Order Number 9019590

Energetics, behavior and performance of growing swine at constant and cyclic high temperatures

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ENERGETICS, BEHAVIOR AND PERFORMANCE OF GROWING SWINE
AT CONSTANT AND CYCLIC HIGH TEMPERATURES

by

HONGWEI XIN

A DISSERTATION

Presented to the Faculty of

The Graduate College in the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor of Philosophy

Major: Interdepartmental Area of Engineering
(Agricultural Engineering Field)

Under the Supervision of Professor James A. DeShazer

Lincoln, Nebraska, U.S.A

December, 1989

ENERGETICS, BEHAVIOR AND PERFORMANCE OF GROWING SWINE AT CONSTANT AND CYCLIC HIGH TEMPERATURES

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Eighteen ad-libitum-fed individual Whiteline (Large White x Landrace) x Duroc gilts with overall average weight of 39 kg were exposed respectively to (a) constant air temperature of 30.8 C (CON); (b) reduced peak diurnal cyclic temperature of 26 to 33 C with mean temperature of 30.8 C (RPK); and (c) reduced night diurnal cyclic temperature of 23.4 to 40 C with mean temperature of 30.8 C (RNT). Six replicates were involved per temperature treatment. Daily average and 24-hr dynamic feed intake, heat losses, water consumption, growth rate, respiratory quotient and the related behaviors were measured for a five-day period.

Daily feed intake, heat losses, water consumption, growth rate and feed conversion of RPK pigs could be predicted with the same responses of CON pigs. This relation holds in the case of RNT pig responses except for feed intake and growth rate. Feed intake (1.56 kg/day-pig) and growth rate (0.70 kg/day) of RNT pigs were significantly reduced ($P<0.01$) compared to RPK pigs (1.78 and 0.84) or CON pigs (1.71 and 0.82). Thus a cycle of 16 C impaired feed intake and growth rate of 40-kg pigs when the mean of cyclic temperatures was above thermoneutral zone.

Ingestion behaviors of the pigs were characterized by meal and drinking size of 160-170 g/meal-pig and 250 to 270 g/drink-pig;

frequency of 9 to 11 meals/day and 36 drinks/day; and duration of 13.7 min/meal and 0.61 min/drink respectively.

Pigs showed high average hourly feed intake of 117/pig-hr from 1200h to 2100h at CON; 87 g/pig-hr from 1300h to 0800h at RPK; and 120 g/pig-hr from 2000h to 0800h at RNT respectively. High heat loss rate generally followed the feed intake hike with about two hours of lag.

Data Dependent Systems (DDS) analysis indicated that CON and RPK pigs had more dynamic feed intake systems and thus more active memory of their feeding history than RNT pigs. RNT pigs appeared unable to adjust their heat dissipation as freely as CON pigs or RPK pigs. Dynamic respiratory quotient appeared positively related to dynamic growth of the pig.

TITLE

Energetics, Behavior and Performance of Growing Swine

at Constant and Cyclic High Temperatures

BY

Hongwei Xin

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ACKNOWLEDGEMENTS

The author wishes to express his sincere acknowledgement to his advisor Dr. J. A. DeShazer for his guidance and assistance throughout the entire Ph.D program.

The author deeply appreciate the contributions to the study by Drs. G. L. Hahn, J. A. Nienaber, D. D. Schulte, A. J. Lewis, and D. W. Leger as members of the supervisory committee. Special thanks go to Drs. J. A. Nienaber and A. J. Lewis for their careful review and valuable suggestions on this dissertation.

Gratitude is also extended to the following individuals and units in no particular order.

. NC-179 regional research project for its financial support that made this study possible;

. Agricultural Engineering Shop for constructing the indirect animal calorimeters;

. Agricultural Research and Development Center of UNL for providing the study with growing pigs and temperature history data in the facility;

. Mr. D. Smith for his constant assistance in maintaining operation of the calorimetry systems and handling of the pigs;

. Mrs. D. Smith, B. Nitsch and K. Tsukata for their assistance in processing the dynamic data of the pigs;

. Mr. M. Milanuk for his cooperation in handling the pigs and providing the climatic data of the swine facility at ARDC, Mead;

. Mr. B. Sandhorst and Ms. S. Smith for their assistance in visual needs and development of the study;

. Mr. T. Way for his assistance in initial operation of the 10K4 DataPac unit.

. Dr. T. L. Thompson for letting me use his computer for environmental control in this study;

. Dr. L. Bashford for providing frame components of the 10K4 DataPac unit;

. Dr. G. Meyer for letting me use his EG&G model 880 Dew-point hygrometer during part of the study;

. Tractor testing center for the use of their Detecto electronic scale to weigh the pigs;

. All other personnel of the Agricultural Engineering Department who made contributions to this study or provided assistance in my Ph.D program at UNL.

. Mr. J. Kelty for adding the third relay to the relay control box for heater control;

. ADM Soybean Processing unit for their kind donation of 100 gallons of degummed soybean oil, which allowed a realistic measurement of latent heat loss of the pigs.

. Swine Nutrition Laboratory of the Animal Science Department at UNL for analyzing the compositions of the swine diets; and

. Audio/visual office of Agricultural Communications at UNL for developing slides on the results of the study.

Last but not the least, I thank my wife, Tong Wang, and my beloved parents (in China) for their consistent support, understanding and encouragement during my Ph.D program.

