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Effect of Different Environmental Housing Conditions on Physiological Reactions of Growing Friesian Calves.

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Abstract. twenty two healthy growing Friesian calves were used to study their diurnal and seasonal physiological reactions as affected by two different housing types; semi open barn with concrete roof and semi closed barn with asbestos roof. The study included two seasons, winter (January to February) and summer (July and August), the measurements were taken at 08.00 hrs. and 14.00 hrs. The studied parameters were climatic conditions indoors and outdoors, thermal properties of building components (roof, walls and floors, thermal responses of animals, respiratory responses, hematological responses, leukocyte differential count and thyroid activity. The physical thermal properties of building components were tested at four times (06.00, 12.00, 15.00 and 20.00 hrs.) throughout the day. The housing components of the two barns showed significantly (P<0.01) seasonal and diurnal effects on all the physiological parameters of the calves. There were highly significant correlations between the calf responses and the air temperature with the relative humidity and between each other as well.

It was evident that the animals had better comfort in the asbestos roofed barn. It is suggested that the colder walls and roof at night and early morning (22.00 and 06.00 hrs.) act as heat sinks which facilitates heat dissipation from animals' body that was accumulated.

Keywords: Environment, Friesian calves, Physiological Reactions, Blood metabolites.

INTRODUCTION

The future of any dairy herd lies in its young stock. Providing shelter that is proper for the environment can help calves and heifers grow to meet the genetic potentiality for milk production.

A satisfactory environment is one that satisfies the following criteria: thermal comfort, physical comfort, disease control and behavioral satisfaction. Environmental stress, which may be direct or indirect, is anything that departs from these criteria. The most important environmental stresses today are those that have resulted from housing and other attempts to ameliorate the thermal environment (Webster, 1983). Heat stress resulting when dairy animals are exposed to hot/hot and humid environmental conditions (West, 1993). Outside the comfort zone, the animal experiences stress to remain homoeothermic (Nardone et al., 2006).

Animal housing design is mainly concerned with the physical environment, in particular climatic and mechanical factors, where healthy animals can be easily handled to produce without stress or suffering from any physical harm. Providing clean and available water, enough shade and good ventilation should be routine (Turner, 1998).

Hot weather causes heat stress in dairy cattle leading to declines in feed intake and production. Heat stress is defined as any combination of environmental parameters producing conditions that are higher than the temperature range of the animal's thermal natural zone (Shultz, 1984).

Any calf housing and management system must provide certain basic requirements to ensure the health, comfort and productivity of the calves confined therein. The most important basic requirements are: fresh air, a dry bed, tender loving care and freedom from stress (Milne, 1983 and Webster, 1984). The major requirements of the calf housing can be translated into specifications for climate, space, allowances, ventilation and shelter or pen design (Lawrence, 1994).

Fulfillment of such requirements results in low death losses, low veterinary and medical expenses. The outcome is full complement of healthy calves and heifers from which to choose milking herd replacements, as well as increased income from sales of surplus stock and a sense of satisfaction from a job well done.

The term heat stress (HS) is defined as the sum of the accumulated heat from the environment and the animal's failure to dissipate heat, which is often associated with a defect in the animal's productive and/or physiological metabolism (Bernabucci and Mele, 2014).

Plenty of authors studied the physiological reactions of different cattle breeds to natural environmental conditions under different housing systems. There was a great deal of agreement between their results. Cattle body reactions were related to temperature humidity index (THI) (Castaneda et al., 2004). Body reaction values increased linearly with increasing air temperature. The values of rectal temperature (RT), skin temperature (ST) and respiration rate (RR) showed high correlations with air temperatures (Sayah, 2005, Ashour et al., 2007, Cardoso et al., 2015 and Gaafar et al., 2021).

The main objectives of this study were to study the effects of diurnal and seasonal changes on the physiological responses of suckling and weanling Friesian calves in three different types of housing models. In addition, to assess the real value and compare the three models of housing and to decide whether these models are satisfactory in their current conditions or not.

MATERIALS AND METHODS

1. Experimental animals:

A total of 22 healthy Friesian calves were selected randomly and used in this study as follows; 10 calves (averaged 22 weeks of age and 125 Kg live body weight) were used in the first study during winter season, and 12 calves (averaged 26 weeks of age and 153 Kg live body weight) were used in the second study during summer season.

