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INFLUENCE OF EWE ENTRY ORDER INTO MILKING PARLOUR ON MORNING MILK YIELD WITH RESPECT TO EWE AGE AND YEAR OF MEASUREMENT

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ABSTRACT

The objective was to analyse effects of ewe entry order into milking parlour with respect to ewe age and year of measurement on morning milk yield. The measurements (5528) of milk yield mostly in the middle of lactation were taken from 550 ewes of Slovak dairy breed over five years (on average two measurements per ewe and year). Mixed model included fixed factors: milking phase (MP1, MP2 and MP3), ewe age (2, 3 to 10), year (2013, 2014 to 2017) and interaction milking phase x ewe age, and random effect of ewe. Ewes were assigned to milking phases according to their entry order into milking parlour (taking into account batch number and stall number within batch). All fixed factors showed the significant effect on milk yield, except for milking phase: 482 ± 11 ml (MP1), 464 ± 8 ml (MP2) and 444 ± 15 ml (MP3), although ewes with earlier entry order had higher milk yields. Three- to six-year old ewes had higher milk yields than two- and seven- to ten-year old ewes. Significant differences were found predominantly between morning milk yields of three- and four-year old ewes (509 ± 12 ml and 538 ± 10 ml), five- to seven-year old ewes (decreasing from 525 ± 11ml to 471 ± 14 ml) on one side, and milk yields of eight-, nine- and ten-year old ewes (decreasing from 421 ± 17 ml to 311 ± 35 ml) on the other side. According to year of measurement, milk yield increased from 406 ± 12 ml (2013) to 530 ± 10 ml (2015), afterwards decreased and increased again (406 ± 9 ml and 510 ± 26 ml). The significant differences were found only between some years. An interaction milking phase x ewe age showed that milk yields tended to follow patterns found when these factors were analysed individually. Higher milk yields were found in four- and five-year old ewes of MP1 group, lower milk yields were found mostly in nine- and ten-old ewes of MP2 and MP3 groups. Only few levels of this interaction showed significant differences between each other.

Key words: sheep; age; milk production; milking phase

INTRODUCTION

In animal husbandry, ever more issues are emerging in relation to lack of staff, while the demand for hygiene of milk production is constantly increasing. Under these conditions, machine milking appears to be the ideal solution. In machine milking of sheep, it is necessary to ensure good task management, correct parameters of the milking equipment, and not least also the knowledge of and respect to the biological needs of sheep during milking and the manipulation with them. Reaction of the sheep to the milking equipment and their behaviour during the entire process is an important factor, which influences lactation milk yield. Sheep learn relatively quickly to enter and leave a milking parlour. The entire process can be sped up by providing fodder feed during milking. During a period of feed deprivation or hunger, however, this can be a strong incentive for increased aggression and disruption of the existing social structures within the flock. Social hierarchy is a natural and important for characterization of flock animals. It directs their mutual cohabitation, determines the position of the individual

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animals within the hierarchy and their behaviour, and overall allows the flock as a unit to satisfy the needs of all animals.

Behaviour of the livestock, social hierarchy, dominance and order of entry into the milking parlour, and other factors that influence this process have been and remain topics of interest for the experts. Animals on the lower hierarchical levels are more careful, they maintain distance, and during random encounters stop or change directions (Gräser-Hermann and Sambraus, 2001). Their reactions, however, depend also on the situation and are influenced by multiple factors.

While most authors found out that the order of entry into the milking parlour is in the cases of sheep, goats or cattle is not random (Stefanowska *et al*., 2000 in cattle; Keszthelyi and Maros, 1992 and Wasilewski, 1999 in sheep; Margetínová *et al*., 2001 in goats), the results of the studies offer differing and contradictory results.

