Diurnal Changes of Heat Dissipation in Different Types of Chicks (*Gallus domestics*)

Shoukry., H. M. S., A. A. El-Shafei., M. A. Al-Gamal., and A. A. A. Abdel-Kawy

Department of Animal Production, Faculty of Agriculture, Al-Azhar University, Nassr City, Cairo, Egypt.
abdelkawyelghoul@azhar.edu.eg

Abstract: A total of 180 chicks of three breeds of chickens aged 3 weeks had different levels of domestication and production types (Dandarawi, Lohmann selected leghorn (L.S.L) and Cobb^{500} chickens) were used. The results revealed that the main effect of time of day is significant ($P \leq 0.05$) in percentages of sensible and latent heat losses. Meanwhile, the main effects of breed and time of the day were significant ($P \leq 0.05$) in cloacal and, skin temperatures and respiration rate. The interaction between breed and time of day in total, sensible and latent heat losses were significant ($P \leq 0.05$). Different responses of broiler chicks to hot environment compared to the other non-meat type breeds indicated that the type of production is most effective rather than level of domestication on acclimatization mechanisms to hot environment.

[Shoukry., H. M. S., A. A. El-Shafei., M. A. Al-Gamal., and A. A. A. Abdel-Kawy. **Diurnal Changes of Heat Dissipation in Different Types of Chicks (*Gallus domestics*).** *J Am Sci* 2018;14(4):8-15]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 2. doi:10.7537/marsjas140418.02.

Keywords: Heat Dissipation, Broilers, Dandarawi, Leghorn, Cloacal and temperatures, Respiration Rate

1. Introduction

In birds, heat is dissipated through respiratory evaporative mechanisms (as a major avenue for heat dissipation), cloacal evaporation, and evaporative cutaneous mechanism (occur across the skin of the head and neck) and sensible heat loss by radiation, conduction and, convection (Williams and Tieleman, 2001; Yahav *et al.,* 2005 and Hoffman *et al.,* 2007). Physiologically, control over the rate of heat transfer is exercised by altering the flow of blood to the body surface, or by altering the rate of evaporation of water from the skin (perspiration) or respiratory tract (Cangar *et al.,* 2008). Heat loss of birds are influenced by, breed, body temperature, ambient temperature, degree of activity, nutritional level, photoperiod, body mass (Whittow, 1986), degree of domestication and adaptation to cope with hot climate (Soleimani *et al.,* 2011) and feather coat (Blanco, 2010).

Different breeds of chickens had different rates of heat loss, even when variations in their surface area and body mass are taken into account (Whittow, 1986). For instance, White Leghorns had higher heat loss than Rhode Island Reds which in turn produced more heat than did New Hampshire-Cornish cross birds (Ota and Mcnally, 1961). Zulovich *et al.,* (1987) found that a layer pullet when housed at typical production temperatures had similar sensible heat loss to that of a broiler at the same body mass while the latent heat loss of the pullet was 50% that of the broiler. The Egyptian native Dandarawi chicken is usually raised in Upper Egypt where dry hot climate is dominant. To our knowledge, non-studies have been done to estimate the diurnal heat dissipation of this breed.

Domestic chickens have a cloacal temperature that is closely regulated around 41 °C. The thermoneutral zone is between 18°C and 23.9°C for adult chickens and about 39.7°C in newly hatched chick, and decreases daily until it reaches a stable level at about three weeks of age. Thermoneutral zone varies with species, age, and body size (Whittow, 1986). Selective breeding for phenotypic traits in the domestication process has resulted in alterations in the physiology of commercial broilers (full-domesticated) and concomitantly the ability to withstand high ambient temperature compared with red jungle fowl (non-domesticated) and village fowl (semi-domesticated), as reported by (Soleimani *et al.,* 2011).

Skin temperature is a quick indication of heat loss condition. Where a smaller difference between ambient and skin temperature decreases the rate of sensible heat loss of excessive internal heat, elevates the body temperature, and may lead to mortality during heat waves (Azoulay *et al.,* 2011). Skin temperature is therefore dependents on both environmental temperature and heat loss from the core (Whittow, 1986). The increased heat flow to the back may not be readily dissipated to the environment because of the increased feather covering; however, the less feathered parts of the body such as the comb, wattles, leg or breast are more efficient for heat loss (Gerken *et al.,* 2006).

In the present study, we classified the chickens as full-domesticated strains (Lohmann selected leghorn for eggs and Cobb^{500} for meat) and semi-domesticated breed (Dandarawi).

The objective of this study was to estimating the sensible and latent (insensible) heat loss of the three breeds of chickens reflect different levels of domestication and types of production under summer conditions to provide data may be used in the design of environmental control systems in poultry houses.

