Eefect Of Heat Stress On Perfprmance Of Dairy Friesian Cows
1- Milk Production And Composition

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Abstract: A total of 1243 available records were collected for 581 Friesian cows during 8 year period from 1997 to 2004 were used to study heat stress on milk production and composition. Average temperature humidity index (THI) values confirm the presence of heat stress during the period from June to September (summer season). Heat stress during summer season led to significant decrease (P<0.05) in lactation period by 35 day and reduced total, 305 and daily milk yield by 39.00, 31.40 and 29.84% and the percentages of fat, protein, lactose, solids not fat, total solids and ash by 7.92, 4.06, 3.97, 4.03, 5.21 and 5.63% compared with winter season, respectively.

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Key words: Friesian cows, heat stress, milk yield and composition.

1. Introduction

Dairy cattle in many subtropical, tropical and semi-arid regions are subject to high ambient temperatures (Ta), relative humidity (RH) and solar radiation for extended periods. This compromises the ability of the lactating cow to dissipate heat, resulting in heat stress. As a result, the cow develops numerous physiological mechanisms for coping with this stress. Unfortunately, these responses have negative effects on the physiology of the cow and milk yield. The Temperature-Humidity Index (THI) is widely used in hot areas all over the world to assess the impact of heat stress on dairy cows (Bouraoui et al., 2002).

Dairy cows are very sensitive to climatic variations that greatly influence their welfare and their ability to produce milk. Heat stress (HS) conditions are normally associated with a decline of the production performances as they determine the activation of thermo‐regulation mechanisms in order to avoid hyperthermia and maintain the vital functions of the animals (Nardone et al., 2006). Heat stress negatively impacts a variety of dairy parameters including milk yield and therefore is a significant financial burden in many dairy-producing areas of the world (St. Pierre et al., 2003).

The detrimental effect of high ambient temperatures on productive and reproductive processes in dairy cattle is well documented. When the environmental temperature rises above the upper critical threshold (27-28°C), the nutritional status and energy balance are impaired. Thermolysis leads to metabolic changes that reduce the food intake: this is the main cause of the decline of milk production. Moreover, the increased blood levels of catecholamine inhibit the release of oxytocin, which partially controls milk ejection (Veissier, 2000). High producing dairy cows are extremely vulnerable to heat stress, as well as cows during peak lactation. Increased respiratory and cardiac rhythms, changes in hormone secretion, digestive trouble, the wide fluctuation of leukocytes etc. are other responses to thermal stress. When the environmental temperature is near or above the body temperature, the animals face the risk of heat shock and milk production can decrease by as much as 50% (Ben Salem and Bouraoui, 2009).

The objective of this study was to investigate the effect of heat stress during summer season on milk production and composition of Friesian cows under Egypt conditions.

2. Materials and methods

A 8 year period from 1997 to 2004, weather data was collected from the Sakha Animal Production Research Station, belonged to Animal Production Research Institute (APRI), Agricultural Research Center, located in Kafr El-Sheikh Province 140 km north Cairo (30°56 N), Egypt. Collected data included average, minimum and maximum monthly temperatures and relative humidity. The THI index was calculated for all seasons using the formula developed by Kibler (1964). It is as follows: $THI = 1.8 \times Ta - (1-HR) \times (Ta - 14.3) + 32$, Where: Ta = Mean monthly ambient temperature in °C; HR = Mean monthly Relative

Humidity on the basis to the unit value. Determined THI values were used to identify heat stress to examine the monthly variation of THI. The classification reported by Du Preez et al. (1990) was adopted to quantify the intensity of heat stress.

A total of 1243 available records of milk production and composition were collected for 581 Friesian cows. The cows have similar feeding systems and management strategies. The animals were provided with a basal ration consisting of concentrates and roughages according to the level of milk production (NRC, 1988), concentrate feed mixture, berseem (*Trifolium alexandrinum*) and rice straw in winter and concentrate feed mixture, berseem hay, corn silage and rice straw in summer.

The animals were housed in open sheds situated in yards and every yard was surrounded by a fence made of three iron tubes fixed in a horizontal position, each of 2 inches in diameter, with 50 cm in between (total height 1.5 meters). In each yard, the shaded part represented one third of the whole area of the yard. Yards were designed to allow free way to the milking parlour, which is located as usual in a middle position among yards.

Cows were machine milked two times a day (at 6:00 and 18:00 h) and daily milk yield recorded and samples taken biweekly from consecutive evening and morning milking and mixed in proportion to yield. Milk fat, protein, lactose and total solids were determined using Milko-Scan (133B Foss Electric). The data were subjected to statistical analysis using general linear models procedure adapted by SPSS (2008) with one-way ANOVA. Duncan test within program SPSS was done to determine the degree of significance between the means.