Age as a factor plays an important role in deciding the social status within a sheep flock (Gräser-Hermann and Sambraus, 2001). Margetínová *et al*. (2003) found out that the older goats enter the milking parlour earlier. However Górecki and Wójtowski (2004) observed (although only for one period of the study) that the younger goats enter the milking parlour earlier. Also, Margetínová *et al*. (2002) reported that the younger ewes entered the milking parlour earlier.

Differing results may be found when an influence of animal entry enter into milking earlier on milk yield is investigated. According to some authors, the animals with higher milk yield enter the milking parlour earlier (Margetínová *et al*., 2003 in goats; Sambraus and Keil, 1997 and Gräser-Herrmann and Sambraus, 2001 in sheep; Polikarpus *et al*., 2014 in dairy cows), whereas Gere *et al*. (2001) reported that animals with lower milk yield enter the milking parlor first (in dairy cows).

The objective of this study was to analyse effects of ewe entry order into milking parlour with respect to ewe age and year of measurement on morning milk yield. Ewes were assigned to three milking phases (MP1, MP2 and MP3) on a base of their entry order into milking parlour (respective batch number and respective stall number within batch).

MATERIALS AND METHODS

The measurements were done with ewes of the Slovak dairy breed kept at the experimental farm of the NPPC – RIAP Nitra located in West Slovakia. The measurements morning milk yield were done under regular production conditions during milking season mostly in the middle of lactation (on average two measurements per ewe and year). A five-year period was included. Ewe entry order into the milking parlour and ewe age were recorded. Morning milk yield measurements were done following ICAR recording guidelines (2014). The first measurement was done within 15 days from the beginning of machine milking. The interval between measurements was 28 days (± 5 days). During milking, ewes were fed with diet supplement of concentrate (100 g per ewe). A total, 550 ewes were included in the analysis. Single-row milking parlour with 24 stands (Farmtec) was used (respective batch number and respective stall number within batch were a base for ewes to be assigned to milking phases: MP1 (48 ewes milked first over individual years), MP2 (ewes neither assigned to ewes milked first nor to ewes milked last) and MP3 (within 48 ewes milked last over individual years). Two measurements of morning milk yields done in the middle of lactation per ewe and year were included in the analysis.

The mixed model methodology using MIXED procedure (SAS, 2009) was applied to study the influence of factors affecting variation of morning milk yield. The model equation was as follows:

$$y_{ijklm} = \mu + MP_i + A_j + MP_i A_j + Y_k + u_l + e_{ijklm}$$

where:

y_{ijklm} – individual measurements of morning milk yield
μ – intercept
MP_i – fixed factor of milking phase (PM1, PM2, PM3); $\sum_i MP = 0$
A_j – fixed factor of ewe age (2, 3, ..., 10); $\sum_j A = 0$
MP_iA_j – interaction milking phase x ewe age $\sum_{ij} MPA = 0$
Y_k – fixed factor of year of measurement (2013, 2014, ..., 2017) ; $\sum_k Y = 0$
u_l – random factor of ewe (1, 2 to 550); $u_n \sim N(0, I\sigma_n^2)$
e_{ijklm} – random error; $e_{ijklm} = N(0, I\sigma_e^2)$

Fixed factors included in the model were estimated using the Least Squares Means (LSM) method. Statistical significances of fixed factors were tested by Fischer F-test; statistical significances of individual differences between estimated levels of fixed factors were tested *post hoc* by Scheffe multiple-range tests. Differences were considered statistically significant when P < 0.05. Ewe and residual error variances were estimated using the Restricted Maximum Likelihood (REML) method. Estimated variances were used to estimate repeatability of morning milk yield that can be interpreted as the proportion of total 0-variance attributable to among-individual variance:

$$r^2 = \frac{\sigma_I^2}{\sigma_I^2 + \sigma_e^2}$$

RESULTS AND DISCUSSION

Analysis of variance of fixed factors affecting morning milk yield (below referenced as milk yield) is given in Table 1. The fixed factors (ewe age and year of measurement) were statistically significant (F = 11.19 and F = 76.31; P < 0.001). The exception was milking phase with P = 0.06 (F = 2.81). The fixed factor of interaction milking phase x ewe age was also statistically significant (F = 2.81; P < 0.001). Differences in milk yield in dependence on individual levels of considered fixed factors are discussed below.

