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Research Article

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Evaluation of Dairy Cattle Breeding in Thrace Region in Terms of Temperature-Humidity Index

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Abstract This research was carried out to determine the effects of heat stress on milk yield depending on the Temperature-Humidity Index values for dairy cattle farms located in the Thrace part of Turkey. In the research, climatic data of Edirne, Kirklareli and Tekirdag provinces were used. The equation proposed by the American National Research Council was used to calculate the Temperature-Humidity Index. As a result of the research, the highest Temperature-Humidity Index value according to the average maximum temperature and relative humidity values was calculated as 87.73 for Edirne province, 85.36 for Kirklareli province and 82.49 for Tekirdag province. According to the Temperature-Humidity Index values, milk yield loss was found as 3.6 kg/head/day for Edirne province, 2.7 kg/head/day for Kirklareli province and 1.8 kg/head/day for Tekirdag province. In order to eliminate the negative effects of heat stress, it has been suggested to take some applicable structural measures such as shading, sprinkling and fogging in businesses.

Keywords Heat stress, Temperature-Humidity Index, Dairy cattle, Milk yield loss

Introduction

The temperature range where animals can perform their productive functions best and be most comfortable is defined as the "Comfort Zone" and covers a narrow temperature range. The temperatures within the comfort zone limits are the optimum temperatures for animals [1]. As you move away from the comfort zone, heat stress, called thermal stress, arises in farm animals. The seasonal effect of heat stress manifests itself in hot and humid regions and especially in hot summer months. However, heat stress can occur at both high and low temperatures. However, since high temperatures pose more problems, when heat stress is mentioned, the problems that occur with high temperature in general come to mind [2].

The effects of heat stress on the animal and its performance are well defined. With high environmental temperature, rectal temperature rises, feed and energy consumption and milk yield decrease. When the ambient temperature exceeds the normal limits (5-25°C), the increase in relative humidity negatively affects the thermoregulation ability of the animal. High-yielding animals are more affected by heat stress than low-yielding animals. Because high-yielding animals are more metabolically active and the extra heat load is higher in these animals. In order to help animals cope with heat stress, some administrative arrangements should be made, such as canopy, misting with water, showering, fan fogging. These applications are; It prevents the animal from overloading with heat from the environment and contributes to the heat removal of the animal from the body by evaporative means [3].

Dairy cattle have high internal heat loads resulting from high milk production. The effects of this heat build-up are exacerbated when the temperature and humidity in the environment increase. To remove this additional heat, cattle breathe excessively, sweat, increase respiratory rate and decrease milk yield. In addition to these effects, reproductive efficiency also decreases. In cases where heat stress reduction mechanisms are insufficient, it carries a potential risk of economic loss for the dairy industry [4].

Heat stress is a combination of environmental factors such as temperature, relative humidity, air movement, radiation and precipitation. Many indices that incorporate different environmental factors have been proposed to measure the heat stress level. However, their use is limited due to lack of data. The majority of studies on heat stress in farm animals are mainly based on temperature and relative humidity [5;6]. Because it is relatively difficult to reach data on the amount of thermal radiation received by the animal, the wind speed and the amount of precipitation. On the other hand, temperature and humidity records can often be obtained from a nearby meteorological station [7].

This research was carried out to determine the effects of heat stress on milk yield depending on the Temperature-Humidity Index values for dairy cattle farms located in the Thrace part of Turkey.

Materials and Methods

The research was carried out in the Thrace part of Turkey. The Thrace region encompasses the provinces of Edirne, Kirklareli and Tekirdag, and only a small part of the provinces of Istanbul and Canakkale. The geographical location of the research area is between 40°-42° north latitude and 26°-29° east longitude. Coastal areas are under the influence of Mediterranean climate and inland areas are under the influence of continental climates. Its average height above sea level is between 50-150 m. The average annual temperature of the region is 13.0-14.6 °C, and the average relative humidity is between 70-76% [8].