3. Results and discussion

Environmental conditions

Mean monthly maximum and minimum temperature (Ta), relative humidity (RH) and calculated temperature humidity index (THI) by the experimental period are shown in Table. Average THI values ranged between 57.98 and 80.40, suggesting the lack of cold stress, but confirm the presence of heat stress for the four months period going from June to September (THI > 72). These high THI values indicate that most dairy herds are exposed to the negative effects of heat stress. These results were greater than the suggested critical threshold of 72 for Holstein cows (Johnson, 1985). The upper critical temperature for Holsteins is 25 ^{o}C (Berman et al., 1985). Figure 1 indicates that dairy cows are exposed to heat stress from June to September with THI values varying between 76.62 and 80.40. Similar trends were observed for Egypt where THI values were higher than 72 for four to six months (Johnson, 1985). Ben Salem and Bouraoui (2009) reported that summer heat stress prevails in Tunisia for four to five months going from May to September with THI values being greater than 72. The upper temperature for lactating cows was 25 ^{o}C and the relative humidity greater than 80% indirectly affects the upper critical temperature (Kume et al., 1998).

Lactation period

Lactation period as affected by heat stress is shown in Table (2) and Fig. (2). Cows calving during summer season exposed to heat stress showed the short lactation period (280.31 day) with the shortest period being 274.71 day during July. However, the long lactation period was detected during winter season (315.31 day) with the longest period being 325.72 day during January. Lactation period decreased significantly ($P<0.05$) by 35 day with increasing THI from 59.82 in the winter season to 78.53 in the summer season.

Milk production

The results in Table 2 and Fig. 3-5 showed a significant ($P<0.05$) heat stress effect on milk production expressed as total, 305 and daily milk yield. It clearly shows a negative relationship between milk production and THI. Indeed, as THI increases from 59.82 in the winter season to 78.53 in the summer season, heat stress reduced total, 305 and daily milk yield by 39.00, 31.40 and 29.84%, respectively. This decrease can be largely explained by the effect of summer heat stress, particularly in July and August when THI values are well above the critical threshold of 72 reported by Johnson (1985) and can be as high as 77. The reason for the drop in milk yield during the early fall could be explained by the carry over effect of the unfavourable conditions during the summer particularly in the absence of environmental control systems. Bouraoui et al. (2002) found that daily THI was negatively correlated to milk yield, which the increase THI value from 68 to 78, milk production decreased by 21% and DMI by 9.6%. Milk yield decreased by 0.41 kg per cow per day for each point increase in the THI values above 69.

Milk composition

There was a significant ($P<0.05$) effect of heat stress on milk composition presented in Table (3) and

Fig. (6-11). Exposed cows to heat stress during summer season showed significant lower ($P<0.05$) in milk components with the lowest values during July, however, the higher components were detected during winter season with the highest values during January. Heat stress significantly ($P<0.05$) reduced milk fat, protein, lactose, SNF, TS and ash contents from 3.79, 3.20, 4.78, 8.69, 12.48 and 0.71% during the winter season to 3.49, 3.07, 4.59, 8.34, 11.83 and 0.67% during the summer season. Heat stress environments have been associated with depressions in milk components percentages (Rodriguez et al., 1985). Knapp and Grummer (1991) indicated a decreased milk composition with increased maximum daily temperature. Bouraoui et al. (2002) found that milk fat and milk protein were lower for the summer season. Ozrenk and Inci (2008) reported that milk fat, protein and total solids percentages in cow milk were the highest during the winter and the lowest during the summer.

Table 1. Ambient temperature, relative humidity and temperature humidity index during the year month in north Delta, Egypt.

Month	Temperature °C			Relative Humidity %			Temperature humidity index		
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
January	18.33	9.44	13.89	75.41	38.83	57.12	64.00	51.96	57.98
February	19.44	10.00	14.72	77.05	39.63	58.34	65.81	52.60	59.20
March	21.67	12.22	16.94	78.67	44.36	61.52	69.43	55.15	62.29
Winter	19.81	10.55	15.18	77.04	40.94	58.99	66.41	53.24	59.82
April	25.55	15.00	20.27	83.25	48.88	66.07	76.11	58.64	67.37
May	28.39	17.58	22.99	86.05	53.58	69.82	81.14	62.12	71.63
June	31.11	21.11	26.11	88.78	60.24	74.51	86.11	67.29	76.70
Spring	28.35	17.90	23.12	86.03	54.23	70.13	81.12	62.68	71.90
July	32.67	23.78	28.23	91.16	66.35	78.76	89.18	71.61	80.40
August	31.67	22.78	27.22	89.43	64.32	76.87	87.17	69.98	78.57
September	30.56	21.67	26.11	87.76	62.23	74.99	85.02	68.22	76.62
Summer	31.63	22.74	27.19	89.45	64.30	76.87	87.12	69.94	78.53
October	27.33	18.89	23.11	83.71	56.15	69.93	79.07	63.99	71.53
November	23.89	15.00	19.44	79.87	50.15	65.01	73.07	58.65	65.86
December	19.44	11.11	15.28	75.30	43.04	59.17	65.72	53.82	59.77
Autumn	23.55	15.00	19.28	79.63	49.78	64.70	72.62	58.82	65.72

Table 2. Lactation period and milk production during the year month.

