MAE Vet Fak Derg, 7 (2): 77-82, 2022
DOI: 10.24880/maeuvfd.1066890

Research Article

The effect of activity on some milking parameters in Holstein cows

Önder Akkaş[1], Eda Akın[1]

[1]Department of Animal Science, Faculty of Veterinary Medicine, Burdur Mehmet Akif Ersoy University, Burdur, TURKEY

Key Words:
holstein
activity
milking parameter

Received : 02.02.2022
Accepted : 12.07.2022
Published Online : 31.08.2022
Article Code : 1066890

Correspondence:
Ö. AKKAŞ
(onderakkas@mehmetakif.edu.tr)

ORCID
Ö. AKKAŞ : 0000-0003-3624-822X
E. AKIN : 0000-0002-3317-9508

ABSTRACT

The study was conducted on 41-second lactation Holstein cows of German origin. The shelter type is a semi-open field type and the research period is 12 months. The activities in the first 100 days of lactation per day were 451.4 ± 133.5, and in the second 100 days, it was determined at 420.78 ± 118.0. The activities are divided into 3 parts within 24 hours (at night, during the day between two milkings, and in the evening). While there was no statistical difference between days 100 and 200 of lactation, the lowest activity was recorded at night and the highest activity during the day. Mean daily milk yield was 28.28 ± 3.86 kg for the first 100 days and 25.15 ± 3.61 kg for the following 100 days, and the difference was found to be significant ($P<0.001$). In order to investigate the influence of the daily activity numbers taken into account as factors on the milking parameters, 4 groups were formed for the 100th and 200th days. Accordingly, the effect of activity on milk conductivity, milking duration, and milk yield could not be determined in the first 100 days; its effect on milk flow rate proved significant ($P<0.05$). No effect of activity on milking parameters was observed in 200 days of lactation. It is assumed that the inclusion of the housing type, lactation number, and lactation period as well as the seasonal effect in activity studies in cows will contribute positively to animal welfare in herd management.

INTRODUCTION

The monitoring and control of milk yield, fertility, diseases, and preventive medical services in modern cattle dairy farms can now be carried out with herd management systems integrated into the milking system. Monitoring of cows individually or on a herd basis; provides meaningful and appropriate zootechnical parameters by interpreting the data coming to the system with artificial intelligence. Some activities of a cow during the day are fixed and immutable. The daily time cows spend eating (4.5-5 hours) drinking (0.5 hours) and milking (2.5 hours) is around eight hours. Of these mandatory activities, fewer than 17 hours a day are spent on recreation, social activities, and waiting at stops. The cows spend 2.4 hours returning from milking, going back and forth between feeders and stalls, and social activities. They wait at standing for about 2 hours (Grant, 2006; Cook, 2008). López-Gatiusa et al., (2005) stated that an increase in the animal's movement is one of the signs of estrus and that there is a remarkable change in the physical activity of animals in estrus. In an animal in estrus, the number of steps, head and neck movements increases from 69% to 170% compared to the normal period (Mayo et al., 2019), and success rates between 51% and 81% have been obtained using various mathematical algorithms to estimate heat based on pedometer data (Rolefs et al., 2005). Increase or decrease in activity in cows, lying periods, when live weight is assessed with performance trait data; at the same time, it also contributes to the assessment of the animal welfare level in the herd (Graf, 2017). It has been stated that besides detecting estrus by activity, it is possible to detect metabolic and digestive disorders of animals by monitoring the changes in the number of daily steps (Edwards & Tozer, 2004). Wangler et al., (2005) reported that the activity was higher in the first 60 days of lactation compared to the following 200th day, and the reason for this was due to integration activities when the cow that left the birthplace started to fight again. The same researchers found that activity was related to milk yield; They reported that although activity decreased in cows with a daily milk yield of 15-35 kg, it increased when they produced more than 35 kg. In the study, which examined the influence of the number of steps on heat and rumination behavior in Holstein cows at the University of Bologna, it was stated that the average number of daily steps in the normal period was 589 (Strapak et al., 2021). Shepley et al., (2020) determined the number of daily steps as 1062.2 in summer and 1179.4 in winter in a free roam area with 11.8 m^2 o crawl space per cow. In a study comparing the behavior of cows that go to pasture and cannot go; it has been reported that cows that go to pasture take 2.7 times more steps per day (1506 or 4064) (Dohme-Meier et al., 2014). In a study investigating activities during estrus, the number of steps in 3 days before and after estrus was determined as 891 and 849 (Zebari et al., 2018). In milking systems with modern herd management; Different milking parameters and mechanical parameters are required concerning udder health and milk hygiene. The electrical conductivity, which expresses the measure of the solution that transfers the current between two

