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SELECTION POSSIBILITIES AIMING THE IMPROVEMENT THE MILKING ABILITY IN HUNGARIAN SIMMENTAL BREEDING STOCKS

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1 BACKROUND OF RESEARCH, OBJECTIVES

In the recent decades selection towards high milk yield has been resulted in spectacular increase of dairy performance in almost all dairy and dual purpose cattle populations. Physiological load on the health status of the udder has been raised simultaneously. The health status per se might be considered as a key factor in realisation of genetically determined traits of milk production ability. Mastitis is known as a polifactorial disease and may cause high economic losses. One of the factors involved in the manifestation of mastitis may be due to improper milk flow rate during milking. From the view-point of low health status of the udder the disease may be caused by imbalance of quarters (overmilking) and slow or fast milk flow rate, however, both are disadvantageous **(Holló and Babodi, 1979; Bahr et al., 1995; Naumann et al., 1997; Vági, 2002).**

Attempts for milk flow measurements were made even in the first half of the last century (1950-1980). As a result of R & D activity all facilities were already available for this purpose (*Uberograf, Elfa-Impulsa type M 901/1,* a milking machine equipped with clusters for milking quarters separately). Routine measurements of milk flow rate in milking parlours, however, were not possible by the types mentioned above. Thus, no further experiments on milk flow rate were done at the end of the last century from the 80ies. Ever since, during the recent years technical development has allowed constructing electronic milk meters *(Lacto Corder – WMB AG and Tru-Test – Tru test Ltd.)* which are adjusted to improved milking technologies and can measure milk flow rate parameters fast and properly.

Conditions outlined above may give reasons for elaboration measurement techniques to record traits influencing milk flow rate on dairy operations equipped with state of the art level and/or up to date feeding and milking practice to be recommended for widespread distribution.

The main goals of the experiments subjected to my Ph.D. thesis were the followings:

1. Methodological development of milk flow rate measurements for the Hungarian Simmental cattle breed adjusted to current demands and technical possibilities.

- Evaluation milk flow parameters of the Hungarian Simmental cattle herds.
- Estimation of the correlation coefficients among milk flow parameters.
- Improve of the milk flow rate measurements' reliability through the estimation of the correlation coefficents among the milk flow rate parameters recorded in the morning and evening milkings.
- Description of the relationship between milk flow parameters and health status of the udder.
- Examination the effects of some factors (time of the day, phase of lactation, parity) on milk flow rate parameters.

2. Analysis the sphincter of teat canal barrier's influence on milk flow rate parameters and health status of the udder.

- Establishment the anatomical changes of the sphincter of teat canal barrier caused by milking.
- Examination the relationship between the morphological traits of the udder and milk flow rate parameters.
- Exploration the connections between the morphological traits and health status of the udder.

2 MATERIALS AND METHODS

2.1 Milk flow rate measurements

The research was conducted at Hungarian Simmental seedstock herds raising potential young breeding bulls. Milk flow rate was measured using 14 *Lacto Corder* (*WMB-AG*) electronic milk flow meters developed for routine recordings. Beside milk flow rate parameters (average and highest milk flow rate, duration of the highest, i. e. peak milk flow rate period, the length of uniform and descending phase) individual curves were also recorded. Applying the milk flow meter's adapter the obtained data can directly be stored into computer and can promptly be analysed with the *Lacto* software (Version 3.74) specifically developed for *Lacto Corder*.

Performances of 1466 Hungarian Simmental cows were recorded either during their first or subsequent lactations in six seedstock herds. At the times of the measurements 599 cows produced milk between the 50-180th day of their lactation. From these 599 individuals 186 and 413 cows were uniparous and multiparous, respectively. Mean values, standard deviations and the correlation coefficients of the milk flow rate parameters, were determined separately for uniparous and multiparous cows.

Adjusting my research protocol to the performance testing code of the Hungarian Simmental Cattle breed, examination the effects of parity on milk flow rate parameters was entirely based on the data of cows (either uniparous or multiparous) that were between the 50-180th day of their lactation.

From the 599 cows which were between the 50-180th day of their lactation, milk flow rate parameters of the morning and evening milking could be recorded on the same day only for 478 cows due to technical and work organisation reasons. Estimation of the correlation coefficients among the milk flow rate parameters recorded in the morning and evening milkings was based solely on the above mentioned 478 cows' performance.

