Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2003
Volume 6
Issue 1
Series ANIMAL HUSBANDRY

KUCZAJ M. 2003. ANALYSIS OF CHANGES IN UDDER SIZE OF HIGH-YELDING COWS IN SUBSEQUENT LACTATIONS WITH REGARD TO MASTITIS **Electronic Journal of Polish Agricultural Universities**, Animal Husbandry, Volume 6, Issue 1.
Available Online http://www.ejpau.media.pl

ANALYSIS OF CHANGES IN UDDER SIZE OF HIGH-YELDING COWS IN SUBSEQUENT LACTATIONS WITH REGARD TO MASTITIS

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ABSTRACT

Udders and teats conformation changes that undergo in subsequent lactations were analysed with regard to mastitis. The studies included 97 Black-and-White and Red-and-White cows managed in a herd of an average annual yield of 10,000 kg of milk, in one of the leading specialist farms located in south-west Poland. First lactation cows are characterised by relatively low somatic cell counts in milk, lower than multiparous cows. SCC in the milk of third lactation cows, compared to milk of primiparous cows, increased over five-fold (at $p \leq 0.05$). Coefficients of correlation (r) for the studied udder conformation traits and SCC in milk were statistically different (at $p \leq 0.05$, $p \leq 0.01$), ranging between r = -0.30**, for rear distance from the udder to the floor and SCC, and r = 0.28**, for rear teats thickness and SCC. Age of the animals significantly (at $p \leq 0.05$, $p \leq 0.01$) differentiated the values of morphometric measurements of the udders; in subsequent lactations, an increase may be expected in nearly all the measurements, except for the distance from the udder to the floor, which decreases. Also, we may expect the cows to show higher vulnerability to mastitis in subsequent lactations.

Key words: dairy cows, udder and teat conformation, SCC, mastitis

INTRODUCTION

Inflammatory states of the milk gland represent the most serious health problem of dairy herds. It results in severe loss for milk producers [4, 8, 11]. The performance standard should favour these conformation traits that are important for performance and health of the cows.

Diagnosis of health condition ans selection of cows resistant to mastitis is based on a number of criteria, including somatic cell count (SCC) in milk, udder conformation, electric conductivity of milk, or genetic markers.

Mastitis resistance may be improved by direct selection for clinical mastitis case incidence. This way has been adopted in Scandinavian countries [4]. It has been commonly recognized that somatic cell count in milk, as a response of the immune system to udder pathogenic bacteria infection, represents a very good measure of udder healthiness and milk quality. Also, possibilities to improve mastitis resistance are known through indirect selection of cows that includes udder conformation traits. Namely, it has been reported [2, 5, 6, 10, 12, 16, 20, 24] that a significant relationship occurs between udder size (suspension, distance from the floor, and shape of the udder and teats) and mastitis incidence. Therefore, selection for decreased SCC, high udder suspension, shorter and more closely located teats, will lead to reduction in mastitis incidence.

Functional traits, which include fertility, health condition, milking performance, conformation traits, and udder healthiness, have been recorded in many countries. They indirectly affect milk production costs, and are officially or unofficially taken into account in bull selection. Single traits of udder, conformation, and limbs are included in selection indexes [1, 3, 4, 19, 23]. Wilmink *et al*. [23] proposed that in dairy cattle selection, besides milk performance, meatiness and conformation traits, also the following traits should be included: fertility, calving easiness, health, udder health index (SCC, udder depth, suspension of fore quarters, and teats location), legs and hooves, and milking speed.

In Poland, further improvement of mastitis-resistant animals may be expected if selection programmes include information on SCC [22] and udder conformation traits [18]. Since 1996, udder conformation evaluation score has constituted 50% of general evaluation for type and conformation in the dairy cattle breeding programme in Poland.

The aim of the study was to analyse changes in udder and teat conformation in high-yielding cows in subsequent lactations, and determination of a relationship between exterior udder conformation and somatic cell count in milk.

