Bulgarian Journal of Agricultural Science, 25 (Suppl. 3) 2019
Agricultural Academy

Behavior of Lacaune sheep in a milking parlour

Ivelina Nedeva[1*], Todor Slavov[1], Ivan Varlyakov[1], Veselin Radev[1], Dimitar Panayotov[2], Krum Nedelkov[3]

[1]*Trakia University, Faculty of Agriculture, Department of Morphology, Physiology and Nutrition of Animals, 6000 Stara Zagora, Bulgaria*
[2]*Trakia University, Faculty of Agriculture, Department of Animal husbandry – Ruminants and Dairy farming, 6000 Stara Zagora, Bulgaria*
[3]*Trakia University, Faculty of Veterinary Medicine, Department of Animal Husbandry, 6000 Stara Zagora, Bulgaria*
[*]*Corresponding author:* iv.nedeva@uni-sz.bg

Abstract

Nedeva, I., Slavov, T., Varlyakov, I., Radev, V., Panayotov D. & Nedelkov, K. (2019). Behavior of Lacaune sheep in a milking parlour. *Bulg. J. Agric. Sci., 25* (Suppl. 3), 74–80

The aim of the study was to evaluate the effect of intensive farming of dairy ewes on their behavior during the milking process. The study was focused on the entry order and preference for a specific milking side, either left or right, of the milking installation. The data from 215 Lacaune ewes over a whole lactational period (240 days) were analyzed. Groups were formed according the following parameters: productivity (high- or low- producing); order/sequence of entry for milking (first group – FG and last group – LG); with preference (SP) or without preference (NoSP) for the side of the milking installation. Our results showed that most of the animals developed a preference for the entry order (FG, Index of Entries in the Milking Installation /IEMI/ = 668.62; LG, IEMI = 129.31) and the side of the milking station (SP, Index of Side preference in the Milking Installation /ISMI/ = 69.38%; NoSP, ISMI = 31.85%), but not to the milking place, which favors the process of machine milking in the milking parlour.

Keywords: sheep; milking order; milking; milk flow; milking parlour

Introduction

Studies investigating behavioral responses of farm animals give us the opportunity to develop new breeding strategies that meet the biological requirements of animals. Thus, besides promoting animal welfare and providing the opportunity to realize the full individual potential, it also achieves an increase in the productivity of the whole herd. Everyday activities, such as milking, can be made more effective by knowing and using the specific behavioral responses of animals (Fraser & Broom, 1990; Wasilewski, 1999; Paranhos Da Costa et al., 2001).

Ewes are social animals that live in groups with a strictly hierarchical structure built for a certain period of time. They walk, run, graze and rest together. These activities are usually initiated and led by the oldest ewes in the group (Bryson, 1984). The characteristics of ewes' social behavior are particularly important when developing intensive sheep dairy farming. Some of the distinctive features of dairy ewes' social behavior in the milking parlour include the consistent order of entry and preferences of the animals towards the side of the milking installation. Some authors (Hopster et al., 1998; Margetinova et al., 2003; Villagre et al., 2007) found thatthe order of entry into the milking parlour depends on the type of animals, breed, social status, milk productivity, lactational stage, health status and others. In some farm animals such as cows (Stefanowska et al., 2000), sheep (Keszthelyi et al., 1992; Wasilewski, 1999) and goats (Donaldson et al., 1967; Margetinova et al., 2003; Varlyakov et al., 2018) it was established that the order of entry into the milking par-

lour was not random, i.e. animals build a conditioned reflex under the influence of various factors. Sometimes milking in a milking parlour can cause stress to the animals, for example if the milking protocol is changed for some reason, and thereby potentially deteriorating their health status. When animals are stressed, their heart rate rises and the release of oxytocin, which helps milk secretion, is reduced or its action is neutralized by the secretion of adrenaline. This causes an interruption of milk letdown and can lead to mammary gland infections (Macuhova et al., 2002; Polikarpus et al., 2015; Tancin et al., 2015).

