South African Journal of Animal Science 2009, 39 (Supplement 1)

Peer-reviewed paper: 10th World Conference on Animal Production

Heat Stress in Tunisia: Effects on dairy cows and potential means of alleviating it

M. Ben Salem[1#] and R. Bouraoui[2]
[1] INRA Tunisia, Laboratory of Forage and Animal Productions, rue Hédi Karray, 2049 Ariana, Tunisia
[2] ESA Mateur, 7030 Mateur, Tunisia

Abstract

Tunisia has a Mediterranean climate characterized by high ambient temperatures for a long period. Thus, one of the challenges to dairy producers is heat stress. The objectives of this work were to characterize the environmental conditions to which Holstein cows are exposed in Tunisia using the Temperature Humidity Index (THI), examine heat stress effects on lactating cows and to suggest potential management strategies that can be used to reduce such effects. THI values were calculated using a 10-year period average monthly temperature and relative humidity data from different weather stations. Milk production and its relationship with THI were than examined using the data of herds under the dairy herd recording programme. Reproductive indices were calculated using data from four selected herds and their relationships with corresponding THI values were examined. Results showed 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 highest THI values were recorded for summer and early fall. Milk yield per cow dropped by about 10% between March and August. First conception (CRI1) and overall conception rates (CR) were lowest in the summer and highest in winter. Regression equations between THI and CRI1 and THI and CR had high R^2 values suggesting a strong relationship between heat stress and reproduction. Maintaining cow performance under hot conditions requires the adoption of environmental control techniques, appropriate feeding strategies, improved nutritional practices, and genetic improvement programs such as crossbreeding for enhanced heat tolerance.

Keywords: Heat stress, dairy cows, production, reproduction, alleviation
Corresponding author. E-mail: lahmar.mondher@iresa.agrinet.tn

Introduction

Heat stress has a negative effect on animal performances in the tropical, the arid and the subtropical Mediterranean zones. This appears to be true for Tunisia which has a Mediterranean climate characterized by hot summer conditions. Indeed, field observations in many parts of the country reveal decreased milk production and reduced reproduction indices in cows during the summer suggesting their exposure to heat stress. Conducting research investigation on heat stress measurement in Tunisia is therefore crucial to quantify its intensity, evaluate its effects on productive and reproductive performances of Holstein cows, and to identify heat stress regions that require appropriate management strategies. Johnson *et al*. (1962) and McDowel *et al*. (1976) suggested that the temperature-humidity index (THI), a widely used parameter to describe heat stress on animals, is a good indicator of stressful climatic conditions which becomes the method of choice in most countries to establish a useful relationship between heat stress and animal productivity.

The objectives of the current work were to characterize the environmental conditions to which dairy cows are exposed in Tunisia, examine the effects of heat stress on performances of lactating cows using the THI, and to suggest potential management strategies available for producers to reduce these effects.

Material and Methods

A 10-year period weather data was collected from the 24 major weather stations located throughout the country. 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:

$$THI = 1.8 * Ta – (1-HR) * (Ta – 14.3) + 32$$

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 seasons and regions in Tunisia and 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 6813 available records on milk production per cow (kg/d) were collected on 157 dairy farms under the national dairy herd recording system. They were used to show the simultaneous variations in milk yield and THI values over the year.

Reproductive records from four dairy herds located in different climatic zones of the country were chosen to evaluate the effects of THI on reproductive parameters. These herds are owned by the same state dairy enterprise. They have similar feeding systems and management strategies, but differ only by their climatic zones (semi-arid superior: site Badrouna in Jendouba, semi-arid inferior: site El Alem in Kairouan, semi arid inferior with sea effect: site Enfidha in Sousse and the sub-humid: site Ghezala in Mateur-Bizerte). For each herd, insemination and calving dates were collected. Major reproductive indicators [conception rate, first conception (CRI1) and conception rate (CR)] were calculated. Regression equations between THI values and their corresponding herd CRI1 and CR values were developed for each site.

