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HEAT TOLERANCE OF FRIESIAN CATTLE UNDER EGYPTIAN CLIMATIC CONDITIONS

By

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This work was carried out in the Faculty of Agriculture, Cairo University, U.A.R., to investigate the reaction of the thermal physiological characteristic of Friesian cattle to Egyptian climatic conditions, from June 1962 to February 1963.

Body, skin and hair temparatures and respiration rate were measured at four diurnal times, once weekly during three seasons; summer, autumn and winter. Simultaneously, air temperature and relative humidity were measured. The effect of exposure to direct sunrays, was tested on these body characters and the pulse rate, in July and August 1963.

The following results were obtained:

There were significant seasonal variations in body temperature, respiration rate and skin and hair temperature. Body temperature and respiration rate were higher in summer and autumn; than in winter. The mean body temperatures were 38.8°C, 38.7°C and 38.5°C for summer, autumn and winter respectively. The corresponding respiration rate per minute was 45.2, 53.9 and 30.1 for the same three seasons respectively. Skin temperature showed lower values in summer and autumn than in winter, 29.5°C, 28.9°C and 33.2°C respectively. The mean values of hair temperatures in the three seasons were 29.4°C, 28.5°C and 25.3°C.

Diurnal variations occurred in the studied items, the lowest level for each was in the morning, but the maximum levels took place at different times in the afternoon.

Exposur to direct sun rays induced significant rise in body reactions. The mean values of body reactions for exposed and shaded animals were 39.8°, 38.9°C in body temperature, 70.6, 27.8 times per minute in respiration rate and 60.1, 53.1 beats per minute in pulse rate.

The importation of exotic breeds of cattle to the tropical and subtropical zones has been practiced as a means of increasing both meat and milk production since the local breeds of these zones have low efficiency in these respects. Such imported breeds, almost in all cases, are of European origin and therefore they face the problem of adaptation to the new hot habitats.

Various authors studied the reaction of different cattle breeds to natural or artificial hot environmental conditions. There are a great deal of agreement between their results

The rectal temperature and respiration rate in cattle showed a significant positive correlation with air temperature (Seath and Miller, 1947 a; Hammond,

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1955; Beakly and Findlay, 1955 d; Kibler, 1957; Mullick, 1961 and Halan *et al.*, 1963 and Haines and Koger, 1954). Gaalass (1945) and Shafie (1958) stated that the respiration rate began to increase at lower air temperature than did body temperature. Not only the degree of air temperature affects body temperature and respiration rate, but also a the duration of heat stress, or the length of time during which environmental temperature is maintained, has a great affect (Lee and Phillips, 1948, and Findlay, 1953 a Hammond, 1955 and Beekly and Findlay, 1955 d). Worstell and Brody (1953) and Johnson *et aq.* (1958) stated that the optimum air temperature for Europian breeds is 60–70°F. while it is 90–95°F. for tropical Indian breeds.

Skin temperature showed higher value of correlation with air temperature, (Bonsma, 1940; Quinlan and Rieschmid, 1941; Thompson *et al.*, 1951 and 1952 and Beakly and Findlay, 1955 b and c). The surface temperature increased linearly to reach 88°F (31°C) for hair and 93°F (34°C) for skin at 65°F (18°C) air temperature. It continued to rise linearly, but by reduced slope beyond 65° F air temperature, showing no significant difference, until 100° — 105°F (37.8° — 40.6 C) when the temperatures of air, skin and hair become equal. Skin and hair temperature were highly correlated with body temperature (Quinlan and Riemerschmid, 1941; and Shafie, 1958). Variations between measurements of skin temperatures were much larger at the low environmental temperatures (Beakly and Findlay, 1955 b, c,) Stewart and Brody (1956) indicated that the variations in hair and skin temperatures lagged behind the variations in ambient air temperature by about 1–2 hours. The type and colour of the hair coat affect the thermal reaction of the animal to the climatic condition (Rhoad, 1940; Bonsma, 1943; Reimerschmid, 1943; Dowling, 1956 and Stewart and Brody, 1956).

