Research Article / Araştırma Makalesi

Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi

International Journal of Agriculture and Wildlife Science

2022, 8(2): 349 – 357, doi: 10.24180/ijaws.1035429

The Effects of Temperature-Humidity Index Values on Some Behaviours in Male Anatolian Black Cattle

Sıcaklık-Nem İndeks Değerlerinin Yerli Kara Erkek Sığırlarda Bazı Davranışlar Üzerine Etkileri

Çağrı Melikşah Sakar[1]

Geliş Tarihi (*Received*): 13.12.2021 **Kabul Tarihi (*Accepted*):** 25.03.2021 **Yayın Tarihi (*Published*):** 22.08.2022

Abstract: In this study, ear temperature and some behavioural data were determined in the four male animals of Anatolian Black cattle raised under the Institute conditions. For this purpose, a chip sensor (CowManager) was attached to the ears of the animals, and data of 51 days were obtained from each animal hourly. During the study, hourly temperature and humidity data of the barn where the animals were housed were collected, and hourly and daily Temperature - Humidity Index (THI) data were calculated from these values. According to these index values, daily THI values were classified in 3 groups, while hourly THI values were classified in 4 groups. In this study, the ear temperature of the bulls was found to be an average of 21.97 °C daily. The ear temperature values increased as the THI values increased, and the differences between the groups were found to be statistically significant (P<0.001). In the study high active, active, not active, eating and rumination data were found to be 7.84, 6.86, 27.15, 26.69 and 28.31%, daily, respectively. In the analysis made according to the THI groups, the differences according to these behavioural characteristics were found to be statistically significant (P<0.01). In the study, as THI values increased high active, active and not active values increased, while eating and rumination values decreased. While the activity and eating values of the animals increased during the daytime, the not active and rumination values of the animals increased during the night hours. As a result, it was concluded that there is a correlation between the THI values, ear temperature and behavioural data, and this could be an indication that the animal behaviour was affected by meteorological events.

Keywords: Anatolian Black cattle, animal behaviour, sensor, active

&

Öz: Bu çalışmada Enstitü koşullarında yetiştirilen dört baş erkek Yerli Kara sığırda kulak sıcaklığı ve bazı davranış verileri belirlenmiştir. Bu amaçla hayvanların kulaklarına çipli sensör (CowManager) takılarak, her hayvandan saatlik olarak toplam 51 gün veri alınmıştır. Çalışma süresince hayvanların barındırıldığı ahırın saatlik olarak sıcaklık ve nem verileri toplanmış olup, bu değerlerden saatlik ve günlük olarak sıcaklık-nem indeksi (SNİ) verileri hesaplanmıştır. Bu indeks değerlerine göre günlük SNİ değerleri 3 grupta sınıflandırılırken, saatlik SNİ değerleri 4 grupta sınıflandırılmıştır. Çalışmada boğaların kulak içi sıcaklıkları günlük olarak ortalama 21.97 °C olarak bulunmuştur. SNİ değerleri artarken kulak sıcaklığı değerleri artmış olup ve SNİ gruplar arası farklılıkları istatiksel olarak önemli (P<0.001) bulunmuştur. Çalışmada günlük olarak hesaplanan yüksek hareketlilik, normal hareketlilik, hareketsizlik, yem yeme ve ruminasyon verileri sırasıyla % 7.84, 6.86, 27.15, 26.69 ve 28.31 olarak bulunmuştur. SNİ gruplarına göre yapılan analizde bu davranış özelliklerine göre farklılıklar istatistiksel olarak önemli (P<0.01) bulunmuştur. Araştırmada SNİ değerleri arttıkça yüksek hareketlilik, normal hareketlilik ve hareketsizlik değerleri artarken, yem yeme ve ruminasyon değerleri azalmıştır. Ayrıca, hayvanların hareketlilik ve yem yeme değerleri gündüz saatlerinde artarken, hareketsizlik ve ruminasyon değerleri gece saatlerinde artmıştır. Sonuç olarak SNİ değerlerinin kulak sıcaklığı ve davranış verileri arasında korelasyon bulunduğu ve bunun hayvan davranışlarının meteorolojik olaylardan etkilendiğinin göstergesi olabileceği sonucuna varılmıştır.