Results and Discussion

Average THI values for the main weather stations are given in Table 1. They ranged between 46 and 79, suggesting the lack of cold stress in Tunisia, but confirm the presence of summer heat stress (THI > 72). Results show that except for the region of Thala, which has a THI of 70, all other regions have summer values greater than the suggested critical threshold of 72 for Holstein cows (Johnson, 1985). Values ranged between 73 and 79 for the period going from June to September. Similar results were reported in South Africa by Du Preez (1990). These high summer THI values indicate that most dairy herds are exposed to the negative effects of heat stress. The highest THI values (76 - 79) were observed in the south for the regions of Gabes, Tozeur and Kebili where it will be difficult for Holstein cows to thrive and maintain their production potential. Respective THI values for the fall (September to November), winter (December to February), and the spring (March to May) seasons varied between 67 and 73, 46 and 59; and 54 and 66 (table 1) indicating the lack of cold and heat stress effects on dairy cows during these seasons. Indeed, the literature suggests that THI values of 35 and 72 respectively represent the lower and upper critical limits for optimal dairy production (Johnson, 1985).

Figure 1 shows the trend for the overall mean THI values and milk per cow. It indicates that dairy herds in Tunisia are exposed to heat stress from June to September with THI values varying between 72 and 77. Similar trends were observed for Egypt and Arizona where THI values were higher than 72 for four to

Table 1 Average seasonal THI values for major weather stations

Station	Autumn	Winter	Spring	Summer
Bizerte	67	54	59	74
Gabes	70	56	63	76
Jendouba	66	52	60	75
Kairouan	69	55	63	77
Mednine	70	56	65	77
Monastir	69	56	62	76
Remada	73	55	64	76
Sfax	69	55	62	75
Thala	60	46	54	70
Tozeur	69	56	66	79
Enfidha	69	59	63	76
Mahdia	70	58	63	75
Kebili	69	54	65	79

six and three to four months, respectively (Johnson, 1985). It clearly shows a negative relationship between milk production and THI. Indeed, as THI increases from 68 to 77 during the summer milk yield per cow drops significantly going from 17.1 in March to 15.3 kg/day in August. That is a decrease of about 10% which 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.

Results on monthly variations of mean THI and CR for each studied herd indicate that CR decrease during the summer when THI values are the highest (Figure 2). The most important decrease was observed for El Alem with CR going from 59% in February to 29% in September.

These results are in agreement with the literature. Roman-Ponce *et al.* (1977) reported a decrease in CR from 44.4 to 25.3% as external temperature increased from 28.4 °C to 36.7 °C in Florida.

Figures 3 shows a strong negative relationship between THI and CRI1 and CR rates for all sites confounded. Indeed, the regression equations between CRI1 and CR and the THI of the month had high R^2 values of 0.7 and 0.86, respectively. For each point increase in THI values between 56 and 78, decreases by

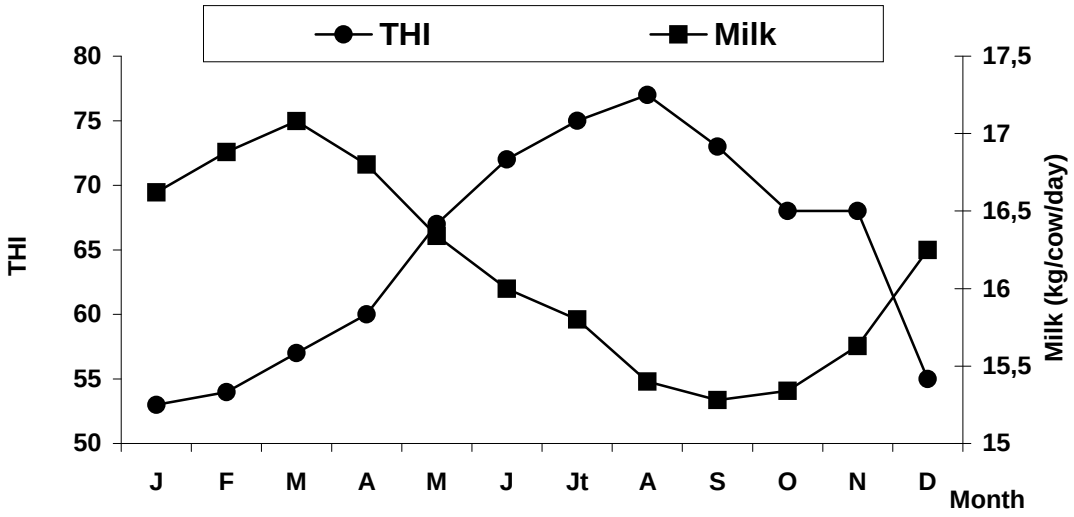

Figure 1 Monthly variation for milk production and Temperature Humidity Index (THI).

