Advancing Technology in Swine Production: A Simulation Model of Swine Performance

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Swine producers in North Dakota and throughout the United States are presently living in an era of restricted margins for profit. Although feed is the major portion of production costs, capital investments and rising interest rates for housing and inflated energy costs have contributed to an elevation of the average break-even price for producing swine. With lower consumer demands for pork, market prices of swine have recently remained relatively low. Producers urgently need to maximize the efficiency of production and marketing to survive todays low profit margins.

The amount of information that must be assimilated and integrated into the development of a successful swine enterprise is staggering. Although much information exists involving the production and marketing of swine, many gaps remain to be filled. Nutrient interactions and nutrient-environment interactions are current examples of unresolved research voids.

Recent advances in computer technology have paved the way for the development of simulation models for biological systems. With the advent of microprocessors and microcomputers on the farm, mathematical models have taken on a powerful new dimension.

What are models? Models use mathematical calculations to predict or simulate biological responses under a variety of conditions. The development of a model is not an easy task. Several "modules" or components must be integrated to build a single massive model. Many calculations are required to form even the simplest modules. However, with the aid of computers, many of the calculations can be derived from existing information. Additional experiments must be designed and conducted to validate or to bridge the gaps in the chain of knowledge that is necessary to derive the remaining calculations involved with the model. The development of a model for swine production will enable researchers to integrate existing knowledge with additional research and assist them in the task of bridging the gap between the producer and the scientific community.

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Such a task is being initiated as an interdepartmental project at North Dakota State University. The Animal and Range Sciences, Agricultural Economics and Agricultural Engineering departments have recently undertaken the task of developing a model that simulates reponses of growing-finishing swine to variables in environment and nutrition, with emphasis on maximizing profits. The cooperative effort among the departments will be the most efficient approach to the development of the model. Additional information and research will be contributed by other experiment stations in Nebraska, Michigan and Ohio.

The inputs and objectives of the various departments at NDSU will be assigned to the cooperating personnel. The existing database of information from previous experiments will be reviewed by the Department of Agricultural Economics to maximize the utilization of existing data and to gain information concerning the efficient design of future experiments.

The objectives of the Animal and Range Sciences Department are to compile existing knowledge about swine nutrition and growth to determine the needs for additional research. New designs will be incorporated into experiments to determine the simultaneous effects of energy, crude protein and lysine in diets fed to growing-finishing swine. Integrating the results of these future experiments with knowledge of the nutrient content and current prices of various feed ingredients will permit the formulation of cost-effective diets.

These experiments will be conducted in the recently constructed swine research facilities at NDSU. The Department of Agricultural Engineering will install electronic sensing equipment in the facilities to monitor the environmental influences upon animal performance. These results may serve as a standard to compare actual swine performance with expected performance. The implication is that the computer model, with environmental inputs (such as air temperature and air velocity at the animal level), can be used to predict and control the environment that best meets the needs of the animal and utilizes dietary and supplemental energy resources most efficiently.

As current information is reviewed and future data are collected, current economical considerations will be incorporated into the model to enable the producer to improve his production and marketing decisions. For example, integrating price expectations at various points into the model would be desirable and useful. Futures market and price outlook information may be useful to determine the expected value of a market hog. The expected value could then be used as an aid in making management decisions that maximize profits. The producer could also use the model to evaluate his decisions and change production and marketing strategies, should developments in the industry so warrant. Economic considerations may also be given to the trade-off between the cost of a ration and its nutritional quality, because such decisions may affect the duration of a feeding program. Environmental control and the trade-off between the cost of maintaining feeding room temperature within a certain range and an animal's performance should also be considered.

The broad nature of the overall effort will create modules in swine housing, nutrition, economics and growth during the period from 35 to 250 pounds. The final model would be available for use in the classroom, in research, by the Extension Service and by individual producers.

The model will be designed to answer "What if?" situations that would enable individuals to determine their most economically sound management alternatives. Potential decisions could be made relating to housing, ventilation, ration formulation and various other aspects of the animal, diet and environment that may result from this model.

Evaluation of swine housing has been conducted primarily by field testing the performance of swine in various type of housing. Because of resources, this type of evaluation is usually limited to a small number of buildings. Mathematical simulation of the responses of swine to environmental modification provided by various types of buildings would provide a useful tool for determining which type of building should be field tested or recommended to the producer. These results could also serve as a standard to compare actual swine performance with expected performance.

The use of mathematics to describe the interaction between livestock and their environment has long been recognized as a method to organize thinking, integrate data resources, and assess new environmental situations. With advent of microprocessors and microcomputers on the farm, mathematical models have taken on a powerful new dimension. Potentially, these models can be an integral part of control systems which modify the housing environment according to predicted animal or building thermal response.

