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PHYSIOLOGY AND REPRODUCTION

Feed and Water Consumption Patterns of Broilers at High Environmental Temperatures[1]

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ABSTRACT Broilers were reared on litter to determine the effect of cyclic environmental temperatures on feed and water consumption patterns. The temperatures were constant at 24 C for several days before cyclic temperatures were started. Control broilers continued at 24 C but the treatment was a daily 24-35-24 C cycle for 3 days. Broilers that were 5, 6, or 7 wk old consumed as much feed or water the 1st day of the cycle as on the succeeding days. Feed and water consumption were determined for 6-h periods each day beginning at minimum temperature with two periods during rising temperature and two periods during declining temperature. Feed consumption was depressed when the temperatures were declining. Water consumption increased during the 12 h when the temperature was maximum. At 7 wk, water consumption was greater for broilers on the cyclic temperature for each 6-h period except for the period of temperature decline immediately preceding the minimum temperature. Broilers exposed to the 3 days of cyclic temperatures consumed more water than controls during a subsequent exposure to temperatures up to 40.8 C. The data show that the increased water consumption and decreased feed consumption observed due to high, cyclic temperatures arise from changes that occur during some times of the day and no changes occur during other times. The increase in water consumption precedes the reduction in feed consumption.
(*Key words*: feed, water, acclimation, heat, stress)

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INTRODUCTION

The incidence of broiler deaths due to heat stress is reduced if broilers have been exposed to high cyclic temperatures for 3 days (Reece *et al.*, 1972). The acclimation mechanism involved has not been defined precisely. Water consumption increases when chickens are exposed to high environmental temperatures (North and Bell, 1990) and survival during heat stress is dependent upon water consumption (Fox, 1951). Fasting improves resistance to heat exposure under some situations (McCormick *et al.*, 1979). Heavier broilers are more susceptible to heat stress (Reece *et al.*, 1972), so the interpretation of the effect of depressed feed consumption can be complicated by the resulting reduction in body weight. Cyclic environmental temperatures may cause broilers to change consumption patterns and consume more feed or less water during the part of the day with the lowest temperature. The objective of the present study was to determine the effect of high cyclic environmental temperatures on the feed and water consumption patterns of broilers.

[1]Trade names in this article are used solely to provide specific information. Use of trade names does not constitute a guarantee or warranty by USDA and does not signify that the product is approved to the exclusion of other comparable products.

MATERIALS AND METHODS

Experiment 1

Male broiler chicks from Arbor Acres female line parent stock[2] were reared on litter with feed and water continuously available. Corn-soybean meal diets were formulated to meet or exceed National Research Council (1984) requirements. A starter diet with 3,142 kcal/kg ME and 21.0% protein was fed until the broilers were 21 days old and a finisher diet with 3,197 kcal/kg and 19.3% protein was fed after 21 days. The chicks were housed in a windowless house with continuous incandescent lighting. The rearing temperature was set at 29 C the 1st wk and reduced 2.8 C each week thereafter until 24 C was reached.

Groups of broilers were moved from the rearing house and placed in two environmental chambers when they were 30, 37, or 44 days old. Each chamber had two floor pens 1.14 × 1.87 m that were stocked with 20 broilers per pen at 30 and 37 days and with 10 broilers at 44 days. The broilers were kept in the chambers only 1 wk and a pooled body weight for each pen was obtained at the beginning and end of the week. Broilers placed in the chambers at 30 and 37 days were provided feed for 1.5 h followed by 4.5 h when feed was not available, with four such periods per day while they were in the chambers. Those placed in the chambers at 44 days were provided feed continuously. Water was continuously available to all groups. Each pen had a tube feeder with a pan 35 cm in diameter and a dome waterer 33 cm in diameter. Water supply containers were suspended from load cells outside the chambers and each feeder was suspended from a load-cell and linear actuator. Each 30 min, the actuator raised the feeders and a computer recorded the weights of feed and water. Feed was unavailable for approximately 1.5 min; consumption of feed and water were determined by difference.

Both environmental chambers were maintained at a constant 24 C temperature and 16 C dewpoint. After each group had been in the chambers 4 days, the temperature in one chamber was changed to a 24-h curvilinear cycle of 24-35-24 C; the dewpoint remained constant at 16 C.