Exposure of cattle breeds to direct solar radiation causes increase in body temperature and respiration rate. The effect is augmented by high air temperture (Quinlan and Riemerschmid, 1941; Seath and Miller, 1947b; Badreldina and Ghany, 1953). The pulse rate shows slight variation with different trends. (Asker *et al.*, 1952; Badreldin and Ghany, 1953 and Salem, 1966). The skin surface temperature increased spontaneously by exposure to direct sun rays. The increase was affected by the type the hair coat (Bonsma, 1943; Stewart, *et al.*, 1951; Dowling, 1956 and Stewart and Brody, 1956).

The aim of the present work was to investigate the thermal physiological response of Friesian cows to seasonal and diurnal variation in air temperature and humidity in Egypt. It was planned also to study the effect of the intensive direct sun rays of the hot season on the animals. The results of this study may provide basic knowledge for the comparative evaluation of the adaptation of Friesian and other temperate cattle breeds to Egyptian climatic conditions. From another point of view it may draw attention to some points related to mangaerial treatments of this breed in our localities.

Material and Methods

The present work was carried out in the Animal Breeding Research Farm, Faculty of Agriculture, Cairo University, Giza, U.A.R. (Subtropical Zone 30°N and 31'E).

The study of the effect of seasonal and diurnal variations in climatic conditions on the body reactions Lasted from June 1962 to February 1963.

This study included 10 mature Friesian cows. The animals were kept under semi-open sheds. They were fed on wheat and/or rice straw as roughage plus concentrated ration composed of cotton seed cakes 65 %, bran 12 %, rice bran 20 %, 2% lime stone and 1 % salt and molasses 5 %. Green corn fodder was offerred in summer and Egyptian clover, Berseem, "Trifolium Alexandinum" in winter. The animals were supplied with water 2–3 times daily. The data were collected on a fixed day at weekly interval during three seasons, summer, (June and July), autumn (August and September) and winter (January and February). The measurements were recorded four times on that day at four hours periods starting from 6 a.m. till 6 p.m. Air temperature and humidity were recorded at each period. Air temperature and humidity were recorded from the readings of dry end wet bulb thermometers hanging from the ceilling of the shed, at a level of about two meters from the ground Body temperature was measured by a clinical thermometer inserted in the rectum for one minute. Respiration rate was counted by the movements of the flanks. Skin and hair temperatures were measured at the fore-flanks region, for both white and black coloured areas. The measurements of skin temperatures were carried out over about 5 square centimetres surface shaved prior to the test. The measurements were done by a precision bridge thermister thermometer the applicator being laid gently on the surface for one minute before reading Statistical analysis was applied after Snedecor (1960).

The effect of exposure to direct sun rays was studied at midday during July and August, 1963, when the air temperature ranged between 31.7° to 33.1°C. in shade. Eight bulls of two years old were used devided into two equal groups. One group was kept always shaded, the other group was exposed to direct sun rays for two hours from 12.n. to 2 p.m. of the day do test. The body reactions of all animals were recorded at 12 n. before the treatment as control. At the end of treatment, 2 p.m. the reactions of the two groups, exposed and that still shaded were recorded. The effect of solar radiation was estimated by the increase in the body reactions of the exposed group at 2 p.m. over the mean values before treatment, control. This solar radiation effect was compared to the variations in the shaded group from 12 n. to 2 p.m. statistical analysis, "t" test was applied to test the significacance of the solar effect.

