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BEHAVIOUR AND PERFORMANCE OF FASTED BROILERS UNDER HIGH TEMPERATURE AND HUMIDITY

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SUMMARY

Relationships among short-term fasting, behaviour, performance and heat tolerance were studied in broiler chicks. Commencing from 28 days of age, birds fasted from 0900 h to 1700 h or fed *ad libitum* were exposed to either high constant ambient temperature (36 ± 2°C) from 1200 h to 1700 h or unheated (minimum, 25°C; maximum, 34°C) as controls. Neither feeding regimen nor temperature had significant effect on growth. Feed-restricted chicks had improved feed efficiency and lower body temperature than those fed *ad libitum* in response to the heat treatment. There were significant feeding regimen by time interactions for eating, resting and drinking activities suggesting that effect of feeding regimen was not the same within each period of time. During the period of feed removal, fasted birds rested more than their *ad libitum* counterparts. There was no consistent trends for drinking and standing behaviours attributable to time or feeding regimen.

Keywords: Fasting, behaviour, high temperature and humidity, broilers.

INTRODUCTION

The dire impact that thermal stressors may inflict upon productivity and well-being of poultry is a concern of long standing. With the growing importance of poultry production among livestock industries in many of the hot regions of the world, heat stress-related predicaments become increasingly critical. Fast growing broilers are more susceptible to acute heat stress than slow growing strains (Sandercock *et al.*, 1995). Intense selection for rapid growth rate in commercial meat-type chickens results in concomitant increase in metabolic heat production while heat dissipation capacity is not affected.

McCormick *et al.* (1979) demonstrated the possibility of enhancing resistance of broilers to high ambient temperatures by withdrawing feed 24, 48 or 72 h. Teeter *et al.* (1987) reported that short-term fasting commencing 3-6 h prior to heat exposure improved survivability. This phenomenon could be attributed to absence of food in the digestive tract which may have profound thermoregulatory effect (Kohne *et al.*, 1973). There is, however, a dearth of information regarding the effectiveness of this practice under chronic heat exposure.

There is the question whether differences in heat production relative to behavioural responses may have also accounted for heat tolerance among fasted birds. It is well documented that activities such as walking, standing and preening may elevate thermogenesis (Freeman, 1983).

In the context of Malaysian conditions, there is a possibility that shifting the birds' feed intake from the period of highest sustained temperature to the cooler period in the evening could improve resistance to high ambient temperatures. However, the major concern in adopting the feed removal approach in broilers is the possible impairment of growth rate. The objectives of this study were to evaluate the effects of short-term feed withdrawal on ability to withstand chronic thermal stressors and the interplay among fasting, behavioural responses and heat tolerance.

MATERIALS AND METHODS

Birds and husbandry

At hatch (Day 0), 144 straight run broiler chicks were wingbanded and randomly assigned in groups of 6 to 24 battery cages with wire floors. Floor space allowance was 1627 cm^2/bird. The batteries were in a conventional open sided house with cyclic temperatures (minimum, 25°C; maximum, 33°C). Relative humidity was between 75 to 90%. The chicks were vaccinated against Newcastle Disease (Days 7 and 14), Infectious Bursal Disease (Days 14 and 28) and Fowl Pox (Day 21). Starter (crumble form; 21% CP and 2950 kcal ME/kg) and finisher (pellet form; 18% CP and 3050 kcal ME/kg) diets were provided from Days 1 to 21, and Day 22 onwards, respectively. Water was available at all times and lighting was continuous.

Commencing from Day 28, equal number of chicks were subjected to either *ad libitum* feeding (AL) or feed removal from 0900 h to 1700 h (FR). For each feeding regimen there was a control (NT) and heated groups (HT). Heated chickens were exposed to ambient temperatures of 36 ± 2°C from 1200 h to 1700 h for 14 days. Heat was imposed by electric brooders and cages were partially covered to trap the heat. Relative humidity of the heated cages was not controlled but measurements showed that it was similar to the unheated pens. Two blocks of batteries were designed to be heated and the remainder as unheated controls.

