Macedonian Veterinary Review
sciendo

Mac Vet Rev 2018; 41 (2): 169-176

Available online at
www.macvetrev.mk

Original Scientific Article

INFLUENCE OF BREED AND PARITY ON TEAT AND MILKING CHARACTERISTICS IN DAIRY CATTLE

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Received 17 November 2017; Received in revised form 13 March 2018; Accepted 11 April 2018

ABSTRACT

The aim of this study was to determine some morphological traits of the udder teat and their influence on the milk flow rate in three dairy cattle breeds (Brown Swiss, Holstein and Simmental). The average milking time and milk yield was 8.79±0.16 minutes and 9.40±0.28 kg, respectively. There was a finding that the breed of the dairy cows had no effect on the total milking time, with the Holstein cows having the highest milk yield ($P<0.01$). The average milk flow rate was 1.09±0.04 kg/minute and the Holstein cows had the highest milk flow rate ($P<0.05$). The cow parity didn't affect the milk flow rate and the milk yield. The average teat length, average teat diameter and average teat volume varied among the cattle breeds and were highest in the Brown Swiss, and lowest in the Simmental cows. In conclusion, the milk flow rate varies among cattle breeds, and it was observed that dairy cows with high milk yields have higher milk flow rates.

Key words: dairy cattle, milk flow rate, teat traits

INTRODUCTION

Milk, which contains four basic nutrients, including proteins, vitamins, minerals and carbohydrates, is an important food source for humans (1). While more than 2000 mammals are known to produce milk, out of these species only very few have been domesticated by man. Today, a very large proportion of the milk consumed by humans (83.1%) is obtained from dairy cattle (2).

The global dairy cattle production industry has undergone major developments in the past decade (3). Selection performed in dairy cattle production systems is mainly aimed at increasing the milk yield. Developments achieved in breeder assessment methods, the extension of the use of artificial insemination and the increased use of bulls of high genetic merit have all contributed to an accelerated genetic advance in milk yields (4). One of the main targets of newly developed animal improvement programmes is to attain longevity in cattle. Due to difficulties in calculating the breeding value of longevity, indirect selection methods are being developed, which are based on traits related to the culling reasons of dairy cattle (5).

The main source of income of dairy cattle enterprises is milk production. Known to be the most time-consuming and laborious daily work performed at a dairy enterprise, milking should be managed with utmost care as it is a major enterprise function, which has impact on both the potential income and the animal capital of the enterprise (6, 7). Given its determinative effect on labour costs, milk flow rate is an important operational trait in dairy cattle production (8). Therefore, dairy cattle enterprises aim to allocate minimum time and effort to milking so as to maximize their profit (9). Advances achieved in the milking technology have enabled the reduction of the total milking time, the

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Competing Interests: The authors have declared that no competing interests exist.
Available Online First: 15 July 2018
Published on: 15 October 2018
https://doi.org/10.2478/macvetrev-2018-0020

milking process become less labour intensive and establishment of more hygienic milking conditions in the milking parlor enable production of more hygienic milk (7). The failure of the milking process results in the straggling of milk in the udder. Furthermore, a prolonged milking time leads to teat injuries which increase the incidence of mastitis (10).

The main aim of this study was to evaluate the milk flow rate in three different breeds of dairy cattle (Brown Swiss, Holstein and Simmental) and to determine the influence of some morphological traits of the teat on the milk flow rate.

MATERIAL AND METHODS

The data used in this survey was obtained from dairy cattle rearing at the Livestock Research and Practice Farm of Ataturk University, Faculty of Veterinary Medicine and included a total of 176 dairy cattle, from which 114 Brown Swiss, 35 Holstein and 27 Simmental cattle. The study was conducted in accordance with ethical rules and procedures, and was approved by the Local Ethics Board for Animal Experiments (Certificate of Authorisation to Experiment on Living Animals N°2017/11, The Local Ethical Committee of Ataturk University). The animals were raised in a loose-housing system and were milked twice a day, at equal intervals, in the morning and in the evening. The milking was performed at a vacuum pressure of 50 kPa, a speed of 60 pulsations/minute, and the pulsation ratio was 60:40.

The teat length was measured by the vertical distance between the udder base and the teat end using a ruler. The teat diameter was measured at the midpoint of the teats, using a calliper. The teat volume was determined by the graduated bowl filled with water by measuring the volume of water that was watering out when the teats were dipped into the bowl. The measurements of the teats and udders were made prior to the evening milking. The data for the total milking time and the milk yield per milking were extracted from the farm herd management system (DeLaval Alpro®), which was used to record the identification, birth and yield information of each animal raised at the farm. Furthermore, the milking was monitored, and these parameters were also determined by manual measurements.