MATERIALS AND METHODS

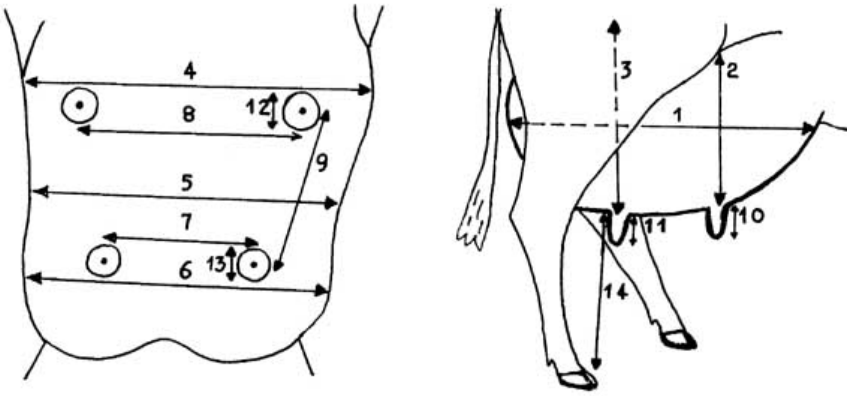
The studies were carried out on the group of 97 Black-and-White and Red-and-White cows with various proportion of Holstein-Friesian cattle genes addition, managed in a herd of mean annual yield reaching 10,000 kg of milk, in one of the leading specialist farms located in south-west Poland.

The cows were managed in loose housing throughout the year. Milking was carried out three times (initial period of lactation, until 150 days) and twice (beyond 150 days) per day, in a Euro Parallel milking parlour (DeLaval). The calves were detached from the dams after birth and fed in individual calf pens; colostrum was given with a direct-to-can milking machine in order to prevent mastitis that might result from partial evacuation of the udder by the suckling calf.

Considering particular structural elements of an udder, four age groups were distinguished: 1st, 2nd, 3rd lactation (I, II, and III, or young cows), and beyond the 3rd lactation (>III, or old cows).

Udder size analyses and somatic cell count (SCC) in milk was carried out between 90 and 120 days of lactation (about the 100th day). Udder measurements were done once, by means of zoometric tools, just before afternoon milking, according to the scheme presented in Fig 1. The following udder traits were analysed (in cm): suspension length, fore depth, rear depth, fore width, rear width, distance between rear teats, distance between fore teats, distance between fore and hind teats, length and diameter of fore and rear teats, distance of the udder from the floor. Udder volume (cm^3) was calculated from suspension length, width and depth.

Fig 1. Scheme of udder measurements: 1 - udder suspension (base) length, 2 - udder fore depth, 3 - udder rear depth, 4 - fore width, 5 - rear width, 6 - distance between rear teats, 7 - distance between fore teats, 8 - distance between side teats, 9 - length of teat (fore or rear), 10 - diameter of teat (fore or rear) measured in half of its length, 11 - distance of fore quarters from the floor, 12 - distance of rear quarters from the floor.



Udder health evaluation was done basing on somatic cell count (SCC per 1 cm^3) in milk samples collected during routine control of milk performance with the method of direct automatic counting in a Combifoss, according to Polish Standards [15].

The results were tested with one-way ANOVA, and the differences between the means tested with Duncan's multiple range test, at the confidence level $p \geq 0.05$ and $p \leq 0.01$. Mean values were calculated, standard deviations, and phenotype correlation indices.

RESULTS

Table 1 presents somatic cell count in 1 cm^3 of milk and changes in udder conformation in relation to cow age. Primiparous cows were characterised by a relatively low SCC, lower than multiparous cows. Together with the age of the cows, increased vulnerability to mastitis was found; SCC in milk in the 1st, 2nd, 3rd, and beyond the 3rd lactation was, respectively (10^3 x cm^{-3}): 78.27, 180.55, 362.56, and 423.92. In the cows in the 3rd and higher lactations, in relation to the first lactation cows, SCC increased about five-fold ($p \leq 0.05$), which demonstrates deterioration of udder health in these animals.

