The use of correction factors in the evaluation of growth performance of Tilapia genotypes

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Abstract
An experiment was conducted at the Asian Institute of Technology (AIT), Bangkok, Thailand from February to June 2001 to evaluate the relative importance of correction factors of growth parameters in separate and communal testing experiments of four tilapia strains, i.e. Chitralada, Fishgen-selected, GIFT and IDRC strains. Results showed that the pond correction factor was more useful than the sex- and sampling-correction factors in reducing the heterogeneity of variance. It was also observed that the two testing methods (separate and communal) had consistency in the ranking of the performance of the strains when all the correction factors for differences in pond productivity, sex and sampling were applied. It was hence concluded that due to inadequate replication in pond-based experiments, a pond correction factor should be applied and that evaluation of different strains require the inclusion of a communal pond.

Key words: Correction factors, Levene Statistic, homogeneity, separate testing, communal testing

Introduction

Tilapia males are typically larger than females of the same age. This poses a problem especially in the evaluation of growth data of different strains or species of tilapia more so when there are differences in sex ratios. For example, during sampling, large fish are likely to be caught by hand or net. This would mean that the sampled fish are likely to be males. Analysis of data from evaluation experiments of fish strains/species with different sex ratios would therefore give misleading results since the differences in performance would be from the differences in sex ratios and/or sampling methods. This can be corrected in part by analyzing the sexes separately, although the problem is that very few females are likely to be caught during sampling. Another problem arises when adequate replication is made to minimize environmental variations. For example, in comparing the relative performance of different species or strains of fish, the confounding effects of interactions among different genetic groups, initial age and size differences between groups, differences in pond productivity among locations and seasons, have been regarded as major obstacles (Palada-de Vera and Eknath, 1993). Therefore when adequate replication is made there are no simple, well-accepted procedures for comparing the relative performance of species and strains of fish and crustacea in aquaculture environments (Basiao and Doyle, 1990). However, communal and separate testing experiments are some of the methods that have been used for comparing genetic groups in the same and in separate culture units, respectively. In separate testing experiment, correction factors have been used for the differences in age and size (Palada-de Vera and Eknath, 1993 and Eknath, *et al.*, 1993), differences in sex ratios and sex-related differences (Palada-de Vera and Eknath, 1993) and differences in the environment (Eknath *et al.*, 1993). Palada-de Vera and Eknath (1993) recommended communal testing experiment as a valid technique as it can lead to efficient utilization of experimental facilities and reliable prediction of genetic differences between groups of fish. This experiment was conducted to find out if the correction factors used in separate testing could reduce the standard error generated from that of inadequate replication or even replace the use of a communal pond.

Materials and methods

Four tilapia strains were used in this study, i.e., Chitralada [a locally adapted strain in Thailand but having growth rates similar to those of selected lines when it is sex-reversed (Pullin and Capili, 1988; Yakupitiyage, 1998)], Fishgen-selected [an improved strain developed in Philippines after three generations of divergent within family selection for 16-week weight applied to a base population consisting of five strains from Africa (Abucay and Mair, 2001)], GIFT [an improved strain developed in Philippines under the Genetically Improved Farm Tilapia – GIFT project after combining the

new germplasm from Africa with the farmed strains available in Philippines (Bolivar *et al*, 1993)] and IDRC [a strain selected from a broad genetic base population of locally adapted strains of tilapia in Philippines using a within-family selection (Bolivar and Newskirk, 2000)]. The fry for Chitralada, Fishgen-selected and IDRC strains were collected from the Asian Institute of Technology fish farm while GIFT (5th generation select) was collected from National Aquaculture Genetic Research Institute (NAGRI), Department of Fisheries, Thailand.