The milking speed (milk flow rate) was calculated by dividing the milk yield per milking by the total milking time.

Data classification

The parity of the dairy cattle was determined on the basis of the farm records, and the animals were allocated to three groups, animals in the 1st, the 2nd and the ≥3rd lactation. On the basis of the amount of milk that flowed through the teats per minute at the time of milking, the cows were classified in 4 groups, slow milking cattle (0.21-0.59 kg/minute, n=23), moderate milking cattle (0.60-0.89 kg/minute, n=44), fast milking cattle (0.90-1.19 kg/minute, n=51), very fast milking cattle (1.20-2.18 kg/minute, n=58).

Statistics

The impact of the breed and parity of the dairy cows on the teat length, teat diameter and teat volume were analysed by two-way analysis of variance (ANOVA). The effects of teat length, teat diameter and teat volume on the classified milking speed were analysed by one-way analysis of variance (ANOVA). The correlation between the parametric data was assessed using Pearson's correlation method. All statistical analyses were performed using the SPSS software package (11).

RESULTS

The results of the variance analyses performed for the total milking time and milk yield per milking are presented in Table 1. The average milking time was determined to be 8.79±0.16 min. It was ascertained that the breed had no effect on the total milking time. But the parity had effect ($P<0.05$) on the total milking time. The average milk yield was determined to be 9.40±0.28 kg, and the Holstein cattle were ascertained to have the highest milk yield ($P<0.01$). The average milk flow rate was found to be 1.09±0.04 kg/min. When milked, the Holstein cattle gave 1.22±0.07 kg of milk per minute, Brown Swiss cattle gave 1.02±0.04 kg of milk per minute, Simmental cattle gave 0.93±0.09 kg of milk per minute, and thus, were found to have the highest milk flow rate ($P<0.05$). It was determined that teat diameter ($P<0.01$) and length ($P<0.05$) affected the milk flow rate (Table 1).

The average teat length (ATL), average teat diameter (ATD) and average teat volume (ATV) were determined to be 5.92 cm, 2.51 cm and 32.80 cm^3, respectively, and it was observed that these parameters significantly ($P<0.01$) differed among the cattle breeds (Table 2).

Table 1. Least squares means and the standard deviations calculated for the total milking times, milk yield per milking and milk flow rates

		N	Milking Time (min)	Amount of milk (kg)	Milk Flow Rate (kg/min)
Breeds	Brown Swiss	114	8.77 ±0.181	8.765^{b} ±0.316	1.022^{b} ±0.039
	Holstein	35	8.660 ±0.316	10.397^{a}±0.552	1.215^{a} ±0.069
	Simmental	27	9.202 ±0.412	8.323^{b} ±0.720	0.932^{c} ±0.090
Parity	1	81	9.254^{a} ±0.251	9.317 ±0.439	1.027 ±0.055
	2	60	8.220^{b} ±0.284	9.571 ±0.497	1.165±0.062
	3≥	35	8.657^{a} ±0.396	9.359 ±0.692	1.116 ±0.086
General Average		176	8.788 ±0.159	9.402 ±0.278	1.092±0.035
				P	
Breeds			0.933	0.010	0.024
Parity			0.041	0.871	0.611
Breeds* Parity			0.349	0.595	0.453
ATL			0.727	0.037	0.048
ATD			0.013	0.000	0.000
ATV			0.651	0.647	0.599

ATL: Average teat length; ATD: Average teat diameter; ATV: Average teat volume
a, b, c: Means within a column with no common superscripts differ significantly

Table 2. Least squares means and the standard deviations calculated for the teat lengths, teat diameters and teat volumes

		N	ATL (cm)	ATD (cm)	ATV (cm3)
Breeds	Brown Swiss	114	6.26±0.07^{a}	2.58±0.23^{a}	36.10±0.64^{a}
	Holstein	35	5.98±0.12^{b}	2.44±0.40^{b}	30.91±1.15^{b}
	Simmental	27	5.26±0.16^{c}	2.42±0.53^{c}	27.98±1.51^{c}
Lactation Parity	1	81	5.33±0.08^{c}	2.36±0.27^{c}	27.78±0.78^{c}
	2	60	5.79±0.11^{b}	2.63±0.37^{a}	31.63±1.05^{b}
	3≥	35	6.38±0.14^{a}	2.44±0.45^{b}	35.57±1.29^{a}
General Average		176	5.92±0.95	2.51±0.29	32.80±8.40
				P	
Breeds			0.000	0.000	0.000
Parity			0.000	0.000	0.000