Results and Discussion

Climatic Data :

There were great seasonal differences in the climatological conditions. Summer and autumn were distinguished by high air temperature and relative humidity. They showed smilar air temperature but they varied in the air humidity. Winter showed the lowest values of air temperature and relative humidity except for the relative humidity in the afternoons when it scored higher than in summer (Figure 1). It is clear from figure 1 that air

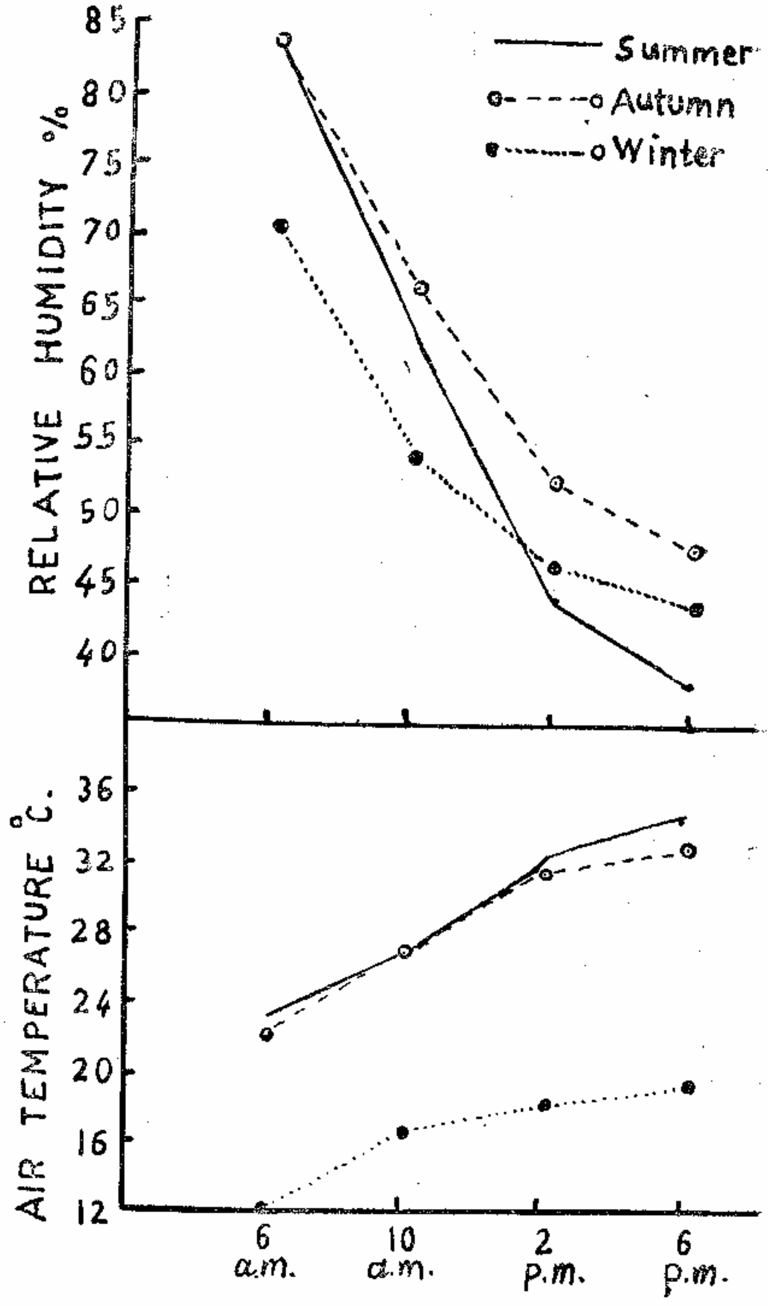


FIG. 1.—Environmental temperature and relative humidity at successive day time during Summer, Autumn and Winter.

temperature in summer and autumn was almost the same but higher than that in winter by about 12.5°C. On the other hand, the relative humidity reached the highest score in autumn followed by summer then winter being 63.8, 57.7 and 53.8 % respectively. In all seasons, air temperature was low in the morning and rose gradually reaching its highest value in the afternoon. The relative humidity took an opposite trend as it began with high values and ended with the lowest values in the afternoon.

Effect of Diurnal Climatic Conditions on Body Reactions :

The effect of diurnal rhythm induced cyclic changes in body reactions (Figures 2 and Table 1).

