Multivariate Models of Tilapia and Carp Growth as an Application of Microcomputers in Aquaculture Research

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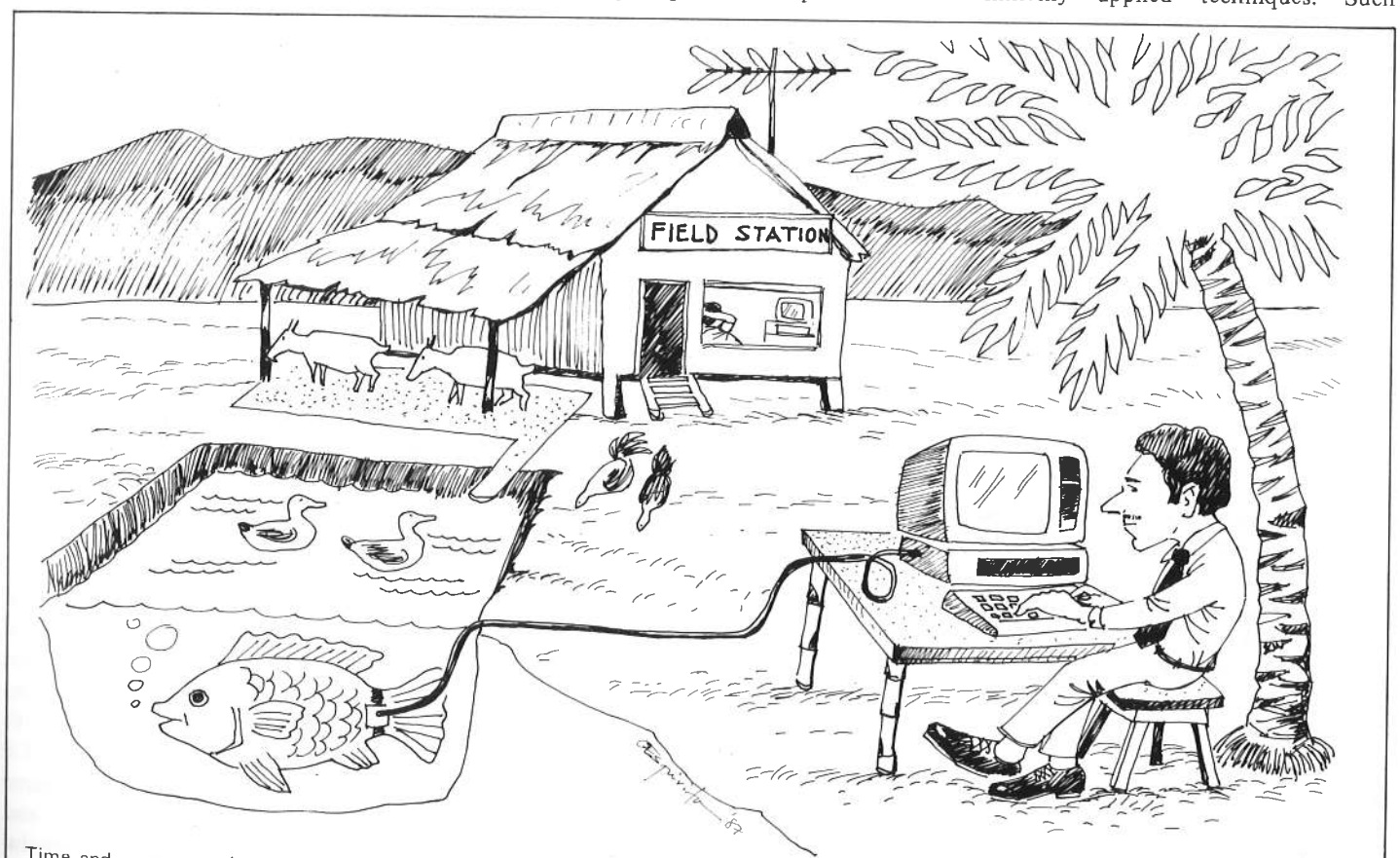
To help improve the nutrition of wide parts of the population in tropical developing countries, small-scale culture systems are being designed and developed that require only low levels of managerial and energy inputs, recycle available nutrients and still generate high harvest yields. Different production units can be coupled together into one integrated farming system, which then becomes a complex structure of interwoven processes and nutrient pathways. The often delicate interdependencies of the most influential variables become difficult to understand, their behavior even more uncertain to predict. The aim is to maximize fish yield under given conditions at different locations.

The ARO/ICLARM/BMZ Project

A direct approach to the issues outlined above is currently being carried out as part of a project funded by the German Ministry for Development and Technical Cooperation (BMZ). The general aims of the project are to make use of modern, applied research methods to develop aquaculture technologies applicable for developing countries. Implementing institutions are the Israeli Agricultural Research Organisation (ARO) and ICLARM, in cooperation with the Central Luzon State University (CLSU) which in the past have gained experience, expertise and vast amounts of fish growth and environmental data collected from numerous experiments and commercial farms rearing tilapias and carps in Israel and the Philippines. Research on the Israeli part of this project is conducted by Drs. Gideon Hulata and Ana Milstein of the Dor Research Station. Their counterparts from ICLARM are Dr. Daniel Pauly, Dr. Roger S.V. Pullin and this author. Although the general perspectives in both experiments were basically the same (parental stock of Nile tilapia, low-level energy and managerial inputs, nutrient recycling), certain differences in detail exist, calling for a comparison, but also a combined analysis of the methods and data.

New Analytical Methods in Aquacultural Research

The main incentive behind the present approach is to use available data sets and analyze them with some of the most powerful statistical methods now available and extract more information from them than has already been done with the commonly applied techniques. Such



Time and money can be saved since all necessary data handling and analysis can be performed on site, permitting immediate feedback to other project and management personnel.