ATL: Average teat length; ATD: Average teat diameter; ATV: Average teat volume
a, b, c: Means within a column with no common superscripts differ significantly

Accordingly, these parameters were highest in the Brown Swiss, median in the Holstein, and lowest in the Simmental cattle. While the average teat length values of the Brown Swiss, Holstein and Simmental cattle were 6.26±0.07 cm, 5.98±0.12 cm and 5.26±0.16 cm, respectively, their average teat diameters were 2.58±0.23 cm, 2.44±0.40 cm and 2.42±0.53 cm, respectively, and their average teat volumes were 36.10±0.64 cm^{3}, 30.91±1.15 cm^{3} and 27.98±1.51 cm^{3}, respectively. Furthermore, it was observed that the average teat length and average teat volume increased with a higher parity, and the highest average teat diameter was determined in the dairy cattle in their second lactation (Fig. 1).

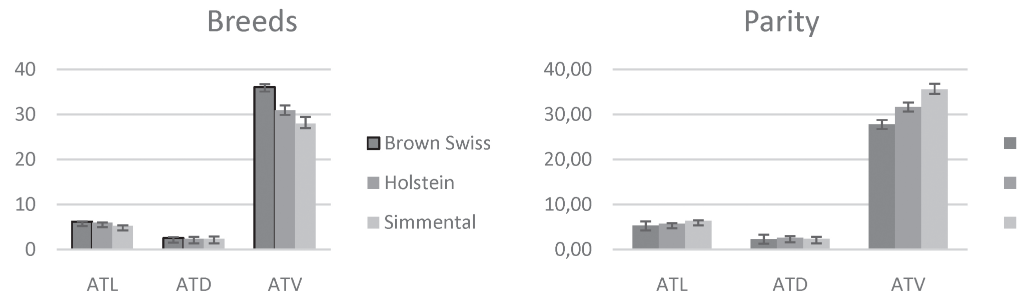

Figure 1. Least squares means and the standard deviations calculated for the teat lengths, teat diameters and teat volumes. ATL: Average teat length; ATD: Average teat diameter; ATV: Average teat volume

While 13% of the milked cattle were included in the group of animals that were milked slowly, 33% of the milked cattle were included in the group of animals that were milked very fast. It was determined that the dairy cattle that were milked slowly had the significant (P<0.01) longer and narrower teats, whilst the dairy cattle that were milked the fastest had the significant (P<0.01) wider teats. Furthermore, the animals included in these two groups were observed to have the significantly (P<0.05) largest teat volume (Table 3).

The results of the present study demonstrated that the milk flow rate was positively correlated with the average teat volume, but negatively correlated with the average teat length, the latter being statistically insignificant. It was ascertained

Table 3. Least squares means and the standard deviations calculated for the teat volume, teat length and teat diameter values in relation to the different categories of milk flow rate

Milking Speed	N	ATV	ATL	ATD
Slow	23	35.1 ±1.7^{a}	6.53 ±0.19^{a}	2.38 ±0.05^{c}
Moderate	44	31.1 ±1.2^{b}	5.76 ±0.14^{b}	2.40 ±0.04^{bc}
Fast	51	30.8 ±1.2^{b}	5.67 ±0.13^{b}	2.51 ±0.04^{b}
Very fast	58	35.0 ±1.1^{a}	6.00 ±0.12^{b}	2.67 ±0.03^{a}
General Average	176	33.0 ±0.7	5.99 ±0.07	2.49 ±0.02
			P	
		0.016	0.002	0.001

ATL: Average teat length; ATD: Average teat diameter; ATV: Average teat volume
a, b, c: Means within a column with no common superscripts differ significantly

Table 4. The correlation coefficients and levels of significance determined for the correlations between the total milking time, milk yield, milk flow rate, average teat volume (ATV), average teat length (ATL) and average teat diameter (ATD)

	Milking time	Milk yield	Milk Flow Rate	ATV	ATL	ATD
Milking Time	1					
Milk Yield	0.187*	1				
Milk Flow Rate	-0.269**	0.877**	1			
ATV	0.034	0.100	0.083	1		
ATL	-0.022	-0.064	-0.045	0.784**	1	
ATD	0.130	0.449**	0.373**	0.503**	0.270**	1

*P<0.05; **P<0.01; ATL: Average teat length; ATD: Average teat diameter; ATV: Average teat volume that, while the dairy cattle with a large teat volume were milked either slowly or very fast, the dairy cattle with long teats were milked only slowly. The milk flow rate and average teat diameter were found to be positively and highly (r=0.373) correlated with each other and this correlation was determined to be statistically significant (P<0.01). Similarly, the milk yield and milk flow rate were also found to be highly (r=0.877) and significantly correlated with each other (P<0.01), (Table 4).