With reference to Table 2, ewes milked first (MP1) had higher milk yield than ewes milked last (MP3) i.e. 482 ± 11 ml vs. 444 ± 15 ml. Remaining ewes (MP2), that were assigned neither to MP1 nor MP3, had milk yield 464 ± 8 ml which fell between values for MP1 and MP3 ewes. No significant differences were found between milk yields of ewes of three groups, although a difference in milk yield between MP1 and MP3 was on the significance limit i.e. P = 0.07 and expected pattern with decreasing milk yield in ewes in dependence of their later entry order was revealed. A similar finding about significance limit (P = 0.05) was reported by Mačuhová *et al*. (2017) between milk yields of ewes milked first and ewes milked last. These authors performed a wider analysis of milkability traits (including milk yield, although this was evening milk yield) and milk composition traits on ewes of various genotypes: purebred Lacaune and crossbreds of Lacaune (sire breed) with either Improved Valachian (dam breed) or Tsigai (dam breed) ewes. Villagrá *et al*. (2007) also reported non-significant effect of entry order into milking parlour on milk yield of Manchega ewes. In contrast,

Table 1. Analysis of variance (statistical significance of Fisher F-test) for morning milk yield

Trait	Sources of variance – Fixed factors			
	Milking phase	Ewe age	Year of measurement	Milking phase x age
Morning milk yield* (ml)	- (P = 0.06)	+++	+++	+++

+++P < 0.001

Table 2. Least squares means and standard errors for morning milk yield by milking phase

Trait	Milking phase		
	MP1 (1) N = 1052	MP2 (2) N = 3420	MP3 (3) N = 1056
Morning milk yield (ml) Scheffe test	482 ± 11	464 ± 8 1:3- (P = 0.07)	444 ± 15

Margetínová *et al*. (2003), who analysed three groups of Slovak White goats assigned according to their order entry into milking parlour, found all differences between these three groups significant ($P < 0.05$ or $P < 0.001$).

Analyses of milk yield according to various ewe ages (Table 3) showed that three- to six-year old ewes had higher milk yields than two-year and seven- to ten-year old ewes. The significant differences were found between milk yields of two-year old ewes (444 ± 15 ml), three- and four-year old ewes (509 ± 12 ml and 538 ± 10 ml), five-, six- and seven-year old ewes (decreasing from 525 ± 11 ml to 471 ± 14 ml) on one side, and milk yields of eight-, nine- and ten-year old ewes (decreasing from 421 ± 17 ml to 311 ± 35 ml) on the other side. Also, milk yield of two-year old ewes significantly differed when was compared to milk yields of three oldest ewe groups i.e. eight-, nine- and ten-old year ewes.

Taking into account year of measurement as a fixed factor included in the statistical model (Table 4), milk yield was increasing from 406 ± 12 ml (2013) and 464 ± 10 ml (2014), respectively, to 530 ± 10 ml (2015); afterwards this decreased to 406 ± 9 ml (2016). In 2017, an increase of milk yield by 104 ml (510 ± 10 ml) than in 2016 was observed. The significant differences ($P < 0.01$ or $P < 0.001$) were found when multiple comparisons were done, see Table 4. These justified that year of measurement was of great importance and variability of milk yield over individual years needed to be account for. This meant that environmental conditions (diet, temperature, rain/drought etc.) within investigated flock might vary over years of measurement.