Traits measured and statistical analyses

Individual body weights were measured on Days 35 and 42. Commencing from Day 21, feed consumption was recorded weekly and feed efficiencies (body weight to feed consumed) were determined. Cloacal body temperature estimates were obtained from 12 (6 birds per sex) randomly selected birds per feeding regimen-temperature subgroup at 1300 h on Days 30 and 41 using electronic thermometer. The probe was inserted about 3 cm into the cloaca for about 30 s. The number of chicks eating, drinking, standing and resting (sitting or dozing) was recorded in each cage at 0730, 1000, 1330, 1700 and 0030 h on Days 32 and 40. Two observations were made each time at 30 min intervals with the mean of each pair used in analyses. Mortality during the heat treatment was recorded daily. Sex of chickens were determined by size of the comb at the end of the trial (except those used for recording of body temperature which were sexed on Days 30 and 41).

Body weights (BW) on Days 35 and 42 were analysed with sex, feeding regimen and temperature (unheated or heated) as main effects. Prior to analyses, body weight data were transformed to common logarithm. The same factorial arrangements were used to analyse body temperatures. Feeding regimen and temperature were included in the model for feed efficiency. Behavioural data, which were percentages, were transformed to arc sine square roots of the ratio of chicks performing each activity. Behavioural data were analysed each day with feeding regimen, temperature, and time as main effects. Data were subjected to analysis of variance in a factorial arrangement in a fixed effect model with the aid of General Linear Models (GLM) of SAS® software (SAS® Institute, 1982). When interactions were significant, separate analysis was conducted within each main effect. Multiple mean comparisons were assessed by Duncan's multiple range test. Mortality data were subjected to chi-square analysis (Steel and Torrie, 1980). Statistical significance was considered as $P \leq 0.05$ throughout the paper.

RESULTS

Except for sexual dimorphism, neither feeding

effect on BW at 35 and 42 days of age (Table 1). Feeding regimen by temperature interactions were significant for feed efficiency during the heat exposure (Days 28 to 42) (Figure 1). Regardless of temperature, FR birds had similar feed efficiencies. In contrast, NT-AL chickens were more feed efficient than their heated counterparts. Mortality during the heat exposure was 13.9, 5.6, 25, and 20.6% for AL-NT, FR-NT, AL-HT, and FR-HT populations, respectively. Except for lower survivability among AL-HT chicks than their FR-NT counterparts, mortality among the feeding regimen-temperature subgroups was similar.

Table 1. Mean (± SEM) body weights by sex, temperature[1] and feeding regimen[2] at 35 and 42 days of age.

	Day 35	Day 42
Sex		
Male	1573 ± 17.0^a	1979 ± 22.4^a
Female	1377 ± 15.5^b	1733 ± 21.2^b
Temperature		
Heat	1457 ± 19.0	1832 ± 24.0
Normal	1468 ± 22.5	1852 ± 29.0
Feeding regimen		
Ad libitum	1477 ± 23.8	1850 ± 31.1
Fasted	1449 ± 18.2	1835 ± 22.9

Means within a column-subgroup with no common superscripts differ significantly ($P \leq 0.05$).

[1] On Day 28 some pens of chicks were exposed to ambient temperatures of 36 ± 2°C from 1200 h to 1700 h for 14 days.

[2] All chicks were fed *ad libitum* from Days 0 to 27. On Day 28, some pens of chicks were fasted from 0900 h to 1700 h.

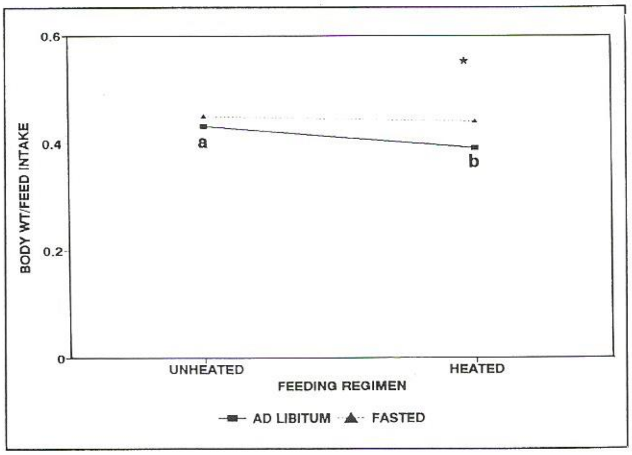

Figure 1. Mean feed efficiencies (body weight to feed consumed) from Days 28 to 42 where temperature by feeding regimen interactions were significant. a,b: Means within a single line with no common letters differ at $P \leq 0.05$. *Differences between feeding regimens $P \leq 0.05$.