2. Housing types and management:

Three housing models were used in this experiment (Fig's 1 and 2). These models were as follows:

2.1. Semi-open barn with concrete roof for weanlings (Fig. 1).

The barn was made of brick walls and the ceiling was made of asbestos sheets at the height of 5 m and concrete at the height of 3 m with earthen floor, the ventilation openings were at the height of 2.25 m from the ground.

2.2. Semi-closed barn roofed by asbestos sheets for weanlings (Fig. 2).

The barn was made of bricks, 2 m high and 25 cm thick, and the ceiling was made of reinforced concrete at the height of 3 m with earthen floor.

Fig. 1. Semi-open barn

Fig. 2. Semi-closed barn

3. Feeding system:

Calves were offered concentrate ration twice a day at 08.00hrs. and 16.00hrs. according to the farm routine. The feeding in summer and in winter was the same ration except green berseem in winter was substituted by berseem hay in summer.

4. Investigations and procedures:

The following parameters were investigated under the two housing models by the same techniques and procedures:

3.1. Environmental conditions in-and outdoors {air temperature (AT), minimum and maximum temperature (mini. & max. temp.) and relative humidity (RH)}. **3.2.** Thermal characteristics of housing models four times a day (internal and external walls and roofs temperatures, and floors temperatures). **3.3.** Thermal and respiratory reactions of animals {rectal temperature (RT), skin temperature (ST) and respiration rate (RR)}. All measurements were taken at 08.00hrs. and 14.00hrs. weekly. **3.4.** Hematological reactions {hemoglobin concentration (Hb) and hematocrit value (Ht)}. **3.5.** Thyroid functions (T_3 and T_4 concentrations in blood plasma).

Blood samples were collected weekly from the jugular vein at 08.00hrs. and 14.00hrs. EDTA was used as an anticoagulant with concentration of 0.1 gm per 5 ml blood. Blood samples were divided into two parts; the first one was centrifuged at 3000 r.p.m. for 5 minutes to separate blood plasma and it was stored at -20 C for hormones assay, and the second part was used for determinations of Hb and Ht.

5. Statistical analysis:

Relevant statistical analysis of data was carried out applying to SAS package (1990). Correlation coefficients among the variables were estimated according to Sendecor (1982). Also Duncan test (1955) was done to determine the degree of significance between the means.

RESULTS AND DISCUSSION

1. Thermal characteristics of buildings in the three housing models:

Data presented in Tables (1 and 2) shows the daily temperature (°C) of walls, roof, floor and internal air temperature in the different barns in winter and summer at 06.00hrs. and 12.00hrs., 15.00hrs. and 22.00hrs. day times.

The winter data (1) reveal that the lowest values of internal temperature of walls, roof, floor and internal air temperature was at 06.00 hrs, followed by great increase at 22.00 hrs, 12.00 hrs with abrupt drop at 15.00 hrs. This trend was more apparent in roof temperature, less in IAT and the less in floor and the walls temperature.

The summer data (2) reveal the same trend, but the deference between the temperature degrees at the four days times were lower as percentage change than the case in winter. These results is in agreement with Sayah (2005) and Gaafar et al. (2021).

Table (1): Daily temperature of walls (W) and roof, floor and internal air temperature (IAT) in the experimental barns in winter (ºC).

House	Day time	Northern W.		Southern W.		Western W.		Eastern W.		Roof		Floor	AT
		Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.		
1	06.00	6	6	7	6	7	6	6	6	5	3	10	10
	12.00	12	12	12	16	11	11	13	15	22	25	14	22
	15.00	14	14	15	17	15	17	15	16	20	22	16	22
	22.00	11	10	11	10	9	6	11	9	6	4	10	11
2	06.00	6	6	11	7	11	7	11	10	7	5	11	11
	12.00	11	15	12	22	12	15	12	15	14	23	13	16
	15.00	12	16	13	21	13	17	13	15	20	27	13	21
	22.00	11	6	12	6	11	5	11	6	5	6	10	13

Table (2): Daily temperature of walls (W) and roof, floor and internal air temperature (IAT) in the experimental barns in summer (ºC).