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CHAPTER I INTRODUCTION

1.1 Background

Air temperature is the major physical environmental parameter that affects the performance of livestock. The effects of constant environmental temperatures on swine performance and well-being have been well documented (Kelly et al., 1948; Heitman and Hughes, 1949; Bond et al., 1952; Heitman et al., 1958; Bond et al.,1959; Heitman et al., 1963; Holmes and Mount, 1967; Close et al., 1971; Holmes, 1973; Holmes, 1974; Mount, 1975; Stombaugh and Roller, 1977; Strom, 1978; Verstegen et al., 1978; van der Hel et al., 1983; Sallvick and Walberg, 1984; and Close, 1987). Mathematical models have been developed to evaluate or predict swine responses to constant environmental temperatures under various nutritional conditions. These mathematical models simulate critical temperatures for swine (Teter et al., 1973; Bruce and Clark, 1979); heat production and growth rate (Teter et al., 1973; Christianson et al., 1982; Black et al., 1986; Jacobson, 1986; Turner et al., 1987); daily feed intake (Teter and DeShazer, 1976; NRC, 1987); partition of retained energy for fat and protein gain (Whittemore and Fawcett, 1974); environmental conditions in the swine confinement as influenced by outside weather (DeShazer et al., 1988); and economical profit of the production (Watt et al., 1987). The constant environments-based data and mathematical models have provided valuable tools for education, management of animal production systems and research in further improvement of animal environments.

However, the maintenance of a constant temperature environment in

swine production facilities is not always practical. In fact, diurnal cyclic temperature of 33 ± 7 C has been reported typical of summer climate in the Midwest U.S. region (AGNET, 1984). This diurnal fluctuation is also shared by temperature inside livestock facilities, although it may not follow exactly the same outside pattern. Thus an applied question is "Would constant temperature-based models be directly applicable to predicting responses of livestock to cyclic temperature conditions?" Namely, "Would average responses of swine be the same to both constant temperatures and cyclic temperatures of the same mean values?" If not, how would the cyclic temperature conditions influence the performance of the pigs and thus the production efficiency? To answer this question, extensive studies are essential to compare responses of the animals to a variety of constant and equal mean cyclic temperatures.

The natural summer diurnal cyclic temperatures of 33 ± 7 C in a Midwest region swine facility may further be modified through cooling schemes such as evaporative cooling and air conditioning. Such modifications of diurnal cyclic environments are designed to make the environments more favorable to animal production efficiency and hence to improve production profit. Different cooling means or schemes, however, may cause the animals to respond or perform differently than expected.

The cooling schemes could also produce different on-farm electrical load allocations. Proper load allocation of on-farm electrical energy will help reduce the peak value of the energy consumption hence lead to a more profit-yielding production operation. Therefore, a question is "Are there certain cooling schemes that are

more favorable to the animals and economical to the producer than others?" To ultimately approach such a problem, a brief up-to-date look at the responses of swine to some cyclic air temperatures would be instructive.

Not much is known regarding to what degree the thermal environments may fluctuate without impairing swine performance. Bond et al. (1963) subjected 70-kg ad-libitum fed pigs (in groups of four pigs) to the following air temperature regimens: a) constant temperature of 21 C; b) a diurnal cycle of 15.6 to 26.7 C; c) a diurnal cycle of 10 to 32.2 C; and d) a diurnal cycle of 4.4 to 37.8 C. The results indicated that pigs at constant air temperature of 21 C had significantly better daily weight gain and feed conversion (0.76 kg/d and 3.50 kg feed/kg gain) than when the air temperature cycled from 10 to 32.2 C (0.49 kg/d and 6.15 kg feed/kg gain) or from 4.4 to 37.8 C (0.61 kg/day and 4.55 kg feed/kg gain). Rate of gain during the 15.6 to 26.7 C cycle was less (0.66 kg/day and 3.88 kg feed/kg gain) but not significantly so than that at 21 C. Bond et al. (1963) also concluded that there was no significant difference between the total daily animal heat loss or evaporative heat loss under the diurnal fluctuating conditions and those under the constant air temperature.

Morrison et al. (1975) reported that growth rate and food conversion of averaging 49-kg and 77-kg pigs were not affected by either a 10 C or a 20 C range in diurnal air temperature cycle compared with a constant temperature equal to the mean of the cycle when the mean temperature was optimal (24 C for the lighter pigs and 21.5 C for the heavier pigs). Incidentally, this finding was different than the result

of Bond et al. (1963). However, when constant temperature and cycle mean were 6 C about the optimum, performance declined with 20 C range cycle but slightly improved with 10 C cycle.

Hahn et al. (1975) reported that hogs in a 59-day test at initial weight of 27 kg showed almost identical growth rate and feed conversion to the temperatures of 33 C and 33 $\pm$ 8 C. Hahn et al. (1987) concluded that daily cycles of $\pm$ 5 to 8 C about the mean temperature cause no adverse consequences on swine performances in the absence of drafts, wet conditions, or strong radiative heat gains or losses.

Scott et al. (1983a) exposed Holstein cows to simulated summer diurnal ambient temperature cycles of Phoenix, Arizona and Atlanta, Georgia and diurnal modifications of these climates. Physiological responses of plasma thyroxine and rectal temperature of the animals were monitored. Their data suggested that night cooling might be a most effective method to alleviate thermoregulatory limitations of a hot climate on animal performance. They indicated that decreasing night time air temperature or THI (Temperature Humidity Index) or increasing diurnal cycle range allowed the cows to more easily dissipate excess body heat accumulated during the day and minimize the thermal inhibition on feed intake, and alterations in plasma thyroxine and rectal temperature.

Nienaber et al. (1989) evaluated cyclic temperature effects on growing swine (20 to 40 kg, 4-week growth) penned individually and on finishing swine (65 to 100 kg, 6-week growth) penned in pairs. In the study, constant air temperatures of 5 C (below lower critical temperature) and 20 C (within thermal neutral zone) were compared to