Over the past few years, there has been an increasing interest in ewes from dairy breeds and dairy sheep products. The largest producer of ewe's milk is China (17%), but nevertheless about 61% of world sheep's milk production comes from the Mediterranean and the Middle East.This milk is mainly used for the production of cheese and other dairy products. Ewe's milk is an excellent source of nutrients (proteins, fats, vitamins and minerals) and provides a suitable substitute for people who are allergic to cow's milk. (Moatsou et. al., 2004; Park et. al., 2007; Bralowska et al., 2011; FAO, 2014). Ewe's milk production in Bulgaria is 71.536 t, which is about 6.9% of the total milk production in 2018 (Agrostatistics, 2018).

In the last few years, one of the most productive dairy ewe breeds – Lacaune has been imported into Bulgaria. Its selection until a few years ago was based on the global criteria for the selection of dairy products (improvement of milk fat and protein content). With the implementation of intensive production systems, including the improvement and modernization of milking parlours, characterizing the ease of milking the ewes has become a key factor in improving the selection process of this breed. The success of the milking process requires an optimum milking rate and a calm behavior of the animals in the milking parlour, which in turn has a beneficial effect on udder health (Marie-Etancelin et al., 2006).

The objective of this study was to evaluate the effect of intensive breeding of Lacaune sheep on their behavior during the milking process. The study was focused on the entry order, the preference for a specific milking place, on the left or right side of the milking station, and the influence of the stage of lactation and productivity on these indicators.

Material and Methods

Study area

The study was carried out at the "Elite Lacaune Breeding Sheep Farm" located in the area of Saedinenie, Plovdiv District. Currently, the farm raises 2200 breeding ewes from which year-round production is obtained. The first 340 sheep on the farm were imported in 2013 from France. The animals are kept in stalls year round where the zoosanitary requirements are met. The micro-climatic conditions in the stalls monitored daily. Feed at the ewe farm is delivered as a total mixed ration with the help of feed mixers. The sheep farm is equipped with a modern *DeLaval 2x36* milking parlour, which can milk 72 ewes at a time. The milking parlour is equipped with the most up-to-date and advanced *DeLaval DelPro* farm management software. The ewes were milked twice daily (6:00 AM and 6:00 PM).

Although we had a common database, the data for 215 sheep reared as one group were selected for analysis. Animals were blocked by age and stage of lactation.

During the experimental lactational period the sheep were fed the following rations (Table 1).

Table 1. Ingredient composition of the diet fed during the lactation period (0-240 days postpartum)

Feeds	Amount fed up to 90 days, kg	Amount fed from 90 to 150 days, kg	Amount fed from 150 to 240 days, kg
Alfalfa haylage	1.1	1.0	0.0
Alfalfa hay	1.2	1.2	0.7
Wheat straw	0.5	0.5	0.5
Concentrated mix.	1.2	0.5	0.5
Ground corn	0.1	0.1	0.0
Sugar beet	0.2	0.0	0.0
Total	4.3	3.3	1.7

Experimental groups of sheep

The indicators and criteria used for forming the experimental groups are presented in Tables 2, 3, 4, 5 and Figure 1.

Based on the obtained data for the production of the experimental Lacaune sheep, we divided them into two groups, respectively: high- (HP) and low- (LP) production. The average daily production of the experimental animals was 2.451 L, and the highest peak of 3.967 L was observed in the middle of the lactation. Taking into account only the average values, we concluded that the maximum daily milk yield was typical for a small number of ewes, because the highest production found at the beginning of lactation was 2.906 L. The lowest daily milk yield of 0.838 L was observed in the early lactation period (Table 3). Noteworthy is the increase in minimum milk yield values with advancing stage of lactation, causing the smallest difference between minimum and maximum values to occur at the end of lactation.