To cite this article:
Akkaş Ö, Akın E. The effect of activity on some milking parameters in Holstein cows. MAE Vet Fak Derg. 2022; 7 (2) :77-82.

electrolytes, is given as mS/cm (millisiemens per centimeter) (Hillerton & Walton, 1991). Grabowski (2000) stated that the electrical conductivity reference values in cow's milk at 25°C were between 4.83-5.23 mS cm-1. The average milk flow rate value expresses the amount of milk in kilograms (kg) passing through the milking system per minute. The values are used to monitor the milking preparation of the udder and the machine. Sharipov et al., (2020) the study, in which they determined the functional properties and the milk yield of the udder with a milking interval of 10.5-11.99 hours, the milk yield of 24.1 kg, the milking time of 5.68 min, the average milk flow at 1.80 kg/min and the maximum milk flow at 3.14 kg/min. In a study on Italian Holstein cows, the average milk flow rate was found to be 2.48 kg/min in the first 150 days of lactation, 2.36 kg/min in the second 150 days of lactation, and the difference between them was significant. In the same study, milking time was 7.36 minutes in the first 150 days and 6.31 minutes in the following 150 days; the peak electrical conductivities were found to be 6.33 mS/cm and 6.56 mS/cm, emphasizing that the difference is significant (Sandrucci et al., 2020).

In this study, the connection between the activity data of the cows, which are continuously recorded in the herd management system, and the milking data from the milking system (lactation time milk yield, daily milk volume, milking time, milk flow from the udder per minute, conductivity rate of the milk, which is one of the indicators for the Milk quality) evaluations are carried out. In this context; It is aimed to take retrospectively the data stored on the herd management system servers (GEA Systems, Dairy Plan) available in the aforementioned enterprise, and to contribute to the herd health, herd management, and thus to the sustainability of the enterprise more efficiently with possible correlations between these data.

MATERIAL and METHODS

The place where the study was carried out: The study was carried out in January-December 2021 at The study was carried out in January-December 2021 at Burdur Mehmet Akif Ersoy University Agriculture, Food and Livestock Research Application, and Research Center Dairy Farm. The facility is located at an altitude of 1300 meters and has the coordinates 370N'54"N 30019'00"E. The facility is a half-open free-range stall and the milking unit is located in the stall. There is at least one free stall and a feeding table for each animal. The stall bed floors are of two-layer sponge+rubber type, and the feeding and walking areas are made of rubber over concrete. The walking areas are open and the floor is concrete. Manure cleaning is done with a scraper system. There is 7.7 m^2 closed and 9.23 m^2 open area per cow.

Data sources

For the study data set; Information on 41 Holstein cows in the second lactation, all of which were imported from Germany in the same age group (second lactation at the age of 36-46 months), was used. Cows were subjected to the same nutritional conditions in the same shelter in all their physiological periods, and group feeding was not done for dairy cows. The type of diet is ad libitum. The ration contents were prepared as (corn silage: 18 kg, alfalfa 3.75 kg, hay 2 kg, concentrate feed: 8.5 kg, cottonseed meal with 28% protein: 1.7 kg, corn flake: 3.75 kg, vitamin premix: 0.5 kg). Data were collected between January and December 2021. In determining the activity behaviors of cows; Foot type Cow Scout brand pedometers (GEA Systems) are used, which are transmitted to the database with a radio frequency antenna. Activation information is transmitted to the database every 15 minutes, and 12 sets of information are created daily, at 2-hour intervals. Milking data is taken from the Dairy Plan database and integrated into the same system. Milk yields were taken as daily morning and evening (kg), daily average milk flow rate (kg/min), milking duration (min) as daily total, and the value per milking was obtained by dividing it into two. The milk conductivity values were recorded according to weekly averages (mS cm^{-1}). Cows were milked with a 2x6 fishbone milking system. The vacuum pressure of the milking system is between 40-42 kPa. Since all the cows in the farm are in the same age group, they were milked at the same time. Milk conductivity values are formed according to the averages of pre-milking, main milking, and last milking. Data from 41 cows were used for the first 100 days of lactation. The number of cows decreased to 31 in the second 100 days as the data were inadequate as some cows left the farm and were born in autumn.