Item	Lactation period (day)	Total milk yield (kg)	305 day milk yield (kg)	Daily milk yield (kg)
Month				
January	325.72^{a}	5481.87^{a}	5133.15^{a}	16.83^{a}
February	312.50^{ab}	5234.38^{b}	5108.75^{b}	16.75^{a}
March	307.72^{ab}	5012.76^{c}	4968.45^{c}	16.29^{ab}
Winter	315.31^{A}	5242.95^{A}	5070.12^{A}	16.62^{A}
April	303.61^{ab}	4696.85^{d}	4718.35^{d}	15.47^{bc}
May	300.14^{ab}	4496.10^{e}	4568.90^{e}	14.98^{c}
June	298.25^{ab}	3984.62^{f}	4074.80^{f}	13.36^{d}
Spring	300.67^{B}	4392.52^{B}	4454.02^{B}	14.60^{B}
July	274.71^{b}	3054.78^{g}	3391.60^{g}	11.12^{g}
August	278.53^{b}	3133.46^{g}	3431.25^{g}	11.82^{f}
September	287.69^{ab}	3406.25^{f}	3611.20^{f}	12.04^{ef}
Summer	280.31^{C}	3198.16^{C}	3478.02^{C}	11.66^{C}
October	293.84^{ab}	3722.95^{e}	3864.35^{d}	12.67^{e}
November	303.53^{ab}	4176.57^{c}	4196.80^{c}	13.76^{d}
December	311.01^{ab}	4677.59^{b}	4587.20^{b}	15.04^{bc}
Autumn	302.79^{B}	4192.37^{B}	4216.12^{B}	13.82^{B}

$^{a, b, c, d, e, f, g:}$ Values in the same column for months with different superscripts differ significantly ($P<0.05$).
$^{A, B, C:}$ Values in the same column for seasons with different superscripts differ significantly ($P<0.05$).

Table 3. Milk composition (%) during the year month.

Month	Fat	Protein	Lactose	SNF	TS	Ash
January	3.89^{a}	3.25^{a}	4.81^{a}	8.77^{a}	12.66^{a}	0.71^{a}
February	3.81^{ab}	3.19^{ab}	4.78^{ab}	8.68^{ab}	12.49^{ab}	0.71^{a}
March	3.67^{ab}	3.16^{ab}	4.76^{ab}	8.62^{ab}	12.29^{ab}	0.70^{ab}
Winter	3.79^{A}	3.20^{A}	4.78^{A}	8.69^{A}	12.48^{A}	0.71^{A}
April	3.65^{ab}	3.13^{ab}	4.75^{ab}	8.57^{ab}	12.22^{ab}	0.69^{ab}
May	3.52^{ab}	3.10^{ab}	4.70^{ab}	8.49^{ab}	12.01^{ab}	0.69^{ab}
June	3.46^{b}	3.07^{b}	4.68^{ab}	8.43^{ab}	11.89^{ab}	0.68^{ab}
Spring	3.54^{C}	3.10^{B}	4.71^{B}	8.50^{B}	12.04^{B}	0.69^{AB}
July	3.43^{b}	3.04^{b}	4.56^{b}	8.27^{b}	11.70^{b}	0.67^{b}
August	3.46^{b}	3.05^{b}	4.60^{ab}	8.32^{ab}	11.78^{ab}	0.67^{b}
September	3.59^{ab}	3.12^{ab}	4.62^{ab}	8.42^{ab}	12.01^{ab}	0.68^{ab}
Summer	3.49^{C}	3.07^{B}	4.59^{C}	8.34^{C}	11.83^{C}	0.67^{B}
October	3.64^{ab}	3.17^{ab}	4.69^{ab}	8.55^{ab}	12.19^{ab}	0.69^{ab}
November	3.70^{ab}	3.21^{ab}	4.74^{ab}	8.65^{ab}	12.35^{ab}	0.70^{ab}
December	3.72^{ab}	3.23^{a}	4.77^{ab}	8.70^{ab}	12.42^{ab}	0.70^{ab}
Autumn	3.69^{B}	3.20^{A}	4.73^{B}	8.63^{A}	12.32^{A}	0.70^{A}

$^{a, b, c, d, e, f, g:}$ Values in the same column for months with different superscripts differ significantly (P<0.05).
$^{A, B, C:}$ Values in the same column for seasons with different superscripts differ significantly (P<0.05).