Two experiments were conducted. In the first experiment, each of the four strains represented a treatment. A 200-m^2 pond was divided into half with a net; each compartment being 100 m^2. The four strains were stocked (in mixed sex) in separate compartments of the pond at a stocking density of 3 fish/m^2. Each treatment was replicated thrice. In the second experiment, the four strains were stocked in a 200-m^2 communal pond at a stocking density of 3 fish/m^2; 150 fish of each strain. In the communal pond, the four strains were given identification marks by both fin clipping and coded wire tagging as shown in Table 1. Fin clipping was done by removing the fin totally at the base after one month and three weeks of hatching by using a hot pair of scissors. Thereafter, a Northwest Marine Technology's magnetic binary coded wire tags applicator was used to insert the coded wire tags into the fish. A Handheld "Wand" Detector was used to detect if the wire tag had really been inserted into the fish muscle.

In all ponds, water level was maintained at 1 m depth and fertilized weekly with 1.2 kg of Urea (28 kg N/ha) and 0.7 kg of Triple Superphosphate (7 kg P/ha). The batch weight of the seined fish and that of 30 sampled fish (10 % of the initial number of stocked fish) were taken every three weeks.

In the separate testing experiment, data were subjected to Analysis of Variance (ANOVA) (Zar 1984)to test if there were significant differences between the sample means. Since the replicates in each treatment differed significantly ($P<0.05$), a pond correction factor (Appendix I) was used to correct for the differences in the environment. Sampling correction factor (Appendix I) was applied because the mean weight of sampled fish was higher than that of the total fish that was seined. A sex correction factor was used because the mean weight of males was higher than that of females. In the communal testing experiment, the pond correction factor was not applied since only one pond was used. It should be noted that in a communal pond, each individual fish was considered as a replicate in the ANOVA. The Levine statistic was used in both experiments to test for homogeneity of the variance. The means were separated by using the Least Significant Difference (LSD) test.

Results

The corrected and uncorrected weights in separate
testing experiment are presented in Table 2. From Table 2, it can be noted that mean weights of the

Table 1. Identification marks of the four strains in a communal pond

Strain	Clipped fin	Location of coded wire tag
Chitralada	Right pelvic	Dorsal
Fishgen-selected	Left pelvic	None
GIFT	Right pectoral	Anal
IDRC	Left pectoral	Below the eye

Table 2. Multiple comparison test of the mean weights ± standard error in separate testing experiment using the Least Significant Difference Test at 5 % level of significance*

Strain	Uncorrected weight	Pond-corrected weight	Sampling-corrected weight	Sex-corrected weight	Pond-, sampling- and sex-corrected weight
Chitralada	39.7 ± 1.2^{c}	46.7 ± 1.3	33.2 ± 1.0^{c}	39.7 ± 1.0^{c}	39.4 ± 1.0^{b}
Fishgen-selected	48.9 ± 1.5^{ab}	46.9 ± 1.2	43.8 ± 1.1^{b}	48.9 ± 1.4^{b}	42.6 ± 1.1^{a}
GIFT	53.1 ± 2.1^{a}	48.8 ± 1.2	50.8 ± 2.3^{a}	53.1 ± 1.4^{a}	45.5 ± 1.1^{a}
IDRC	46.6 ± 1.5^{b}	45.8 ± 1.5	40.7 ± 1.4^{b}	46.7 ± 1.4^{b}	39.5 ± 1.1^{b}

*Means having the same letter in any given column are not significantly different ($P>0.05$)

four strains were not significantly different when the weights were corrected for the differences in the pond productivity. In addition, the uncorrected mean weights were evened out when a pond-correction factor was applied and reduced when the sampling-correction factor was applied. The sex-correction factor did not reduce or increase the values of the uncorrected mean weights and the standard error was almost uniform and greatly reduced when all correction factors were applied.

For communal testing, the sampling correction factor reduced the uncorrected mean weights while the sex correction factor did not (Table 3).

Test for homogeneity

For separate testing experiment, the results indicate that for the uncorrected, sampling- and sex-corrected weights, the data were significantly heterogeneous ($P<0.05$) while data on the pond-corrected weight and the pond, sampling and sex corrected weights were not significantly heterogeneous ($P>0.05$) as shown in Table 4.

On the other hand, it can be observed in Table 5 that the data on communal testing were significantly homogeneous ($P>0.05$).