2. Materials and Methods

Experimental Birds and Management of the Flock:

The study was carried out at the Poultry Research Station, Animal Production Department, Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, Egypt. A total number of 60 Dandarawi, 60 L.S.L and 60 Cobb^{500} chickens were used. The study was conducted from July 21, 2014 to September 21, 2014.

Day-old chicks were reared in floor pens with density of (six birds/m^{2}) with natural cyclic temperature (minimum: 28°C; maximum: 32°C) and relative humidity was between 37 and 69% until the end of the experiment. Birds have free accesses to feed and water. The Dandarawi and L.S.L. chicks were provided with 13L: 11D natural lighting where, the Cobb^{500} chicks followed 23L: 1D light schedule during experimental period. All chicks were vaccinated according to the vaccination program for common diseases. The chicks were fed commercial starter and grower rations for layers (Dandarawi and L.S.L chicks) and commercial starter and grower ration for broiler chicks from Feedmix Egypt Feed Industry Company at El-Obour City, Cairo. Table (1) shows the analysis of commercial rations.

Table (1): Analysis of experimental rations on dry basis:

	Layer Starter ration (D and L.S.L.)	**Broiler Starter ration (Cobb^{500})**	**Layer Grower ration (D and L.S.L.)**	**Broiler Grower ration (Cobb^{500})**
Crude protein (%)	20	23	18	21
Metabolizable energy (kcal/kg)	2900	3000	2890	3100
Crude fiber (%)	3.82	3.8	3.61	3.5
Crude fat (%)	3.87	5.6	3.18	5.8

Experimental Design and Procedures:

At the beginning of the experiment, day-old chicks were divided into three experimental groups, 60 birds each of mixed sex. Averages of body weight in the 3 experimental groups were apparently uniform. At 3 weeks of age 30 chicks form all breeds were divided into two equal groups; five chicks from each breed were used per group to study diurnal changes of heat loss measurements or diurnal changes of thermo-respiratory activity measurements in first and second groups, respectively. All birds were transferred to battery cages in the holding room and were deprived from food and water throughout the measurements period.

Diurnal changes of heat loss:

Five chicks of all breeds were used per day for three consecutive days. Birds transferred from holding room to individual plastic desiccators with raised wire floors in respiratory circuit in the measurements room (Diagram, 1). The three breeds were distributed on the desiccators at the day of measurements in the way that all breeds were simultaneously subjected to measurements. Live body weight, dry bulb temperature (˚F) and relative humidity (%) were recorded six times a day at hours 4, 8, 12, 16, 20, and 24 meanwhile, the volume of passing air per minute (ft3/min) and atmospheric pressure (mmHg) and ambient temperature (°C) were taken twice daily at start and end of respiratory trial.

The measurements taken were inlet and outlet of dry and wet bulb temperatures (˚F), humidity ratio (lb/lb), specific Volume (ft3/lb), flow rate (ft3/min) and enthalpy (BTU/lb). A set of psychrometric equations used to calculate total heat loss, sensible heat loss, and latent (insensible) heat loss was according to Esmay, (1978). The respiratory circuit was constructed by Shoukry (2013) based on principles of Bernstein *et al.,* (1977) with modifications. The set of heat loss psychrometric equations according to Esmay (1978) is represented as follows:

1. Air Mass Flow (lb. /hr.) = (V2*60)/Vs.
V2 = Outlet Air Volume (ft3/min).
Vs = Outlet Specific Volume (ft3/min/lb dry air).

2. Total Heat Loss (Joule.gBWT/hr) = ((M*(H2-H1))*1055.65)/BWT.
M = Air Mass Flow (lb/hr).
H1 = Inlet Enthalpy (BTU/hr).
H2 = Outlet Enthalpy (BTU/hr).
1055.65 = Conversion factor from BTU to Joule.

3. Sensible Heat Loss (Joule.gBWT/hr) = ((M*(H3-H1))*1055.65)/BWT.
H3 = Inlet Humidity Ratio at specific outlet dry bulb temperature (BTU/lb).

4. Latent Heat Loss (Joule.gBWT/hr) = ((M*(H2-H3))*1055.65)/BWT.

5. Water Flow Rate (mg.gBWT/hr) = ((M*(W2-W1))*453592.40)/BWT.
W1 = Inlet Humidity Ratio (lb/lb).
W2 = Outlet Humidity Ratio (lb/lb).
453592.40 = Conversion factor from lb to mg.

