The Effect of Light and Darkness on Acclimatization of Laying Hens

B. Izzeldin[1] and H. Kassim*
Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia

ABSTRACT : Laying hens kept in different light and dark periods of the day at high ambient temperature of maximum 35℃ were challenged to 38.5±0.5℃ acute heat 3 hours daily for 7 consecutive days. They were found to have a significant ($p<0.01$) acclimatization response (rectal temperature) to heat stress during the dark period compared to those exposed to the same temperature during the light period. The blood pH was not significantly different. The partial pressure of carbon dioxide (PCO_2) was significantly high ($p<0.01$) except in day 4. Similarly the blood bicarbonate (HCO_3^-) concentration was significantly high ($p<0.05$) except day three and day four. Acute heat exposure in the first day increased the body temperature in both groups (Light and Dark) reaching 44℃, followed by gradual reduction in body temperature. The dark treated birds showed rapid reduction in body temperature (42.88℃) and adaptation to high temperature during days 2-4 but that this was lost to some extent in days 6-8. However this was not obvious in the light treated birds. It is concluded that darkness reduce hyperthermia and enhance acclimatization responses during acute heat stress. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 5 : 694-697*)

Key Words : Acclimatization, Heat Stress, Hyperthermia, Light, Darkness

INTRODUCTION

The environment in which animals exist is composed of many interacting factors. Each is capable, in great enough magnitude, of eliciting a defensive reaction in the animal's biochemical and physiological constitution. Any changes in the environment will cause both specific and nonspecific responses that are directed at re-establishing a state of homeostasis in the animal (Edens, 1983).

Acclimatization was defined as the sum of physiological adaptation to maintain normal body temperature, during repeated acute heat exposures. Broiler acclimatization to heat stress is frequently used to describe the bird's increased ability to cope with repeated high ambient temperatures. During heat stress, heat production associated with food metabolism is more pronounced, therefore, acclimatization response magnitude might differ in fed and starved birds. It was concluded that food and/or energy consumption level markedly influenced the birds capacity to exhibit a heat stress acclimatization responses (McCormick et al., 1979; Teeter et al., 1987; Smith and Teeter, 1988; Wiernuz and Teeter, 1993, 1996). Acclimatization to either a hot or cold environment took three to five days, which was the time required for body temperature to become constant as the criterion of acclimatization (Hillerman and Wilson, 1955). Birds are vulnerable to respiratory alkalosis when exposed to high ambient temperatures of 35℃ or 41℃ that initiate panting (hyperventilation), which in turn lower the PCO_2 and the concentration of HCO_3^- resulting in relatively high blood pH (7.53 to 7.65) (El Hadi and Sykes, 1982). In all species of animals investigated, melatonin concentration displays a circadian variation with high levels during the dark period of the light/dark cycle (Waldhauser and Wurtman, 1983).

Previous studies has shown that melatonin injection lowered the body temperature by 4.7±0.3℃ in English sparrow during the light period. A dose of 1.2 to 2.5 mg melatonin per bird has no effect on the amplitude of the response. The pineal is required for normal thermoregulation in chicken, pigeon and the sparrow (Hillman et al., 1985; John et al., 1978).

In White Leghorn laying hens melatonin administration resulted in a significant dose-dependent, reduction in body temperature and prevented hyperthermia during heat stress (Rozenboim et al., 1996). The mortality in both conventionally lit laying hens and 49-day old broiler chickens increased as the day length increased. It was concluded that livability in laying hens was improved by the use of intermittent lighting, however intermittent lighting program should not be initiated close to time of peak egg production (Lesson et al., 1982; Lewis et al., 1996). The purpose of this research was to determine the effect of darkness upon acclimatization of laying hens exposed to acute heat stress using the criteria of body temperature, blood pH, PCO_2, and HCO_3^- during the exposure time.

MATERIALS AND METHODS

Birds and diet

Forty mature laying hens (38 weeks of age) were divided into two equal groups. They were fed on commercial layer feed (isocaloric, isonitrogenous) in

* Corresponding Author: H. Kassim. Tel: +60-3-9486101, Fax: +60-3-9486317, E-mail: kassim@vet.upm.edu.my.
[1] Department of Physiology, Faculty of Veterinary Sciences, University of Khartoum Sudan, P. O. Box 32, Khartoum North.
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mash form *ad libitum*.

Housing and photoschedule

The two groups of layers were housed separately in light controlled rooms maintained on 16 hours light and 8 hours darkness 10 weeks before the treatment. The dark period for the first group starts from 12:00 hr to 20:00 hr. where as for the second group (the control) the dark period starts from 24:00 hr to 8:00 hr. The highest ambient temperatures (32-35℃) existed between 12:00 hr and 16:00 hr where the first group was in the dark period and the second group (control) in the light period. The rooms temperature where the birds were kept (i.e. during the non-test period) range from 26℃ (early morning) to 35℃ (afternoon).