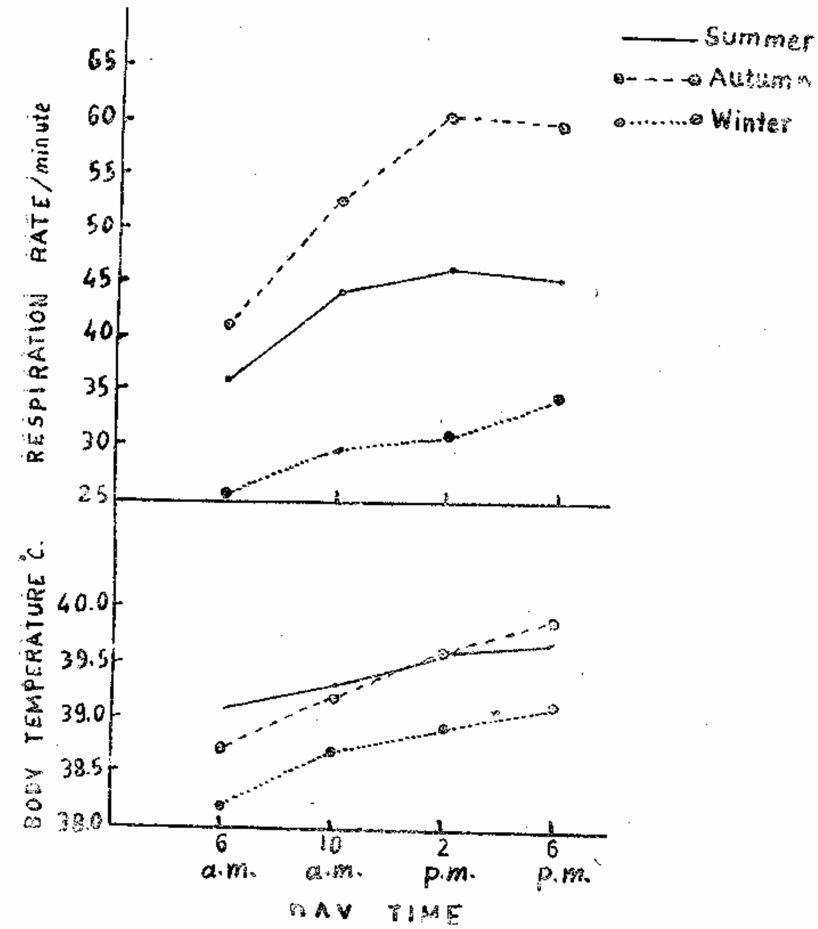


FIG. 2.—Seasonal and diurnal variations in body temperature & respiration rate.

TABLE 1.—DIURNAL VARIATION IN BODY REACTIONS IN THE DIFFERENT SEASONS

Season	Day time	Body temp. °C	Resp. rate (Min.)	Skin temp. (W)	Skin temp. (B)	Hair temp. (W)	Hair temp. (B)
Summer . . .	3	38.5 ± 0	37.8 ± 2.9	23.8 ± 0.7	24.0 ± 0.7	24.0 ± 0.7	24.0 ± 0.1
	10	38.7 ± 0	43.8 ± 2.7	28.0 ± 0.6	27.3 ± 0.7	28.0 ± 0.6	28.1 ± 1.4
	2	39.0 ± 04	46.4 ± 2.7	32.0 ± 1.0	32.2 ± 0.5	31.9 ± 0.0	32.2 ± 1.1
	6	39.1 ± 0.1	45.8 ± 7.9	33.5 ± 1.0	33.8 ± 1.0	33.6 ± 0.1	33.7 ± 0.8
Autumn . .	6	38.1 ± 0.1	41.1 ± 2.7	22.7 ± 0.7	22.8 ± 0.7	22.5 ± 0.9	22.5 ± 0.7
	10	38.6 ± 0.2	52.4 ± 3.0	27.5 ± 0.9	27.8 ± 0.7	27.2 ± 0.4	27.1 ± 0.7
	2	39.0 ± 0.0	60.0 ± 2.5	32.1 ± 0.8	32.1 ± 0.9	32.1 ± 0.4	31.5 ± 0.8
	6	39.2 ± 0.1	59.3 ± 4.9	34.2 ± 0.9	34.2 ± 1.0	35.3 ± 0.8	34.1 ± 1.1
Winter . . .	6	38.0 ± 0.2	25.6 ± 1.3	31.9 ± 0.7	31.8 ± 0.7	23.4 ± 0.7	24.0 ± 1.0
	10	38.5 ± 0.1	29.5 ± 1.0	32.3 ± 0.8	32.5 ± 0.8	24.3 ± 0.7	24.7 ± 0.7
	2	38.7 ± 0.1	30.9 ± 1.8	33.6 ± 0.7	33.9 ± 0.6	26.2 ± 0.8	26.3 ± 0.9
	6	38.9 ± 0.1	34.3 ± 2.1	34.5 ± 0.4	34.9 ± 0.5	26.7 ± 1.0	27.6 ± 1.0