Anahtar Kelimeler: Yerli Kara, hayvan davranışı, sensor, hareket

Atıf/Cite as: Sakar, Ç. M. (2022). The Effects of Temperature-Humidity Index Values on Some Behaviours in Male Anatolian Black Cattle. Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi, 8 (2), 349-357. DOI: 10.24180/ijaws.1035429

İntihal-Plagiarism/Etik-Ethic: Bu makale, en az iki hakem tarafından incelenmiş ve intihal içermediği, araştırma ve yayın etiğine uyulduğu teyit edilmiştir. / This article has been reviewed by at least two referees and it has been confirmed that it is plagiarism-free and complies with research and publication ethics. https://dergipark.org.tr/tr/pub/ijaws

[1]Dr. Çağrı Melikşah SAKAR, International Livestock Research and Training Center Lalahan/ANKARA, melikksahi@gmail.com (Corresponding author/ Sorumlu Yazar

INTRODUCTION

Animal behaviour have been researched since the 1990s (Corujo and Timms, 2017). With the combination of accelerometer and wireless technologies, many data have become commercially available for producers thanks to the algorithms and smart software that can be converted into easy-to-use decision tools about animal behaviour (Corujo and Timms, 2017). In livestock, it is important to observe physiological and behavioural changes or abnormalities as early as possible to minimize the loss of costs. With the development of technology in many parts of the world, the time that breeders spend on cows individually or a herd basis has decreased. This trend, which emerged by reducing workload and increasing productivity and profitability, has led to a rapid increase in the interest of farmers and industry for precision livestock technology (Bikker et al., 2014).

Monitoring rumination and feeding behaviours with sensitive monitoring technologies can replace visual observations (Borchers et al., 2016). Rumination, feeding and activity behaviours are widely evaluated with individually related indicators of animals (Bikker et al., 2014). Measurement of these parameters can help to understand the physiology of animals. Automatic measurement of chewing and rumination activity can enable early detection of nutritional deficiencies and aid in ration regulation (Zehner et al., 2012). These behavioural data provide information about the fertility, health, nutrition and location of the individual animal as well as the herd.

There are not enough research findings on the behavioural characteristics of Anatolian Black cattle. In this study, ear temperature and some behavioural data were defined using earrings attached to the ears of male Anatolian Black cattle raised under Institute conditions, changes in these data according to THI groups were also determined.

MATERIAL AND METHOD

Animal Material

The research was carried out at the International Center for Livestock Research and Training-Ankara in October and November 2019. As an animal material, a total of four heads of Anatolian Black male cattle raised within the scope of the "Conservation of Domestic Animal Genetic Resources and Sustainable Use" were used. Two of the animals in the study were 1 year-old and two of them were 2 years old.

The animals were housed in a 20 x 8 m semi-open chamber with other male Anatolian Black and a total of 20 animals. The animals were fed twice a day at 09:00 in the morning and at 19:00 in the evening, and roughage and concentrated feed were given separately. The animals were fed in the form of 70-30% roughage-concentrated feed according to the nutrition program implemented within the scope of the Conservation Project. The roughage was applied *ad-libitum* as a total mixed feed. Only barley straw and dry meadow grass were given as a roughage. Cows have always had clean and healthy water available in their shelters.

Sensor Parameters

Data were recorded with computer software by attaching an electronic chip sensor (The CowManager® system) to the ears of the animals. The CowManager tag is a device designed by Agis Automatisering. It is placed on the ear of a cow or steer and will measure how active it is, its core body temperature, and the amount of time it spends eating and ruminating. The system consists of 3 parts: a chip sensor, transmitting antennas and computer software. The following parameters were taken with the help of a chip sensor attached to the animals' ears. The records were analysed in two sections. In Figure 1 shows the attachment of the ear tag to the animal.

- Ear temperature (°C): It was recorded individually from each animal for hourly intervals.

- Behaviour values: These data are high active, active, not active, eating and rumination. The following behavioural activities of each animal were recorded for hourly intervals as a % (percentage) distribution. In other words, the distribution of the 5 behavioural characteristics mentioned is studied, and the sum of these behaviours (hourly or daily) is 100 according to the analysis.

Figure 1. Earring Attachment to the Anatolian Black Bull.
Şekil 1. Yerli Kara Boğaya Kulak Küpesi Takılışı.

The sensor detected and identified ear and head movements and through algorithms classified behaviours data. Because the algorithms used by the CowManager developer are proprietary it is not completely clear how animal behaviour is split across these distinct categories. In the preliminary evaluation carried out to test the accuracy of the ear tag system used, 2 animals were taken into separate sections of 6 m² for 2 hours. No feed or water was given to the animals here. In the examination made at the end of the process, the eating rate was found to be 0% and the activity rates were very low.

Meteorological Measurements

Meteorological records made with the electronic system were collected for hourly intervals. "Temperature - Humidity Index (THI)" calculation was made based on the result of the temperature (° C) and humidity (%) measurements. The following formula was used in the calculation of THI: THI = 0.8 x T + [(H/100) (T-14.3)] + 46.4 (T= temperature, H = humidity) (EFSA, 2012).