Table 1. Changes in udder conformation with consideration of SCC in milk in relation to lactation number of high-yielding cows (mean ± SD)

Trait	Lactation number				Significance of differences between groups of cows					
	I	II	III	>III	I-II	I-III	I->III	II-III	II->III	III->III
Number of cows	40	20	25	12						
CSS, $10^3/cm^3$	78.27 106.74	180.55 220.33	362.56 668.79	423.92 845.92		*	*			
Distance from rear teats to floor [cm]	53.45 5.46	48.60 5.62	45.16 4.69	37.92 4.19	**	**	**	*	**	**
Distance from fore teats to floor [cm]	53.90 5.01	48.95 4.90	46.68 4.42	39.42 4.14	**	**	**		**	**
Fore udder depth [cm]	26.92 2.57	30.95 2.48	30.80 1.96	32.67 2.93	**	**	**			*
Udder suspension length[cm]	43.92 3.87	45.50 4.37	46.52 4.14	49.0 2.92		*	**		*	*
Fore udder width [cm]	36.65 2.55	38.75 3.85	39.32 4.99	42.00 4.65	*	*	**		*	
Udder volume [dm^3]	43.35 6.51	54.64 9.05	56.55 10.59	67.44 11.38	**	**	**		**	**

*** difference statistically significant at $p \leq 0.05$, ** at $p \leq 0.01$**

Except for the length of rear and fore teats and side teats distance, the age significantly ($p \leq 0.05$ and $p \leq 0.01$) differentiated zoometric measurements of the udders. In primiparous cows, the zoometric measurements were as follows (in cm): suspension (base) length – 43.93, fore depth – 26.92, fore width – 36.65, rear and fore teats distance from the floor – respectively 53.45 and 53.90, distance between fore, rear and side teats – respectively 18.95, 10.22, and 13.17.

Length, width, and depth of udders increased significantly ($p \leq 0.05$ and $p \leq 0.01$) with age. Fore width in multiparous cows of the group II, III, and >III, compared to the primiparous cows, and between the II and >III lactation, increased significantly by, respectively, 5.73, 7.28, 14.60, and 8.39%. With the lactation number, the lowest increase was found for suspension length of udder (between the groups: I-III, I->III, II-III and between III->III– respectively by 5.92, 11.57, 7.69 and 5.33%). Fore depth increased the most (between the groups: I and II, I and III, I and >III, and III and >III – respectively by 4.03 , 3.88 , 5.75 , and 1.87 cm, which constitutes 14.97, 14.41, 21.36, and 6.07%), which no doubt had an effect on a reduction in the percentage of cows with globular shape of the udder – the best for machine milking – and increased frequency of those with droopy udders. Therefore, along with the passed lactations, the distance from the udder to the floor decreased significantly in nearly all the groups (with one exception). For example, fore and rear udder quarters of the cow beyond the 3rd lactation, as compared with the 1st lactation cows, decreased respectively by 14.48 and 15.53 cm (which constitutes 26.86 and 29.05%).

The highest significant (at $p \leq 0.05$ and $p \leq 0.01$) growth dynamics, measured as a relative difference, was found for the changes in udder volume between the primiparous cows and old cows (I->III; difference was 24.09 dm^3, which constitutes 55.57%) and remaining groups of cows (I-III, I-II, II->III, III->III – differences were respectively: 30.45, 26.04, 23.43, 19.26%).

Table 2 presets the results of the evaluation of effect of age on average size and distance between teats. The cows were characterised by cylindric yet slightly short rear teats (4.72 in I and 5.19 cm in >III). The fore teats were slightly longer (5.72 in I and 6.27 cm in >III). It was found that in multiparous cows at a higher lactation than 3, compared with primiparous cows, fore and rear teats elongated respectively by 0.55 and 0.44 cm, which constituted 9.61 and 9.32%.

Table 2. Mean values of length, diameter, and span of teats of high-yielding cows in subsequent lactations (mean ± SD)

Trait	Lactation number				Significance of differences between groups of cows					
	I	II	III	>III	I-II	I-III	I->III	II-III	II->III	III->III
Number of cows	40	20	25	12						
Fore teats length	5.72 0.82	6.10 1.11	6.12 0.99	6.27 1.43						
Rear teats length	4.72 0.74	5.05 0.72	4.98 0.80	5.16 1.24						
Fore teats thickness	2.88 0.29	3.04 0.22	3.04 0.19	3.20 0.21	*	*	**			
Rear teats thickness	2.86 0.32	3.06 0.25	3.08 0.24	3.32 0.29	*	**	**		*	*
Fore teats span	18.95 3.85	20.75 4.62	20.44 4.06	23.92 4.60			**		*	*
Rear teats span	10.22 3.41	12.30 4.34	12.36 3.07	14.42 2.54	*	*	**			
Side teats span	13.17 1.92	13.50 2.06	13.92 3.05	14.58 2.15						