Feed and water consumption were totaled for 6- and 24-h periods when, the temperature was cycling. The 6-h periods were selected for the period beginning at minimum temperature, the succeeding 6-h period ending at the maximum temperature, the 6-h period after the maximum temperature, and the final 6-h period that ended at the minimum temperature. The total weight of broilers in each pen was calculated for each 6-h period based on beginning and ending body weights for the period when broilers were in the chambers. Reece and Lott (1983) have shown that weight increase is linear for this period. Feed and water consumption were calculated as percentage of body water.

Experiment 2

Male Avian × Avian broilers obtained from a commercial hatchery[2] were housed on litter in four environmental chambers. Each chamber had two 1.17 × 1.88-m pens that were stocked with 20 broiler chicks. Chamber temperatures were set initially at 32 C and reduced 2.8 C/wk until 24 C was reached. The dewpoint temperature was initially at 24 C and reduced to 21 C on Day 9 and further reduced to 18 C on Day 23. The number of broilers per pen was reduced to 12 on Day 39. On Day 43, the temperature regimen in two chambers was changed to a daily cycle of 24-35-24 C. On Day 46, a heat exposure regimen was conducted in all four chambers. At 0800 h the temperature in each chamber was set at 26.7 C and temperatures were increased 2.8 C/h until 40.8 C was reached. Water consumption and body temperatures were determined during the heat exposure.

Statistical Analysis

The data were analyzed with PCSAS® Release 6.02.[3] A one way analysis of variance was used and Duncan's (1955) multiple range test was used to identify significant differences among treatment means.

[2]Choctaw Maid Farms, Carthage, MS 39051.
[3]SAS Institute Inc., Cary, NC 27511.

RESULTS

Experiment 1

Daily feed and water consumption for the 3 days of acclimation are given in Table 1. Statistical analysis showed significant effects of age and temperature on both feed and water consumption, which were determined as percentage of body weight. No other main effects or interactions were statistically significant. The high cyclic temperatures resulted in significantly reduced feed consumption by 6- and 7-wk-old broilers but not by 5-wk-old broilers. Average feed consumption for all ages was reduced by the cyclic temperatures. Seven-week-old broilers at the control temperature consumed less feed as a percentage of body weight than younger control broilers. Also, less water as a percentage of body weight was consumed by 7-wk-old control broilers than by younger broilers. At cyclic temperatures water consumption declined with increasing age. High cyclic temperatures resulted in increased water consumption at each age. The number of days of acclimation had no significant effect on either feed or water consumption. Because the length of the acclimation period did not affect the quantity of feed or water consumed each day the data were summarized over the 3 days for analysis of the effect of temperature on consumption.

Exposure to daily cyclic temperatures of 24-35-24 C resulted in reduced feed intake when the temperature was declining but not when the temperature was increasing (Figure 1). The effect was more severe for older broilers and at 5 wk was only significant for the second 6 h of declining temperature. Water consumption of broilers in the cyclic temperatures increased during the 12 h when the temperature was highest (Figure 2). At 7 wk, the increase in water consumption started earlier, beginning when the temperature began to increase. Broilers exposed to cyclic temperatures did not consume more feed or less water than the controls at any time of the day.

Experiment 2

Figure 3 shows the effect of 3 days of acclimating temperatures on water consumption during heat exposure. Acclimated broilers consumed more water than controls during the heat exposure; the effect of acclimation was greater as the exposure period lengthened and the temperature increased. The acclimated broilers consumed significantly ($P<.01$) more water than the controls during the period from 0700 to 1500 h. For the 8-h period, water consumption as a percentage of body weight was 5.55% for controls and 7.14% for acclimated broilers. When the heat exposure was terminated, the body temperature of controls averaged 42.62 C and acclimated broilers averaged 42.24 C; the difference was not significant.