Table 2. Mean (± SEM) body temperatures on Days 30 and 41 where temperature[1] by feeding regimen[2] interactions were significant

	Day 30		Day 41	
	Ad libitum	Fasted	*Ad libitum*	Fasted
Temperature				
Unheated	43.2 ± 0.08	43.0 ± 0.15^{NS}	43.0 ± 0.15^{a}	42.7 ± 0.07^{b}
	*	NS	*	NS
Heated	44.5 ± 0.31^{a}	43.5 ± 0.21^{b}	44.1 ± 0.20^{a}	43.1 ± 0.19^{b}

Means within a row-subgroup with no common letters differ significantly ($P \leq 0.05$).
* A significant difference ($P \leq 0.05$) between means within a column.
[1] On Day 28 some pens of chicks were exposed to ambient temperatures of 36 ± 2°C from 1200 h to 1700 h for 14 days.
[2] All chicks were fed *ad libitum* from Days 0 to 27. On Day 28, some pens of chicks were fasted from 0900 h to 1700 h.

There was a significant feeding regimen by temperature interaction for body temperature estimates on Days 30 and 41 (Table 2). The interaction was caused by different effects of temperature on FR and AL birds. Within AL birds, the heat treatment increased body temperature, whereas, the high ambient temperatures had no influence on the measurement in FR chicks. There was no sexual dimorphism for body temperature at 30 (male, 43.7 ± 0.17°C; female 43.4 ± 0.19°C) and 41 (male, 43.3 ± 0.16°C; female 43.1 ± 0.14°C) days of age.

Presented in Figures 2, 3, and 4 are percentages of chicks eating, resting and drinking, respectively, on Days 32 and 40. Feeding regimen by time interaction was significant for these three activities on both days.

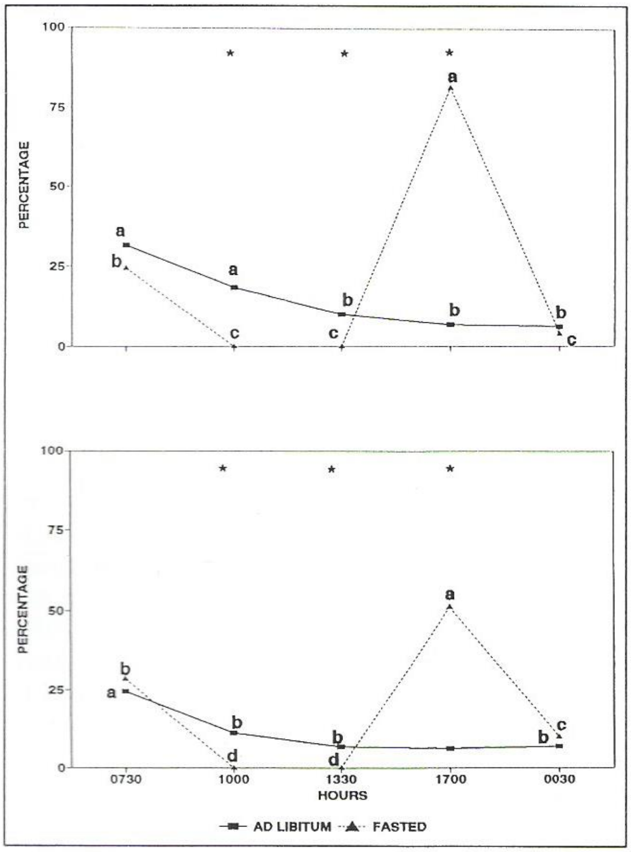

Figure 2. Percentage of birds eating on Days 32 (top) and 40 (bottom) where feeding regimen by time interactions were significant. a,b,c,d. Means within a single line with no common letters differ at $P \leq 0.05$. *Differences between feeding regimens $P \leq 0.05$.