For the high-producing group we identified those with an average daily milk yield of 2.948 liters, with values ranging from 2.143-3.967 liters (Table 4). In the HP group was

Table 2. Indicators and criteria for the formation of experimental groups

Indicators	Experimental groups	Methods of determination
Productivity	High producing (HP)	$x_{max} - (x_{max} - \bar{x})/2$
	Low producing (LP)	$\bar{x} - (\bar{x} - x_{min})/2$
Lactation stage	Beginning of lactation	90 day
	Middle of lactation	90-150 dey
	End of lactation	150-240 dey
Score	Dominant(FG)	Index Rank ≥ 80%
	Subordinates (LG)	Index Rank ≤ 20%
Side of the milking installation	Preference (PS)	ISMI ≥ 66%
	No preference (NoPS)	ISMI ≤ 65%

Table 3. Herd productivity data (liters per day)

Parameters	Lactation stage			Total
	Beginning	Middle	End	
n	165	237	218	215
x	2.906	2.239	2.208	2.451
Sx	0.070	0.252	0.189	0.171
Max	3.844	3.967	3.813	3.967
Min	0.838	1.018	1.431	0.838
Diff	3.006	2.950	2.383	3.130

Table 4. Daily milk yield – high producing (liters per day)

Parameters	Lactation stage			High Productivity
	Beginning	Middle	End	
n	33	48	44	43
x	3.122	2.989	2.838	2.948
Sx	0.034	0.040	0.065	0.054
Max	3.844	3.967	3.813	3.967
Min	2.918	2.143	2.201	2.143
Diff	0.926	1.824	1.612	1.824

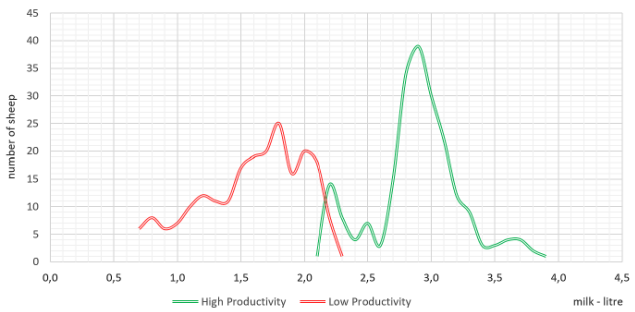

Figure 1. Frequency distribution – Daily milk production

observed a clear peak in the frequency of distribution of the index for milk production during the middle lactation period (Figure 1).

Table 5. Daily milk yield – low producing (liters per day)

Parameters	Lactation stage			Low Productivity
	Beginning	Middle	End	
n	33	48	44	43
x	1.993	1.752	1.367	1.634
Sx	0.056	0.048	0.053	0.063
Max	2.316	2.154	1.938	2.316
Min	0.809	0.808	0.700	0.700
Diff	1.507	1.346	1.238	1.615

The average daily milk yield of ewes identified as LP during the study period was 1.634 liters, with values ranging from 0.700-2.316 liters (Table 5), with the highest daily milk yield being at the beginning of lactation. A downward trend was evident with the advancement of the lactation stage. Maximum values were found at the beginning of lactation and minimum values at the end, respectively.

Table 6. Behavioral indexes

Index	Content	Behavioral patterns	Formulas	Factors of influence
IEMI	Index of Entries in the Milking Installation	Hierarchy	TR = BSc x n_{ent} RR = TR – n_{ent} IR = $(RR/R_{max}).10^3$	Productivity level Lactation stage THNA
ISMI	Index of Side preference in the Milking Installation	Rank, Orienting response	CSMI = FVLSMI/FVRSMI Preference ≥ 66% No Preference 50% > 65%	Productivity level Lactation stage THNA

TR – Total Rank; RR – Real Rank; IR – Index Rank; BSc – Batch Scores; n_{ent} – Number of entries in Milking Installation; THNA – Type of Higher Nervous Activity; FVLSMI – Frequency of Visiting Left Side of Milking Installation; FVRSMI – Frequency of Visiting Right Side of Milking Installation

Figure 1 shows the differences in the distribution of animals from the two production groups. There is a pronounced peak for animals with a predominant production of about 3 liters and lack of such a peak in the low-production group. It should be mentioned that the so-called "low-production" ewes had unachievably high production for the majority of ewe farms in Bulgaria. The overlap of peaks in the central part of the graph is a result of the changes in production during the lactation period.