TABLE 1. Effect of age and length of temperature acclimation on feed and water consumption by broilers

Days of age	Feed consumption[1,2] Temperature (C) 24	24-35-24	Water consumption[1,2] Temperature (C) 24	24-35-24
35	9.9	9.5(1)	18.7	23.5(1)
36	9.9	9.4(2)	18.1	23.3(2)
37	10.2	9.6(3)	18.0	22.7(3)
42	9.2	7.5(1)	18.3	21.2(1)
43	9.2	7.5(2)	17.1	20.8(2)
44	9.2	7.3(3)	16.9	21.5(3)
49	7.0	5.7(1)	13.9	18.5(1)
50	7.2	6.1(2)	14.8	18.6(2)
51	7.2	6.8(3)	14.5	19.9(3)
	Average (3 days)			
35 to 37	10.0^a	9.5^a	18.3^{cd}	23.2^a
42 to 44	9.2^a	7.4^b	17.4^d	21.2^b
49 to 51	7.1^b	6.2^c	14.4^e	19.0^c
	Average (3 wk)			
35 to 51	8.8^a	7.7^b	16.7^b	21.1^a

a–e Values within consumption type and within the category of mean without common superscripts differ significantly ($P\leq.05$).

[1]Consumption is given as percentage of body weight.

[2]Parentheses enclose the number of days exposure to the cyclic temperature.

DISCUSSION

The results show different patterns for the changes in feed and water consumption due to the high cyclic temperatures. The increase in water consumption preceded the peak temperature, but the