House	Day time	Northern W.		Southern W.		Western W.		Eastern W.		Roof		Floor	AT
		Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.		
1	06.00	22	19	21	18	21	19	21	21	17	13	21	19
	12.00	26	32	23	25	25	37	23	24	47	50	26	32
	15.00	31	31	29	38	31	37	26	27	40	45	27	31
	22.00	25	23	25	23	25	25	25	25	17	14	25	23
2	06.00	24	22	24	20	24	20	23	18	21	14	22	22
	12.00	22	25	23	23	24	48	22	27	28	52	24	30
	15.00	24	25	25	34	25	43	24	26	25	44	24	31
	22.00	25	22	25	23	26	24	25	21	24	21	24	25

* (1) Calves under asbestos and (2) Calves under concrete.
* (Int.) Internal, (Ext.) External and (AT) Air temperature within the house

2. Thermal reactions of calves:

2.1. Rectal temperature (RT):

Data presented in table (3) shows the seasonal daily means of RT of Friesian calves in winter and summer.

Rectal temperature of Friesian calves was significantly higher at 14.00hrs. in summer than the other times in winter and summer in any of the three types of housing. The lowest values of RT were obtained at 08.00 hrs. in winter in the three types of housing. Shafie and El-Sheikh Aly (1970) and Sayah (2005) reported that the steady increase in the body reaction in Friesian cattle from the morning to the evening could be attributed to the gradual rise in atmospheric temperature and the increase in the body activities of the animals. Similar results were obtained by (Kobeisy, 1983, Sayah, 1997, Cardoso et al., 2015 and Gaafar et al. 2021).

Table (3): Seasonal daily means ± S.E. of rectal temperature (RT ºC) of Friesian calves kept in asbestos (as) and concrete (co) roofed barns.

Items	08.00 hrs.		14.00 hrs.	
	winter	summer	winter	summer
Calves (as)	38.7 ^{e} ±0.1	39.1 ^{bcd} ±0.1	39.2 ^{bcd} ±0.1	39.7 ^{a} ±0.1
Calves (co)	38.9 ^{de} ±0.1	39.2 ^{bcd} ±0.1	39.3 ^{bc} ±0.1	39.7 ^{a} ±0.1

* (as) Calves under asbestos and (co) Calves under concrete.

2.2. Skin temperature (ST):

Data presented in table (4) shows the seasonal daily means of white and black skin temperature of Friesian calves in winter and summer.

There was a high significant difference between the daily measurements of WST and BST at 08.00hrs. and 14.00hrs. during the same season in the two types of housing. The lowest values were obtained in the morning and the highest values were obtained in the afternoon. This result is in agreement with Amakiri (1979), Thiagarajan and Thomas (1992), Sayah, (2005) and Gaafar et al 2021). Also there was a highly significant difference between winter and summer measurements in the two types of housing, the lowest values were obtained in the winter, while the highest values were in the summer. This result is in agreement with Shafie and El-Sheikh Aly (1970), Chikamune (1986), Sayah (2005) and Gaafar et al 2021).

Table (4): Seasonal daily means ± S.E. of white and black (WST and BST) skin temperatures (ºC) of Friesian calves kept in asbestos (as) and concrete (co) roofed barns.

Items	08.00 hrs.		14.00 hrs.	
	winter	summer	winter	summer
WST :				
Calves (as)	33.4 [d] ±0.1	35.3 [b] ±0.1	34.7 [c] ±0.2	36.6 [a] ±0.1
Calves (co)	33.7 [d] ±0.1	35.4 [b] ±0.1	34.6 [c] ±0.1	36.6 [a] ±0.1
BST :				
Calves (as)	34.2 [f] ±0.1	35.6 [bc] ±0.1	35.2 [cd] ±0.1	36.9 [a] ±0.1
Calves (co)	34.3 [f] ±0.1	35.6 [bc] ±0.1	35.1 [de] ±0.1	36.9 [a] ±0.1

* (WST) White Skin Temperature and (BST) Black Skin Temperature.

3. Respiratory responses:

Respiration rate (RR):

Data presented in table (5) shows the seasonal daily means of respiration rate of Friesian calves in winter and summer.

In the two types of housing, there were significant differences between RR in summer and winter at 08.00hrs. and 14.00hrs. being greater in summer. This due to increase in AT, when the animals were exposed to rising ambient temperature, collectively that of building elements and internal air temperatures. The present results are in a good accordance with those obtained by Shafie and El-Sheik Aly (1970), Abdel - Ghani et al. (1975), Kobiesy (1983) Sayah (2005) and Gaafar et al 2021).