Ethological indicators

For the purpose of the study two ethological indicators were used - Index of Entries in the Milking Installation (IEMI) and Index of Side preference in the Milking Installation (ISMI). To calculate the both indices (IEMI and ISMI), we used the data collected through the herd management software during the milking process. Table 6 show how the indices were calculated the behaviors that characterize them and the factors of influence that were examined.

It shows (Table 6) that IEMI gives us an idea of the hierarchy in the herd, and ISMI is formed by the peculiarities of the type of higher nervous activity, and especially as a result of the manifestation of the animal's orienting response.

Statistics

The data was processed and analyzed by a standard software created and adapted for ethological research purposes by our team and configured in Microsoft Excel environment. The obtained data were also processed by the methods of variational statistics, through the method for analysis of discrete variables. For experimental groups, correlation coefficients at all possible combinations of the studied indicators and factors of influence were calculated.

Results and Discussion

Data for IEMI (Table 7) showed that the values increased with advancing lactation and reach a maximum at the end of lactation. The mean values ranged from 385.16 to 424.85 and there were no statistical differences between the stages of lactation. As described in the Materials and Methods, the index value was calculated after eliminating all the side and random factors and it is a reliable source to make an inference that the group has a stable hierarchical order, which is also manifested by the established entry order of milking.

To evaluate the differences between animals entering first or last for milking, we applied a very strict criterion - 20% of the whole group, although according to many researchers even 66%, i.e. 2/3 of the group is a high enough threshold. From the total number of 215 experimental ewes, 127 entered the milking parlour as a first group (FG), with an average IEMI of 668.62±4.02 versus only 129.31±6.02 for last group (LG) (Table 8). While in FG group within the lactation there was a clear tendency for an increase of the index values, in LG such a tendency was not observed. This is an indirect indicator of disharmony in animals that are not only the last in rank, but obviously they can hardly build and maintain relationships with each other. This is also evident from the frequency distribution presented in Figure 2. For the group of ewes entering first there was a clearly shaped peak in the range of 650-700, while for the LG group the distribution was similar to the milk production in the range of 90-210, without having a pronounced peak. The established habits for entry order in the milking parlour or their change can be characterized by processes that indicate the presence of stressful situations or dysfunctions related to the milking process. Gadbury (1975), Ojeda (1978), and Gorecki & Wojtowsku (2004) found that animals who enter first in the milking parlour usually give more milk than those entering last.

Our results showed a weak, divergent correlation between milk production and the entry order into the milking installation. The highest r = 0.11 was observed at the end of lactation (Table 9).

Similar results were obtained by Villagra et al. (2007) and Macuhova et al. (2017) who did not establish a rela-

Table 7. Index of Entries in the Milking Installation – the whole experimental group

Lactation stage	Number	Index of Entries in the Milking Installation			
		Min	Max	x	Sx
Beginning	165	88.00	664.00	385.16	11.82
Middle	245	14.59	735.42	405.53	14.87
End	223	18.06	750.00	424.85	15.08
Total	633	14.59	750.00	405.18	13.92

Table 8. Index of Entries in the Milking Installation – First and Last Group

Lactation stage	Number	First Group > 80%		Last Group < 20%	
		x	Sx	x	Sx
Beginning	33	594.91	5.78	172.61	3.49
Middle	49	695.70	3.34	88.74	6.59
End	45	715.25	2.93	126.57	7.97
Total	127	668.62	4.02	129.31	6.02

Figure 2. Frequency distribution – IEMI

tionship between ewes' productivity and entry order into the milking parlour. Their studies show that ewes in the so-called last group prefer to enter last in the milking parlour because of their temperament and social rank in the flock. Others have argued that the order to enter the milking parlour is directly related to a higher milk yield. These results were observed in cows and goats (Margetinova et al., 2003; Gorecki & Wojtowski, 2004; Grasso et al., 2007). Also, Dimitrov et al. (2012) assessed the level of fear of dairy ewes during the milking process at different ages and temperaments. They found that the age (first and second lactation) and ewes' temperament did not affect their entry order into the milking parlour. Varlyakov et al. (2018) studied the behavioral responses of goats during milking and established that in the so-called old flock there was a stable hierarchical order for entering into the milking parlour, and for the young flock born in Bulgaria and raised under the same conditions, the hierarchical order was established to be even more strict.