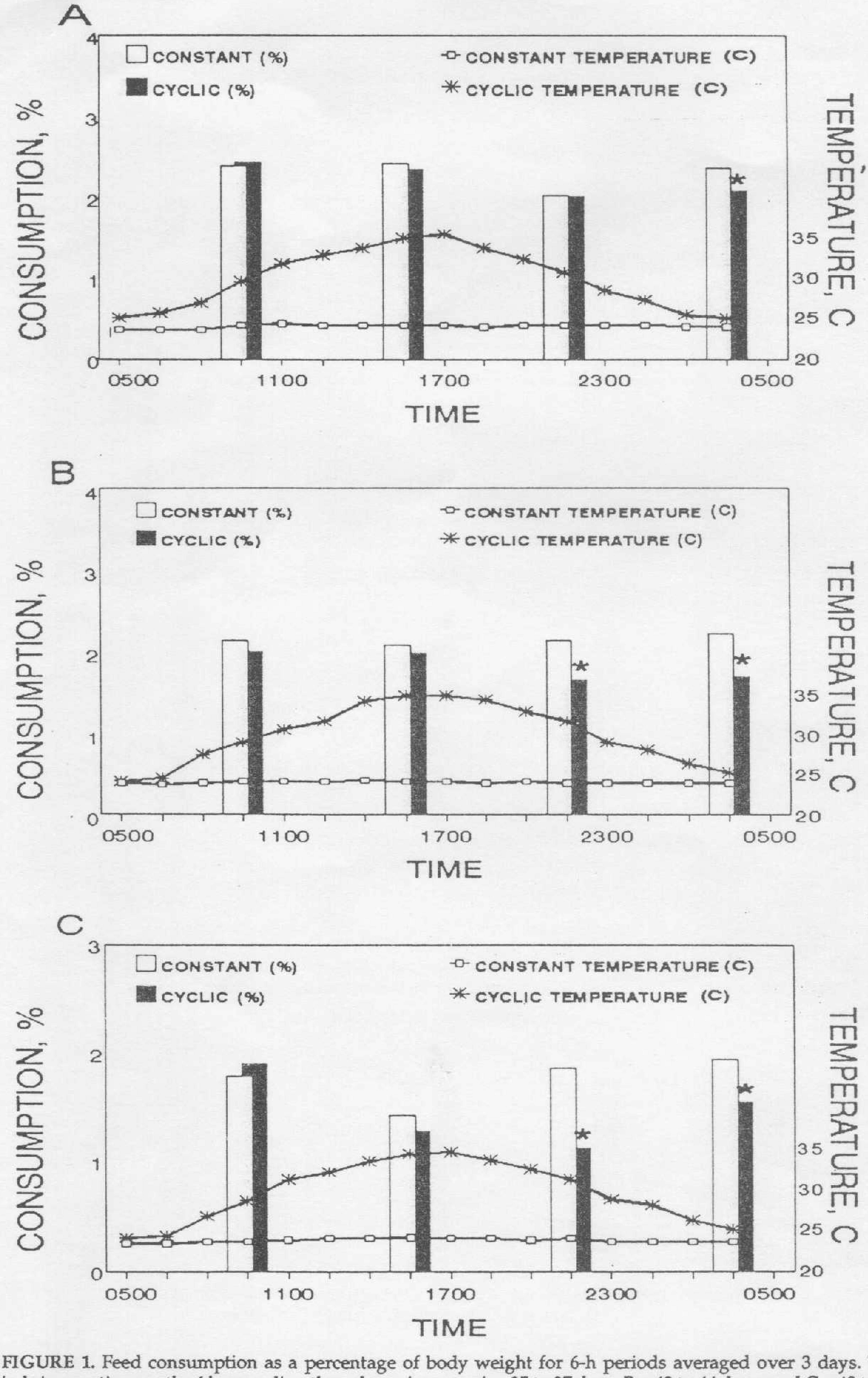

FIGURE 1. Feed consumption as a percentage of body weight for 6-h periods averaged over 3 days. The periods in question are the 6 h preceding the values. Ages are A = 35 to 37 days; B = 42 to 44 days; and C = 49 to 51 days. Asterisks indicate consumption in the cyclic treatment is significantly different ($P<.05$) from consumption in the constant temperature. The temperature is chamber temperature. Time is given in hours.