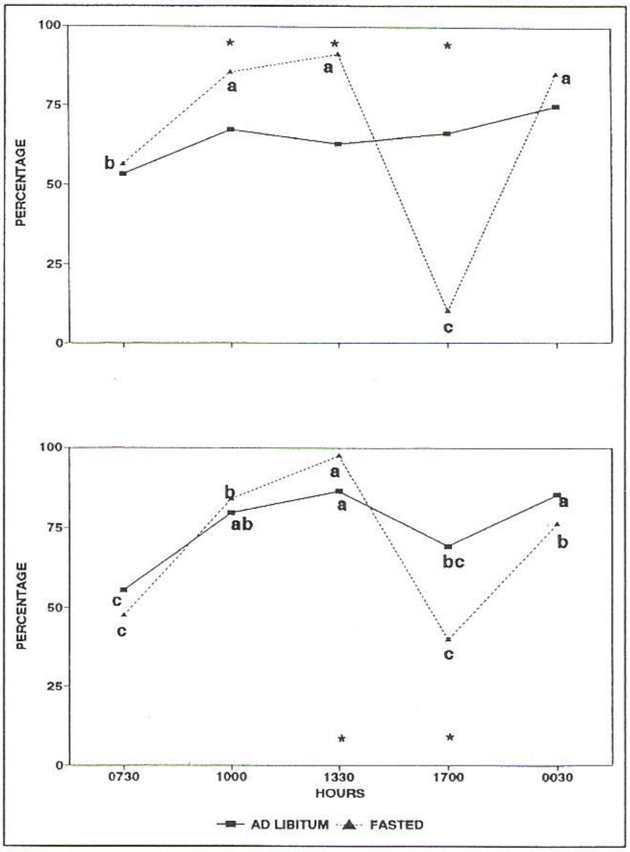

Figure 3. Percentage of birds resting on Days 32 (top) and 40 (bottom) where feeding regimen by temperature interactions were significant. a,b,c. Means within a single line with no common letter differ at $P \leq 0.05$. *Differences between feeding regimens $P \leq 0.05$.

The interaction for feeding activity, however, may be inherent because FR chicks were feed-deprived during 1000 h and 1300 h. On Day 32, within FR birds, the number of chicks resting demonstrated different trends with time. On the contrary, resting activity remained constant in AL birds resulting the interaction for the trait. On Day 41, the percentage of FR and AL chicks resting varied according to time. Within the FR group, resting behaviour peaked and declined dramatically at 1330 h and 1700 h, respectively, while the activity was similar at 1000, 1330, and 0030 h for AL birds. The interaction for drinking was attributable to greater activity among AL birds at 1330 h (Day 32) and 1700 h (Days 32 and 40) and no differences between FR and AL groups during other periods. The differences in eating, resting, and drinking activities due to temperature were not significant on Days 32 (NT, eating, 19.8 ± 3.7%; resting, 63.0 ± 3.8%; drinking, 5.4 ± 1.2%; HT, eating, 16.5 ± 3.6%; resting, 67.4 ± 3.7%; drinking, 6.8 ± 1.4%) and 40 (NT, eating, 12.6 ± 2.1%; resting, 73.0 ± 2.8%; drinking, 5.8 ± 1.3%; HT, eating, 16.1 ± 2.7%; resting, 71.0 ± 3.1%; drinking, 5.8 ± 1.2%).