(W) = White region (B) Black region.

All body reactions had the lowest values in the morning. The values increased gradually to reach the highest level at afternoon readings. This was related to atmospheric conditions. Analysis of variance showed that there were highly significant effect of daytime on the body reactions Table 2). These findings are in good agreement with those of Gaalaas (1945), Badreldin *et al.*, (1951), Alim and Ahmed (1956) and Salem (1966).

TABLE 2.—TEST OF SIGNIFICANCE OF THE FACTORS AFFECTING THE BODY REACTIONS

Body reactions	(F) values	
	Season	Day time
Body temperature	66.1**	90.3**
Respiration rate	124.7**	33.8**
Skin temperature (W) . .	105.7**	165.3**
Skin temperature (R) . .	95.6**	123.6**
Hair temperature (W) . .	49.2	100.6**
Hair temperature (B) . .	53.9	114.6**

** Significant at 1 % level.
* Significant at 5 % level.

The steady increase in the body reaction 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. Special managerial treatments could help in checking the effect of the hot middays and evenings on these animals. Shearing the insulating dense hair coat at the start of hot seasons will help greatly in this respect. Daily sprinkling is of significant value in maintaining normal body conditions (Ragab *et al.*, 1953, and El Fouly, 1969).

Effect of Seasonal Climatic Conditions on Body Reactions :

Body Temperature :

The seasonal averages of body temperature varied slightly (Figure 2 and Table 3). This proves the great efficiency of adaptability of Friesian in the long term seasonal variations under the special housing conditionss in this study. However this seasonal differences in body temperature was significant between both hot seasons and winter but not between summer and autumn (Table 2).

In spite of the difference in air humidity between summer and autumn the body temperature was nearly the same (Fig. 2). Therefore, it could be concluded that the body temperature is correlated to the air temperature and not affected by humidity at this level of air temperature. The results are in good agreement with (Seath and Miller 1947 a and b; Johnston and Branton 1952; Mullick and Kehar, 1950 and 1959 and Kibler, 1964).

TABLE 3.—SEASONAL AVERAGES IN CLIMATIC CONDITIONS AND BODY REACTIONS

Item	Summer	Autumn	Winter
Air temperature	29.3	28.5	16.6
Air humidity	58.4	62.7	49.9
Body temperature	38.8	38.7	38.5
Respiration rate	45.2	53.9	30.1
Skin temperature (W) . .	29.3	28.8	33.1
Skin temperature (B) . .	29.7	28.9	33.3
Hair temperature (W) . .	29.3	28.7	25.0
Hair temperature (B) . .	29.4	28.5	25.5

(W) = White region. (B) = Black region.

Respiration Rate :

The respiration rate reached its highest limit in autumn followed by summer and lastly by winter (Fig. 2). It seems that respiration rate is affected by air temperature and relative humidity. The difference in respiration rate between autumn and summer was 10.2 % respirations which may be attributed to the effect of the rise in relative humidity in autumn by 10.9 % than in summer in spite of the fact that air temperature was lower in autumn than in summer by 0.7°C.