Statistical Calculations

Ear temperature and behavioural data of animals were collected hourly. In addition, daily average values were obtained from the data collected hourly. Minitab 16 statistic program was used to evaluate the data obtained in the study (Minitab, 2010). In all parameters obtained, the mean values of four animals were determined using the General Linear Model, for each day and each hour separately. In the study, THI values were calculated hourly, and they were divided into 4 groups (under 48, 48-56, 56-64, and above 64). The " General Linear Model" method was used to examine the factors affecting ear temperature and behavioural data according to these groups, and the following mathematical model was used;

$$Yij = \mu + ai + eij \qquad (1)$$

In the formula (1);

Y_{ij}: i. THI group, k. the value of the cow,

μ: expected average

a_i: i. amount of influence of THI group (under 48, 48-56, 56-64, and above 64);

e_{ij}: normal, independent and chance error.

RESULTS AND DISCUSSION

The study was carried out in a total of 51 days between October and November 2019. The THI data obtained from the temperature and humidity values collected daily during these days were found to be under 48 for 7 days, 48-56 for 25 days and 56-64 for 19 days. In the research, daily ear temperatures and behaviours data of the bulls according to THI groups were prepared and presented in Table 1.

Table 1. Least squares mean and standard error values of daily of the ear temperatures and the behaviour data of bulls.
Çizelge 1. Boğaların günlük kulak sıcaklıkları ve davranış verilerinin en küçük kareler ortalama ve standart hata değerleri.

Hours	n	Ear Temperature (℃)	High Active (%)	Active (%)	Not Active (%)	Eating (%)	Rumination (%)
General	51	21.97±0.40	7.84±0.34	6.86±0.27	27.15±1.29	26.69±0.55	28.31±0.69
THI Groups							
Under 48	7	18.89±0.94^{b}	5.15±0.79^{b}	5.89±0.63^{b}	20.91±3.01^{b}	27.25±1.29^{ab}	33.89±1.62^{a}
48-56	25	20.40±0.50^{b}	7.24±0.42^{b}	6.22±0.33^{b}	28.26±1.59^{ab}	28.51±0.68^{a}	27.17±0.86^{b}
56-64	19	26.62±0.57^{a}	11.14±0.48^{a}	8.48±0.38^{a}	32.27±1.83^{a}	24.32±0.78^{b}	23.87±0.98^{c}
P Values		0.001	0.001	0.001	0.008	0.001	0.001
Minimum Values		14.57	3.79	4.19	4.80	20.42	18.79
Maximum Values		30.07	15.53	12.06	42.32	36.35	45.29

^{a}, ^{b}, ^{c} - The difference between same column which has shown with different letters are statistically significant (P<0.05).

Table 2 shows the distribution of the number of times the THI groups are present at which times. In the study, the THI values calculated for 51 days were generally low at night. During the daytime, with the increase in the air temperature, high THI values were found to be higher during these hours. According to the hourly distribution of the THI values shown in Table 2, the changes in ear temperature and behavioural data are shown graphically below.

Table 2. Distribution of THI values by hours.
Çizelge 2. SNİ değerlerinin saatlik olarak dağılımı.

THI Groups	0	1	2	3	4	5	6	7	8	9	10	11
Under 48	21	24	26	31	31	37	35	36	25	18	7	4
48-56	24	22	23	18	19	14	16	15	22	15	17	5
56-64	6	5	2	2	1	-	-	-	4	18	24	28
Above 64	-	-	-	-	-	-	-	-	-	-	3	14
Total	51	51	51	51	51	51	51	51	51	51	51	51

Table 2. Continue.
Çizelge 2. Devamı.

THI Groups	12	13	14	15	16	17	18	19	20	21	22	23
Under 48	-	-	-	-	-	-	-	4	6	9	16	20
48-56	6	6	3	3	3	6	11	15	20	23	20	23
56-64	30	24	20	21	25	29	30	27	21	19	15	8
Above 64	15	21	28	27	23	16	10	5	4	-	-	-
Total	51	51	51	51	51	51	51	51	51	51	51	51

Ear Temperature

The daily ear temperatures of the animals in the study are shown in Table 1, and this value was found to be 21.97 ℃. In the analysis made according to the THI groups, the higher the THI values, the higher the ear temperature values of the animals. When the differences between the THI groups were examined, there was no statistical difference between the values between 48-56 and values below 48. However, the differences of the values between 56-64 group compared to the other 2 groups were found to be statistically significant (P<0.001). This is compatible in line with the values that Corujo and Tims (2017) found in their study with the same system as 50-55 °F (approximately 10-13 ℃) in winter and 85-95 °F (approximately 30-35 ℃) in summer.