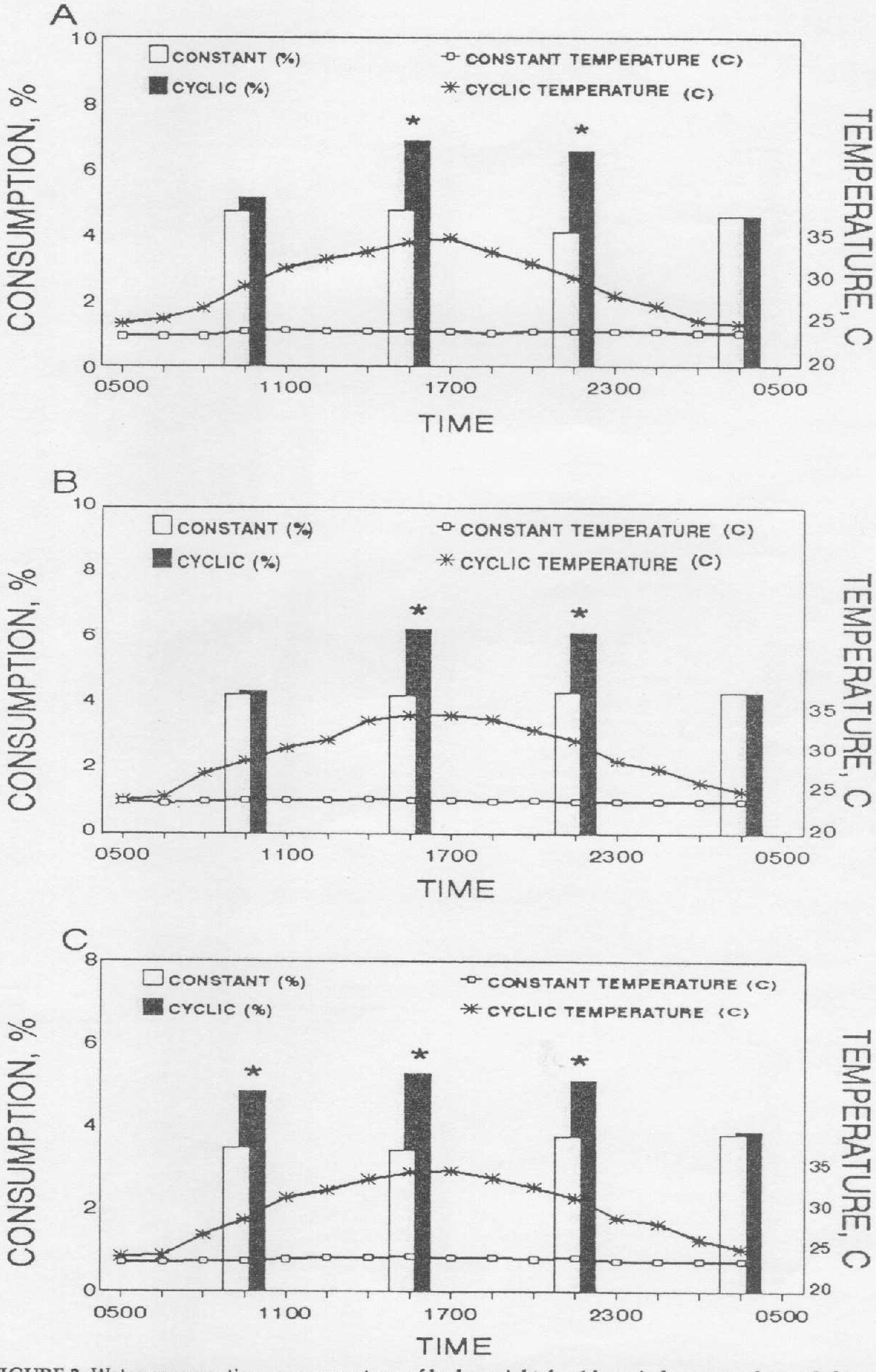

FIGURE 2. Water consumption as a percentage of body weight for 6-h periods averaged over 3 days. The periods in question are the 6 h preceding the values. Ages are A = 35 to 37 days; B = 42 to 44 days; and C = 49 to 51 days. Asterisks indicate consumption in the cyclic treatment is significantly different (P<.05) from consumption in the constant temperature. The temperature is chamber temperature. Time is given in hours.

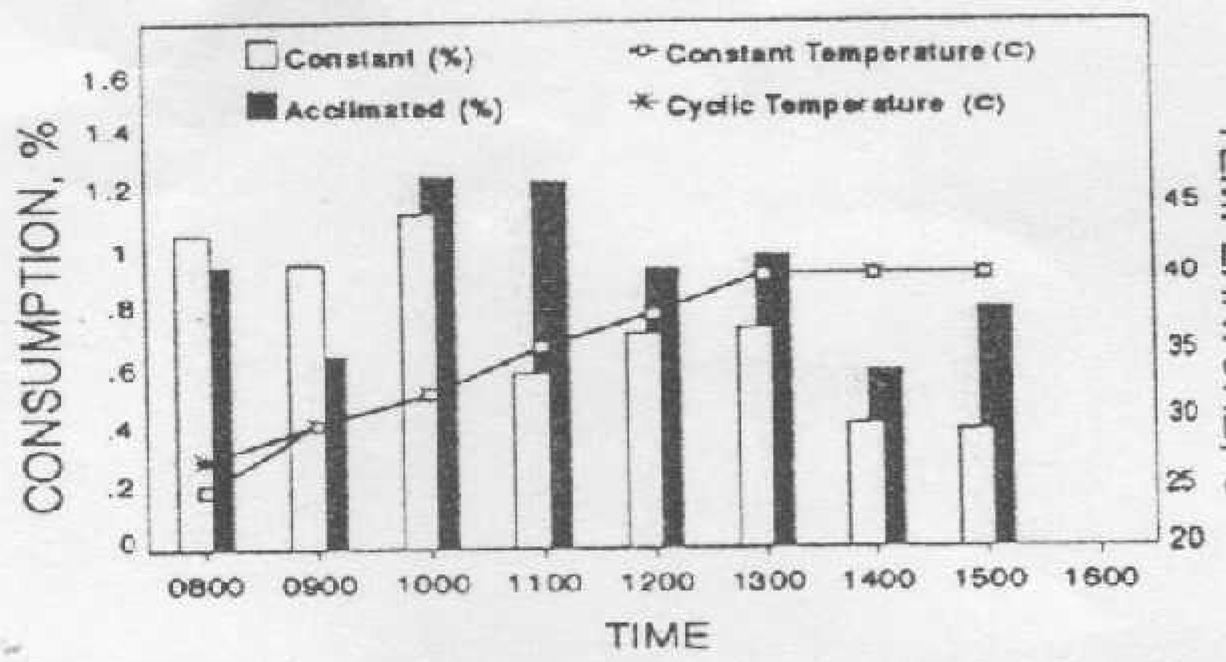

FIGURE 3. Water consumption during heat exposure for controls and broilers acclimated for 3 days to a 24-35-24 C cycle. Hourly consumption values as a percentage of body weight have been multiplied by 24. Time is given in hours.