On the other hand the difference between summer and winter was 12.– respirations. This was mainly due to the difference in air temperature; being 12.8°C.

The difference in respiration rate between winter and autumn 23.1 respirations, expresses the effect of both air temperature and humidity. The effect of air temperature and humidity on respiration rate proved to be significant (Fig. 2, Table 3).

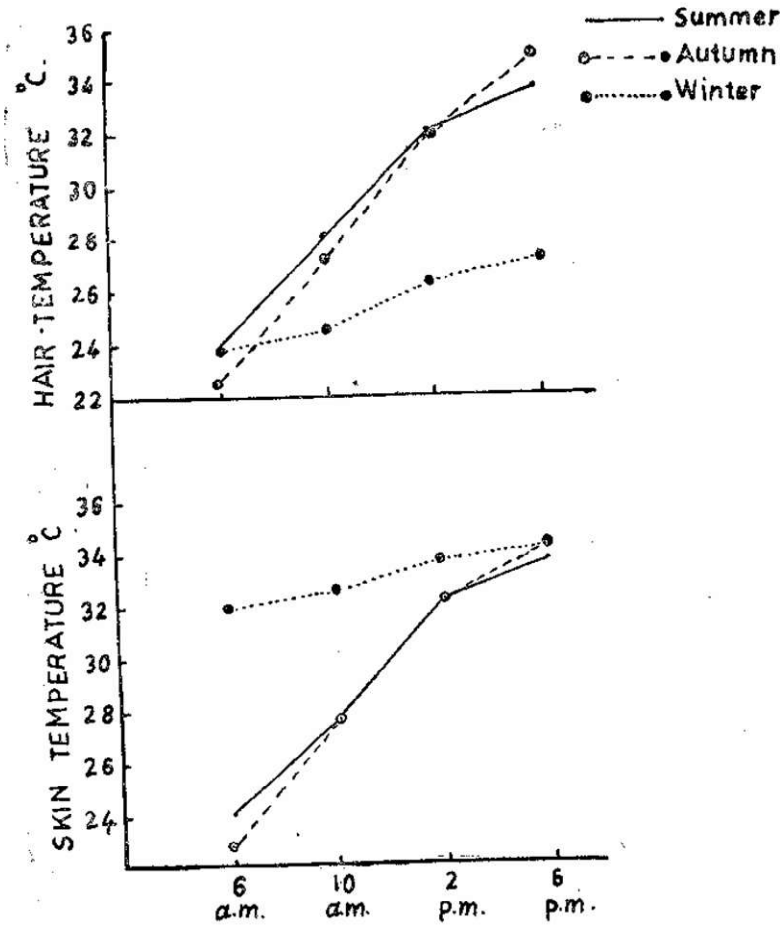
The rise in relative humidity at high air temperature, 68.9 % R.H. and 28.7°C air temperature depresses evaporative cooling activities and consequently increases the heat load and body temperature. This increase in body temperature evokes the hypothalamus to stimulate the respiratory centre which induces increase in the respiration rate.

These results agree with those of Riek and Lee (1948 a and b) for Jersey cows and calves and Findlay (1933 a, b) for Ayrshire calves. Thomposon *et al.* (1953) and Kibler and Brody (1953) stated that increasing atmospheric humidity levels at air temperature from 75° to 100°F (23.9° to 37.8°C) increased the respiration rates of Jersey, Friesian, Brahman and Brown Swiss cattle due to the depression of respiratory vaporization.

Skin and Hair Temperatures:

Skin temperature showed an opposite trend to that of the two previous reactions; body temperature and respiration rate. Skin had low temperature throughout the hot seasons, and high values during the cold season (Figure 3). It was interesting to notice that skin temperature was equal to air temperature in summer and autumn; the hot seasons; whilst it was nearly double that of winter. Skin in both white and black regions had nearly the same temperature at any season.