Simultaneously representative milk samples were collected for SCC analysis by built in samplers (*of Lacto Corder*) between the 50-180th day of the lactation. Individual somatic cell counts were logarithmically transformed. Relationship between milk flow parameters and health status of the udder was determined using the transformed data.

The effect of the lactation phase on milk flow rate parameters was evaluated using the data of 1466 cows from their first or latter lactations. Lactation was divided into 60 days long periods. In each period six groups were formed. Individuals were sorted into these groups taking the phase of their lactation into account.

2.2 Ultrasonic udder morphology examination

Ultrasonic measurements were taken on 72 Hungarian Simmental cows *(Hitachi Oculus 9100 type)* at the dairy farm Kakasd (*Pannonia Agricultural Ltd., Bonyhád, Hungary*). Measurements covered all quarters (teats) just before and after each milking as well as 1 and 2 hours later. Teats were placed into water bath of 37-38 °C in all cases. Recordings were processed by *Nikon Lucia M* software where area of teat end, that of sphincter and length of teat canal (ductus capillaries) were determined. After the UV measurements, milk flow rate parameters were measured using *Lacto Corder* electronic milk meter, as well. In order to be able to establish relationship between anatomic characteristics of teat and health status of the udder 72 Hungarian Simmental cows were assorted to low and high SCC groups consisting of 36 individuals each, with milk somatic cell counts below 250000 and above 400000 per ml milk, respectively. Animals were randomly selected following the order of the subsequent calvings. Statistical analysis was conducted using the SPSS (for Windows 9.0) package.

3 RESULTS AND DISCUSSION

3.1 Milk flow rate measurements

3.1.1 Milk flow rate parameters of uniparous and multiparous Hungarian Simmental cows

In the first lactation, average milk flow rate was lower (1.78 kg/min) than the desired value (2.00 kg/min) in breeding goal of Hungarian Simmental cows. The former value improved compared to previous records and was equal to average milk flow rate measured in Simmental populations of other countries. From the view-point of udder health status, it is favourable that the highest milk flow rate of uniparous cows exceeded the desired value by only 0.80 kg/min. Moreover the highest milk flow rate above 4.00 kg/min,

which is too fast from the physiological aspect was found only in few cases. That means a relatively consistent milk flow during the milking process reducing the risk of mastitis.

Analysis of time parameters characterising the milk flow rate curves' shape showed that in the first lactation duration of the constant and descending phase of milk let down was almost equal (2.22 and 1.94 min.). Consequently, duration of milk let down in Hungarian Simmental cows can be characterised by two equal phases with a consistent and decreasing milk flow, which highlights the importance of proper machine stripping practice.

Comparing milk flow rate parameters average and maximum values did not differ among lactations. It has to be noted however, that the ratio of the constant and descending phases of milk let down was worse in multiparous than in uniparous cows.

3.1.2 Correlation coefficients among milk flow parameters

It was noteworthy that the correlation coefficients between the milk yield and the average and highest milk flow rate were moderate and low ($r = 0.35$; $r = 0.18$). Vági (2002) received similar results, contrary to the findings of other authors (**Dohy, 1958; Guba, 1964; Szajkó, 1969; Eckhard and Breitenstein, 1970; Naumann, 2001**).

Moderately high correlation coefficient ($r = 0.64$) was observed ($P \leq 0.001$) between the main milk flow rate's duration and milk yield, which means higher milk yield resulted longer duration of the main milk flow rate.
From methodological view-point, the high correlation coefficient between average and maximum milk flow rate has to be noted ($r = 0.84$; $P \leq 0.001$). This correlation provides opportunity for the application of the average milk flow rate as a selection criterion in the breeding scheme.

3.1.3 Time of the day's effect on the milk flow rate parameters

Correlation coefficients estimated between the average and maximum milk flow rates, and between the durations of consistent milk flow periods recorded in the morning and evening milkings were high ($r = 0.80$, $r = 0.86$, $r = 0.72$; $P \leq 0.001$). However, parameters such as the duration of consistent and descending phase of the milk flow period showed high variance,

connected with the high sensitivity of the cows to external stimuli (noise, massage of the udder), which can influence milk let down (alters the milk flow rate curves' shape).