Environmental chamber

The environmental chamber used for the heat stress test measured 79.5 m^3 thermostatically controlled. The chamber is tidily closed, light controlled and provided with ventilation facilities.

Acute heat treatment

The chamber temperature was increased and adjusted to 38.5±0.5℃ twelve hours before the transfer of the birds from their rooms. The temperature in the heating chamber during the period of heat stress did not differ between treatments. Twelve hens from each group were subjected to acute heat stress in the controlled chamber (38.5±0.5℃) 3 hrs daily for 7 days consecutively. The control group was transferred to the environmental chamber one hour after the onset of light, from 9:00 hr to 12:00 hr, whereas the other group was transferred to the chamber one hour following the onset of darkness, from 13:00 hr to 16:00 hr.

Temperature measurements

The rectal temperature (Tr. ℃) was measured using a digital thermometer (Electro-therm, Model 99A). The thermometer probe was inserted 5 cm into the rectum. The temperature was recorded before and hourly during the acute heat exposures. The highest temperature reached for the day was recorded

Blood sampling and analysis

Blood was taken from the brachial vein, within the 2nd hour of acute heat exposure, using 26 gauge needle and carefully transferred into a heparinised vacutainer tube and kept cold in ice to be analyzed within two hours. Blood pH, PCO_2 and HCO_3^- were analyzed using blood gas analyzer (AVL automatic blood gas system, type 995-Hb).

Statistical analysis

The significant differences between means were determined by t-test (Snedecor and Cochran, 1982).

RESULTS AND DISCUSSION

Acute heat exposure on the first day resulted in high rectal temperature in both groups. The reduction in rectal temperature on the following days as a sign of acclimatization was significant ($p<0.01$) in the group subjected to acute heat stress during darkness (figure 1). However the two groups expressed acclimatization response commenced at the third day of heat exposure which coincides with the findings of Hillerman and Wilson (1955).

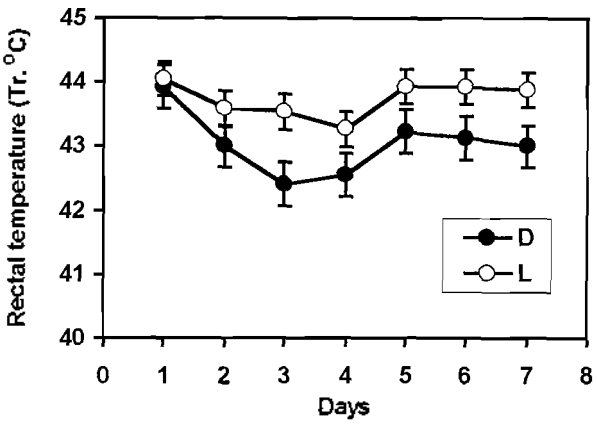

Figure 1. Rectal temperature (Mean±SD) of laying hens exposed to acute heat (38.5±0.5℃) 3 hours daily for 7 consecutive days during the light period (L) and the dark period (D)

The blood pH is high (7.59±0.053 and 7.58±0.028 for the two groups in light and dark periods, respectively) during acute heat exposure. Despite the nonsignificant difference in blood pH between the two groups during acute heat exposures, the blood pH is lower and maintained in the group exposed to heat stress during the dark period in days 1, 2 and days 6, 7, compared to the group exposed to the same conditions during the light period (figure 2). This is because of the low PCO_2 (16.96 mmHg) ($p<0.01$), which in turn lowers the concentration of blood HCO_3^- (16.40 mmol/l) ($p<0.05$) and elevate the blood pH (7.59±0.053) during the light period. The low blood PCO_2 could be due to the lowered feed intake. The net production of carbon dioxide is decreased due to the lowered metabolism (Lee et al., 1994).