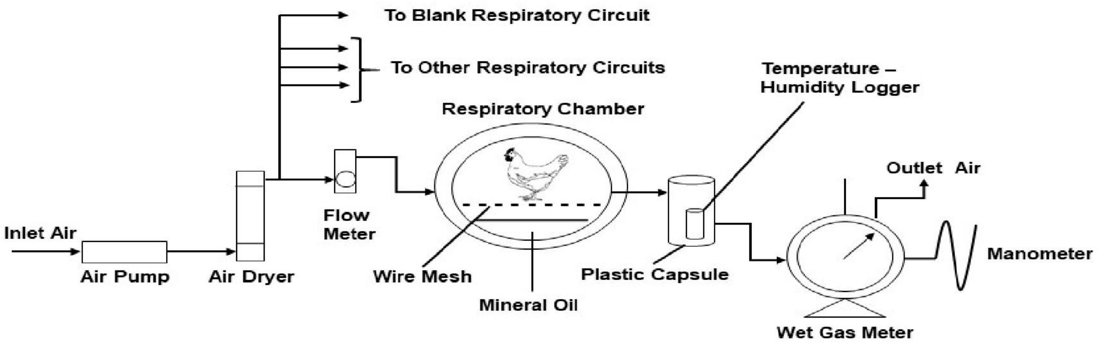

Diagram (1): The respiratory circuit contained air pump to push air in the system. Air was dried by passing into container filled with dry-rite then the dry air flowed through flow meter (Cole Parmer, USA). After adjusting the air flow by flowmeter air entered plastic desiccators. Paraffin oil was used to receive droppings of the bird. Outflow air entered plastic capsule contained temperature and humidity data logger (OMEGA-EL-USB-2, England) to record data every 4 hrs. Then air left the recording capsule to wet gas meter (GCA/PRECISION SCIENTIFIC, USA) to measure the volume of passing air per minute. There was water manometer attached to gas meter to ensure that the gas pressure in the circuit equaled the ambient air pressure. All gas volumes were corrected to its STPD volume.

Diurnal changes of thermo-respiratory activity:

Five birds from the three breeds used per day and kept in holding room for three consecutive days for thermo-respiratory activity trial at 3 weeks of age. The birds were kept in individual cages. Cloacal, skin and plumage temperatures and respiration rate were measured six times a day at hours 4, 8, 12, 16, 20 and 24 for the three consecutive days during the trial. The thermo-respiratory activity trial was done in parallel with diurnal changes of heat loss trial. Birds were deprived from food and water over night before taking the measurements. Cloacal temperature (Tc) was measured with a digital thermometer with 0.1°C resolution by inserting a probe of electronic thermometer 2 cm inside the cloaca contacting the epithelial lining for a minute. Skin temperature (Ts) was taken by digital thermometer with a probe of electronic thermometer with contacting skin fold under the right wing for a minute. Plumage temperature in iterscapular region (Tp) was measured with an infrared thermometer with 0.1°C resolution. Respiration rate (RR) was measured by counting the movement of body wall for a minute.

Micro-environmental Data:

. The environmental conditions during the trial period were moderately hot, with typical daytime temperatures in the range from 29° to 31°C. Average of relative humidity was 54%, with minimum 44 % during midday and the maximum 63 % at midnight.

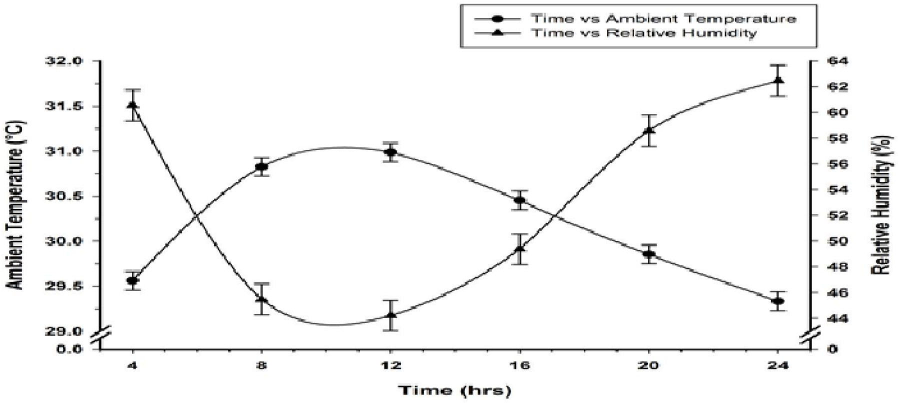

Figure (1): Micro environmental data associated with thermo-respiratory activity of birds.

Statistical Analysis:

Two-way analysis of variance repeated in one-way (Split-plot design) was used to test the effects of breed, time of the day and their interactions according to (Winer, 1971). Least squares means were used to compare means at the level of ($P \leq 0.05$) The statistical analysis of data was carried out by applying the software package of SAS (1988) using GLM procedure.

3. Results and Discussion

Diurnal changes of heat loss:

Table (2) shows that no significant effect of breed on total, sensible, and latent heat losses and, percentages of sensible and latent heat losses. However, the effect of time was significant ($P \leq 0.05$) on the fore mentioned variables. The interaction between breed and time in total, sensible and latent heat losses were significant ($P \leq 0.05$). However, the same interactions in percentages of sensible and latent heat loss were not significant.