Statistical analysis

The movement data of the cows were taken as the first 100 and the second 100 days, consisting of 12 data daily, and the data recorded in the MS Excell program were evaluated one by one. In an animal in estrus, the number of steps and head and neck movements increases from 69% to 170% compared to the normal period (Mayo et al., 2019). For this reason, unusual increases and subsequent 18-21-day increases are not included in the data set so that they do not affect the average values. "Minitab 19" program was used for statistical analysis (Minitab, 2019). Descriptive statistics were made for the averages of the activity data, and they were divided into 4 groups as quartiles and classified as a factor. For movement behavior during the day; was divided into 3 slices, between 00:01 night and morning milking, between two milkings, between evening milking and 24:00 o'clock, divided. The significance test of the examined factors was done with a single factor analysis of variance and the Tukey test was applied to compare the subgroups with each other. The Pearson method was used to determine the phenotypic correlations of milking data (Tekin, 2010).

It was approved in accordance with the decision of Burdur Mehmet Akif Ersoy University non-interventional ethics committee no. GO 2021/389.

RESULTS

The number of activities in the first 100 and 200 days of lactation, the average values of the milking data, and the statistical evaluation results are given in Table 1.

As a result of the research, the number of daily activities was determined as 451.4 in the first 100 days of lactation and 420.70 in the second 100 days (Table 1). It was observed that there was a decrease of 30.62 on the 200th day of lactation, but the difference between them was statistically insignificant.

Table 1. The average and statistical evaluation results of activity and milking data in the first 100 and, second 100 days of lactation ($\bar{x} \pm S\bar{x}$).

Lactation 0-100 days			Lactation 100-200 days			
Characteristics	**n**	$\bar{x}$ $S\bar{x}$	**Characteristics**	**n**	$\bar{x}$ $S\bar{x}$	**P**
Activity (hour)	41	451.4±133.5	Activity (hour)	31	420.70±118	**NS**
00:01-08:30	41	80.93±18.54	00:01-08:30	31	74.82±17.21	**NS**
08:31-18:00	41	234.68±88.06	08:31-18:00	31	212.97±7.7	**NS**
18:01-23:59	41	135.84±34.66	18:01-23:59	31	132.93±39.4	**NS**
Conductivity (mS/cm)	41	512.53±32.19	Conductivity (mS/cm)	31	501.19±25.25	**NS**
Milk flow rate (kg/min)	41	2.63±0.51	Milk flow rate (kg/min)	31	2.55±0.56	**NS**
Milking duration (min)	41	6:34±1:37	Milking duration (min)	31	6:09±1:37	**NS**
Daily milk (kg)	41	28.28±3.86 ^{a}	Daily milk (kg)	31	25.16±3.61 ^{b}	**0.001 *****

***: P<0.001 NS: Non significant

a,b: Differences between groups, indicated by different letters on the same line, are important

In the activity behaviors during the day, it was determined that the least activity was between 00:01 at night and morning milking (74.28- 80.93), and the highest activity was between two milkings (212.97-234.68). Milk conductivity values were found as 512.53 mS/cm in the first 100 days and 501.19 mS/cm in the second 100 days, and the difference was not statistically significant. The average milk flow rate was determined to be 2.63 kg/min in the first 100 days of lactation and 2.55 kg/min on the 200th day of lactation, the difference between them not being statistically significant. It was found that the milking time was 6:34 minutes in the first 100 days and decreased to 6:09 minutes in the following 100 days, and the difference between them was not statistically significant. The daily milk yields in the first 100 days were found to be 28.28 kg and in the second 100 days, 25.16 kg, and the difference between them was significant (P<0.001).