The interaction milking phase x ewe age showed that milk yields tended to follow patterns found when these factors were analysed individually (Figure 1). According to ewe assignment to MP1,

Table 3. Least squares means and standard errors for morning milk yield by ewe age

Trait	Age	N	Estimate	Scheffe test
Morning milk yield* (ml)	2	1180	444 ± 15	2:8^{+}, 9, 10^{++}
	3	1120	509 ± 12	3:7^{+}, 8, 9, 10^{+++}
	4	937	538 ± 10	4:8, 9, 10^{+++}
	5	711	525 ± 11	5:8,9,10^{+++}
	6	608	503 ± 13	6:8^{+}, 9, 10^{++}
	7	415	471 ± 14	7:9, 10^{+}
	8	289	421 ± 17	
	9	171	359 ± 25	
	10	97	311 ± 35	

$^{+}P < 0.05$, $^{++}P < 0.01$, $^{+++}P < 0.001$

Table 4. Least squares means and standard errors for morning milk yield by year of measurement

Trait	Year of measurement				
	2013 (1) N = 752	2014 (2) N = 1375	2015 (3) N = 998	2016 (4) N = 1420	2017 (5) N = 983
Morning milk yield (ml)	406 ± 12	464 ± 10	530 ± 10	406 ± 9	510 ± 10
Scheffe test	1:2, 3, 5^{+++}; 2:3, 4,5^{+++}; 3:4^{+++}, 4:5^{+++}				

$^{+++}P < 0.001$

MP2 or MP3, the youngest i.e. two-year and three-year old ewes appeared to have higher milk yields in MP2 and MP3 groups. When frequency of these ewes over milking phases was investigated (results not shown), they mostly entered the milking parlour later (43 % and 56 % in MP2 and MP3 vs. 28 % in MP1. The oldest i.e. seven-, eight- and nine-year old ewes appeared to have higher milk yield in MP1 group. The exception was the group of ten-year old ewes which appeared to have higher milk yields in MP2 and MP3 groups. When frequency of the oldest ewes over milking phases was investigated, they mostly entered the milking parlour earlier (23 % in MP1 and 17 % in MP2 vs. 14 % in MP3). This might indicate that ewes gain information and experience and form a habit with age. Consequently, older ewes seemed to enter the milking parlour earlier than younger less experienced ewes. In general, higher milk yields were found in four- and five-year old ewes of MP1 group in comparison to milk yields of ewes of these ages of MP2 and MP3 groups. Only few levels of interaction milking phase x ewe age showed significant differences between each other. No difference between milking phases of ewes of the same age were found.

Findings in this study correspond with experiences of farmers who noticed that especially young ewes in their first milking season entered the milking parlour later due to fact they lack of experience. Many authors reported that ewe age plays an important role in behaviour of ewes within flock. Gräser-Herrmann and Sambraus (2001) analysed East Friesian dairy ewes from three different farms and found that ewe age significantly influenced ($P \leq 0.01$) social status of ewes of various ages within flocks. These authors reported the mutual relation between hierarchical status and milk performance of ewes (ewes with higher milk yield entered the milking parlour earlier). Margetínová *et al*. (2003) reported that entry order into the milking parlour is influenced by age and milk performance in the favour of older sheep. Whereas, Margetínová *et al*. (2002) reported that younger ewes entered the milking parlour earlier than older ewes. This was most likely caused by out-of-season mating, due to which older ewes were started to be milked later in respective milking season. Thus, older ewes were introduced into an already existing system with a predominance of younger sheep and this was probably a reason why they entered the milking parlour later. According to Mačuhová *et al*. (2017), ewes entering the milking parlour first had more favourable milk flow parameters (shorter latency time, higher peak flow rate, and higher milk yield in 30 s and 60 s). With cattle, Polikarpus *et al*. (2014) reported that cows with higher milk yield entered the milking parlour first. The positive relationship between entry order