In the research, climatic data from the General Directorate of Meteorology for many years (1959-2021) were used. By using the daily average and maximum temperature and relative humidity values of Edirne, Kirklareli and Tekirdag provinces in the Thrace region, monthly average and maximum temperature and relative humidity values were obtained. The data obtained were used in the calculation of the Temperature-Humidity Index and in the evaluation of heat stress. The following Equation 1 proposed by the American National Research Council was used to calculate the Temperature-Humidity Index [9]. Calculations were made for 12 months in order to evaluate the heat stress in the region more accurately.

$$THI = (1.8 \times T_{db} + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times T_{db} - 26.8)] \quad (1)$$

In equality; THI: Temperature-Humidity Index, Tdb: Dry bulb temperature (°C), RH: Relative humidity in %.

Due to the decrease in dry matter intake in farm animals due to high environmental temperature and relative humidity, the increase in metabolic and physiological activities to remove the heat produced in the body, and the increase in energy need for survival, milk yield may be lost. In the study, Equation 2 given below was used to calculate milk yield losses due to heat stress [6].

$$Milk_{loss} = 0.0695\ (THI_{max} - THI_{threshold})^2 \times D \quad (2)$$

In equality; $Milk_{loss}$: Decrease in milk yield (kg), D: Expresses the ratio of daily total stress time to 24 hours ($THI_{max.} > THI_{threshold}$). This equation is based on the critical THI level of 70 [6].

Results and Discussion

Heat stress is an important factor that affects the health of animals as well as negatively affecting their productivity and welfare, and is effective in the success of the enterprises. For this reason, it is important to take structural measures to reduce the effect of heat stress for a more successful enterprises, as well as to determine the change process of heat stress and how it will progress in the future through the Temperature-Humidity Index values. The Thrace region, where the research was carried out, has an important place for Turkey in terms of dairy cattle breeding. The total number of dairy animals in Turkey is approximately 6 580 753 heads as of 2021,

of which 2.71% (178 338 heads) are raised in the research area. Again, 92.1% of the total milk produced in Turkey is obtained from cows and 3.06% of this milk is obtained from livestock enterprises in the research area [10]. Free or free-stall barns are generally used in livestock enterprises. Animals spend most of their time in the paddocks, especially during the transitional seasons and summer seasons. When perennial meteorological data are analyzed, it is possible to see heat stress in dairy cattle especially in summer and some months of the transition seasons. The Temperature-Humidity Index, which is used as a criterion in the definition of heat stress, was calculated separately for the provinces of Edirne, Kirklareli and Tekirdag in the research area. In the calculations, the monthly ambient temperature and relative humidity values and the monthly average maximum temperature and relative humidity values were calculated using Equation 1, and the results are given in Table 1.

Table 1: Temperature-Humidity Index values calculated according to monthly average temperature and relative humidity data of the settlements in the research area and monthly average maximum temperature and relative humidity data

Months	Settlement					
	Edirne		Kirklareli		Tekirdag	
	$THI_{avr.}$	$THI_{avr.\ max.}$	$THI_{avr.}$	$THI_{avr.\ max.}$	$THI_{avr.}$	$THI_{avr.\ max..}$
1	38.86	44.20	39.22	44.63	42.45	46.77
2	42.40	49.12	41.14	42.97	43.75	48.36
3	47.64	56.01	46.28	54.06	43.77	52.01
4	55.67	66.09	54.45	64.10	52.25	60.21
5	63.33	75.10	62.07	73.02	61.47	68.80
6	69.19	85.18	68.19	80.06	68.19	76.92
7	72.25	86.87	71.15	84.13	71.69	81.62
8	71.98	87.73	71.03	85.36	71.84	82.49
9	66.30	80.32	65.23	78.16	66.83	75.62
10	58.05	68.74	57.42	67.32	59.91	67.01
11	49.52	57.95	49.68	56.91	52.83	58.64
12	41.94	47.48	42.60	47.90	46.33	50.80

In addition, the Temperature-Humidity Index values calculated for the settlements in the research area are graphically given in Figure 1 for Edirne province, Figure 2 for Kirklareli province and Figure 3 for Tekirdag province.