decrease in feed consumption followed the peak temperature. The failure to detect a reduction in feed consumption for 5-wk-old broilers when analyzed by days was probably due to the limited number of observations. Summarizing over days for 6-h periods increased the sensitivity. The cause of the delayed reduction in feed consumption is not clear from these results. A relationship between feed and water consumption exists for growing broilers. Kellerup *et al.* (1965) demonstrated that restricting water consumption caused broilers to reduce their feed consumption. It is possible that increased water consumption due to increasing temperature stimulated continued feed consumption. Because feed consumption during the 6 h before peak temperature was not affected but water consumption increased, the ratio of feed:water was changed. The increase in water consumption may have contributed to maintenance of feed intake during the period of increasing temperature. Broilers at 5 and 6 wk of age were on the feeding regimen of 1.5 h feed and 4.5 h off feed. Other research by the present authors (unpublished data) suggests this did not affect total feed consumption and should not contribute to any differences due to age.

Broilers that were 5 to 7 wk old consumed as much water the 1st day of exposure to the 24-35-24 C cycle as the 2nd or 3rd day. This may simply mean that they possessed the capacity to handle the water needed to cope with those cyclic temperatures. To the contrary, after 3 days of exposure to the 24-35-24 C cycle they consumed more water than controls when exposed to the higher temperatures of heat exposure. This reflects an increased capacity to either consume or excrete the increased quantity of water. If water consumption is the major factor in resistance to heat stress and the capacity to conserve electrolytes is an important factor, various temperatures of acclimation may develop to various degrees the ability to consume and excrete water while conserving electrolytes. The size of the broiler and the temperature of acclimation may interact to determine whether during acclimation the water consumption increases with increasing length of acclimation period.

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Determination of Blood Constituents Reference Values in Broilers[1]

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ABSTRACT Eight hundred broilers were examined to define the reference values of nine blood constituents (total proteins, albumin, total and free cholesterol, triglycerides, aspartate aminotransferase (AST), alkaline phosphatase (ALP), calcium, and phosphorus). The broilers, coming from 20 different commercial poultry operations, were equally divided into different groups according to age (21 and 45 days), strain (Arbor Acres and Hybro), sex, and sampling season (summer or winter). Age and sampling season were the variation sources that most influenced the values of the hematochemical variables examined. The interaction of age with strain influenced total proteins, total and free cholesterol, triglycerides, and ALP. The interaction of age with sampling season influenced all hematochemical constituents except triglycerides. Reference limits defined by .975 and .025 fractiles were computed for each blood constituent according to the significance of different variation sources and their combinations. Reference limits defined herein could be used as indicators of metabolic and health conditions of a poultry farm.

(*Key words*: reference values, blood constituents, age, strain, broilers)

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INTRODUCTION

Hematochemistry constitutes an increasingly useful aid in zootechnical and veterinary research. It permits the study of specific pathological alterations of certain blood constituents and recognition, under strictly controlled experimental conditions, of the existence of metabolic alterations of different origin. Many factors can influence the level of a particular blood constituent: genetic type, feeding, micro- and macro-climate, rearing technique, age, physiological state, and sex, as well as pathological factors. Moreover, methods of sampling and obtaining the biological material and the method of analysis can also influence results.

It would therefore be useful to define a range of values or limits to serve as reference for each blood constituent. The reference limits define an interval and the values within it are considered "normal" (International Federation of Clinical Chemistry, 1978). The reference values can be used to evaluate the state of health of either a single bird or an entire population and would constitute a basic requirement for an indispensable preliminary knowledge of the biological material chosen for scientific research.

In avian species, hematochemical studies are nearly always performed for research purposes, in order to evaluate the effect of rearing technique (Meluzzi *et al.*, 1984; Verga *et al.*, 1984; Cerolini *et al.*, 1986; Giordani *et al.*, 1986; Franchini *et al.*, 1988b), feeding regimens (Franchini *et al.*, 1988a, 1989), environmental conditions, and other parameters. Hematochemical tests are generally not utilized for avian diagnostics, because no reference values

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