Based on the estimated phenotypic correlation coefficients in the course of milk flow rate measurements, individual average and maximum milk flow rates can be determined by a single daily recording without substantially decreasing the reliability. However, if the necessary technical equipments are available and recording the time parameters characterising the milk flow rate curves' shape belong to our objectives then at least two daily measurements are needed in order to obtain reliable data.

3.1.4 Correlation coefficients between milk flow parameters and health status of the udder

Low and negative correlation coefficients were estimated between SCC one of the indicators of udder health and the two most important milk flow characteristics, namely the average and peak milk flow rate ($r = -0.27$; $r = -0.23$). Findings suggest that increasing the milk flow rate may reduce the risk of mastitis.

Thus the longered duration of the milk flow period enhances the probability of mastitis development justified by the received positive correlation coefficient ($r = 0.31$, $P \leq 0.01$) between the SCC and duration of consistent milk flow period.

Time parameters (uniform and descending phases) characterising the milk flow rate curves' shape and SCC showed low correlation coefficients ($r = 0.22$, $r = 0.15$; $P \leq 0.01$).

3.1.5 Factors influencing milk flow rate parameters

From the methodological view-point the appropriate lactation phase and parity has to be specified for reliable measurements of milk flow rate. Based on the results significant differences were found for the highest milk flow rate prior to the 180^{th} day of lactation and afterwards.

Moreover milk flow rates recorded in multiparous cows can efficiently be used in the selection of potential sires as no significant differences were found between the measurements of the first six lactations. Consequently

size of database for breeding value estimation can be enlarged, which is the key factor in order to increase the reliability of the predicted breeding values.

3.2 **Ultrasonic udder morphology examination**

3.2.1 Impact of milking on the morphological traits of the udder

Based on the investigations for udder morphology by ultrasonic measurements it was observed that due to mechanical effects of milking the length of the teat canal increased cca 10% (from 13.14 mm to 14.38 mm). The length gradually decreased during the regeneration process reaching 13.81 mm one hour after milking and regained its original value in another 60 minutes.

Mechanical effects of milking induced similar increasing and decreasing changes in the area of the teat end and sphincter muscle. Area of the teat end increased from 493.78 mm^2 to 525.17 mm^2 and regressed back to its original length two hours after milking. Area of the sphincter muscle showed similar pattern 431 mm^2 measured prior to milking, which increased to 475.26 mm^2 and gradually decreased thereafter.

3.2.2 Correlation coefficients between the morphological traits of the udder and milk flow rate parameters

The sphincter muscle of teat canal barrier's correct functioning hence preserving its mechanical preventive role is a key factor to avoid intramammary infections. Inconsistent results can be found in the literature about the effects of the teat canal length and are of the sphincter muscle on the milk let down and milk flow rate parameters.

Development of the sphincter muscle of teat canal effected the highest milk flow rate more than the average milk flow rate. Accordingly the observed correlation coefficients were $r = -0.32$ and $r = -0.21$, respectively.

Enlargement of the area of the sphincter muscle decreased both the average and the highest milk flow rate which phenomenon may be explained by the

sphincter of teat canal barrier's influence on milk flow rate. Low but significant correlation coefficients were found between the investigated morphological traits of the udder (teat canal length, area of the sphincter muscle) and time parameters (constant and descending phase of milk let down) ($r = 0.14\text{-}0.16$; $P \leq 0.05$).

3.2.3 Correlation coefficients between the morphological traits and health status of the udder

In the course of my research I wanted to determine the effect of morphological parameters (teat canal length, area of sphincter muscle) - obtained through ultrasonic measurements - on the health status of the udder.

It can be concluded that the enlargement of the teat canal length and sphincter muscle development increases the risk of mastitis, which is justified by the increasing SCC. Teat canal length and area of sphincter muscle showed low but significantly positive correlation coefficients ($r = 0{,}18$; $r = 0{,}24$; $P \leq 0.05$) with SCC one of the indicators of udder health. The received correlation coefficients may be explained by the sphincter of teat canal barrier's influence on milk let down. It may be argued that in the Hungarian Simmental cows 12-13 mm teat canal length is optimal which does not hinder the milk let down and its mechanical preventive role can also be realised.