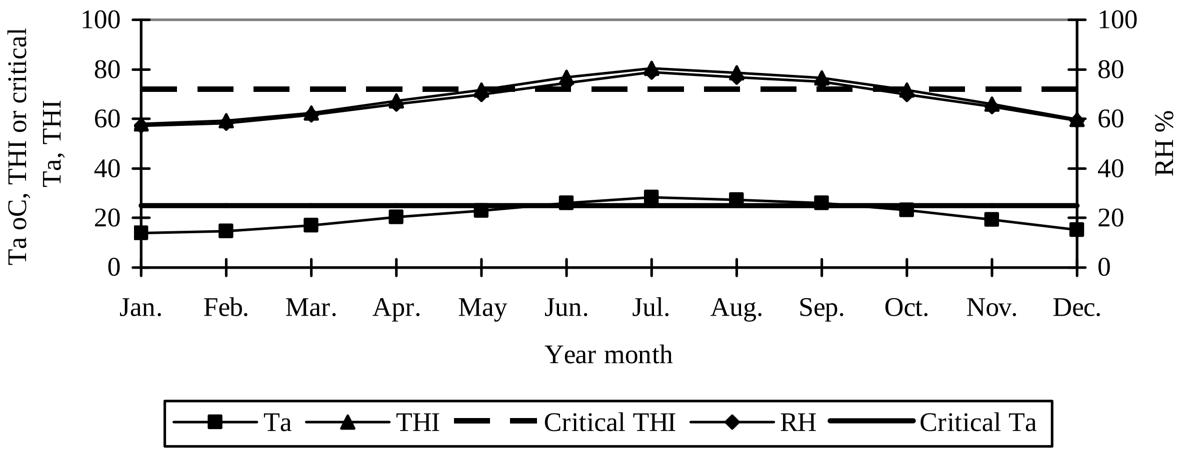

Fig. 1. Ambient temperature, relative humidity and temperature humidity index during the year month in north Delta, Egypt.

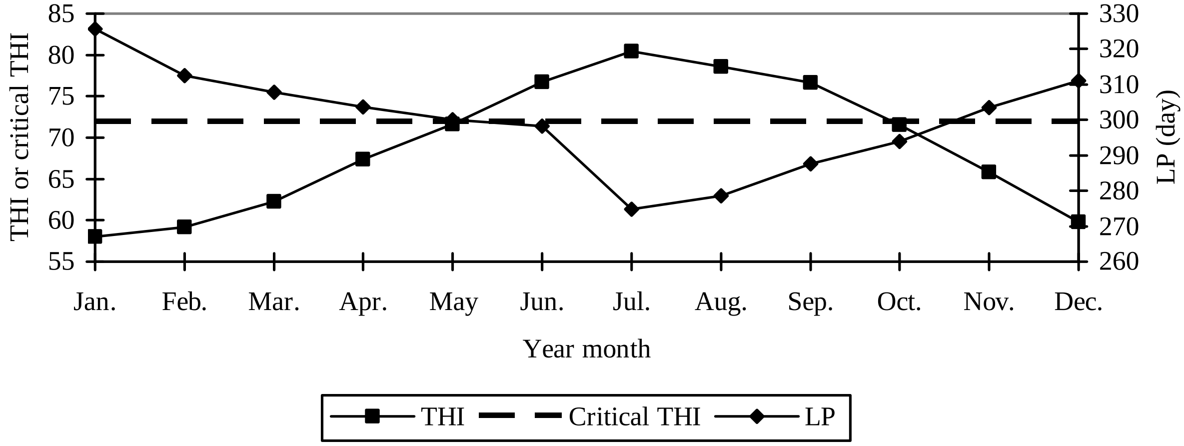

Fig. 2. Effect of heat stress on lactation period.