Mathematical models have been developed from several approaches: statistical models relating known human environmental indices to the production and/or physiological response of the animal; development of new environmental indices and energetic models using thermodynamic principles; and physiological models predicting the response of the animal at cellular, organ and/or system level and integrated for the total response.

Heat loss data have been analyzed in regression form and then placed in tabular or graphical form (Bond, 1959). European investigators are presently developing heat loss data in general equation form (Sallvic, 1981). The CIGR – Section II Working – group on General Heat Loss Equations is taking into consideration the production level of the animal and has integrated its work with that of Strom and Feenstra (1980). In Europe, models have been developed mainly for given feeding levels (Bruce and Clark, 1979; Whittemore and Fawcett, 1976). In the United States, *ad libitum* intake has been predicted for *ad lib* feeding either by empirical equations (Teter, 1974) or by use of physiological principles (Paine, 1974).

These models are presently being verified by others and used for efficient environmental design with the computer. Boon (1981) has successfully used Bruce and Clark's (1979) model to predict the critical temperature for groups of pigs and to relate it to the postural behavior of pigs. The implication is that a computer model, with environmental inputs such as air temperature and air velocity at the animal level, can be used to predict and control the environment that best meets the needs of the animal and utilizes energy inputs most efficiently.

WHAT'S IN IT FOR NORTH DAKOTA

The model being developed will be programmed on an IBM Personal Computer using the BASIC computer language. The model will be fully interactive. This model will be useful in evaluating the influence of different thermal environments on weight gain, feed efficiency, and heat loss or gains to the pig. The heat exchange data will be useful in developing heating or cooling strategies for growing pigs. The model will be structured so that future adjustment of any of the parameters can be implemented as new data are gathered.

This simulation model will have considerable potential for making decisions in housing, heating, and management. It can be used for ventilation calculations, ration formulation, and various other aspects of the animal, diet, and environment. The simulation model will be used in agricultural engineering coursework to give student engineers experience in environmental management for growing livestock.

REFERENCES

Boon, C.R. 1981. The effect of departures from lower critical temperature on the group postural behavior of pigs. **Anim. Prod** 33:71-79.

Bond, T.E., C.F. Kelly and H. Heitman, Jr. 1959. Hog house air conditioning and ventilation data. **Trans. ASAE** 2(1):1-4.

Bruce, J.M. and J.J. Clark. 1979. Models of heat production and critical temperature for growing pigs. **Anim. Prod.** 28:353-369.

Paine, M.D., J.A. Witz, A.F. Butchbaker, C.M. Bacon and J.E. McCroskey. 1974. Mathematical simulation of energy metabolism in beef animals. **Trans. ASAE**, 17(1):102-107.

Sallvik, K.G., H. Bartussek, J. Christiaens, S. Pedersen, H-F. Wolfermann, U. Chiappini, H. Lilleng, M. Rist, J. Bruce, J. de la Farge. 1981. The CIGR - work for climatization in animal houses. ASAE Paper #80-4059, ASAE, St. Joseph, MI 49085.

Strom, J.S. and A. Feenstra. 1980. Heat loss from cattle, swine and poultry. ASAE Paper #80-4021, ASAE, St. Joseph, MI 49085.

Teter, N.C. and J.A. DeShazer. 1974. Effects of temperature on nutrient requirement of meat animals. **Proc. First International Symposium Feed Composition, Animal Nutrient Requirements, and Computerization of Diets.** (Eds.) P.V. Fonnesbeck, L.E. Harris and L.C. Kearl, 497-501.

Whittemore, C.T. and R.H. Fawcett. 1976. Theoretical aspects of a flexible model to simulate protein and lipid growth in pigs. **Anim. Prod.** 22:87-96.

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Records produced may indicate average days cows are dry, expected calving dates, expected heat dates and other management reports.

A Florida producer generates between 60 and 100 management reports per week! The list of useful management reports is probably limited by lack of imagination rather than by computer and/or electronic technology.

The electronic age as brought dairy management into a very sophisticated state and promises to do even more that will help managers know more about their operation than ever before. Time saved may not be great but wiser decisions will be made because of more and better information.

New techniques must result in greater profitability if they are to survive the test of time. The projected "pay back" in increased production or feed and labor saved should be in the range of 2.00 to 3.5 years depending upon system purchased, production level, herd size, interest rate and use made of system. At the present time there are at least 20 computerized feeding systems in use by North Dakota dairy producers.