There were significant differences between RR in the two types of housing in summer but not in winter. These results are due to that in summer the animals were exposed to heat stress in any of the barn so it used panting for heat dissipation. In case of winter season at the two day times, the thermal condition is expected to be within the thermo-neutral zone thus imposing no severing stress on the animals. However the RR in winter was faster than that recorded in several studies of outdoors responses Sharade et al (1961), Salem (1966), El-Barody (1987), Sayah (2005), Sayah (1997) and Gaafar et al 2021). Thiagarajan (1992) suggested additional effect of thermal radiation from the building elements (walls and roof).

Table (5): Seasonal daily means ± S.E. of respiration rate (RR) of Friesian calves kept in asbestos (as) and concrete (co) roofed barns.

Items	08.00 hrs.		14.00 hrs.	
	winter	summer	winter	summer
Calves (as)	27.2 [i] ±0.6	60.9 [d] ±2.3	36.1 [gh] ±0.6	80.8 [b] ±2.5
Calves (co)	28.7 [hi] ±0.8	67.4 [c] ±2.1	42.3 [f] ±1.4	90.0 [a] ±2.3

* (as) Calves under asbestos and (co) Calves under concrete.

4. Hematological responses:

Seasonal daily means of Hb concentration and Ht percentage of Friesian calves are presented in (Table 6). The values of Hb and Ht were lower in summer than in winter at any daytime, this result is in agreement with Lee et al. (1976), Chikamune et al. (1983), Kotby et al. (1987) and Ashour (1990) Sayah (2005) and Gaafar et al 2021).

It is evident that the calves kept in the concrete roofed barn had always (seasonal and daily) greater values of Hb and Ht than calves kept in asbestos roofed barn. The cause of this difference may refer to the higher rate of respiration, thus more respiratory vaporization, of the animals in the concrete roofed barn may have caused a considerable loss of body water, consequently concentration of blood cells due to reduced plasma volume.

Table (6): Seasonal daily means ± S.E.of hemoglobin concentration in blood (Hb g/100 ml) and hematocrit value (Ht %) of Friesian calves kept under asbestos (as) and concrete (co) roofed barns.

Items	08.00 hrs.		14.00 hrs.	
	winter	summer	winter	summer
Hb :				
Calves (as)	12.4 [a] ±0.3	10.1 [b] ±0.3	11.9 [a] ±0.3	10.0 [b] ±0.5
Calves (co)	12.9 [a] ±0.3	10.4 [b] ±0.7	12.7 [a] ±0.2	10.3 [b] ±0.3
Ht :				
Calves (as)	31.8 [bc] ±0.6	27.3 [d] ±0.8	30.1 [c] ±0.6	26.0 [d] ±0.7
Calves (co)	35.9 [a] ±0.7	29.7 [c] ±0.6	33.6 [ab] ±0.7	26.9 [d] ±0.5

* (Hb) Hemoglobin and (Ht) Hematocrit.

5. Thyroid functions:

Seasonal daily means of T_4 and T_3 of Friesian calves are presented in table (7). Results showed that there were a little significant difference in T_4 between winter and summer at 08.00hrs. and 14.00hrs. in the two types of housing. These results may be due to routine feeding system of the farm, the calves were fed according to the routine farm, where the rations were lower in winter during this season, and this resulted in decreasing in body weight gain (BWG) and thyroid secretion rate. Yousef and Johnson (1966) suggested that reduction in feed intake due to higher environmental temperatures causes depression in many physiological reactions including thyroid activity which is reduced in cows consuming the same amount of feed at high temperatures (30 and 35 ^{o}C) as they did at 18 ^{o}C thermoneutral temperature. Mohamed (1984) reported that there was a significant increase in T_4 in animals exposed to 30 ^{o}C than animals exposed to 20 ^{o}C., the same result was obtained by Collier et al. (1982). These results is in agreement with Ashour (1990) Sayah (2005) and Gaafar et al 2021).

On the other hand, Gallab et al (1991) found that concentration of plasma T_4 decreased as a results of treatments: shad, solar radiation and wetting.