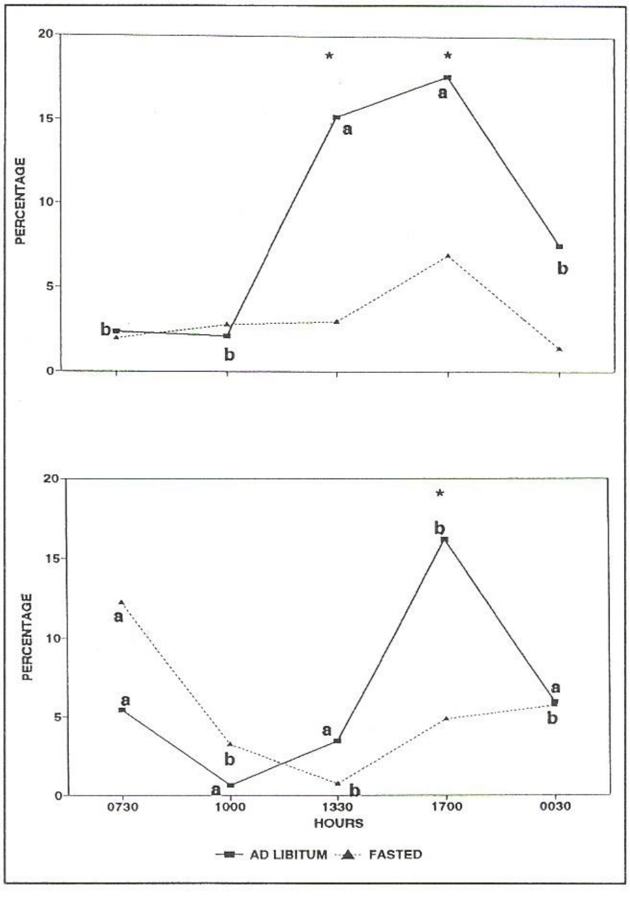

Figure 4. Percentage of birds drinking on Days 32 (top) and 40 (bottom) where feeding regimen by temperature interactions were significant. a,b: Means within a single line with no common letters differ at $P \leq 0.05$. *Differences between feeding regimens $P \leq 0.05$.

Percentage of chicks standing on Day 32 was lower at 1700 h than at 0730, 1000, and 0030 h (values at 0730, 1000 and 0030 h were similar). Standing activity at 1330 h did not differ from any other periods. No difference was found between AL (11.9 ± 1.4%) and FR (9.3 ± 1.4%) chicks for standing activity on Day 32. Percentages for NT (11.7 ± 1.5%) and HT (9.5 ± 1.4%) were similar. Interaction of temperature by time was significant for standing activity on Day 40 (Figure 5). The interaction resulted from similar percentages among periods for NT chicks and higher standing activity at 0730 h for HT birds. Percentage of birds standing was similar for AL (7.9 ± 1.5%) and FR (7.9 ± 1.3%) birds.

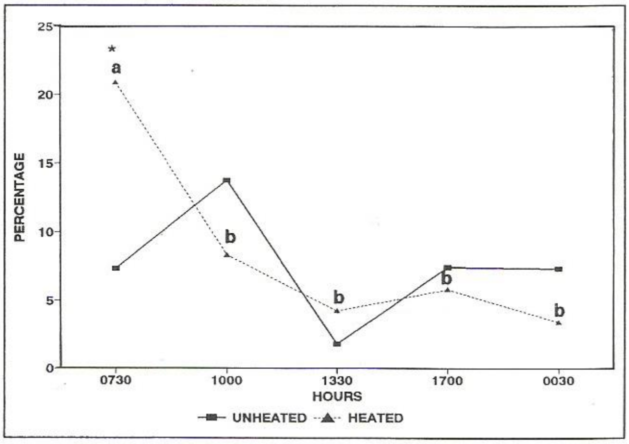

Figure 5. Percentage of birds standing on Day 40 where temperature by time interaction was significant. a,b: Means within a single line with no common letters differ at $P \leq 0.05$. *Differences between temperature treatments $P \leq 0.05$.

DISCUSSION

Earlier findings (McCormick *et al.*, 1979; Smith and Teeter, 1988) suggested that heat-stress related problems is less severe for fasted than *ad libitum* fed broilers. Of major concern to broiler growers, however, is the possible reduction in weight gain due to fasting. The results of this study were in agreement with those showing that short-term feed removal had negligible impact on growth (Smith and Teeter, 1988; Engku Azahan, 1995). These findings suggest compensatory feed intake when birds were released to *ad libitum* feeding.

Although the 5 h/day heat treatment for 14 days resulted hyperthermia (as indicated by rectal temperature) among the AL birds, regardless of feeding regimen and temperature, all chicks had similar body weights. However, it is important to take note that the control temperature (minimum, 25°C; maximum, 34°C) may also suppressed weight gain. Thus, it may have precluded the difference in growth between the unheated (control) and heated groups.