"multivariable" data sets can be analyzed by multivariate statistical methods. "Older" methods should not be replaced but supplemented by the new procedures.

Dr. Milstein has shown in a series of papers the value and applicability of principal component analysis and canonical correlation for the interpretation of pond production data. Dr. Pauly, together with Dr. Kevin Hopkins, proposed a new method (see January 1983 Newsletter, p. 10-12) derived from the von Bertalanffy growth function, combined with multiple regression analysis. The latter method and a related one–path analysis–make it possible to identify and quantify the effects of environmental variables on fish growth as has been shown by this author. The ICLARM/CLSU data set contains 60 variables in over 700 cases, making factor analysis appropriate. Other methods applied in fisheries biology together with indices of growth performance also permit the analysis of fish growth under different culture conditions. Each of these methods has its advantages over the others and these should be further exploited.

Why Microcomputers in Aquaculture Research?

Until recently, storage and computational performance required for even less sophisticated statistical methods was limited to mainframes which are not common in developing countries. Even with mainframes, there are problems of accessibility, user friendliness and even response time. With the availability of microcomputers and their steadily increasing computing power, things have drastically changed for the weary aquaculture scientist. With the present-day capacity of spreadsheet programs and storage media for microcomputers, even large data sets from longer time periods can easily be entered and processed. The storage media (mostly floppy disks) are easily transported, mailed or duplicated for safety purposes (it has happened that a record book with four months of integrated farming data was eaten by the farm animals) and have a high storage capacity. For example, a large aquaculture data set presently being analyzed consists of 45,000 data points and uses only 350 kilobytes on one normal floppy disk. Data in the form of ASCII files can be transmitted between continents via data networks or telephone lines within seconds. The ease of interchangeability makes it possible for colleagues to compare the performance of different analytical techniques on the same data and compare the results.

Graphical and Statistical Analysis

With all data in a standard format for immediate retrieval, powerful graphics software packages can be used to conduct first steps of "exploratory data analysis", plotting many different variables in search of trends and relationships. Plots can consist of even thousands of data points and are established within seconds.

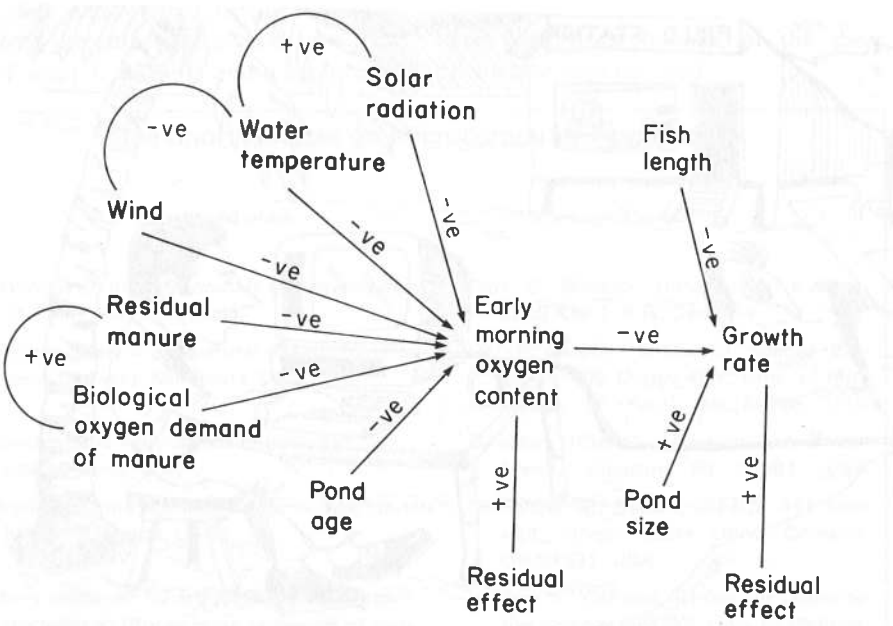
Specially designed statistical analysis programs for micros, or microcomputer versions of sophisticated analysis software packages, previously limited to mainframes, are now available. Often their use is regarded as even superior to the mainframe versions since there is no batch processing time, no system servicing and breakdowns, and printouts or plots are obtained immediately.

In the present project, data sets are being compiled on microcomputers and exchanged, and the new procedures mentioned above are being applied. The respective results obtained by the different methods will be compared and final conclusions drawn.

Future Outlook

In future experiments, data recordings of aquaculture and environmental variables will be performed using long-lasting, self-cleaning probes connected to robust data loggers. Powered by solar energy, these systems can be installed in remote sites and data transmitted daily or weekly via ordinary telephone lines to a central microcomputer station for immediate processing, storage and analysis. No manual work will be involved, saving time and omitting considerable sources of error.

Compared to the closely related sciences of agriculture, fisheries biology, limnology and hydrology, the field of aquaculture is extremely "undermathematized" and still seems to be more in the state of an art than of a science. It is inevitable that methods from these and other disciplines should be applied to aquaculture to develop models of production and economics. This desperate need should be considered in the design of future projects. Moreoever, the results, in the form of adequately documented raw data, should be made accessible to other researchers, possibly in form of a data bank, to permit analysis of the same data sets with different methods and models, threafter drawing final conclusions. This is common practice, for example, in physical oceanography. ●



Schematized causal path diagram showing the direction of influences on fish growth in a manured pond system, based on a linearized model. Early morning oxygen content correlates negatively with trophic state (i.e., plankton content) of the pond environment and the challenge is to increase the trophic state (through manuring) without depleting early morning oxygen.