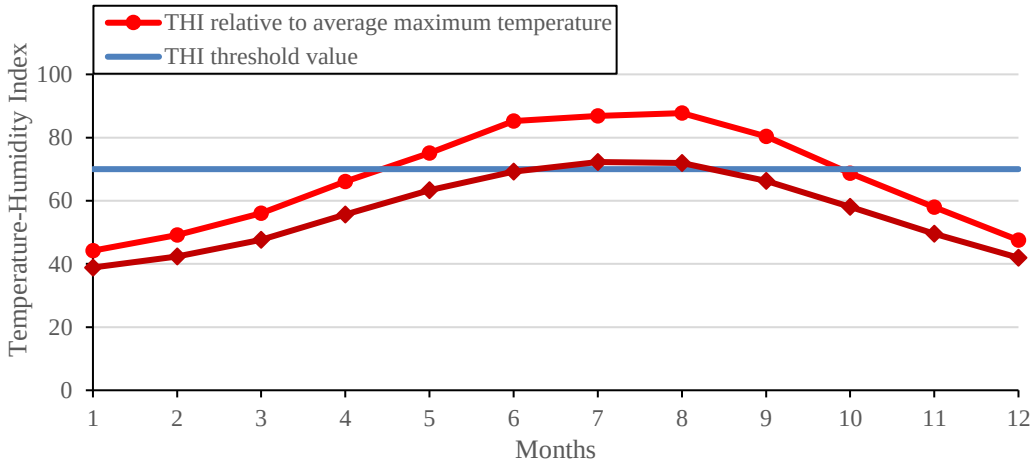

Figure 1: Monthly Temperature-Humidity Index values calculated for Edirne province

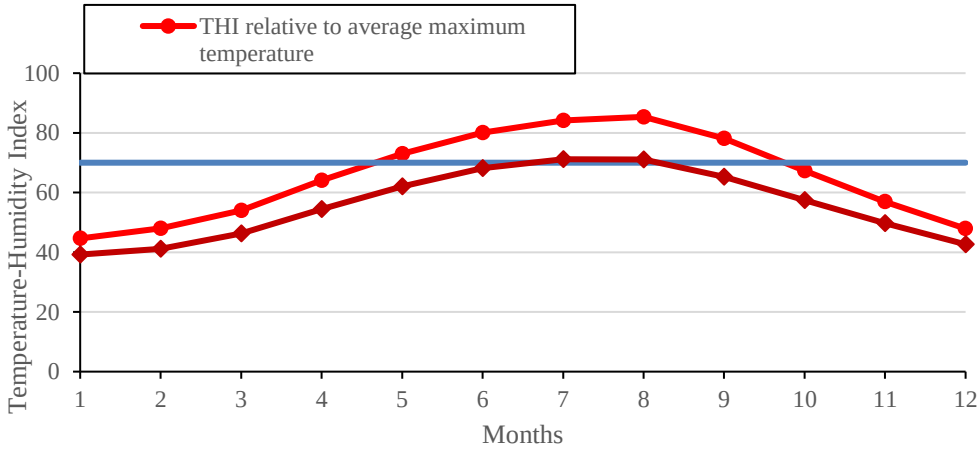

Figure 2: Monthly Temperature-Humidity Index values calculated for Kirklareli province