The results of the present study demonstrated a very high correlation between the average teat length and average teat diameter (r=0.270), (P<0.01). Accordingly, it was concluded that the dairy cattle with long teats had a large teat diameter (Table 3).

The total milking time and milk flow rate were found to be negatively and significantly correlated with each other (r=-0.269), (P<0.01). The coefficient calculated for the correlation between the milk yield and milk flow rate (r=0.877) suggested that dairy cattle with high milk yields are able to be milked faster (P<0.05), (Table 4).

DISCUSSION

In order to reduce labour costs in dairy cattle production systems, it is required to complete the milking process in the shortest time possible (8, 9). The milking speed which is also referred to as the milk flow rate, implies the amount of milk that is milked from a teat in one minute (12, 13). In the present study, the average milk flow rate was determined as 1.09±0.04 kg/min. Another study reported an average milk flow rate of 1.049 kg/min (14). Higher milk flow rates have been reported in some other studies (13, 15, 16, 17). In the present study, the milk flow rate of the Holstein cattle (1.22 kg/min) was found to be higher than that of the Simmental (0.93 kg/min) and Brown Swiss (1.02 kg/min) cattle (P<0.05). Similarly, one study reported that the milk flow rate of Holstein cattle was higher than that of Simmental cattle (18). Mijić et al. (19) reported that the average milk flow rate of 67% of the Holstein cattle they assessed was 1.61-3.60 kg/min, whilst the average milk flow rate of 72.2% of the Simmental cattle they assessed was 2.40 kg/min. A different study reported average milk flow rates of 2.07 kg/min, 2.31 kg/min and 1.97 kg/min for Holstein cattle in their first, second and third lactation, respectively (20). Strapák et al. (21) indicated that, in Holstein cattle, the highest milk flow rate was achieved in the second lactation and reported that the average milk flow rate of the Holstein cattle in their second lactation was 3.01 kg/min. Carlstrom et al. (22) demonstrated that a higher parity led to an increased milk flow rate. Some studies (15, 21, 23) have suggested that a moderately positive correlation exists between the milk flow rate and somatic cell count (SCC). It was found that teat length, diameter and the volume were increased by increasing lactation parity; since these factors were used as covariates, lactation parity was not determined as effective on milk ability.

An increase in the milk yield per milking was observed to be associated with an increase in the milk flow rate. Similar results have been reported in previous research (14, 15) with increasing parity of the cattle, milk production increases. However in the present study, parity of the cattle was not found to have an effect on milk yield. This result was attributed to the culling of the high yielded animals, because of mastitis.

Of the teat conformation traits, only the teat diameter was determined to be positively and moderately correlated with the milk flow rate. However, the categorization of the milk flow rate revealed a difference in the correlation of the milk flow rate with the teat length and teat diameter. Thus, it was concluded that the correlation of the teat volume and teat length with the milk flow rate was non-linear. While a greater length of the teats was associated with a reduced milk flow rate, a greater teat diameter was associated with an increased milk flow rate. Furthermore, the teat volume, which is a functional trait of the teat diameter and teat length, was found to be greater in the cattle that were milked slowly and very fast. Thus, the teat volume gave important clues for the identification of these two groups. Contrary to our findings, the coefficients of the correlations of the milk flow rate with the teat length and teat diameter were insignificant (18). On the other hand, on the basis of their comparison of slow and fast milked cattle, one study reported that the cattle, which were milked slowly, had a greater teat length and teat diameter (24).