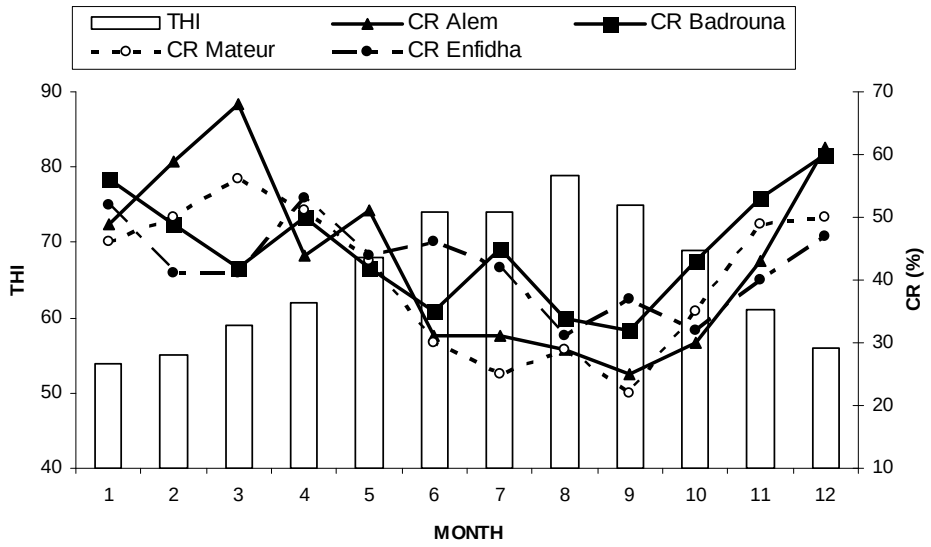

Figure 2 Monthly variations of THI and overall conception rate for each site.

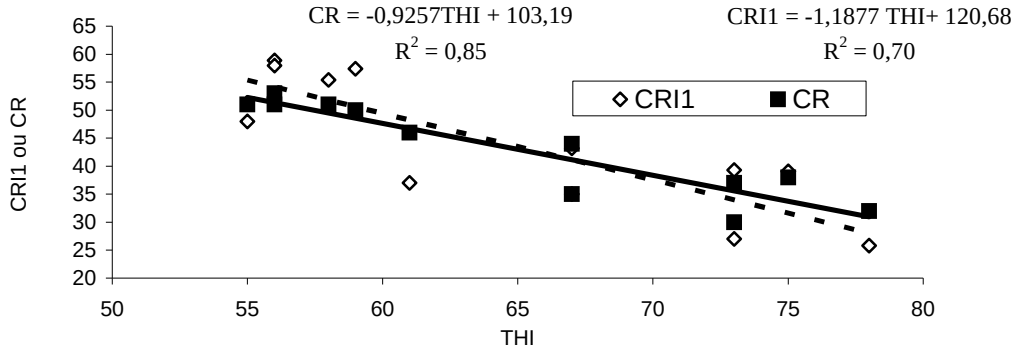

Figure 3 Relationships between Temperature Humidity Index (THI) and conception rate, first conception (CRI1) and conception rate (CR).

1 and 1.2% are observed in the overall and first service conception rates, respectively. These results are in agreement with findings reported by Ingraham *et al.* (1976) and Du Preez *et al.* (1991).

Our previous work (Ben Salem *et al.*, 2006) showed that feeding and management strategies of most dairy herds in Tunisia are inadequate and barns are lacking heat stress control techniques which aggravate the observed negative effects of heat stress on cow performances. Thus, practical and economical heat stress relief systems, such as shades and fans need to be adopted. Dietary fibre adjustments, protected fat supplementation as well as feeding during cool hours constitute additional potential feeding strategies which can be used during the summer to reduce heat stress negative effects on the reproduction of dairy cows.

Conclusions

The results showed that the hot season in Tunisia is relatively long and that summer heat stress occurs for four to five months, from May to September with THI values being greater than the recommended critical THI value of 72 for Holstein cows. This requires active managerial intervention strategies.

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