Comparing breeds within time of the day revealed the following trends. The total heat loss of Dandarawi was significantly ($P \leq 0.05$) higher than those of L.S.L. and Cobb^{500} at first half of the daytime (hours 8 and 12) as shown in table (2). Total heat loss of L.S.L. showed significantly ($P \leq 0.05$) lower value at hour 16 compared to the other two breeds. Except the former times of the day, no significant differences were noticed among breeds within time. The trend of latent heat loss was similar to that of total heat loss. While latent heat loss was significantly ($P \leq 0.05$), lower in L.S.L. and Cobb^{500} than that of Dandarawi chicken at hour 12. Latent heat loss of L.S.L. was significantly ($P \leq 0.05$) lower than those of the other two breeds at hour 16 (Table, 2). Latent heat loss of L.S.L. was significantly ($P \leq 0.05$) lower than that in Cobb^{500} chicken at hour 20. On contrary, the sensible heat loss showed different trend. Where, it was significantly ($P \leq 0.05$) lower in Dandarawi and Cobb^{500} chickens than that of L.S.L. at hours 4, 12 and 16 (Table, 2). Sensible heat loss of Cobb^{500} was significantly ($P \leq 0.05$) lower than those of Dandarawi and L.S.L. at hour 8.

Comparing the time of the day within breeds revealed the following trends. Total heat loss of Dandarawi chicken was significantly ($P \leq 0.05$) higher at hour 8 and insignificantly through the period from hours 12 to 20 then decreased insignificantly through the period from hour 24 to hour 4. In L.S.L. the total heat loss was significantly ($P \leq 0.05$) higher at hours 24 and 8 then showed insignificant decrease at hour 12 then significant ($P \leq 0.05$) decrease in total heat loss at hours 16 and 20. The total heat loss of Cobb^{500} was significantly ($P \leq 0.05$) higher through the period from hour 16 to 24 then hour 8. It significantly ($P \leq 0.05$) decreased at hour 12 (Table, 2). No significant differences in latent heat loss among times of day of Dandarawi chicken. Meanwhile, latent heat loss of L.S.L. and Cobb^{500} showed similar trend of total heat loss except for at hour 12 (Table, 2). In L.S.L. total heat loss significantly ($P \leq 0.05$) decreased at afternoon period (hours 16 to 20), and latent heat loss significantly ($P \leq 0.05$) decreased at afternoon period (hours 12 to 20), meanwhile, total heat loss and latent heat loss of Cobb^{500} decreased significantly at hour 12. Dandarawi showed significant ($P \leq 0.05$) decrease in sensible heat loss through the periods at hours 4, 12 and 16 with lowest value at hour 24. Chicks of L.S.L showed the lowest value at hour 24 similar to Dandarawi; however, they showed significant ($P \leq 0.05$) decrease in sensible heat loss at hours 4, and 16. No significant differences in sensible heat loss among times of the day in the Cobb^{500} (Table, 2).

It was noticed that the trends of total heat loss and latent heat loss were somehow opposite to that of sensible heat loss, which may indicate that the pattern of diurnal heat loss differed among the three breeds. In this regard, Dandarawi and Cobb^{500} showed less diurnal changes in total and latent heat losses compared to L.S.L. Meanwhile, Dandarawi and L.S.L. showed temporary increase in sensible heat loss in the morning around hour 8. However, L.S.L. showed another increase at hour 16. Cobb^{500} showed no significant diurnal changes in sensible heat loss with tendency to decrease heat loss during night (hour 24).

These values are in agreement with the results of Chepete *et al.,* (2004) who found that the total heat loss, sensible heat loss and latent heat loss of 170 g layer pullets (W-98) aged 21 days and reared under 25.6°C and 35 to 50% RH were 14.8 (53.28), 9.4 (33.84) and 5.4 (19.44) W/kg (Joule/g bwt.hr), respectively. Chwalibog *et al.,* (1985) stated that the values of evaporative heat loss (latent heat loss) of Plymouth Rock chicken at 21 day of age reread under 28˚C and 60 % RH were 227 KJ/bird.day. Meanwhile, in the present study the values of latent heat loss of Dandarawi and L.S.L. chickens at 21 day of age reread under 29- 31˚C and ≤ 90 % RH were 136.7 and 95.4 KJ/bird.day, respectively. Gates *et al.,* (1996) reported that the total heat loss, sensible heat loss and latent heat loss of 750 g broilers aged 21 days and reared under 26.7˚C and 50% RH were 11.7 (42.12), 4.6 (16.56), and 7.1 (25.26) W/kg (Joule/g bwt.hr), respectively. Furthermore, Chepete (2002) stated that the total heat loss, sensible heat loss and latent heat loss of 400 g broilers reared under 29.4˚C and 70% RH were 12.5 (45), 4.6 (16.56), and 7.9 (28.44) W/kg (Joule/g bwt.hr) at 24 days of age, respectively. Meanwhile, Reece and Lott (1982) noticed that the average of total heat loss, sensible heat loss and latent heat loss of 728 g broilers at 28 day of age under 26.7-30 ˚C and 44 % RH were 10.4 (37.44), 3.3 (11.88) and 7.1 (25.56) W/kg (Joule/g bwt.hr) respectively. The results of the present study are in agreements with values reviewed for total and latent heat losses. However, sensible heat loss values in the present study were considerably lower than that of reviewed values. This difference may be due to the extremely high RH imposed on the chicks, which depressed the sensible heat loss avenue of these chicks (Genç and Portier, 2005).