The drop in PCO_2 (figure 3) associated with decreased HCO_3^- (figure 4) was attributed to hyper-ventilation, which is a thermoregulative mechanism through which heat is dissipated by evaporative cooling which is in agreement with Lorcher and

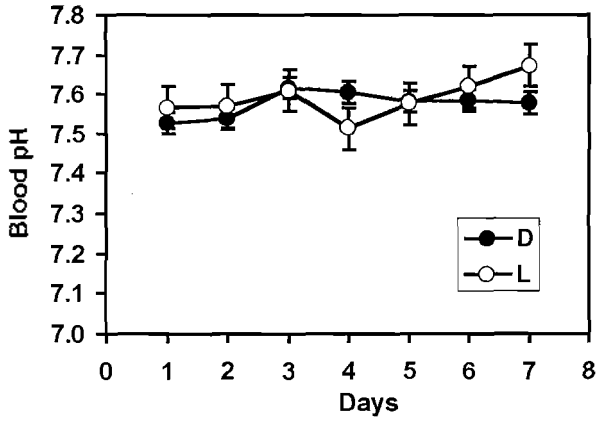

Figure 2. Blood pH (Mean±SD) of laying hens exposed to acute heat (38.5±0.5℃) 3 hrs daily for 7 consecutive days during the light period (L) and the dark period (D)

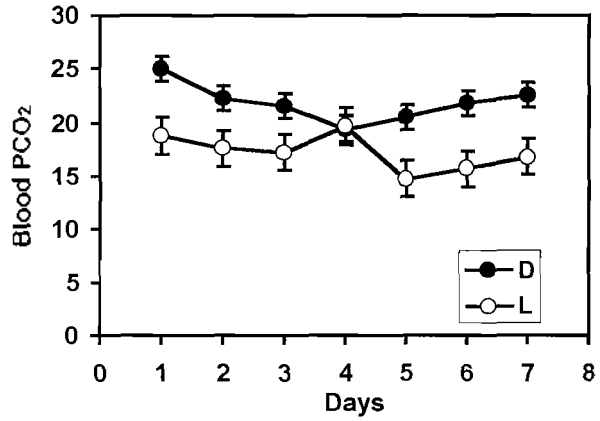

Figure 3. Blood PCO_2 (Mean±SD) of laying hens exposed to acute heat (38.5±0.5℃) 3 hrs daily for 7 consecutive days during the light period (L) and the dark period (D)

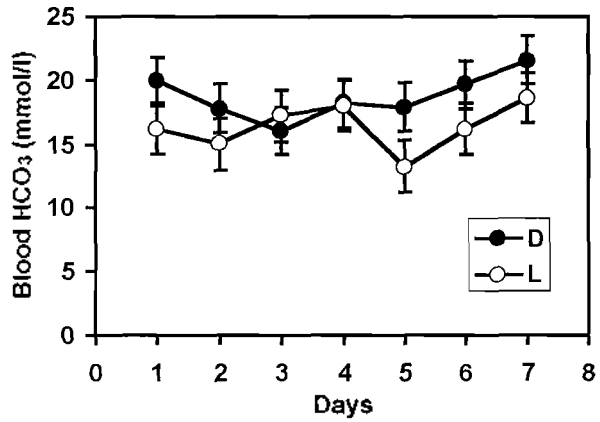

Figure 4. Blood HCO_3^- (Mean±SD) of laying hens exposed to acute heat (38.5±0.5℃) 3 hours daily for 7 consecutive days during the light period (L) and the dark period (D)

Hodges (1969) and Makled and Charles (1987). Hyperventilation occurred in hens housed at high temperature (35℃) reflected in respiratory alkalosis, which was a result of carbon dioxide (CO_2) loss and associated with decreased HCO_3^- in the blood. The loss of CO_2 is accentuated by the need for blood bicarbonate to buffer the hydrogen ions produced during eggshell formation. It was previously stated by ElHadi and Sykes (1982) that hyperventilation was initiated as a result of increase in body temperature when the birds were exposed to sufficiently high ambient temperature. Kassim and Sykes (1982) stated that phase I panting was initiated when the body temperature of chicken reached 41-42℃. Similarly, Zhou et al. (1997) observed that panting in broilers started at body temperature of about 41.5℃. In the present study, the body temperature was high enough to stimulate panting. The results concluded that acute heat during the light period elevates rectal temperature and blood pH was also increased as a consequence of the decrease in PCO_2, and HCO_3^-. The increase in body temperature is consistent with the finding of Woodard et al. (1964) that light alone increase body temperature.

The high body temperature (43.7℃±0.27) and the blood (pH, PCO_2 and HCO_3^-) changes during the light period were decreased during the dark period under the same conditions. This might be as a result of suppression of circulating melatonin by light (Pang et al., 1993), as melatonin biosynthesis in chicken retina occurs as circadian rhythm with high level at night (Hamm and Menaker, 1980). Since melatonin injections reduced hyperthemia (Hillman et al., 1985; Rozenboim, 1996) and the concentration of melatonin display a circadian variation with high levels during the dark period of the light/dark cycle (Waldhauser and Wurtman, 1983). These indicate that the improvements of acclimatization responses during the dark period might be relevant to melatonin circadian variation during the light and dark periods.

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