Discussion

Separate testing experiment showed that the differences observed from uncorrected mean weights were largely due to the differences in pond productivity, as application of pond-correction factor did not result in significant differences among the strains. For both separate and communal testing experiments, the reduction in uncorrected mean weights when a sampling correction factor was applied showed that the 30 fish that were handpicked had higher mean weights than the total fish that was seined. This means sampling introduced a bias towards larger fish. There was little or no change in uncorrected mean weights when a sex-correction factor was applied because this correction factor forces the means of the two sexes within a treatment to be equal and does not change the overall mean of the treatment. Similar results were obtained when all the correction factors were applied in the

Table 3. Multiple comparison test of the mean weights of fish (± standard error) in communal testing experiment using the Least Significant Difference Test at 5 % level of significance*

Strain	Uncorrected weight	Pond-corrected weight	Sampling-corrected weight	Sex-corrected weight	Pond-, sampling- and sex-corrected weight
Chitralada	55.6 ± 2.8^b	-	54.2 ± 2.7^b	55.6 ± 2.8^b	54.2 ± 2.7^b
Fishgen-selected	67.5 ± 2.5^a	-	67.0 ± 2.5^a	67.5 ± 2.3^a	67.0 ± 2.3^a
GIFT	69.7 ± 2.9^a	-	67.3 ± 2.8^a	69.7 ± 2.4^a	67.3 ± 2.3^a
IDRC	54.5 ± 2.3^b	-	53.5 ± 2.2^b	54.4 ± 2.0^b	53.5 ± 1.9^b

*Means having the same letter in any given column are not significantly different ($P>0.05$)

It should be noted that there was no pond correction factor in communal testing because only one pond was used. The standard errors in the communal pond (Table 3) were higher than those in separate testing experiment (Table 2).

Table 4. Test of homogeneity of variances in separate testing experiment

Parameter	Levene Statistic	Level of significance
Uncorrected weight	12.55	0.00
Pond corrected weight	2.43	0.07
Sampling corrected weight	39.80	0.00
Sex corrected weight	16.31	0.00
Pond, sampling and sex corrected weight	0.88	0.45

Table 5. Test of homogeneity of variances in communal testing experiment

Parameter	Levene Statistic	Level of significance
Uncorrected weight	12.55	0.00
Pond corrected weight	2.43	0.07
Sampling corrected weight	39.80	0.00
Sex corrected weight	16.31	0.00
Pond, sampling and sex corrected weight	0.88	0.45

multiple comparison test (LSD) where in both testing experiments GIFT and Fishgen-selected strains gave significantly ($P < 0.05$) higher mean weights than Chitralada and IDRC strains.

In terms of the homogeneity of variances, only the pond corrected mean weights and pond, sampling and sex corrected mean weights were homogeneous in Experiment 1 unlike in Experiment 2 where all the test parameters were homogeneous. This means that the major cause of the heterogeneity of data was the differences in pond productivity.

While it would appear that the use of correction factors could replace the use of a communal pond, this might not be the case in some experiments having different genetic groups. For example, Wohlfarth and Moar (1985) noted that the differences observed in a communal pond were due to the mutual competitive interactions between test groups, which could not occur when they were stocked separately. Such interactions might be due to differences in initial weights among the groups or to differences in competitive ability not associated with differences in initial weights.

Finally, it can be concluded that pond-, sampling-, and sex- correction factors should be applied to weight measurements in separate testing experiments while sampling- and sex-correction factors should be applied to communal ponds. It is thus recommended that in strain evaluation experiments, a communal testing experiment may be used to reduce replication as required in separate testing experiments.

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Appendix I

The following formulae were used to calculate the correction factors for each strain:

Sex correction factor = Mean weight of fish of both sexes/mean weight of fish of each sex
(Josephine Mair, personal communication)

From the above formula, the following formulae were worked out:

Pond correction factor = Grand mean weight of fish in all ponds/Mean weight of fish in individual ponds

Sampling correction factor = Mean weight of fish from seined batch/Mean weight of 30 sampled fish