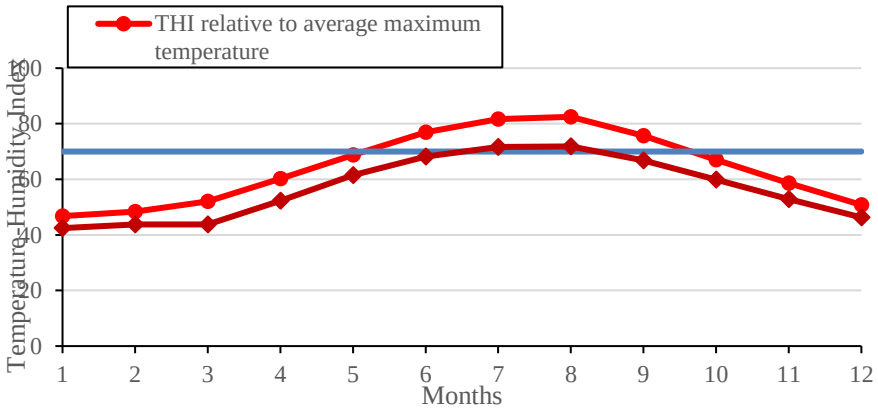

Figure 3: Monthly Temperature-Humidity Index values calculated for Tekirdag province

When Table 1, Figure 1, Figure 2 and Figure 3 are evaluated together, it is seen that the Temperature-Humidity Index values in the whole study area exceed 70, which is accepted as the stress onset threshold value for dairy cattle, during the summer months [6]. According to the Temperature-Humidity Index values among the three provinces in the research area, Edirne province has the highest probability of heat stress, followed by Kırklareli and Tekirdağ provinces. According to the monthly average temperature and relative humidity values, the highest Temperature-Humidity Index value was calculated as 72.25 for Edirne province in July, 71.15 for Kirklareli province in July and 71.84 for Tekirdag province in August. Data obtained from Collier et al. When compared with the Temperature-Humidity Index values (mild-moderate, 71-79) given by [11], according to the monthly average data, it can be said that there may be a slight stress in the animals during the summer months. Likewise, according to the average maximum temperature and relative humidity values, the highest Temperature-Humidity Index value was calculated as 87.73 for Edirne province in August, as 85.36 for Kirklareli province in August and as 82.49 for Tekirdag province in August. These data are again provided by Collier et al. When compared with the Temperature-Humidity Index values (moderate-severe, 80-89) given by [11], it can be said that there may be severe stress in animals in the summer months according to the monthly average maximum data.

According to these data, the months with the highest probability of heat stress for dairy cattle breeding in the research area are June, July and August. When the Temperature-Humidity Index values calculated according to

the average maximum data in Table 1 are examined, there is a possibility of heat stress in the research area in May and September as well. However, the Temperature-Humidity Index values calculated for these months are just above the threshold value of 70, which is accepted as the beginning of stress, and are not at a level that will adversely affect animal welfare and productivity. The National Animal Disease Information Service reported that dairy cattle are not affected by heat stress when the temperature-humidity index is 71 and below, and that some yield losses may occur in cases where the Temperature-Humidity Index is between 72-79. On the other hand, it has been reported that in cases where the Temperature-Humidity Index is 80 and above, they are significantly affected by heat stress [12]. Almost all of the culture breeds raised as dairy cattle in the livestock enterprises in the research area consist of Holstein cattle. The effect of the breed is very important in terms of resistance or sensitivity to heat stress in dairy cattle. Holstein cattle, which are known to have superior characteristics in terms of milk yield all over the world, have the lowest resistance to heat stress. If the genetic tendency is positive in terms of both increase in milk yield and body temperature, if evaluated together with the effect of global warming, it shows that heat stress will have an increasing effect in dairy cattle breeding in the future [13]. Therefore, some managerial measures should be taken in livestock enterprises in regions where heat stress is likely to occur. For this purpose, some administrative arrangements such as canopy, misting with water, shower application, fan fogging should be made to help animals cope with heat stress. Thanks to these applications, heat loading from the environment is prevented and it contributes to heat removal from the body of the animals by evaporative way [3].

In the study, milk yield losses due to heat stress were calculated with the help of Equation 2 and given in Figure 4. The hours with the highest heat stress were determined as between 14, which is the meteorological observation hour, when the maximum temperature is seen during the summer months, and 18 local hours, when the cooling starts.