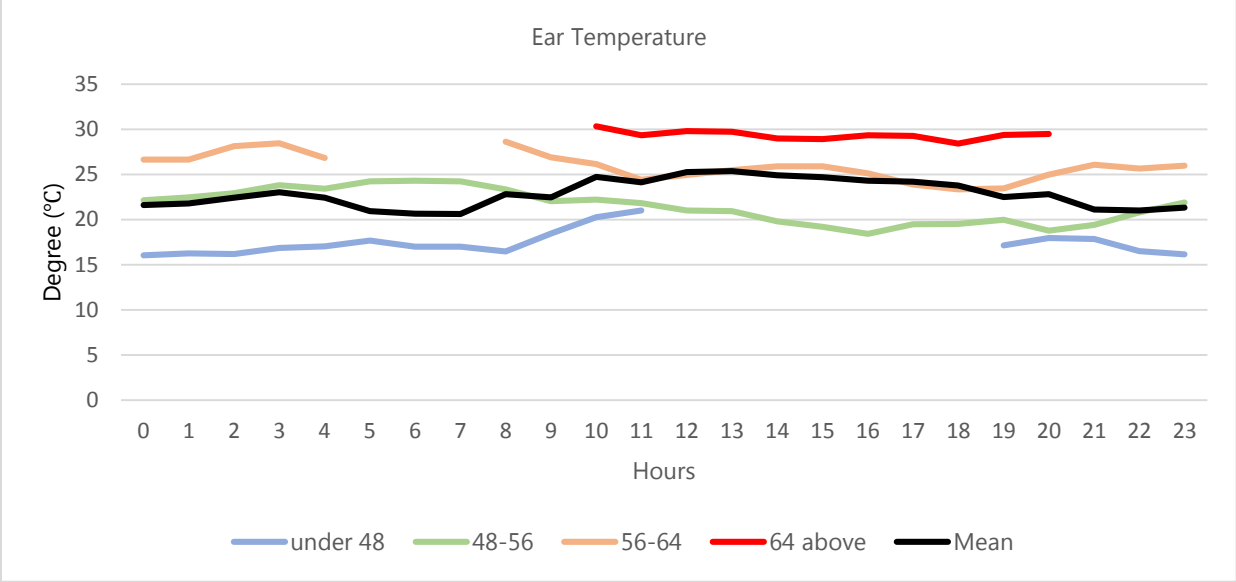

Figure 2. Hourly display of ear temperature values (℃).
Şekil 2. Kulak sıcaklık değerlerinin saatlik gösterimi (℃.

Ear temperature values according to the THI groups obtained hourly are presented in Figure 2. In this figure, the hours of the day are shown on the X axis and the ear temperatures of the animals are shown in degrees on the Y axis. As it can be seen, the ear temperature values of animals are higher at noon than night and morning hours. When the variation of hourly ear temperatures is examined according to the THI groups, the ear temperatures of the animals increase as the THI values increase, just like the daily calculated values. While the ear temperature of the animals is around 30 ℃ when the THI value is above 64, it varies between 15-20 ℃ when it is below 48. These values were compared with Mader and Kreikemeier (2006) and Dolecheck et al. (2015) reported that ear temperature is affected by both body temperature and ambient temperature.

Behaviour Values

In the study, high active, active, not active, eating and rumination data were calculated as % (percent) and these data were found to be 7.84, 6.86, 27.15, 26.69 and 28.31% daily, respectively (Table 1). Differences between THI groups were found to be statistically significant ($P<0.01$) in all behavioural data. On the other hand, In the analysis performed according to THI groups, as THI values increase, high active, active and not active values increase, but rumination values decrease. Therefore, it can be said that THI values are directly proportional to high active, active and not active values, and inversely proportional to rumination values. Although eating values are generally inversely proportional to THI values, the highest value was found in the THI 48-56 group. Bikker et al. (2014) found the behavioural data (rumination, eating, resting and mobility) in 15 milking cows to be 42.6, 15.9, 31.6 and 9.9% by sensor, and 42.1, 13.0, 30.0 and 14.9% by observation, respectively. Among these values, especially rumination data were found to be higher than the values found in this study. Adin et al. (2009) reported that dairy cows ruminate for 7-8 hours a day. Wolfger et al. (2015) observed 26% feeding and 23% rumination data in beef cattle.

In addition, the average values of the behavioural data according to the THI groups obtained hourly were prepared in figures. Accordingly, figures of high active, active, not active, eating, and rumination values are presented in Charts 2, 3, 4, 5 and 6, respectively. In these figures, the hours of the day are shown on the X axis and the values of the animals' behaviours are shown as percentages on the Y axis. That is, the changes in the behaviour of the bulls according to the hourly calculated THI groups are presented in these figures.