Statistical assessment results for determining the effect of activity on milking data in the first 100 and 200 days of lactation are given in Table 2 and Table 3.

Table 2 and Table 3 show the effect of activity levels on milking parameters. The first 100 days showed the lower and upper ranges of conductivity (mS/cm), flow rate (kg/min), milking duration (min), and daily milk yield (kg) as 497.54–526.29; 2.32-2.94; 5:59-7:33; 26.17-29.35 was determined. In the second 100 days, the values were recorded as 493.56–513.00; 2.46-2.69; 5:59-6:32 and 23,76-27,32 determined. The number of steps in the first 100 and 200 days of lactation for the given parameters was not found to be significant, except for the flow rate in the first 100 days (p<0.05).

The phenotypic correlation coefficients (rp) between milking parameters examined on the first 200th day of lactation are given in Table 4.

Phenotypic correlations performed for the first 200 days of lactation showed a significantly high negative correlation between milking duration and flow rate (P < 0.001). A moderate positive correlation was found between daily milk yield and milking duration (P<0.001).

As a result, it was concluded that the effects of different factors such as barn type, resting and crawling areas in the barn, herd management preferences, seasonal effects, and lactation

Table 2. Statistical evaluation results of determining the effect of activity on milking data on the 100th day of lactation ($\bar{x} \pm S\bar{x}$).

Lactation 100 days					
Activity (days)	**n**	**Conductivity (mS/cm)**	**Milk flow rate (kg/min)**	**Milking duration (min)**	**Daily milk (kg)**
352,0≤	10	497.54±24.88	2.32±0.42 ^{b}	7:33±2:07	29.14±3.31
352,0-434,2	11	513.04±20.78	2.58±0.30 ^{ab}	6:02±0:58	26.17±3.31
434,2-549,0	10	513.22±21.67	2.94±0.51 ^{a}	5:59±0:49	28.68±4.33
≥549,0	10	526.29±50.76	2.70±0.65 ^{ab}	6:44±1:52	29.35±4.08
P		NS	*	NS	NS

*: P<0.05 NS: Non significant

a,b: Differences between groups, indicated by different letters on the same line, are important

Table 3. Statistical evaluation results to determine the effect of activity on milking data between 100-200 days of lactation.

Activity (days)	n	Conductivity (mS/cm)	Milk flow rate (kg/min)	Milking duration (min)	Daily milk (kg)
		Lactation 100-200 days			
338,1≤	8	499.81±17.47	2.69±0.44	6:03±1:14	27.32±4.33
338,1,-394,7	8	513.00±39.42	2.46±0.58	6:05±1:52	23.76±2.38
394,7-482,4	7	493.56±21.85	2.54±0.73	6:32±2:09	25.51±2.66
≥482,4	8	497.43±15.10	2.50±0.58	5:59±1:24	24.08±4.03
P		NS	NS	NS	NS

NS: Non significant

Table 4. Phenotypic correlation coefficients (rp) between milk conductivity, milk flow rate, milking duration, and daily milk yield in the first 200 days of lactation.

	Conductivity (mS/cm)	Milk flow rate (kg/min)	Milking duration (min)
Milk flow rate (kg/min)	0.082		
Milking duration (min)	0.064	- 0.759***	
Daily milk (kg)	0.257	0.172	0.422***

***: P<0.001

periods should also be evaluated in studies to determine the effect of activity on milking parameters in dairy cows.