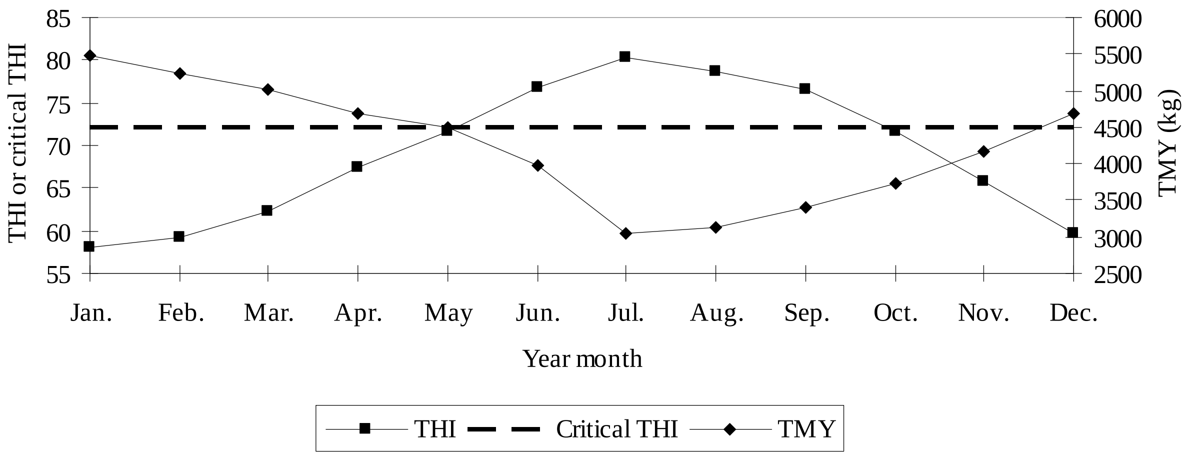

Fig. 3. Effect of heat stress on total milk yield.

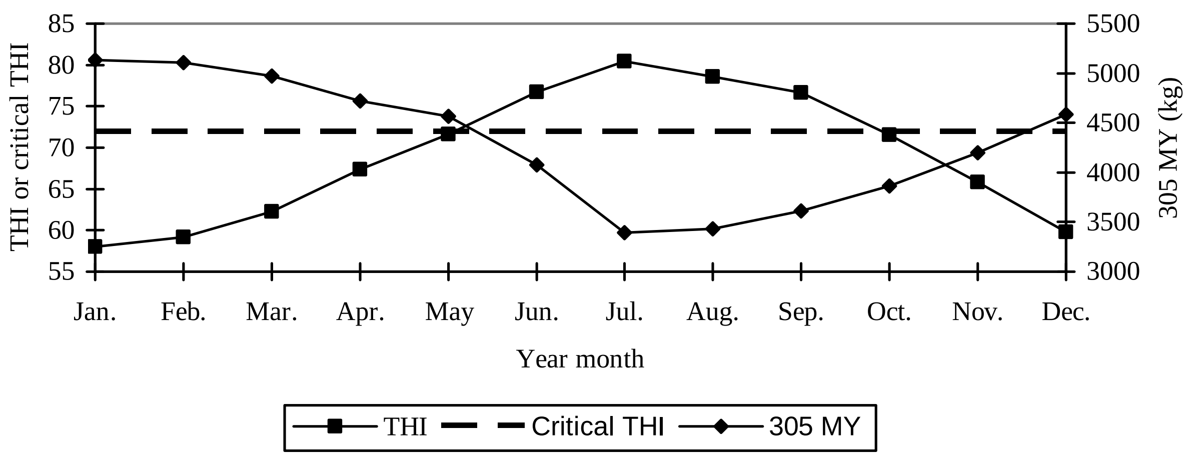

Fig. 4. Effect of heat stress on 305 day milk yield.

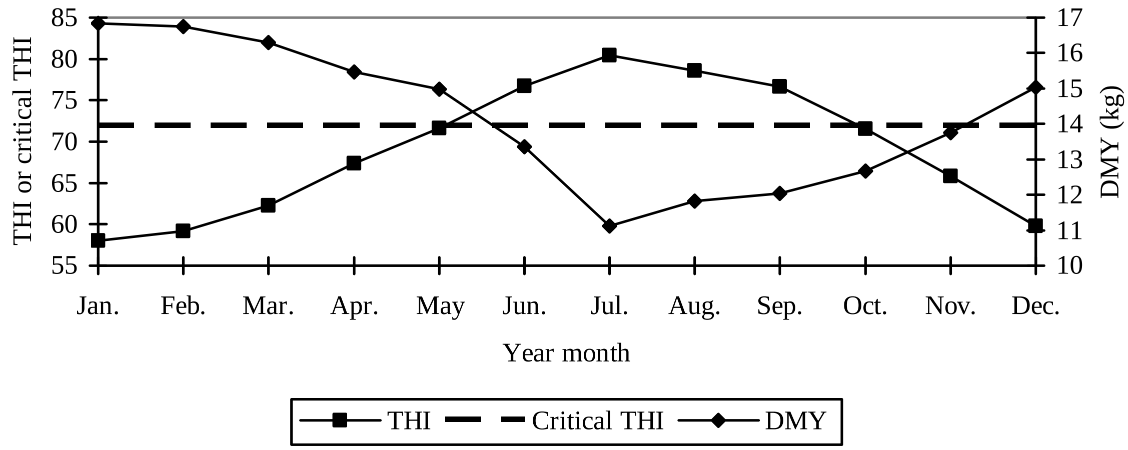

Fig. 5. Effect of heat stress on daily milk yield.