Elicitation of thermoregulatory responses lead to changes in allocation of feed energy at the expense of productive purposes (see Daghir, 1995). In the present study, we observed the possibility of optimising feed utilisation of heat-stressed broilers by imposing short-term feed restriction. These findings suggest that fasting promotes reduction in energy expended in maintaining thermal neutrality and a concomitant increase in the availability of energy utilised for production.

Results of this experiment were consistent with previous reports that fasting prior to heat exposure lowered body temperature (Teeter *et al.*, 1987; Ait-Boulahsen, 1993). This interplay could be partly explained by the close relationship between nutritional status and metabolic heat production. Absence of feed in the gastrointestinal tract lead to reduction in dietary thermogenesis (Kohne *et al.*, 1973). Hence, depriving feed after onset of heat exposure is of minimal benefit (Teeter *et al.*, 1987).

Although FR-HT birds had lower body temperatures than AL-HT group, their mortality rate during the heat exposure was similar. The lack of effect of feed removal on survivability reveals an inconsistency between our findings and those of McCormick *et al.* (1979), and Teeter *et al.* (1987). The discrepancies could be attributed to duration of fasting and heat treatment. In earlier studies, birds were either subjected to longer period of feed removal or acute heat stress. It appears that length of fasting and heat treatment were additive in determining the ability to survive thermal insults.

Feed restriction may elicit both metabolic and behavioural responses (see Mench, 1992). Preston (1987) reported that fasted laying hens exhibited more sitting activity than their *ad libitum* fed counterparts. Our data provide additional support to these findings because, FR chicks spent more time resting during the period of feed removal than those subjected AL. It is well established that capacity for heat loss can be modified by reduction in activity (Squibb and Wogan, 1960). Hence, apart from reduction in dietary thermogenesis, differences in behavioural responses during the heat treatment may have also contributed to the lower body temperature and improved feed efficiency of the FR birds. Similarly, Francis *et al.* (1991) noted decline in feed consumption due to darkness resulted in reduction of energy allocated for locomotor activity and enhanced heat tolerance, concomitantly.

Although several studies indicated the ability of poultry to anticipate a period of feed removal (see Savory, 1980), the present findings were consistent with observations by Petherick and Waddington (1991) which suggested the converse. Feeding activity was similar for AL and FR birds at 0730 h (feed was removed at 0900 h) on both Days 32 and 41.

The significant effects of time (Day 32), and time by temperature interaction (Day 40) for standing

regarding the effect of fasting on water intake in poultry is conflicting. Appleby *et al.* (1992) indicated that feed deprivation elicited polydipsia, while Preston *et al.* (1992) demonstrated no excessive drinking among fasted-chickens. In the current study, on Day 32, AL birds exhibited higher drinking activity than for FR group at 1330 h. This phenomenon could be attributed to the positive correlation between food and water intake in fowls (Savory, 1978; Ramlah and Tengku-Azhariyah, 1994). On the contrary, on Day 40, feeding regimen had no significant effect on percentage of chicks drinking during the period of feed deprivation. In conclusion, our data suggest the possibility of optimising productivity and circumventing hyperthermia in chronically heat-stressed broiler chickens by short-term fasting.

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REFERENCES

Ait-Boulahsen, A., Garlich, J.D. and Edens, F.W. (1993). Calcium deficiency and food deprivation improve the response of chickens to acute heat stress. *J. Nutr.*, **123:** 98-105.

Daghir, N.J. (1995). Broiler Feeding. Daghir, N.J. (Ed.). CAB International, Wallingford, United Kingdom.

Engku Azahan, E.A. (1995). Effects of periodic feeding on the performance of broiler chickens. *Malays. Appl. Biol.*, **24(1):** 73-75.

Francis, C.A., MacLeod, M.G and Anderson, J.E.M. (1991). Alleviation of acute heat stress by food withdrawal or darkness. *Bri. Poult. Sci.* **32:** 219-225.

Freeman, B.M. (1983). Energy metabolism. *In*: Pysiology and Biochemistry of the Domestic Fowl. Freeman, B.M. (Ed.). Academic Press Inc., New York. Vol. 4 pp. 137-146.