Significant ($P \le 0.05$) differences in main effect of time of the day were noticed in percentages of latent and sensible heat loss (Table, 2). Percentage of latent heat loss start to increase at hour 16 up to 4, however, it decreased significantly ($P \le 0.05$) at hour 8 and 12 (Table, 2). The percentage of sensible heat loss showed opposite trend to latent heat loss. Similar results were obtained by Feddes *et al.,* (1984) who found that the latent heat loss over the period of the production cycles amounted approximately 40-70% of the total heat produced in the broiler houses.

Table (2): Diurnal changes of total heat loss, sensible heat loss, latent heat loss, percentage of sensible heat loss, and percentage of latent heat loss of Dandarawi, Lohmann Selected Leghorn, and Cobb^{500} breeds of chickens at 3 weeks of age.

Variables		Total heat loss (Joule/g bwt.hr)	Sensible heat loss (Joule/g bwt.hr)	Latent heat loss (Joule/g bwt.hr)	Percentage of Sensible heat loss (%)	Percentage of Latent heat (%)
Breed						
Dandarawi		$37.782^{1}\pm3.45$	4.278±1.84	33.504±4.25	12.495±7.23	87.505±7.23
L.S.L.		35.043±4.22	7.200±2.25	24.843±5.20	20.980±8.85	79.021±8.85
Cobb^{500}		34.461±3.78	3.680±2.01	30.777±4.66	18.605±7.92	81.395±7.92
Time (hr)						
4		34.479±2.20	4.680±0.71	29.799±2.01	$13.226^{bc}\pm6.05$	$86.774^{ab}\pm6.05$
8		39.682±2.20	8.510±0.71	31.172±2.01	$22.276^{ab}\pm6.05$	$77.724^{b}\pm6.05$
12		30.927±2.20	6.440±0.71	24.488±2.01	$35.357^{a}\pm6.05$	$64.643^{b}\pm6.05$
16		35.803±2.20	4.573±0.71	31.230±2.01	$15.645^{bc}\pm6.05$	$84.355^{ab}\pm6.05$
20		34.928±2.20	4.350±0.71	30.578±2.01	$12.801^{bc}\pm6.05$	$87.199^{ab}\pm6.05$
24		38.750±2.20	1.767±0.71	36.983±2.01	$4.853^{c}\pm6.05$	$95.147^{a}\pm6.05$
		Total heat loss (Joule/g bwt.hr)	Sensible heat loss (Joule/g bwt.hr)	Latent heat loss (Joule/g bwt.hr)	Percentage of Sensible heat loss (%)	Percentage of Latent heat (%)
Breed *Time						
Dandarawi	4	$33.189^{bA}\pm3.44$	$3.448^{bcB}\pm1.11$	$29.741^{aA}\pm3.13$	9.876±9.43	90.124±9.43
	8	$44.926^{aA}\pm3.44$	$10.390^{aA}\pm1.11$	$34.536^{aA}\pm3.13$	24.055±9.43	75.945±9.43
	12	$37.140^{abA}\pm3.44$	$3.505^{bcB}\pm1.11$	$33.636^{aA}\pm3.13$	11.599±9.43	88.401±9.43
	16	$39.651^{abA}\pm3.44$	$2.740^{bcB}\pm1.11$	$36.912^{aA}\pm3.13$	11.223±9.43	88.777±9.43
	20	$36.539^{abA}\pm3.44$	$4.379^{bA}\pm1.11$	$32.160^{aAB}\pm3.13$	13.701±9.43	86.299±9.43
	24	$35.245^{bA}\pm3.44$	$1.205^{cA}\pm1.11$	$34.040^{aA}\pm3.13$	4.515±9.43	95.485±9.43
L.S.L.	4	$37.445^{abA}\pm4.21$	$7.209^{bcA}\pm1.11$	$30.236^{abA}\pm3.84$	18.956±11.55	81.044±11.55
	8	$40.969^{aAB}\pm4.21$	$10.102^{abA}\pm1.35$	$30.867^{abA}\pm3.84$	26.245±11.55	73.755±11.55
	12	$33.074^{abAB}\pm4.21$	$11.823^{aA}\pm1.35$	$21.251^{bB}\pm3.84$	35.607±11.55	64.393±11.55
	16	$27.542^{bB}\pm4.21$	$7.270^{bcA}\pm1.35$	$20.272^{bB}\pm3.84$	25.501±11.55	74.499±11.55
	20	$29.171^{bA}\pm4.21$	$4.472^{cdA}\pm1.35$	$24.670^{bA}\pm3.84$	13.431±11.55	86.569±11.55
	24	$42.054^{aA}\pm4.21$	$2.319^{dA}\pm1.35$	$39.735^{aA}\pm3.84$	6.136±11.55	93.864±11.55
Cobb^{500}	4	$32.803^{abA}\pm3.77$	$3.383^{aB}\pm1.21$	$29.420^{aA}\pm3.43$	10.846±10.33	89.154±10.33
	8	$33.152^{aB}\pm3.77$	$5.038^{aB}\pm1.21$	$28.11^{aA}\pm3.43$	16.527±10.33	83.473±10.33
	12	$22.568^{bB}\pm3.77$	$3.992^{aB}\pm1.21$	$18.576^{bB}\pm3.43$	58.864±10.33	41.136±10.33
	16	$40.216^{aA}\pm3.77$	$3.709^{aB}\pm1.21$	$36.507^{aA}\pm3.43$	10.213±10.33	89.787±10.33
	20	$39.074^{aA}\pm3.77$	$4.200^{aA}\pm1.21$	$34.874^{aA}\pm3.43$	11.270±10.33	88.730±10.33
	24	$38.952^{aA}\pm3.77$	$1.778^{aA}\pm1.21$	$37.174^{aA}\pm3.43$	3.909±10.33	96.091±10.33
Source of variance		$P \le$ values				
Breed		0.981	0.489	0.706	0.736	0.736
Time		0.004	0.000	0.009	0.024	0.024
Breed*Time		0.006	0.009	0.014	0.352	0.352

