

A recent Newsletter article "A method for the analysis of pond growth experiments" by D. Pauly and K.D. Hopkins (January 1983, p. 10-12) prompted letters by Drs. M. Pedini, Fishery Resources Officer at FAO and L. Lovshin, Auburn University, U.S.A. Dr. Lovshin's letter, slightly abbreviated, is published here; Dr. Pedini's comments and questions were virtually the same. Dr. Pauly's answer follows.

Dear Dr. Pauly:

As so often happens, aquaculture researchers are very limited in their knowledge of statistics and mathematicians are limited in the nuances of pond culture. As a researcher and pond culturist perhaps I can give you some insight into the problems of pond culture research and sampling that should be given consideration.

1—I don't believe you can assume that mortality is nil because we always have some mortality. Of course, mortality can be determined at final harvest when the pond is drained. I would assume that your samples can then be corrected for mortality. The problem is to determine when the mortality occurs. Unfortunately, we don't always know when mortality occurs because we can't always see the dead fish especially when the fish are small and/or predators are abundant.

2—We don't really know the effects of sampling on the growth of fish. How frequently can we sample before growth is adversely affected? Some fish can be sampled twice a week without any apparent effects. Other species can't be handled once a month without the risk of mortality or growth reduction.

3—I have found it very hard to get a good estimate of growth and yield by sampling ponds with a net for many species of fish. First, many species are very good at avoiding a seine even in a small pond. Often, you can't get a good sample without repeated seining which can cause water quality problems if the pond bottoms are rich in organic matter. Second, even a decent sample, 20% of your population, can be very misleading because of size bias. Often, you get a high percentage of large or small individuals because of ability to escape capture. For example, a day before pond draining, I have sampled a number of tilapia ponds with a seine, capturing a normal 20% of the population. After draining, a comparison of the sample average fish weight and harvest average weight was made. I often had a difference of 20%. The best I ever got was a 4% difference.

4—Your statement that a "new approach to designing experimental aquaculture facilities is offered since an alternative to replication of treatments is available", is misleading. No matter what the type of statis-

tical analyses used we are always better off to replicate. Your method may explain what is the cause of variance in a fish pond but it does not eliminate the variance. If you use only one pond per treatment and have high mortality due to an O₂ deficiency how can a good comparison of yield between 2 treatments be made? Even if analysis of variance is not used but some form of analysis of curves, I believe replication is wise to give more secure answers.

We need the help of interested mathematicians. Design research that can determine some of the sampling biases I have mentioned. Most tilapia species are ideal experimental animals but should not be used as the standard for all aquatic animals. Some good culture species are not born to be excessively handled and sampled. Good luck, your work is cut out for you.

Sincerely,

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Reply

First of all, I would like to thank Dr. Lovshin for his comments on our Newsletter article. Also, I have to mention here that my answer to his questions should not be perceived as a 'rebuttal' but rather as a late statement of things which should have been included in our article but were not, due to lack of space and sheer negligence. I now answer Dr. Lovshin's points in turn:

1—*Actually, when we wrote that mortality must be nil as one of the assumptions that must be met for our method to be applicable, we took a shortcut which we hope would help the reader concentrate, when assessing our method, on cases where mortality is indeed negligible. In fact, the method can be used when mortality is non-negligible, granted it is not linked to any factor affecting growth, i.e., not caused by any of the treatments. Put differently, variables which the method identifies as enhancing growth will also enhance yields if they are not simultaneously the cause of mortalities.*

2—I agree that sampling itself will have an effect on growth, and this effect should generally be negative. On the other hand, there is nothing preventing us from using sampling frequency itself as a variable and hence to eliminate its effect on the estimated statistics. For example, in coral fish caught with traps, and whose growth is negatively affected by trapping, the application of our method allowed both the identification and the removal of the effects of trapping on the fish whose growth was studied¹.

3—*There is obviously no simple solution to the problem of obtaining representative sizes from pond samples, and it will be the task of the investigator concerned to choose a sampling gear which is as non-selective as possible.*

4—*With regard to replication, let me state that if one pond per treatment is used and there is a high mortality in one of the ponds, the method we propose allows use of the growth increments up to the time when the mortality occurred—which isn't possible when comparing final yields only.*

I concede that it was mistaken to suggest that "no replication is needed", because something equivalent to replication is needed when multiple linear regression models are used, namely that (a) each variable considered must be represented by a wide range of values and (b) that the variables considered must not vary together (these two requirements imply a 'replication' of some sort, but different from what is required e.g., in ANOVA).

We were aware, when we wrote our article that a more detailed presentation will be needed for the advantages of this new method to be fully appreciated, but went ahead with a preliminary publication because we assumed that some readers of the ICLARM Newsletter would be interested in the preliminary version. As it turned out, several colleagues after reading the article have expressed interest in the method, and in designing their pond growth experiments such that they will be able to apply and test it. We have decided to await the results of these tests, and of an in-depth analysis of the experiments conducted in the original ICLARM-supported project (see ICLARM Newsletter, October 1980, p. 12-13) to prepare a comprehensive paper on the method.

¹D. Pauly and J. Ingles. 1981. Proc. 4th Int. Coral Reef Symp., Manila.

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