The average milking time was determined to be 8.79±0.16min. This time period was either similar to (14, 17, 20, 25), lower (14, 22, 25), or higher (13, 18) than values reported in previous research. Although, parity had significant effect on milking time (P<0.05); the breed of the cattle did not influence that factor, statistically. Blottner et al. (20) determined that Holstein cattle had a shorter milking time than Holstein and Brown Swiss crossbreeds. Different studies reported that the total milking time was longer in Simmental cattle, in comparison to Holstein cattle (18) and the total milking time increased with a higher parity (22). In the present study, a moderately positive correlation was determined to exist between the milk yield and the total milking time. Furthermore, the milk flow rate and total milking time were ascertained to be negatively and moderately correlated with each other. In this study, the cattle breed displaying the highest milk yield and the highest milk ability was determined to be the Holstein, thus it was considered that the breed of the animal had no effect on the duration of its total milking time. But, it was determined that the dairy cattle in their second lactation had impact on the total milking time.

In the present study, the average teat length and teat diameter were determined to be 5.92±0.95 cm and 2.51±0.29 cm, respectively. The Brown Swiss cattle had the longest and widest teats. Similarly, reported average teat length and teat diameter values of 5.88±0.05 cm and 2.23±0.01 cm, respectively (26). The average lengths of the front and rear teats of Brown Swiss cattle have been reported as 6.65 cm and 5.40 cm, respectively, by Ozbeyaz et al. (4), 7.3 cm and 6.1 cm, respectively, by Alacam et al. (27), and 59.45 mm and 49.72 mm, respectively, by Tilki et al. (28). Furthermore, a study reported the average length of the front teats as 9.41±0.21 cm in Brown Swiss cattle (29). When compared to the results obtained in the present study, the study showed smaller lengths for the front teats (5.1±1.1 cm) and rear teats (4.3±0.8 cm) of Holstein cattle (30). The diameters reported by Ozbeyaz et al. (4) for the front and rear teats of Brown Swiss cattle (2.67 cm and 2.51 cm, respectively) are similar to the results obtained in the present study, whilst the diameters reported by Alacam et al. (27) (2.2 cm and 2.2 cm) and Tilki et al. (28) (22.14 mm and 21.53 mm) for the same breed are lower than the values measured in the present study. Batra and McAllister (30), determined that the diameters of the front and rear teats of Holstein cattle were similar (2.5±0.5 cm). Bobić et al. (18) indicated that, the teat canals of the front and rear teats, were longer and wider in Simmental cattle, when compared to Holstein cattle. In the present study, the teat length was observed to increase with a higher parity and the largest teat diameter was determined in the dairy cattle, which were in their second lactation. Ozbeyaz et al. (4) reported that, in Brown Swiss cattle, the differences observed between the lactation periods for the diameter of the rear teats at the 6^{th}+ lactation and the diameter of the front teats at the 4^{th} lactation were statistically significant. These researchers determined that the differences observed between the teat length values for the parity were insignificant.

The results of the present study demonstrated that the dairy cattle with a large teat volume were milked either slowly or very fast, whilst the dairy cattle with long teats were able to be milked only slowly. Furthermore, it was ascertained that the milk flow rate increased with a larger teat diameter.

The results obtained in the present study showed that the average teat volume, average teat length and average teat diameter had no correlation with the total milking time. Similarly, the other study reported that, while the lengths of the front and rear teats and the diameters of the front teats were not correlated with the total milking time, the diameters of the rear teats were positively and moderately correlated with the total milking time (18).

CONCLUSION

In conclusion, it was determined that in dairy cattle breed of the cattle had no effect on the total milking time, but it had very significant impact on the milk yield. The highest milk yield belonged to the Holsteins. Lactation parity had significant effect on the milking time. It was ascertained that the milk flow rate varies among cattle breeds, and it was observed that dairy cattle with high milk yields displayed higher milk flow rates. A non-linear correlation was determined to exist between the teat conformation traits and milkability. To the authors knowledge, there is no previous literature report on the impact of teat volume on milk flow rate and the total milking time. Teat volume is a functional trait of the teat diameter and teat length. In this respect, it is considered that the teat volume could serve as a significant criterion for the assessment of the teat diameter and teat length together.

CONFLICT OF INTEREST STATEMENT

The authors declared that they have no potential conflict of interest with respect to the authorship and/or publication of this article.

ACKNOWLEDGMENT

The authors acknowledge the Livestock Research and Practice Farm of Ataturk University Faculty of Veterinary Medicine for providing support to carry out this project.

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Please cite this article as: Genc M., Coban O., Ozenturk U., Eltas O. Influence of breed and parity on teat and milking characteristics in dairy cattle. Mac Vet Rev 2018; 41 (2): 169-176. https://doi.org/10.2478/macvetrev-2018-0020