[1] Least square means ± Standard error.

$^{A, B}$ Means having different letter exponents are significantly different ($p \le 0.05$) among rows of breeds within times of day.

$^{A, b, c}$ Means having different letter exponents are significantly different ($p \le 0.05$) among rows of main effects (breed or time) or among rows of times of day within breed whenever the interaction is significant.

Diurnal changes in thermo-respiratory activity:

Table (3) shows no significant interactions between breed and time of the day effects on cloacal, skin, and plumage temperatures and respiration rate at 3 weeks of age. The main effects of breed and time of the day were significant ($P \le 0.05$) in cloacal, skin temperatures, and of respiration rate (Table, 3). No significant differences were found in plumage temperature.

Cobb^{500} cloacal temperature was significantly ($P \leq 0.05$) higher than those of the two other breeds. No significant difference in cloacal temperature between Dandarawi and L.S.L. chickens was found (Table, 3). Diurnal changes in cloacal temperature appeared a clear trend. Where cloacal temperature was significantly ($P \leq 0.05$) higher at hours 4, 8 and, 12 than that at hour 16 then temperature started to increase insignificantly at hours 20 and, 24 (Table, 3).

It seems that dehydrated birds increased their temperature in hot humid environment (Figure, 1) at the cooler part of the day to dissipate the heat they were gained during the daytime and they attained lowest temperature at afternoon. Then they started to gain more heat as ambient temperature started to increase. This trend followed to a good extent the trend of sensible heat loss as shown in table (3) with different magnitudes for the three breeds. The trends of diurnal changes of cloacal temperature and sensible heat loss were not identical may be due to measurements were taken in two different groups of chickens.

The increase of cloacal temperature at the cooler part of the day may be explained, as dehydrated birds in hot weather tend to increase its body temperature to increase heat dissipation via sensible heat loss to decrease evaporative cooling as water economy strategy the mechanism that called heat storage (Whittow, 1986).

Table (3): Diurnal changes of cloacal temperature, skin temperature, plumage temperature, and respiration rate of Dandarawi, Lohmann Selected Leghorn, and Cobb^{500} breeds of chickens at 3 weeks of age.