For symbol explanations see Table 1

With age, teat diameter grew significantly ($p \leq 0.05$ and $p \leq 0.01$), except for the groups II-III, II->III, III->III (fore teats) and II-III lactation (rear teats). Diameter of fore and rear teats in primiparous cows was, respectively, 2.88 and 2.86 cm; in older cows, >III lactation, respectively 3.20 and 3.32 cm. The cows beyond the 3rd lactation, in relation to I, had rear teats thicker by 16.08% and fore teats thicker by 11.11%.

In subsequent lactations, also the distance between teats increased. The highest values of zoometric measurements for the distance between fore teats (23.92 cm), rear (14.42 cm), and side teats (14.58 cm) were found in the oldest animals > III. The differences in fore teats distance between the primiparous cows and the >III cows (4.97 cm, or 26.23%) and between the groups II and >III (3.17 cm, which is 15.28%) and III and >III lactation (3.48 cm, which is 17.02%) and the distance between rear teats between the groups I and >III (4.20 cm, which is 41.09%), I and III (2.14 cm, which is 20.94%), I and II (2.08 cm, or 20.35%) turned out to be statistically significant ($p \leq 0.05$ and $p \leq 0.01$). The values of side teats distance for all the studied groups of cows were found to statistically similar.

Table 3. Values of coefficients of correlation (r) for zoometric measurements of udder vs. SCC in milk

Trait	SCC
Distance from rear teats to floor	-0.30**
Distance from fore teats to floor	-0.29**
Fore udder depth	0.24*
Udder suspension length	0.16
Fore udder width	0.15
Fore teats length	0.04
Rear teats length	0.08
Fore teats thickness	0.27**
Rear teats thickness	0.28**
Fore teats span	0.08
Rear teats span	0.22*
Side teats span	-0.07
Udders volume	0.26*

For symbol explanations see Table 1.

Table 3 groups the coefficients of correlation for particular elements of conformation and volume of udders and the somatic cell count (SCC) in milk. The values of the coefficients of correlation r for the analysed traits of udder conformation and SCC in milk were statistically varied (at $p \leq 0.05$ and $p \leq 0.01$); they ranged between r = -0.30**, for the distance from rear udder to the floor and SCC in milk, and r = 0.28**, for rear teats thickness and SCC. Positive correlations were found between SCC and the thickness of fore and rear teats (respectively, r = 0.27** and r = 0.28**), udder volume (r = 0.26*), fore depth of udder (r = 0.24**), as well as the distance between rear teats (r = 0.22*). Negative coefficients of correlation were found between SCC in milk and distance from fore and rear teats to the floor (respectively, r = -0.29** and r = -0.30**); the remaining relationships were low and statistically non-significant.

DISCUSSION

Cytological milk quality, according to the criteria given by Polish Standards [15], placed the milk of the primiparous cows in the class “extra”, that of the groups II and III in the 1st class, and of >III group of cows – in the 2nd class. The results obtained in this study deviate considerably from some published data [9, 13]. Ormian *et al*. [13] found a 2-fold increase of somatic cell number in the milk of IV lactation cows in relation to first lactation cows; the lowest SCC was recorded for samples from second lactation cows (415 x 10^3 cm^{-3}). The result similar to this report were obtained by Ludwiczuk *et al*. [9], who demonstrated the lowest SCC in milk of primiparous cows (276 x 10^3 cm^{-3}) and the highest in the 7th and higher lactations (710 x 10^3 cm^{-3}).

The analysed herd of high-yielding cows was characterised by normal udder conformation, especially in primiparous cows. The studied animals, as compared with primiparous B&W cows imported from Holland [7], displayed similar, and those imported from France to Poland [17], slightly lower indices of udder conformation. It was also demonstrated that the cows from France were little more vulnerable for udder diseases than their contemporaries imported from Germany [13].