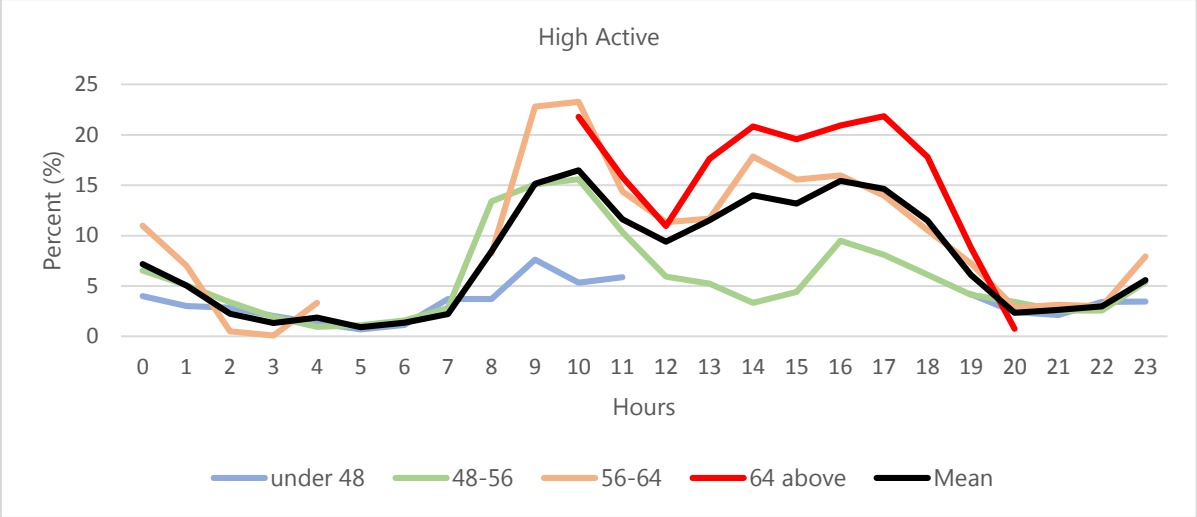

Figure 3. Hourly display of high active values (%).
Şekil 3. Yüksek aktivite değerlerinin saatlik gösterimi (%).

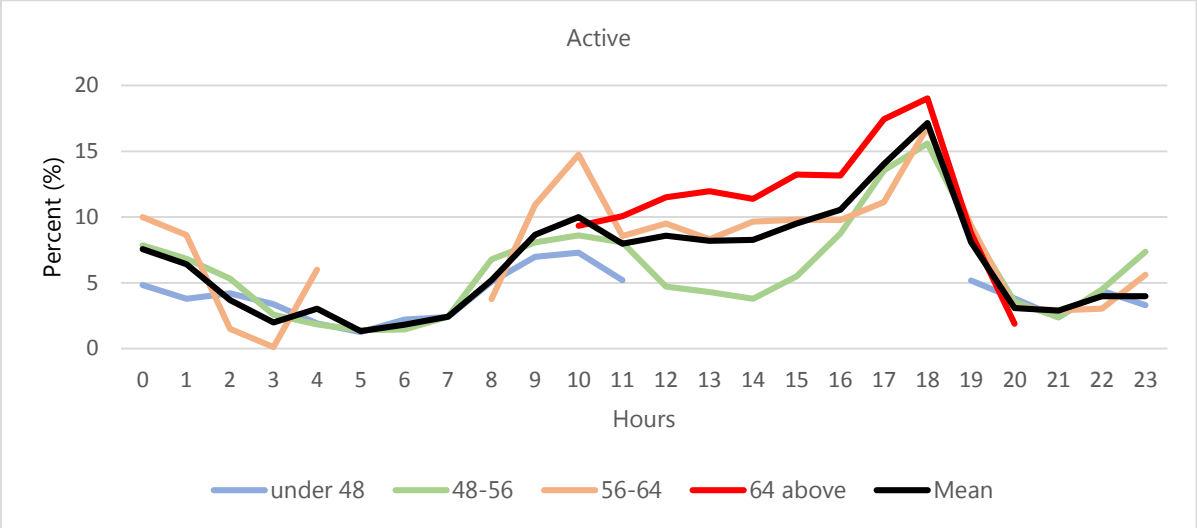

Figure 4. Hourly display of active values (%).
Şekil 4. Normal aktivite değerlerinin saatlik gösterimi (%).