Hair temperature showed equal values to that of air temperature during summer and autumn, while it was higher than air temperature in winter but still very low in comparison to that of hot seasons (Fig. 3). As in skin temperature, hair temperature had equal averages for both white and black regions (Table 3). In hot seasons, the temperatures of both skin and hair were equal to that of ambient temperature being about 29°C. These results agree with Thompson et al., (1951 & 1952) for Jerseys and Friesians in temperature chamber up to 39.4°C. Also Beakly and Findlay, (1955 b and c) found the same case in Ayrshires. The seasonal effect was significant only in case of the skin temperature but not on hair temperaure (Table 2). The phenomenon that the skin temperature was hig herin winter than in summer and autumn could be interpreted by the effect of many factors increasing het conservation and insulating activities to protect the body against the cold conditions. The structure of hair coat and the physiological activities in the skin such as hair erection, sebum secretion and vasomotion have great role in the insulation capacity. The study of the seasonal changes of hair coat by Dowling and Nay (1960) showed that the coat in cattle varies from an insulating (winter) type coat, with long and less medullated hair fibers to a non-insulating (summer) type coat characterized by shorter and medullated fibers. Kassab and Stegenga (1965) in Holland found that during the cold weather, the coat of dairy Duch cattle (F.H. and M.R.Y.) was heavy and long with a low percentage of medullation and thinner hair diameter than in the other seasons.



DAY TIME

FIG. 3.—Seasonal and diurnal variations in skin and hair temperature.

Effect of Direct Solar Radiation on Body Reactions.

The direct exposure of animals to sun rays for two hours at mid-day of August, when the average air temperature in shade was in rage from 31.7° - 33.1°C, induced great and significant increase in the physiological reactions of the animals (Tables 4 and 5). The body temperature showed a rise of 1°C in the exposed group of animals but only 0.1°C in the exposed animals in comparison with 2.8% in the shaded ones (Table 4). Seath and Miller (1947 b) reported that exposing Jersey cows to sunshine for two hours resulted in increasing body temperature and respiration and pulse rates. Asker *et al.* (1952), Ragab *et al.* (1953), Stewart and Brody (1956) and Kibler and Brody (1951) working on European and Indian cattle, reported similar results. Direct solar radiation increased the pulse rate by 16% in the exposed group, while that of the control remained nearly stable. This result agrees with Bonsma and Pretorius (1943).

TABLE 4.—EFFECT OF EXPOSURE TO DIRECT SOLAR RADIATION ON BODY REACTIONS

Body reactions	Control 12 n. Shaded (1)	Treatement 2. p. m.		Variations		% Variations	
		Shaded	Exposed	(3)-(1)	(2)-(1)	(3)-(1)	(2)-(1)
Body temperature °C	38.8	38.9	39.8	1.0	0.1	2.6	0.2
Skin temperature (W)	28.6	28.2	30.2	1.6	— 0.4	5.6	— 1.4
Skin temperature (B)	28.8	28.3	30.7	1.9	— 0.5	6.6	— 1.7
Hair temperature (W)	28.9	27.5	30.2	1.3	— 1.4	4.5	— 4.8
Hair temperature (B)	28.3	27.3	30.6	2.3	— 1.0	8.1	— 3.5
Pulse rate/min.	51.8	53.1	60.1	8.3	1.3	16.0	2.5
Respiration r./min	28.3	29.1	70.1	42.3	0.8	150.0	2.8

(W) = White region. (B) = Black region.

TABLE 5.—TEST OF SIGNIFICANCE OF THE EFFECT OF SOLAR RADIATION "T VALUE" ON THE DIFFERENT BODY REACTIONS.

Body reactions	Exposed and Control	Exposed and Shaded
Body temperature	2.26*	3.69**
Skin temperature (W)	4.39**	3.38**
Skin temperature (B)	5.35**	4.85**
Hair temperature (W)	6.10**	4.24**
Hair temperature (B)	7.09**	5.08**
Pulse rate	2.86*	1.00
Respiration rate	5.86**	4.84**

* Significant at 1,0 % level.

