not the best (they were close to the average of that generation). Secondly, the formal GIFT selection program ended at the fifth generation, and there was no selection when matings were conducted to produce sixth and seventh generations. The sixth generation was sent to Malaysia and was used there to establish the population now located in Jitra Aquaculture Extension Center, Kedah state. That means that among these nine generations, we have two in which no selection of superior individuals for growth rate or any other trait was conducted.

CONCLUSIONS

The present study confirms that GIFT is a superior tilapia strain that has accumulated at least 63 per cent of genetic gain in growth rate since the base population was established. Dey and Gupta (2000) predict that the adoption of the GIFT strain can improve the productivity and profitability of tilapia production in Asia, and that this would bring about lower fish prices, thus benefiting the lower income groups. In Africa, where very little has been done in terms of genetic improvement of Nile tilapia, one may safely assume that the productivity of the current stock is at the level of the base GIFT population or lower (Brummett *et al.* 2004). Hence, one may also safely assume that the introduction of GIFT to Africa would improve growth by at least 63 per cent, and quite likely by more. This is not a trivial gain that could benefit emerging aquaculture industries in many Sub Saharan African countries.

REFERENCES

Brummet, R.E., Angoni, D.E. and Pouomogne, V. (2004) *Aquaculture* **242**: 157.

Dey, M.M. and Gupta, M.V. (2000) *Aquaculture Economics and Management* **4**: 5.

Dickerson, G.E. (1969) In "Techniques and procedures in animal science", p. 36, American Society of Animal Science, Albany, New York.

Eknath, A.E., Acosta, B.O. (1998) "Genetic improvement of farmed tilapias (GIFT) project: Final report, March 1988 to December 1997". International Center for Living Aquatic Resources Management, Makati City, Philippines.

Eknath, A.E., Dey, M.M., Rye, M., Gjerde, B., Abella, T.A., Sevilleja, R., Tayamen, M.M., Reyes, R.A. and Bentsen, H.B. (1998) *Proc 6th WCGALP* **27**: 89.

FAO Fisheries Department, Fishery Information, Data and Statistics Unit (2006) Fishstat Plus: Universal software for fisheries statistical time series, Version 2.3. Available: http://www.fao.org/figis/servlet/static?dom=org&xml=FIDI_STAT_org.xml [Accessed Oct 9, 2006].

ICLARM Germplasm Enhancement and Breeding Program (1993) "Genetic improvement of farmed tilapias (GIFT) project", International Center for Living Aquatic Resources Management, Makati City, Philippines,

James, J.W. (1987). In "Merino Improvement Programs in Australia", Proc. of a National Symposium, p. 147, editor B.J. McGuirk, Leura, NSW, Australia.

Ponzoni, R.W., Hamzah, A., Tan, S. and Kamaruzzaman, N. (2005) *Aquaculture* **247**: 203.

Pullin, R.S.V. (1985) *Biologist* **32 (2):** 84.

Romana-Eguia, M.R.R., Ikeda, M., Basiao, Z.U. and Taniguchi, N. (2004) *Aquaculture* **236**: 131.

Rye, M. and Gjedrem, T. (2005) In "Selection and breeding programs in aquaculture", p. 243, editor T. Gjedrem, Springer, Netherland.

SAS Institute Inc. (1997) "SAS/STAT® Software: Changes and Enhancements through Release 6.12", Cary, NC, USA.

Shelton, W.L. (2002) In "Tilapia Farming in the 21st Century", Proc. Int. Forum on Tilapia Farming in the 21st Century, February 2002", p. 1, editors Guerrero III, R.D., Guerrero-del Castillo, M.R., Los Baños, Philippines.