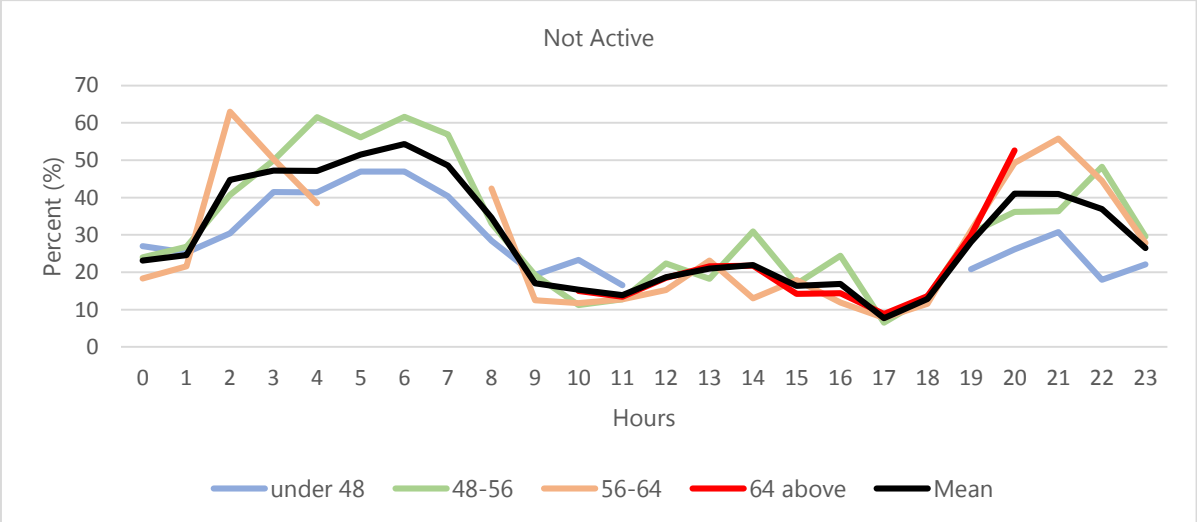

Figure 5. Hourly display of not active values (%).
Şekil 5. Hareketsizlik değerlerinin saatlik gösterimi (%).

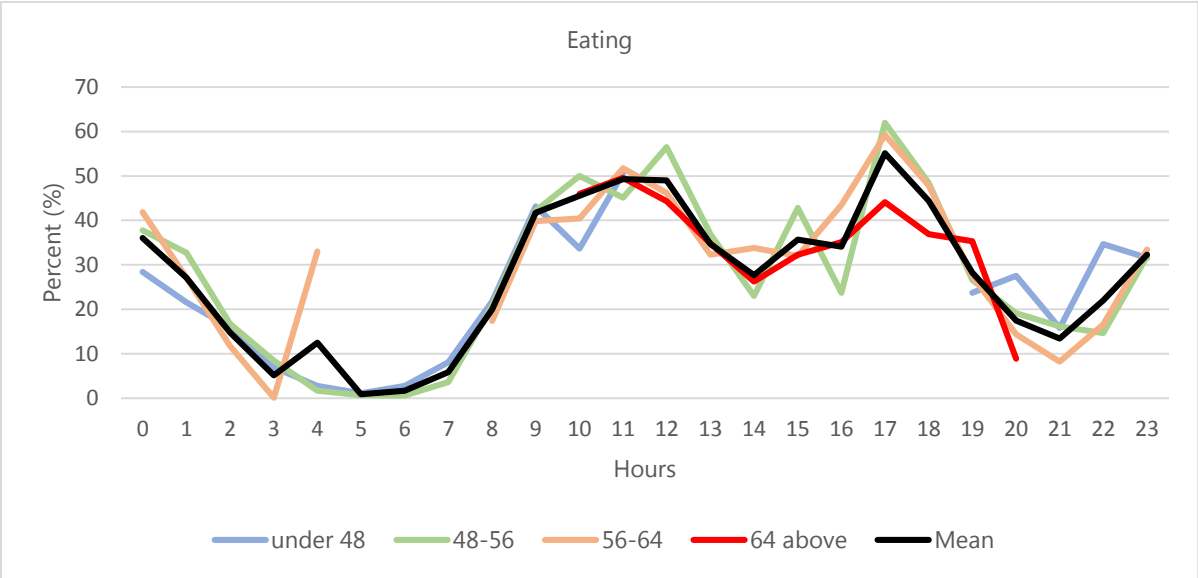

Figure 6. Hourly display of eating values (%).
Şekil 6. Yem yeme değerlerinin saatlik gösterimi (%).