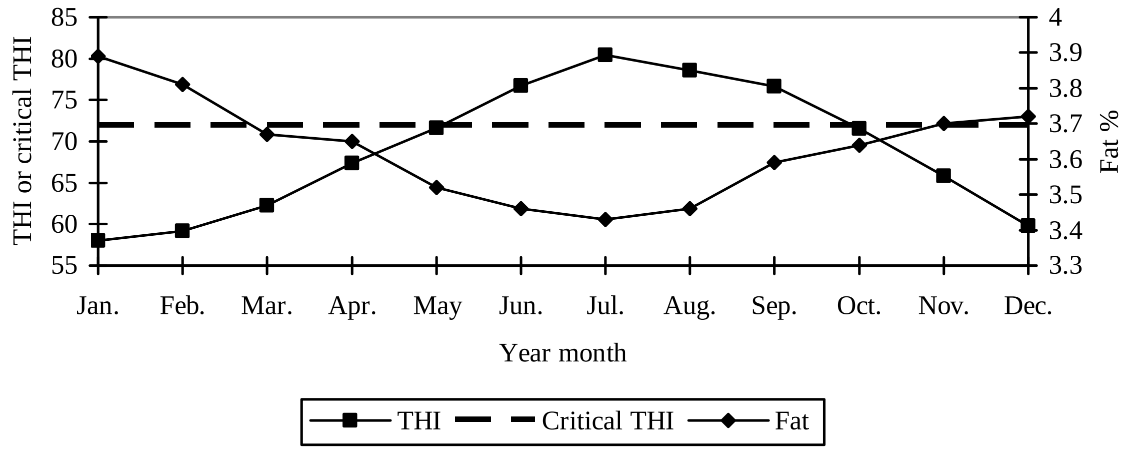

Fig. 6. Effect of heat stress on milk fat content.

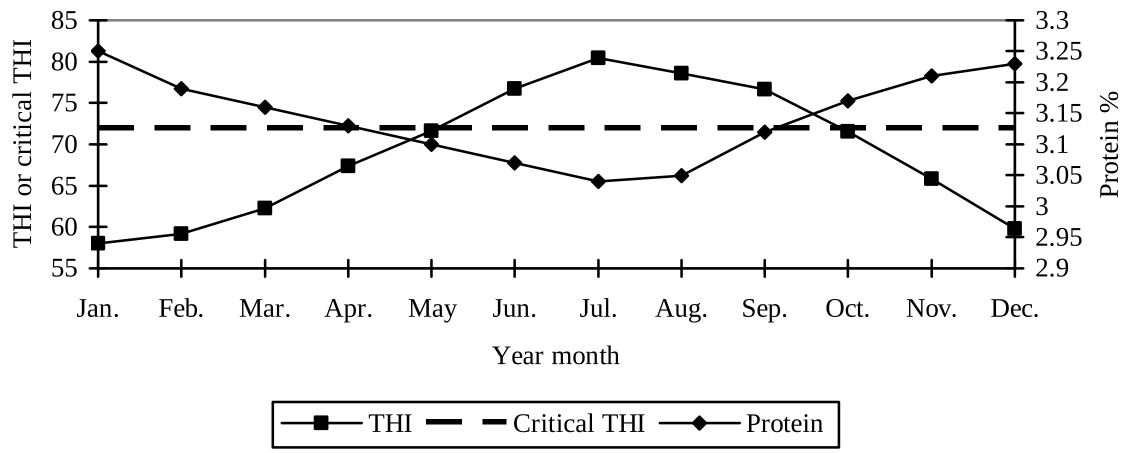

Fig. 7. Effect of heat stress on milk protein content.