** Significant at 5,0 % level.

It is clear from this test that the greatly affected and most sensitive reaction was respiration rate. The effect of solar radiation on pulse rate seems to be a secondary effect resulting from the variations in the respiratory function.

Skin temperatures of the exposed group showed 5.6% and 6.6% in the white and black regions respectively, while that under shade decreased about 1.6%. The rise in hair temperature due to direct solar radiation was 4.5% and 8.1% in the white and black regions respectively, while that of shaded animals decreased by 4.8 and 3.5%. It is interesting to find that the increase in both skin and hair temperatures of black regions was greater than that of white regions. The rise in hair temperature of the black regions was nearly double that of the whilte regions. This could be attributed to the low absorptivity of sun rays by white colour, (Riemerschmid, 1943; Riemerschmid and Elder, 1945 and Findlay, 1950). Moreover white regions in Friesian cattle have high percentage of medullated fibers (Kassab and Stegenga, 1965; and Shafie and Tannikhy, 1970). The more medullated the fibers, the more reflection of the infra red wave lenght of solar radiation (Dowling, 1959).

It could be concluded from this work that Friesian cattle possess good adaptability to hot climates, Provided that they are kept away from direct sun rays. They showed fairly stable seasonal mean values in their body temperatures, skin and hair temperature. The respiration rate showed seasonal variation within normal range, less than the double between hot and cold seasons. These symptoms of physiological stability and heat tolerance are much better than that of other temperate breeds in Egypt especially the Dairy Shorthorn. However it is advisable to provide these animals by special accomodations during the hot middays and evenings to check the increase in their reactions at this times.

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التحمل الحرارى لماشية الفريزيان تحت الظروف الجوية بمصر

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الملخص

اجرى هــذا البحث بكلية الزراعة جامعة القاهرة لدراســة سـلوك الظواهر الحرارية للفريزيان تحت الظروف المناخية بمصر . وقد تم قياس درجة الجسم والجلد والشعر وكذلك معــدل التنفس فى أربع مرات بطول يوم معين على فترات أســبوعية فى ثلاثة فصــول ــ الصــيف والخريف والشتاء . كما درس تأثير تعريض هذه الأبقار لأشعة الشمس المباشرة وأثر ذلك على معدل النبض علاوة على الظواهر السابقة .

وفيما يلى ملخص نتائج البحث :

اختلفت درجات حرارة الجسم والجلد والشعر وكذلك معدل التنفس اختلافا معنويا بين الفصول وكانت حرارة الجسم والتنفس أعلى فى الصيف والخريف عن الشتاء ومتوسط حرارة الجســم ٣٨ر٨° م ، ٣٨ر٧° م ، ٣٨ر٥° م ومتوسط التنفس فى الدقيقة ٤٥ر٣ ، ٣٩ر٥ ، ٣٠ر١ فى الصيف والخــريف والشــتاء على التوالى . وعلى العــكس كانت حرارة الجــلد اقل فى الصيف والخريف عنها فى الشتاء بمتوسط ٢٩ر٥°م ، ٢٨ر٩°م ، ٣٣ر٢°م على التــوالى أما متوســـط حرارة الشــعر فكان ٢٩ر٤°م ، ٢٨ر٥°م ، ٢٥ر٣°م .

اختلفت قيمة هــذه الظواهر فى الفترات اليومية وكانت اقل دائمــا فى الصباح فى حين بلغت أعلى قيمة بعد الظهر .

كان لأشعة الشمس المباشرة أثر كبير على هذه الظواهر وكان متوسط القيم فى الحيوانات المعرضة للشمس والمظللة ، ٣٩ر٨° م ، ٣٨ر٩° لحرارة الجسم ، ٧٠ر٦ ، ٢٧ر٨٢ لمعدل التنفس فى الدقيقة ، ٦٠ر١ ، ٥٣ر١ لمعدل النبض فى الدقيقة .