4 CONCLUSION

4.1 Milk flow rate measurements

- Hungarian Simmental uniparous cows showed lower average milk flow rate (1.78 kg/min) than the desired value (2.00 kg/min) in breeding goal of the breed. The former value improved compared to previous records and was equal to average milk flow rate measured in Simmental populations of other countries.
- From the aspect of udder health status, it is favourable that during the first lactation the highest milk flow rate of the Hungarian Simmental cows exceeded the average milk flow rate only with 0.80 kg/min. Moreover the highest milk flow rate above 4.00 kg/min, which is too fast from the physiological view-point was rarely found. That means a relatively consistent milk flow during the milking process reducing the risk of mastitis.
- Based on the examination of time parameters characterising the milk flow rate curves' shape it can be concluded that duration of the constant and descending phase of milk let down of uniparous cows was almost equal (2.22 and 1.94 min.). Consequently, two equal phases with a consistent and decreasing milk flow is a peculiarity of the Hungarian Simmental cows concerning the duration of milk let down. This feature highlights the significance of proper machine stripping practice.
- Comparing average and maximum milk flow rates the values of these parameters did not differ among uniparous and multiparous cows. Nevertheless the ratio of the constant and descending phases of milk let down was worse in the latter than in the first lactation.
- Investigating the correlation coefficients among milk flow parameters moderate and low correlation coefficients were established between the

milk yield and the average and highest milk flow rate (r = 0.35; r = 0.18).

- From methodological view-point, the high correlation coefficient between average and maximum milk flow rate (r = 0.84; P≤0.001) is worth mentioning, which enables the breeders to record only average milk flow rate in the course of the milk flow rate measurements.
- Among the parameters recorded on the same day correlation coefficients between the average and maximum milk flow rates, and between the durations of consistent milk flow periods of the morning and evening milkings were high and significant (P≤0.001). Time parameters characterising the milk flow rate curves' shape (duration of consistent and descending phase of the milk flow period) showed high variance compared to the other previously mentioned parameters.
- The two most important milk flow characteristics, namely the average and peak milk flow rate showed low and negative correlation coefficients with SCC one of the indicators of udder health (r = -0.27; r = -0.23). This result suggests that adequate milk flow rate can decrease the risk of mastitis.
- The present research seems to justify the previous supposition that milk flow rate parameters can be effected by the phase of lactation. Significant differences were found (P≤0.001) for the highest milk flow rate measured prior to the 180^{th} day of lactation and thereafter.
- Milk flow rates recorded from multiparious cows can be used in the selection process of sire candidates as no significant differences were found between the measurements of the first six lactations.

- The accomplished experimental work of my thesis proved that the current electronic milk flow meters make quick efficient measurements of milk flow rate possible without disturbing the work scheme.

4.2 Ultrasonic udder morphology examination

- Ultrasonic measurements proved that due to mechanical effects of milking the length of the teat canal, area of the teat end and area of the sphincter muscle increased more than 10%. During the regeneration process subsequent to milking their length and area approximated back to the original values.
- Enlargement of the teat canal length and area of the sphincter muscle decreased the two most important milk flow rate parameters (average and the highest milk flow rate). Analysis of the predicted correlation coefficients pointed out that dilatation of the teat canal connected with development of the sphincter muscle effected the highest milk flow rate more than the average milk flow rate.
- In connection with the ultrasonic measurements it can be concluded that the enlargement of the teat canal length increases the risk of mastitis which finding was justified with the increasing SCC. This may be explained by the influence of the teat canal length on milk let down. According to the results it may be argued that in the Hungarian Simmental cows 12-13 mm teat canal length is optimal, which does not hinder the milk let down and its mechanical preventive role can also be realised.

5 NEW SCIENTIFIC RESULTS

- In spite of the considerable genetic improvement achieved during the last three decades milk flow rate parameters of the Hungarian Simmental cattle breed still show high heterogeneity. Among the time parameters characterising the milk flow rate the approximately equal duration of the constant and descending phase of milk let down highlights the significance of proper machine stripping practice.
- Instead of two daily measurements which is a common practice when electronic milk meters are applied a single daily recording is sufficient as correlation coefficients estimated between the average and maximum milk flow rates of the morning and evening milkings are high.
- Milk flow rate parameters are effected by the phase of lactation. Selection aiming to improve milk flow rate parameters has to be based on data measured prior to the 180^{th} day of lactation. However contrary to the previous standard directions breeding programs may use milk flow rates recorded in the second and third lactations besides that of the firs lactation.

6 SCIENTIFIC PAPERS AND PRESENTATIONS ON THE SUBJECT OF THE DISSERTATION

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