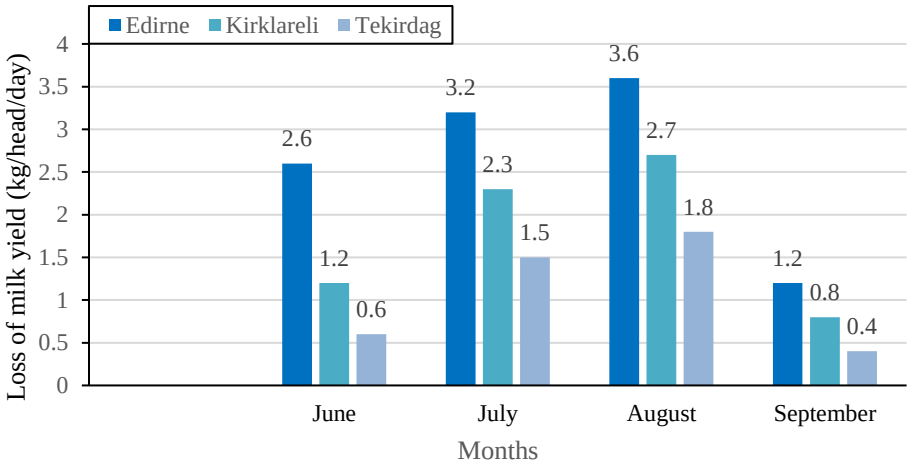

Figure 4: Daily milk yield losses calculated per dairy cattle based on the Temperature-Humidity Index relationship in three provinces in the research area

When Figure 4 is examined, the maximum loss of milk yield per animal occurs in August, depending on the Temperature-Humidity Index. It is followed by the months of July and June. In August, daily milk yield loss per dairy cattle was highest in Edirne with 3.6 kg/head/day, followed by Kirklareli with 2.7 kg/head/day and Tekirdag with 1.8 kg/head/day. The main reason for the highest loss of milk yield per dairy animal in Edirne is due to the fact that the province is mostly under the influence of continental climate and the summer months are hotter than other provinces. In a similar study, it was determined that there was a 14.20% decrease in daily milk yield in Holstein dairy cattle when the Temperature-Humidity Index was 79 and above [14]. In another study, it

was determined that a one-unit increase in the Temperature-Humidity Index in Holstein-Friesian cows caused 0.011 kg, 0.108 kg and 0.046 kg daily milk yield loss in spring, summer and autumn seasons, respectively [15]. In the study, based on the milk yield losses per dairy cattle in the summer in Figure 4, the daily average total milk yield losses for the months of June, July and August are calculated according to the total number of dairy cattle in the provinces, and are given in Table 2. In order not to make mistakes in the calculations, only the number of dairy cattle of culture breeds was taken as a basis. The number of cultural breed dairy cattle of the provinces is taken from the data of the Turkish Statistical Institute [10].

Table 2: The average daily total milk yield losses according to the number of dairy cattle of culture breeds depending on the Temperature-Humidity Index relationship of the provinces in the study area

Settlement		Edirne	Kirklareli	Tekirdag
Number of culture breed animals (head)		50957	44677	52544
Total milk yield loss per day (ton)	June	132.5	53.6	31.5
	July	163.1	102.7	78.8
	August	183.4	120.6	94.6

When Table 2 is examined, the daily average total milk loss according to the total number of cattle owned by the three provinces in the research area is 72.5 tons, 114.8 tons and 132.8 tons for the months of June, July and August, respectively.

Conclusions

According to these results, especially in summer, heat stress in the research area reaches dimensions that will negatively affect animal productivity and welfare. Temperature-Humidity Index values calculated according to the average maximum temperature values of the region occur most in Edirne province, followed by Kirklareli and Tekirdag provinces. Milk yield losses calculated according to the Temperature-Humidity Index values cause significant financial losses for both the local farmer and the country's economy. In order to increase animal welfare and therefore to minimize milk yield losses, the negative effects of heat stress can be minimized by taking some applicable structural measures such as shading, sprinkling and fogging during the summer months when heat stress occurs in dairy cattle farms.

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