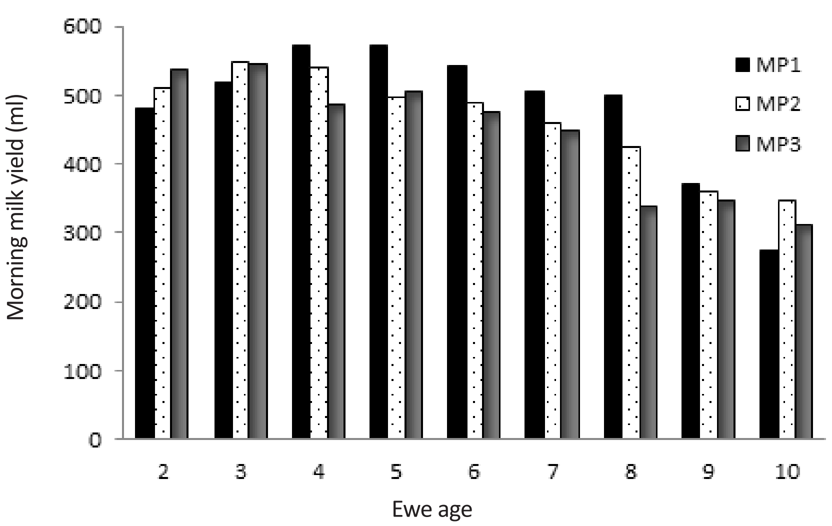

Figure 1. Least squares means for morning milk yield by milking phase x ewe age

into milking parlour and amount of milk was reported by Grasso *et al*. (2007) in cows after first calving (correlation coefficient equalled to 0.22). Littooij and Butterworth (2018) found that older cows were more likely to enter the milking parlour earlier than younger animals.

However, it is necessary to point out another important fact. Social status of an animal within a group is also influenced by feed diet to some extent. Hierarchy and dominance in a group is formed in order to achieve a certain status in a group, which allows respective animal better opportunity to access feed earlier, and often in better quality when comparing to other members of a group. Deprivation, however, causes increased aggression in animals (Syme *et al.*, 1974) and in such situations, subdominant animals cease to respect their order in the group. Animals with higher status have stronger predispositions to satisfy their needs. Farmers use feed mixture offered during milking as a stimulus. Thus, animal are strongly motivated and the vision of feed prompts them towards achieving "benefit". This may work as an advantage for older and more experienced animals. The aspect of supplementary feeding is particularly important during dry grazing season (recently occurring in some regions of Slovakia quite often) and causes aggressive competitive behaviour within the group. Under such circumstances, more noticeable aggression is observed in the dominant animals (Erhard, 2004). Because a social hierarchy is not random, weaker animals are forced to be back during milking. Advantageous access to fodder in dominant animals then influences their milk yield. Larger volume of milk creates pressure in milk gland and "forces" animals to earlier milking. Order of entry into the milking parlour may be also influenced by health issues (Polikarpus *et al.*, 2015). Mačuhová *et al*. (2017) suggest that for ewes with inadequate udder anatomy, milking can be painful and therefore they avoid entering the milking parlour early. Moreover, way of animal handling during milking may cause them pain or discomfort. Dimitrov *et al*. (2017) reported an increased fear in primiparous ewes during milking when teat cups are put on i.e. the preparation of younger ewes to and good organization of machine milking are very important. Other authors (Munksgaard *et al*., 2001; Rushen *et al*., 2001; Grasso *et al*., 2007) also recommended that animals need to be handled gently and, if possible, not to be disturbed. Paranhos da Costa and Broom (2001) observed that some animals, if they have the option, favour the same side repeatedly during milking. This phenomenon, however, was not statistically confirmed until now.

CONCLUSION

Knowledge of the ethological and adaptation abilities of livestock animals, their behaviour and respect to their social and biological needs give the farmer good presuppositions to create optimal breeding conditions. It is necessary to remember that the animals of lower status also need to satisfy their basic needs. To achieve this, also these animals need suitable conditions and stable hierarchy, which has a calming effect on the entire flock. The results of our study can be beneficial with regard to the behaviour of ewes during machine milking.

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