Table (7): Seasonal daily means ± S.E. of thyroxine (T4, mg/dl) and triiodothyronine (T3, ng/dl) concentrations in Friesian calves kept in asbestos (as) and concrete (co) roofed barns.

Items	08.00 hrs.		14.00 hrs.	
	winter	summer	winter	summer
T_4 :				
Calves (as)	4.2 [cd] ±0.4	5.7 [ab] ±0.4	4.7 [bcd] ±0.4	6.0 [a] ±0.5
Calves (co)	4.1 [cd] ±0.4	5.3 [abc] ±0.3	4.3 [cd] ±0.3	5.8 [ab] ±0.3
T_3 :				
Calves (as)	116.5 [a] ± 9.8	94.4 [a] ±10.5	122.5 [a] ±17.0	95.8 [a] ±11.6
Calves (co)	101.0 [a] ±13.1	122.2 [a] ±7.8	130.9 [a] ±11.0	122.5 [a] ±11.0

* (T_4) Thyroxine and (T_3) Triiodothyronine.

Regarding T_3 concentration, there were no significant differences in T_3 between winter and summer or between the calves in the different barns. Bobex et al. (1980) found that there was higher concentrations of T_3 were stable along the day in the two seasons. These results is in agreement with Ashour (1990) Sayah (2005).

The greater concentration of T_4 in summer than in winter is, maybe, due to that the conversion of T_4 to T_3 was done slowly in summer. The T_3 concentration can be quite useful since T_3 is metabolically more active than T_4 and a significant proportion of T_4 is converted to T_3 (Lengemann, 1984). Johnson and Yousef (1966) explained that the direct effect of the temperature may occur via the receptors of the skin that stimulate the hypothalmus-sensetive in the brain to activate a thyrotropin-releasing factor which in turn influences thyroid activity to increase hormone secretions.

CONCLUSION

From this study, it is recommended for using the asbestos shad or any other shed material instead of using the concrete roof. It was evident that the Friesian calves kept under the asbestos roofed barn had better comfort and showed better results for the physiological reactions regarding the hematological and the respiratory parameters.

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تأثير ظروف الإيواء المختلفة بيئياً على الاستجابة الفسيولوجية لعجول الفريزيان النامية

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مستخلص. تم فى هذه الدراسة استخدام اثنين وعشرين من عجول الفريزيان السليمة صحياً وذلك لدراسة أستجاباتها الفسيولوجية اليومية والموسمية نتيجة تأثير نوعين مختلفين من الحظائر؛ حظيرة شبه مفتوحة مع سقف خرساني وحظيرة شبه مغلقة مع سقف أسبستوس. اشتملت الدراسة على موسمين، الشتاء (من يناير إلى فبراير) والصيف (يوليو وأغسطس)، وقد تم أخذ القياسات في الساعة ٨:٠٠ صباحًا و١٤,٠٠ مساءا. وكانت العوامل المدروسة هي الظروف المناخية في الداخل والخارج ، الخصائص الحرارية لمكونات المبنى (السقف ، الجدران والأرضيات، الاستجابات الحرارية للحيوانات، الاستجابات التنفسية ، الاستجابات الدموية ، ونشاط الغدة الدرقية. وتم تقدير الخصائص الحرارية الفيزيائية لمكونات المبنى في أربع أوقات (الساعات ٠٦,٠٠، ١٢,٠٠، ١٥,٠٠، ٢٠,٠٠) على مدار اليوم. وقد أظهرت مكونات المسكن للحظيرتين تأثيرا معنويا ($P<0.01$) موسمي ونهاري على جميع المتغيرات الفسيولوجية للعجول. استجابات العجل ودرجة حرارة الهواء مع الرطوبة النسبية وبين بعضها البعض أيضًا.

كان من الواضح أن الحيوانات كانت تتمتع براحة أفضل في الحظيرة المسقوفة بالأسبستوس. يُقترح أن تكون الجدران والسقف الأكثر برودة في الليل وفي الصباح الباكر (الساعة ٢٢,٠٠ والساعة ٠٦,٠٠) بمثابة أحواض حرارية تسهل تبديد الحرارة المتراكمة من أجسام الحيوانات.

الكلمات الدالة: البيئة، عجول الفريزيان، التفاعلات الفسيولوجية، مستقلبات الدم.