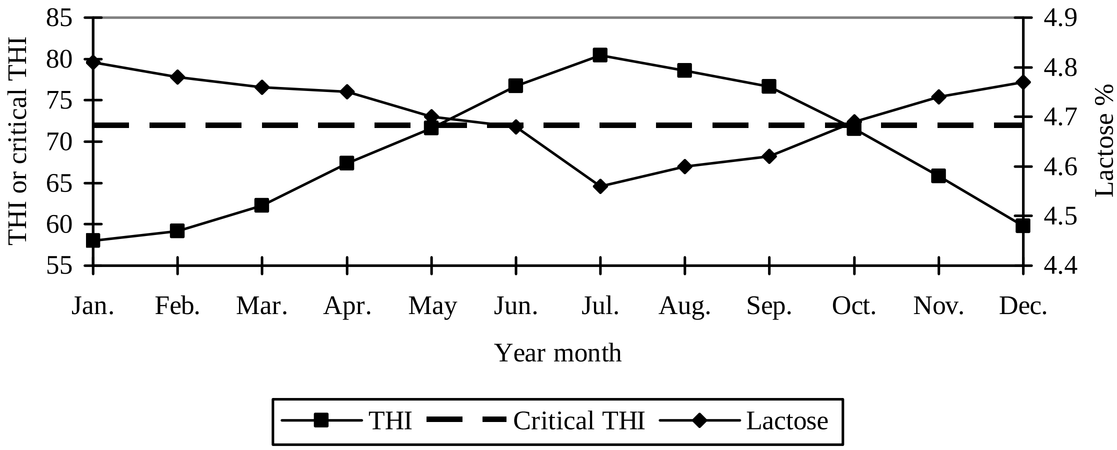

Fig. 8. Effect of heat stress on milk lactose content.

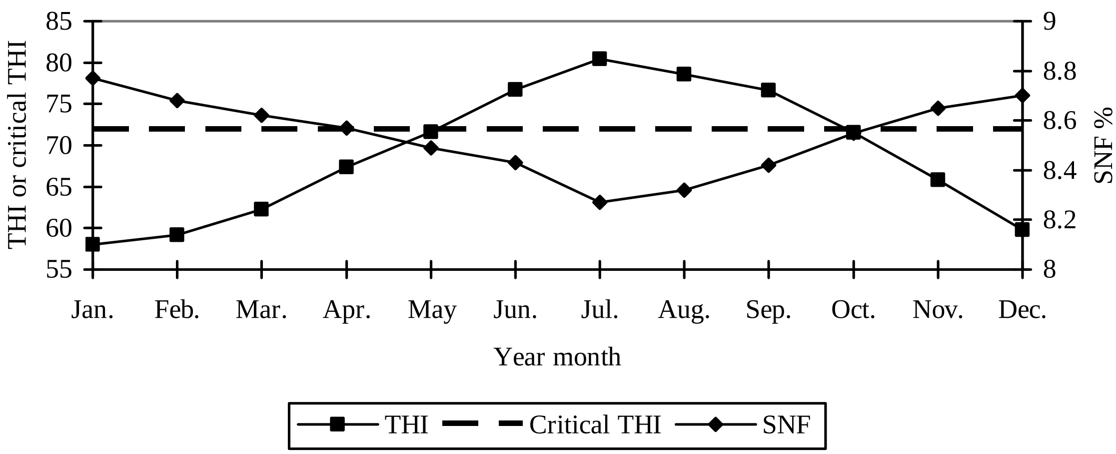

Fig. 9. Effect of heat stress on milk solids not fat content.

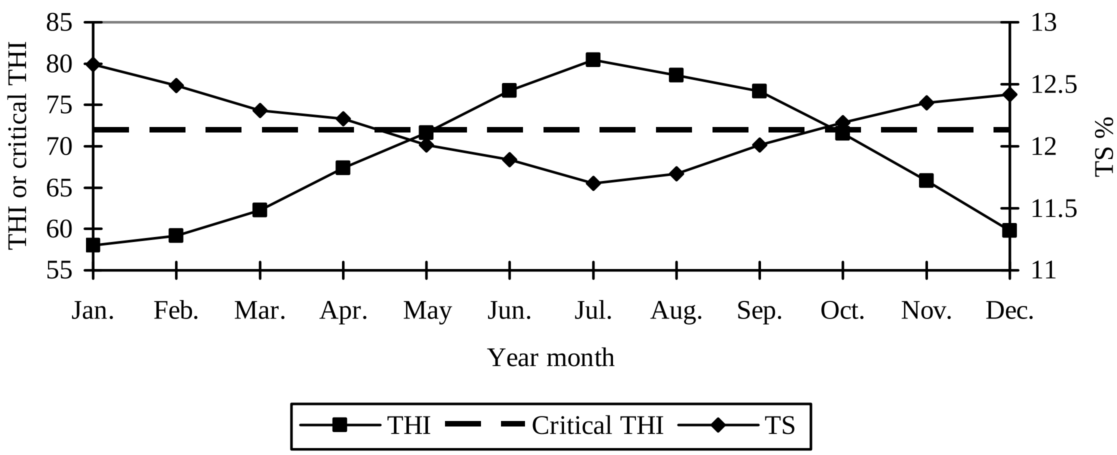

Fig. 10. Effect of heat stress on milk total solids content.