DISCUSSION

The increase in activity during the first 100 days compared to 200 days seen in Table 1 agrees with the data reported by Wangler et al., (2005) reported data. They expressed the efforts of the cow that left the barn to be involved in the class struggle in the first 60 days and increased activity through integration activities. In this study, it was found that the daily activity numbers found (849-1506) were generally lower than those reported in the literature (Dohme-Meier et al., 2014; Zebari et al., 2018; Shepley et al., 2020). These findings are consistent with the findings reporting that the lowest activity during the day in dairy cows occurs between 04-08 in the morning (Rolefs et al., 2005). In a doctoral thesis investigating the effects of manure and sand litters on welfare and behavioral characteristics, the number of daily steps was found to be 2380 in holsteins with manure bases and 2742 in sand litters, and it was stated that the difference was significant (Akdeniz, 2020). The difference in activity numbers between our research and other studies; It is possible to attribute this to the significant impact of housing type and conditions on the number of activities reported (Demir, 2010). Because in this study, shelter conditions and the effects of shelter conditions on animal behavior were not examined. It has been observed that the electrical conductivity and flow rate values of the milk are within the specified reference range (Grabowski, 2000; Sandrucci et al., 2020; Sharipov et al., 2020). In our study it was even higher in the first 100 days of lactation; As reported by Bruckmaier et al., (1995); milking duration at the beginning of lactation was high, but decreased towards the middle and end of lactation. In addition, it was observed that the maximum machine milking time (7.0 kg/min) in Holstein cattle was less than stated by the same researchers. In addition, the maximum machine milking time observed in Holstein cattle was lower (7.0 kg/min) than reported by the same investigators (Table 1). From the beginning of lactation milk production increases and usually peaks between 6-8 weeks and then tends to decrease (Huth, 1995). Similarly, in the second 100 days of lactation in this study, a decrease in daily milk yield was observed that was statistically significant (P<0.001). It has been reported that there is an increase in milk flow rate depending on the increase in milk yield but decreases in milk flow rate in the later stages of lactation (Tilki et al., 2005). Similarly, milk flow rate and, although not significantly, milking time decreased in the second 100 days in this study. It has been reported that there are positive correlations between milk yield and flow rate, and there will be a decrease in milk yield due to a decrease in milk flow rate (Bruckmaier et al., 1995; Huth, 1995; Tilki et al., 2005). In this study, the positive correlation (rp=0.172) between milk flow rate and milk yield indicated in Table 4 was considered as one of the reasons for the decrease in milk yield in the 200 days of lactation.

In Table 2 and Table 3, where the effect of activity on milk parameters is shown, the conductivity of the milk was not affected by the number of steps. We can say that it is compatible with Rossing et al.'s (1987) finding that the variation shows little variation according to the way of breeding, but a strong variation on the individual animal basis and from day to day. The milk flow rate was affected by the number of steps in the first 100 days. The cows included in this study were divided into four different groups according to their activity numbers. It is seen that the cows showing the highest activity among these groups actually reach near-normal activities. In the literature, it is reported that the number of daily activities in the shelter is between 589-1179.4 (Dohme – Meier et al., 2014; Strapak et al., 2021). In Table 2, it is seen that the highest milk yielding group is 549 and above daily activity, and at the same time, the flow rate increases as it approaches the normal activity limits. Although in our study there is a difference depending on the activity; The seasonal effect can be regarded as the determining influence on the results, because the seasonal influence on the discharge rate was higher, especially for cows calving in the summer between May and August (Rossing et al., 1987). Because in our study, the effect of the month and season was not examined and some cows gave birth in the summer period. It is also possible to attribute this to the individual differences of the cows in the study group. Because Firk et al., (2002) noted that the reproducibility of activity traits varies greatly between and within cows. While the repetition rate of the activity was found 27.4%, the degree in milk parameters was determined as 70-78.7% (Firk et al., 2002). One reason why flow rate is important in the first 100 days is to relate it to milking time. While the highest milking time was detected in the activity range where the flow rate was the lowest, the lowest milking time was determined when the flow rate was the highest. We can say that this is in accordance with the emphasis by Jarshaji and Zülkadir (2019) that the individual differences in milking speed between cows affect the milking duration.

In the first 100 and 200 days, the effect of activity on milking duration and daily milk yield could not be determined. However, although it was not determined as important, it is seen that the milk yields of the groups with less than 352 and more than 549 activities in the first 100 days of lactation were higher. This can be attributed to the fact that low-activity cows engage in less class fighting and integration activities after calving (Wangler et al., 2005). Accordingly, we can say that the cow uses its energy mostly for milk production. Likewise, it was observed that the activity had a positive effect on milk yield in cows whose activity was close to the normal limits and with more than 549 activity (Table 2). Although the milk yield was not significant in the second 100 days of lactation, the highest milk yield was observed in the cows with the least activity (Table 3). We can state that these cows direct their energy to milk yield by moving less as in the first 100 days.