Presented results confirm the opinion of a number of authors [5, 14, 17, 21], who state that the number of undergone lactations (or age) affects the size and shape of the udder. These study allowed concluding that multiparous cows had a significantly (at $p \leq 0.01$) larger volume of the udders than primiparous cows. Similar rate of changes in udder volume with age was observed in other studies, including the fact that udder volume in III lactation in comparison with I lactation increased by 47.7% [21], or by 54.27% [14], or even by 67.6% [8]. As a consequence of udder depth increase, the distance from the udder to the floor was reduced. It has been widely recognized that the udder that is suspended too low, below 45 cm from the floor, impede putting on the teatcups. The trend of udder lowering with age of a cow has been commonly observed in practical cattle breeding [5, 8, 14, 21].

This study demonstrated that for a cow after a number of lactations, rear teats grew more intensively than fore teats. Other authors [8, 14, 17, 21], who studied B&W cow populations, found a similar trend for the growth of teat diameter; in the 3rd lactation, as compared with the 1st, rear teat were thicker by, on average, 10.0%, while fore teats – by 8.5%. Fore and rear teats lengths, similar to those obtained in this study, were found in primiparous B&W cows (respectively 5.20 and 4.69 cm), imported from France [17], and slightly shorter teats (respectively 4.91 and 3.95 cm) in young B&W cows imported from Holland [7].

The changes with subsequent lactations in teat span, observed in this study, were influenced by larger growth of udder width than their length. Similar trend in the growth of udder size in B&W cows was found in previous studies [17]. On the other hand, larger growth of udder length than their width, in relation to age of cows, was demonstrated by many authors in their reports [5, 8, 14, 21].

It has been observed that the young cows, which have the udders suspended high above the floor (more than 45 cm), of not so long rear teats (about 5.0 cm) and fore teats (6.1 cm), and their average diameter, about 3.0 cm, produced milk classified as “extra” [15]. On the other hand, the old cows with droopy udders, less than 45 cm, of too long rear teats (more than 5.1 cm) and fore teats (6.2 cm), as well as of diameter above 3.2 cm, were more vulnerable to inflammatory states of udders (increased number of somatic cells in milk). Similar dependencies between udder conformation of B&W cows and mastitis were reported in another study [6]. Also in other studies [2], it was observed that cows with excessively droopy udders, significantly more frequently showed macroscopic changes in milk, positive results of on-site cellular reaction test, mechanical and bacterial irritations.

For the studied population of high-yielding cows, the increase in the thickness of fore and rear tears, depth of fore udders, rear teats span, and volume of udders versus SCC in milk, were related with increased number of somatic cells in 1 cm^3 of milk. On the other hand, the increased values of zoometric measurements, distance from fore and rear teats from the floor, and size span between teats were accompanied by a reduced number of somatic cells in milk. This means that with udder conformation improvement, i.e. with increasing distance from the udder to the floor, and with side teats span, hygienic quality of milk improved. Also in other reports [2, 5, 6, 10, 12, 16, 20, 24], a significant relationship has been observed between cow udder size (suspension, distance from the floor, and udder and teat shape) and incidence of mastitis. The authors stress, nearly in accordance, that genetic correlations between udder conformation traits and somatic cell count and clinical mastitis incidence are low, but indicate mastitis-predisposition of the cows with faulty suspended udders, long and abnormally distributed teats. On the other hands, studies carried out by Dutch researchers [1] demonstrated that genetic correlations between breeding values, milking speed, and somatic cell count or udder traits, were low and close to zero.

CONCLUSIONS

1. Age of the cows significantly influences the growth of values of zoometric measurements of udders, except for the distance from the udder to the floor, which decreased.
2. The relationship between udder fore depth, rear teats span, and udder volume and somatic cell count were statistically significant ($p \leq 0.05$), while between teat diameter, distance to the floor, and SCC in milk were statistically highly significant ($p \leq 0.01$). Therefore, selection for cows with high suspension of udders is recommended.
3. In subsequent lactations, somatic cell count in milk showed rising trend, which demonstrates higher vulnerability of the cows to mastitis.

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