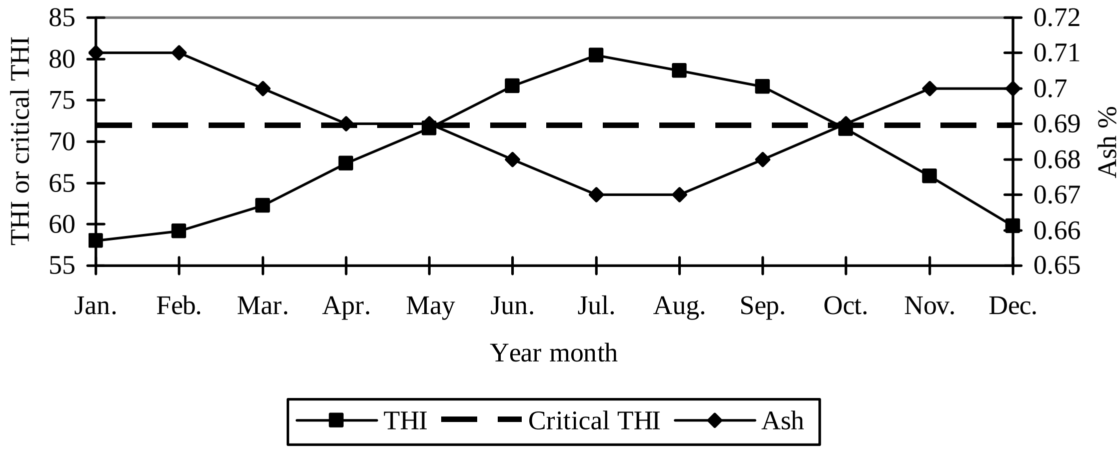

Fig. 11. Effect of heat stress on milk ash content.

4. Conclusions

From these results it could be concluded that expose Friesian cows in Egypt to heat stress during the period from June to September reduced lactation period, milk production and composition. Management strategies are needed to minimize heat stress and attain optimal animal performance.

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References

[1] Bouraoui R, Lahmar M, Majdoub A, Djemali M, Belyea R. The relationship of temperature-humidity index with milk production of dairy cows in a Mediterranean climate. Anim. Res. 2002, 51: 479-491.

[2] Nardone A, Ronchi, B, Lacetera, N, Bernabucci U. Climatic effects on productive traits in livestock. Veterinary Research Communications 2006, 30(Suppl.1): 75-81.

[3] St. Pierre NR, Cobanov B, Schnitkey G. Economic losses from heat stress by US livestock industries. J. Dairy Sci. 2003, 86:E52-E77.

[4] Veissier I, Boissy A, Capdeville J, Sarignac C. Le bien-être des animaux d'élevage: comment peut-on le définir et l'évaluer?, Point Vet. 2000, 31: 205.

[5] Ben Salem M, Bouraoui R. Heat Stress in Tunisia: Effects on dairy cows and potential means of alleviating it. South African Journal of Animal Science 2009, 39 (Supplement 1): 256-259.

[6] Kibler HH. Environmental physiology and shelter engineering. LXVII. Thermal effects of various temperature-humidity combinations of Holstein cattle as measured by eight physiological responses, Research Bulletin Missouri Agricultural Experiment station 1964, 862.

[7] Du Preez JH, Giesecke WH, Hattingh PJ. Heat Stress in dairy cattle and other livestock under southern African conditions. I. Temperature-Humidity index mean values during the four main seasons. Onderstepoort J. Vet. Res. 1990, 57: 77-87.

[8] NRC. Nutrient requirements of dairy cattle. 6th rev. ed. National Research Council, National Academy Press, Washington, DC, USA. 1988.

[9] SPSS. Statistical package for the social science, Release 16, SPSS INC, Chicago, USA. 2008.

[10] Johnson HD. Physiological responses and productivity of cattle, In: Stress physiology in livestock. Basic Principles. Ed. Yousef, M.K., Boca Raton, Florida, CRC Press 1985, 1: 4-19.

[11] Berman A, Folman Y, Kaim M, Mamen M, Herz Z, Wolfenson D, Arieli A, Graber Y. Upper critical temperatures and forced ventilation effects for high yielding dairy cows in a subtropical climate, J. Dairy Sci. 1985, 68: 1488–1495.

[12] Kume S, Tohamat T, Kobavashi N. Effect of restricted feed intake of dams and heat stress on mineral status of newborn calves. J. Dairy Sci. 1998, 81: 1581-1590.
[13] Rodriguez LW, Mekonnen G, Wilcox CJ, Martin FG,, Krienk WA. Effects of relative humidity, maximum and minimum temperature, pregnancy and stage of lactation on milk composition and yield, J. Dairy Sci. 1985, 68: 973–978.
[14] Knapp DM, Grummer RR. Response of lactating dairy cows to fat supplementation during heat stress, J. Dairy Sci. 1991, 74: 2573–2579.
[15] Ozrenk E, Inci SS. The effect of seasonal variation on the composition of cow milk in Van Province. Pakistan J. Nutr. 2008, 7: 161-164.

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