Kohne, H.J., Boone, M. and Jones, J.E. (1973). The effect of feed consumption on the survival time of adult turkey hens under conditions of acute thermal stress. *Poultry. Sci.*, **52:** 1780-1783.

McCormick, C.C., Garlich, J.D. and Edens, F.W. (1979). Fasting and diet affect the tolerance of young chickens exposed to acute heat stress. *J. Nutr.*, **109:** 1089-1097.

Mench, J.A. (1992). The welfare of poultry in modern production systems. *Poult. Sci. Rev.*, **4:** 107-128.

Petherick, J. L. and Waddington, D. (1991). Can domestic fowl (*Gallus gallus domesticus*) anticipate a period of food deprivation. *Appl. Anim. Behav. Sci.*, **32:** 219-226.

Preston, A.P. (1987). Restricted feeding time and the behaviour of caged laying hens. *Bri. Poult. Sci.*, **28:** 387-396.

Ramlah, A.H. and Tengku-Azhariyah, T.M. (1994). Effect of water restriction on the performance of broilers. *J. Vet.*

Sandercock, D.A., Mitchell, M.A. and MacLeod, M.G. (1995). Metabolic heat production in fast and slowing broiler chickens during acute heat stress. *Bri. Poult. Sci.*, **36:** 868-869.

SAS Institute (1982). SAS® User's Guide: Statistics. 1982 Edition, SAS Institute Inc., Cary, NC.

Savory, C.J. (1978). The relationship between food and water intake and the effects of water restriction on laying brown Leghorn hens. *Bri. Poult. Sci.*, **19:** 631-641.

Savory, C.J. (1980). Diurnal feeding patterns in domestic fowl: a review. *Appl. Anim. Ethol.*, **6:** 71-82.

Smith, M.O. and Teeter, R.G. (1988). Practical applications of potassium chloride and fasting during naturally occurring summer heat stress. *Poultry Sci.*, **67:** 36.

Squibb, R.L. and Wogan, G.N. (1960). Ambient environmental conditions associated with reported spontaneous occurrence of thermal death in poultry. *Wld's. Poult. Sci. J.*, **16:** 126-137.

Steel, R.G.D. and Torrie, J.H. (1980). Principles and Procedures of Statistics, A Biometrical Approach. McGraw-Hill Book Co., New York, NY.

Teeter, R.G., Smith, M.O., Sangiah, S. and Mather, F.B. (1987). Effects of feed intake and fasting duration upon body temperature and survival of thermostressed broilers. *Nutrn. Rpts. Int.*, **35:** 531-537.

Webster, A.B. and Hurnik, J.F. (1990). An ethogram of White Leghorn-type hens in battery cages. *Can. J. Anim. Sci.*, **70:** 751-760

RINGKASAN

KELAKUAN DAN PRESTASI AYAM PEDAGING SEKAT MAKAN DI BAWAH SUHU DAN KELEMBAPAN TINGGI

Perkaitan di antara sekatan makan tempoh singkat, kelakuan, prestasi dan daya tahan haba telah di kaji pada anak ayam pedaging. Bermula daripada umur 28 hari, ayam yang disekat makan dari 0900 j hingga 1700 j atau diberi makan secara ad libitum *telah didedahkan kepada suhu ambien malar tinggi (36 ± 2°C) dari 1200 j hingga 1700 j ataupun tidak terdedah haba tinggi (minimum, 25°C; maksimum, 34°C) sebagai kawalan. Rejim makan atau suhu tidak memberi kesan tererti terhadap pertumbuhan ayam. Sebagai gerak balas terhadap perlakuan haba, ayam tersekat makan menunjukkan kecekapan makanan yang tertingkat dan suhu badan lebih rendah daripada ayam yang diberi makanan secara* ad libitum. *Saling tindakan di antara rejim makan dan masa adalah tererti untuk kegiatan makan, rehat, dan minum dan ini menyarankan yang kesan rejim makan tidak sama dalam setiap tempoh masa. Pada tempoh penarikan makanan, ayam disekat makan rehat lebih lama daripada ayam diberi makan* ad libitum. *Tiada trend konsisten didapati dalam kelakuan minum dan berdiri yang boleh disabitkan dengan masa atau rejim makan.*