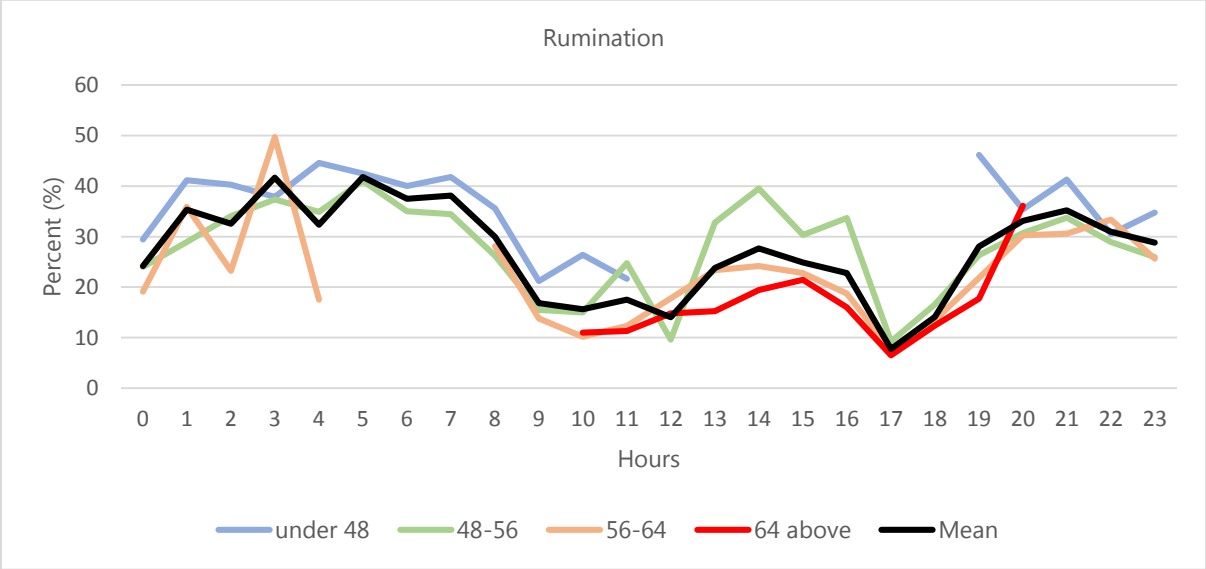

Figure 7. Hourly display of rumination values (%).
Şekil 7. Ruminasyon değerlerinin saatlik gösterimi (%).

As seen in the figures, while the activity and eating values increase during the daytime, the not active and rumination values increase during the night hours. Animals tend to stand more in the afternoon hours, as reported by Allen *et al* (2015) and Heinicke *et al* (2020). In general, animals under heat stress tend to orient themselves in different directions and spend more time standing to avoid direct solar and ground radiation (Sejian et al., 2018; Bayssa et al., 2021). In this study, it was determined that bulls mostly slept at night to alleviate the effects of heat stress experienced during the daytime. While the bulls remained in a rather inactive state between 3 and 7 hours, when the values below THI 48 were the most, in these hours the values of not activity and rumination were found to be the highest. In addition, it has been determined that animals are more active to eat food in the morning and evening feeding times.

The variation of the hourly behavioural data according to the THI groups was found to be similar to the variation of the daily behavioural data according to the THI groups. Especially high active and active data were highly affected by the changes in the hourly calculated THI groups (Figure 3, 4). These values were found to be compatible with studies reported that increased standing and decreased lying time of animals

were associated with higher ambient temperatures (Darcan et al., 2008; Hienicke et al., 2020). The variation of the not active values of the animals according to the THI values was found to be more prominent especially at night hours, and as the THI values of the animals increased during these hours, the not activity of the animals also increased (Figure 5). In the daytime, although this situation is reversed with the effect of air temperature, it is seen that the values are close to the average. In other words, it is observed that the animals are more active during the day as the THI values increase. Eating values were not affected much by hourly THI changes, and the values found in THI groups were generally close to the average (Figure 6). Rumination values of bulls were also affected by hourly THI changes, and these values were generally below the average as THI values increased (Figure 7).

CONCLUSION

As a result, THI values were correlated with ear temperature and behavioural data of bulls. As THI values increased, ear temperature and activity values increased in animals. In addition, it was determined that the eating values increased during the daytime hours. According to these findings, it can be said that animal behaviour is affected by meteorological events. In addition, the behaviour of animals can be easily monitored from the computer whenever we want, instead of following by disturbing the animals in the herd, thanks to the chip ear tag. Thus, the workload has decreased and the stress that may occur on the animals has been prevented. In order to provide optimal conditions for animal welfare, the use of technological tools such as this system in animal husbandry should be expanded.

CONFLICT OF INTEREST

The author declare that no conflict of interest.

ACKNOWLEDGMENT

I would like to thank the Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies, for granting the necessary permissions for the use of materials in this study. This research was presented as an oral presentation at the International Congress on Domestic Animal Breeding Genetics and Husbandry (ICABGEH-2021) held on 27-30 September 2021 as online.