Variables		Cloacal temperature (˚C)	Skin temperature (˚C)	Plumage temperature (˚C)	Respiration rate (r.p.m)
Breeds					
Dandarawi		41.390^{1b}±0.12	39.440^{ab}±0.13	35.950±0.17	79.367^{a}±2.31
L.S.L.		41.173^{b}±0.12	39.200^{b}±0.13	36.120±0.17	70.533^{b}±2.31
Cobb^{500}		41.743^{a}±0.12	39.773^{a}±0.13	35.943±0.17	71.867^{b}±2.31
Time (hrs)					
4		41.533^{a}±0.09	39.407^{bcd}±0.10	36.013±0.23	70.400^{b}±2.05
8		41.540^{a}±0.09	39.487^{abc}±0.10	36.173±0.23	73.933^{b}±2.05
12		41.560^{a}±0.09	39.700^{a}±0.10	35.900±0.23	80.333^{a}±2.05
16		41.213^{b}±0.09	39.380^{cd}±0.10	36.027±0.23	74.133^{b}±2.05
20		41.327^{ab}±0.09	39.180^{d}±0.10	36.360±0.23	74.000^{b}±2.05
24		41.420^{ab}±0.09	39.673^{ab}±0.10	36.553±0.23	70.733^{b}±2.05
Breed*Time					
Dandarawi	4	41.620±0.16	39.440±0.17	36.320±0.40	72.000±3.55
	8	41.600±0.16	39.580±0.17	36.260±0.40	80.000±3.55
	12	41.660±0.16	39.760±0.17	35.640±0.40	88.200±3.55
	16	41.020±0.16	39.300±0.17	36.260±0.40	80.000±3.55
	20	41.180±0.16	39.060±0.17	36.140±0.40	79.200±3.55
	24	41.260±0.16	39.500±0.17	35.080±0.40	76.800±3.55
L.S.L.	4	41.200±0.16	39.040±0.17	35.760±0.40	70.800±3.55
	8	41.500±0.16	39.520±0.17	36.260±0.40	68.800±3.55
	12	41.160±0.16	39.380±0.17	35.820±0.40	74.000±3.55
	16	40.920±0.16	39.060±0.17	35.900±0.40	69.600±3.55
	20	41.100±0.16	38.820±0.17	36.520±0.40	74.000±3.55
	24	41.160±0.16	39.380±0.17	36.460±0.40	66.000±3.55
Cobb^{500}	4	41.840±.0.16	39.740±0.17	35.960±0.40	68.400±3.55
	8	41.520±0.16	39.360±0.17	36.000±0.40	73.000±3.55
	12	41.860±0.16	39.960±0.17	36.240±0.40	78.800±3.55
	16	41.700±0.16	39.780±0.17	35.920±0.40	72.800±3.55
	20	41.700±0.16	39.660±0.17	36.420±0.40	68.800±3.55
	24	41.840±0.16	40.140±0.17	35.120±0.40	69.400±3.55
Source of Variance		P ≤ values			
Breed		0.014	0.033	0.706	0.041
Time		0.041	0.005	0.242	0.017
Breed*Time		0.238	0.192	0.421	0.813

[1] Least square means ± Standard error.

[A, B] Means having different letter exponents are significantly different ($p \leq 0.05$) among rows of breeds within times of day.

[A, b, c] Means having different letter exponents are significantly different ($p \leq 0.05$) among rows of main effects (Breed or Time) or among rows of times of day within breed whenever the interaction is significant.

No significant differences were noticed in skin temperature between Cobb^{500} and Dandarawi or between L.S.L. and Dandarawi chicken. However, the Cobb^{500} chicken had significantly ($P \leq 0.05$)

higher skin temperature than that of L.S.L. chicken. Skin temperatures were significantly ($P \leq 0.05$) higher at hour 12 than other times of the day (Table, 3). Plumage temperature showed no significant differences among breeds and time of the day (Table, 3).

No significant differences were observed in respiration rate between L.S.L. and Cobb^{500} chickens. However, the Dandarawi chicken had significant ($P \leq 0.05$) higher respiration rate than that of L.S.L. and Cobb^{500} chickens (Table, 3). The heat adaptability of Dandarawi may be responsible of its significant ($P \leq 0.05$) higher respiration rate without increasing latent heat loss (Table, 3) compared to the other two breeds (Marder *et al.,* 1974). In Cobb^{500,} respiration rate was lower than that of Dandarawi without affecting latent heat loss (Table, 3). The significantly ($P \leq 0.05$) highest respiration rate was noticed at hour 12 (Table, 3). Respiration rate in all other hours did not differ significantly.

Conclusions:

Different responses of broiler chicks to hot environment at 3 weeks of age compared to the other non-meat type breeds indicated that the type of production is most effective rather than level of domestication on acclimatization mechanisms to hot environment. The indicated different acclimatization responses were diurnal changes in sensible heat loss, and cloacal temperature.

The heat adaptability of Dandarawi may be responsible of its significant ($P \leq 0.05$) higher respiration rate without increasing latent heat loss compared to the other two breeds. In Cobb^{500,} respiration rate was lower than that of Dandarawi without affecting latent heat loss. These trends may reflect the adaptability of the semi-domesticated Dandarawi compared to the fully domesticated ones.