The high negative correlation (-0.759) between milking time and flow rate given in Table 4 was consistent with the literature data (Bruckmaier et al., 1995; Tilki et al., 2005; Edwards et al., 2014). Edwards et al., (2014) found a slightly lower positive correlation between daily milk yield and milking time than our study.

CONCLUSION

As a result, it was determined that the most activity in dairy cows occurred between the bright hours of the day (08:31-18:00), while the least activity was between midnight and morning hours (00:01-08:30). It was observed that milk yield was higher in the first 100 days of lactation compared to the following 100 days. It has been observed that increasing the number of steps in the first 100 days to 549 and above has a positive effect on milk yield. It has been observed that the cows with the least activity in the first 200 days of lactation direct their energy to milk production rather than movement, and therefore milk yields are higher. Studies to be carried out in combination with animal behavior and preferences such as feeding, drinking water, standing, and walking times during the day; It is thought that it will contribute to the development of herd management and sustainable animal husbandry as well as improving animal welfare in farms.

DECLARATIONS

Ethics Approval

It was approved in accordance with the decision of Burdur Mehmet Akif Ersoy University non-interventional ethics committee no. GO 2021/389.

Conflict of Interest

There is no conflict of interest.

Consent for Publication

Does not need a publication consent.

Author contribution

Idea, concept and design: OA, EA

Data collection and analysis: EA, OA

Drafting of the manuscript: OA, EA

Critical review: OA, EA

REFERENCES

1. Akdeniz, M. (2020). Holştayn Irki Siğirlarda Gübre Ve Kum Altlik Kullaniminin Bazi Refah Ve Davraniş Özellikleri Üzerine Etkileri. Aydin Adnan Menderes Üniversitesi Sağlik Bilimleri Enstitüsü, Yüksek Lisans Tezi, Aydın

2. Bruckmaier, RM., Rothenanger, E., Blum, JW. (1995). Milking characteristics in dairy cows of different breeds from different farms and during lactation. Journal of Animal Breeding and Genetics, 112, 293-302

3. Cook, NB. (2008). Time budgets for dairy cows: how do cow comfort influence health, reproduction, and productivity. Penn State Dairy Cattle Nutrition Workshop, Grantville, PA

4. Demir, MÖ. (2010). Esmer Irk İneklerde Süt Verimi, Sütün Elektrik Ġletkenliği ve Pedometre Aktivitesine Bazı Çevre Faktörlerinin Etkileri. Selçuk Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Konya

5. Dohme-Meier, F., Kaufmann, LD., Görs, S., Junghans, P., Metges, CC., Van Dorland, HA., Bruckmaier, RM., Münger, A. (2014). Comparison of energy expenditure, eating pattern and physical activity of grazing and zero-grazing dairy cows at different time points during lactation. Livestock Science, 162, 86–96. https://doi.org/10.1016/j.livsci.2014.01.006

6. Edwards, JL. & Tozer, PR. (2004). Using Activity and Milk Yield as Predictors of Fresh Cow Disorders. Journal of Dairy Science, 87(2), 524–531. DOI: 10.3168/js.S0022-0302(04)73192-6

7. Edwards, JP., Jago, JG., Lopez- Villalabos, N. (2014). Analysis of milking characteristics in New Zealand dairy cows. Journal of Dairy Science, 97(1), 259-269

8. Firk, R., Stamer, E., Junge, W., Krieter, J. (2002). Systematic effects on activity, milk yield, milk flow rate and electrical

conductivity. Archiv fur Tierzucht, 45(3), 213-222

9. Grabowski, NT. (2000). Körpergewichtsentwicklung, Milchinhaltsstoffe und Milchmengenleistung als Kriterien zur laktationsbegleitenden Beurteilung des Gesundheitszustandes hochleistender DSB-Kühe in Laufstallhaltung. Hannover, Tierärztliche Hochschule, Dissertation.