REFERENCES

APA Adin, G., Solomon, R., Nikbachat, M., Zenou, A., Yosef, E., Brosh, A., Shabtay, A., Mabjeesh, S. J., Halachmi, I., & Miron. J. (2009). Effect of feeding cows in early lactation with diets differing in roughageneutral detergent fiber content on intake behaviour, rumination, and milk production. *Journal of Dairy Science, 92*, 3364–3373. https://doi.org/10.3168/jds.2009-2078.

Allen, J. D., Hall, L. W., Collier, R. J., & Smith, J. F. (2015). Effect of core body temperature, time of day, and climate conditions on behavioral patterns of lactating dairy cows experiencing mild to moderate heat stress. *Journal of Dairy Science*, *98*(1), 118-127. https://doi.org/10.3168/jds.2013-7704.

Bayssa, M., Yigrem, S., Betsha, S., & Tolera, A. 2021. Production, reproduction and some adaptation characteristics of Boran cattle breed under changing climate: A systematic review and meta-analysis. *PloS One 16*(5), e0244836. https://doi.org/10.1371/journal.pone.0244836.

Bikker, J. P., Van Laar, H., Rump, P., Doorenbos, J., Van Meurs, K., Griffioen, G. M., & Dijkstra, J. (2014). Evaluation of an ear-attached movement sensor to record cow feeding behaviour and activity. *Journal of Dairy Science,* 97(5), 2974-2979. https://doi.org/10.3168/jds.2013-7560.

Borchers, M., Chang, Y., Tsai, I., Wadsworth, B., & Bewley, J. (2016). A validation of technologies monitoring dairy cow feeding, ruminating, and lying behaviours. *Journal of Dairy Science, 99*(9), 7458-7466. https://doi.org/10.3168/jds.2015-10843.

Corujo, G., & Timms, L. (2017). Uses of an ear tag based behavioural and temperature monitoring system (CowManagerR) at the ISU dairy. *Animal Industry Report, 663*(1), 38. https://doi.org/10.31274/ans_air-180814-391.

Darcan, N., Cedden, F., & Çankaya, S. 2008. Spraying effects on some physiological and behavioural traits of goats in a subtropical climate. *It. J. Anim. Sci. 7*, 77–85. https://doi.org/10.4081/ijas.2008.77

Dolecheck, K. A., Silvia, W. J., Heersche Jr., G., Chang, Y. M., Ray, D. L., Stone, A. E., Wadsworth, B. A., & Bewley, J. M. (2015). Behavioral and physiological changes around estrus events identified using multiple automated monitoring technologies. *Journal of Dairy Science, 98*(12), 8723-8731. https://doi.org/10.3168/jds.2015-9645.

EFSA. (2012). Scientific opinion on the welfare of cattle kept for beef production and the welfare in intensive calf farming systems. *EFSA Journal, 10*(5), 2669. https://doi.org/10.2903/j.efsa.2012.2669.

Heinicke, J., Ott, A., Ammon, C., & Amon, T. (2020). Accepted Author Versıon Of The Manuscrıpt: Heat load-induced changes in lying behavior and lying cubicle occupancy of lactating dairy cows in a naturally ventilated barn. http://dx.doi.org/10.2478/aoas-2020-0113.

Mader, T. L., & Kreikemeier, W. (2006). Effects of growth-promoting agents and season on blood metabolites and body temperature in heifers. *Journal of Dairy Science,* 84, 1030–1037. https://doi.org/10.2527/2006.8441030x.

Minitab. (2010). Minitab for Windows. Version16. Minitab. Inc., United States.

Sejian, V., Bhatta, R., Gaughan, J.B., Dunshea, F.R., & Lacetera, N. 2018. Adaptation of animals to heat stress. *Animal*, 12(2), 431-444. https://doi.org/10.1017/s1751731118001945.

Wolfger, B., Timsit, E., Pajor, E. A., Cook, N., Barkema, H. W., & Orsel, K. (2015). Accuracy of an ear tag-attached accelerometer to monitor rumination and feeding behavior in feedlot cattle. *Journal of Dairy Science, 93*(6), 3164-3168. https://doi.org/10.2527/jas.2014-8802.

Zehner, N., Niederhauser, J. J., Nydegger, F., Grothmann, A., Keller, M., Hoch, M., & Schick, M. (2012, July). *Validation of a new health monitoring system (RumiWatch) for combined automatic measurement of rumination, feed intake, water intake and locomotion in dairy cows*. Proceedings of international conference of agricultural engineering CIGR-Ageng (p. C0438).