References

1. Azoulay, Y.; S. Druyan; L. Yadgary; Y. Hadad and A. Cahaner 2011. The viability and performance under hot conditions of featherless broilers versus fully feathered broilers. Poultry science, 90(1): 19–29.
2. Bernstein, M.H.; D.M. Hudson; J.M. Stearns and R.W. Hoyt 1977. Measurement of evaporative water loss in small animals by dew-point hygrometry. Journal of applied physiology: respiratory, environmental and exercise physiology, 43(2): 382–385.
3. Blanco, O. A. 2010. A dynamic mechanistic analysis of the thermal interaction between a broiler chicken and its surrounding environment. Ph.D. Thesis, Department of Animal and Poultry Science, Faculty of Science and Agriculture, University of KwaZulu-Natal Pietermaritzburg, Argentina.
4. Cangar, O.; J.M. Aerts; J. Buyse and D. Berckmans 2008. Spatial distribution of surface temperatures and heat loss in broiler chickens. Livestock Environment VIII. 31 August – 4 September 2008, Iguassu Falls, Brazil, American Society of Agricultural and Biological Engineers. pp 8.
5. Chepete, H.; H. Xin; M. Puma and R. Gates 2004. Heat and Moisture Production of Poultry and Their Housing Systems: Pullets and Layers. ASHRAE Transactions: 286–299.
6. Chepete, H.J. 2002. Current state and updating of heat and moisture production of poultry and their housing systems. Ph.D. Thesis, Department of Agricultural Structures and Environment, Faculty of Agricultural Engineering, Iowa State University, Ames, Iowa.
7. Chwalibog, A.; J. Pedersen and B.O. Eggum 1985. Evaporative and sensible heat-loss from chickens kept at different temperatures. Archiv Fur Geflugelkunde 49(2): 50–54.
8. Esmay, M.L. 1978. Principles of animal environment. AVI Pub. Co., Inc., Westport Conn., p 58-68.
9. Feddes J.J.R.; J.J. Leonard and J.B. McQuitty 1984. Broiler heat and moisture production under commercial conditions. Canadian Agricultural Engineering 26(1): 57–64.
10. Gates, R.S.; D.G. Overhults and S.H. Zhang 1996. Minimum Ventilation for Modern Broiler Facilities. Transactions of the ASAE 39(3): 1135–1144.
11. Genç, L. and K.M. Portier 2005. Sensible and latent heat productions from broilers in laboratory conditions. Turkish Journal of Veterinary and Animal Sciences, 29(3): 635–643.
12. Gerken, M., R. Afnan, and J. Dörl. 2006. Adaptive behaviour in chickens in relation to thermoregulation. Arch. Geflügelk. 70:199–207.
13. Hoffman, T.C.M.; G.E. Walsberg and D.F. DeNardo 2007. Cloacal evaporation: an important and previously undescribed mechanism for avian thermoregulation. Journal of Experimental Biology, 210(5): 741–749.
14. Marder, J.; Z. Arad and M. Gafni 1974. The effect of high ambient temperatures on acid-base balance of panting Bedouin fowl (Gallus domesticus). Physiological Zoology 47(3): 180–189.
15. Ota, H. and E.H. Mcnally 1961. Poultry Respiration Calorimetric Studies of Laying Hens: Single Comb White Leghorns, Rhode

Island Reds, and New Hampshire X Cornish Cross, Agricultural Research Service, US Department of Agriculture.
16. Reece, F.N. and B.D. Lott 1982. The effect of environmental temperature on sensible and latent heat production of broiler chickens. Poultry Science 61(8):1590- 1593.
17. SAS Institute Inc. 1988. SAS/Stat User’s guide release 6.03 ed. SAS Institute Inc., Cary NC. USA.
18. Shoukry, H.M.S. 2013. Unpublished Data.
19. Soleimani, A.F.; I. Zulkifli; A.R. Omar and A.R. Raha 2011. Physiological responses of 3 chicken breeds to acute heat stress. Poultry science 90(7): 1435–1440.
20. Whittow, G.C. 1986. Regulation of body temperature. Avian physiology, Springer: 221–252.
21. Williams, J.B. and B.I. Tieleman 2001. Physiological ecology and behavior of desert birds. Current Ornithology, Volume 16: 299–353.
22. Winer, B.J.; D.R. Brown and K.M. Michels 1971. Statistical principles in experimental design, McGraw-Hill New York.
23. Yahav, S.; D. Shinder; J. Tanny and S. Cohen 2005. Sensible heat loss: the broiler's paradox. World's Poultry Science Journal 61(3): 419–434.
24. Zulovich, J.M.; H.B. Manbeck and W.B. Roush 1987. Whole House Heat and Moisture Production of Young Floor Brooded Layer Pullets. Transactions of the ASAE 30(2): 455–4.

4/25/2018