10. Graf, AM. (2017). Untersuchungen zu Auswirkungen von simulierten Energieausfällen eines automatischen Melksystems auf ausgewählte Stressparameter von Milchkühen. Disserrtation. Ernährung, Landnutzung und Umwelt der Technischen Universität München, München

11. Grant, R. (2006). Incorporating dairy cow behavior into management tools. Penn State Dairy Cattle Nutrition Workshop, Grantville

12. Hillerton, JE., Walton, AW. (1991). Identification of subclinical mastitis with a hand- held electrical conductivymeter. Veterinary Record, 128(22), 513-515

13. Huth, FW. (1995). Die Laktation des Rindes. Analyse, Einfluss, Korrektur. Eugen Ullmer-Verlag, Stuttgart

14. Jarshaji, OHQ., Zülkadir, U. (2019). Konya İlinde Özel Bir İşletmede Yetiştirilen Siyah Alaca Sığırların Bazı Süt Verim Özelliklerine Ait Fenotipik Parametre Tahminleri. KSÜ Tarım ve Doğa Dergisi, 22(Ek Sayı 1), 162-168

15. López-Gatiusa, F., Santolaria, P., Mundet, I., Yanız, J. (2005). Walking activity at estrus and subsequent fertility in dairy cows. Theriogenology, 63(5), 1419-1429

16. Mayo, LM., Silvia, WJ., Ray, DL., Jones, BW., Stone, AE., Tsai, IC., Clark, JD., Bewley, JM., Heersche, G. (2019). Automated estrous detection using multiple commercial precision dairy monitoring technologies in synchronized dairy cows. Journal of Dairy Science, 102, 2645–2656. Doi.org/10.3168/jds.2018-14738

17. Minitab. Minitab forWindows Version Release 19, 2019; Minitab Inc

18. Rolefs, JB., Van Eerdenburg, FJCM., Soede, NM., Bas, KK. (2005). Pedometer readings for estrous detection and as predictors for time of ovulation in dairy cattle. Theriogenology, 64, 1690- 1703

19. Rossing, WE., Benders, PH., Hogewerf, H., Hopster, H., Maatje, K. (1987). Practical experiences with real-time measurements of milk conductivity for detecting mastitis. In: Proceedings of the "3rd symposium Automation in Dairying" Wageningen. pp: 138-146

20. Sandrucci, A., Tamburini, A., Bava, L., Zucali, M. (2020). Factors Affecting Milk Flow Traits in Dairy Cows: Results: of a Field Study. Journal of Dairy Science, 90, 1159–1167

21. Sharipov, D., Kayumov, R., Akhmetov, T., Ravilov, R., Akhmetzyanova, F. (2020). The effect of milking frequency and intervals on milk production and functional properties of the cows' udder in automatic milking systems. BIO Web of Conferences, 17, 00036

22. Shepley, E., Lensink, J., Leruste, H., Vasseur, E. (2020). The effect of free-stall versus straw yard housing and access to pasture on dairy cow locomotor activity and time budget. Applied Animal Behaviour Science, 224, 104928

23. Strapak, P., Mičiaková, M., Strapáková, E., Neirurerová, P., Bujko, J. (2021). Influence of estrus on changes of locomotion activity and rumination time in cattle dams. Acta fytotechn zootechn, 24, 127-130

24. Tekin, M.E. (2010). Health Science (Veterinary, Medicine, Dentistry, Pharmacy) for statistics on the computer with examples. Selcuk University Press.

25. Tilki, M., Çolak, M., İnal, Ş., Çağlayan, T. (2005). Effects of Teat Shape on Milk Yield and Milking Traits in Brown Swiss Cows. Turkish Journal of Veterinary and Animal Sciences, 29, 275-278

26. Wangler, A., Meyer, A., Rehbock, F., Sanftleben, P. (2005). Wie effizient ist die Aktivitätsmessung als ein Hilfsmittel in der Brunsterkennung bei Milchrindern. Züchtungskunde, 77(2/3), 110–127

27. Zebari, HM., Rutter, MS., Bleach, ECL. (2018). Characterizing changes in activity and feeding behavior of lactating dairy cows during behavioral and silent oestrus. Applied. Animal. Behaviour. Science, 206, 12-17