Table 9. Correlation coefficients

Behavioral Indexes		Beginning of lactation	Middle of lactation	End of lactation
IEMI	Total	**0.039**	**-0.026**	**0.110**
	FG	0.051	-0.008	0.025
	LG	-0.138	-0.089	0.110
ISMI	Total	**-0.012**	**0.025**	**0.021**
	PS	-0.044	0.043	0.028
	NoPS	-0.295	0.145	-0.067
IEMI : ISMI		0.273	0.114	0.149
FG		0.214	0.045	0.276
LG		0.455	-0.395	0.055
PS		0.285	0.188	0.008
NoPS		-0.081	-0.141	0.100

The data in Figure 3 are related to the Index of Side selection in the Milking Installation (ISMI). The data shows that the examined Lacaune ewes had a clear preference for the side in the milking installation throughout the whole lactation period. Approximately 70% (PSMI > 66%, Table 10) of all 215 experimental ewes showed a preference for the side of the milking installation. The left side of the milking installation was more preferred (about 6% more) and only 29.78% of the tested animals did not show a clear preference for the side of the milking installation. These results showed once again, that there was a hierarchical order in the herd, because the reflex to follow was also manifested in many animals while they have been selecting the side in the milking parlour. The preference for the left side of the installation was probably stimulated by the shorter way out of the parlour or by the peculiarities of the orienting reflex, which is not sufficiently studied in ewes in contrast

Table 10. Index of Side Preference in the Milking Installation

Lactation stage	Number	PSMI ≥66%		Side Preference in the Milking Installation			
		n	%	n	Left Side (%)	n	Right Side (%)
Beginning	165	108	66.06	56	34.54	52	31.52
Middle	249	176	70.52	90	36.07	86	34.46
End	232	167	72.16	99	42.58	69	29.58
Total	645	451	69.38	244	37.53	207	31.85

to the detailed studies with primates (including humans), dogs, cows and more.

The divergent correlation between milk yield and ISMI values was similar to those found at IEMI (Table 7), with the highest r = -0.295 found at animals without preference (NoPS) at the start of lactation. The tendency of IEMI-LG for higher, though divergent, values of the correlation coefficient at NoPS remained unchanged.

The frequency of distribution had similar characteristics in all animals – with (PS) or without preference towards the side of the milking installation (Figure. 3). Although the twice wider range in ewes shows clear preferences, the figure clearly shows the quantitative prevalence already found in the data from Table 10.

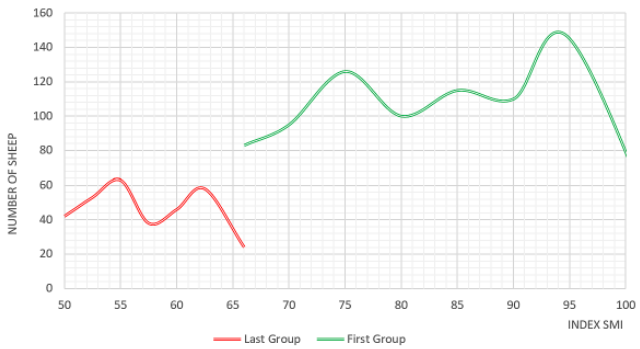

Figure 3. Frequency distribution – ISMI

Many authors have studied the social behavior of sheep during the milking process (Keszthelui & Maros, 1992; Wesilewski, 1999; Graser-Herrmann & Sambraus, 2001; Villagra et al., 2007; Dimitrov et al., 2012), because it is a key factor in achieving economic goals (Varlyakov, 1989; Varlyakov & Ivanov, 1994; Varlyakov et al., 2011). In a study of the social behavior of cows and buffaloes in a milking parlour, Hopster et al. (1998), Grasso et al. (2007), and Policarpus et al. (2014) found that the side selection of the milking installation was not random. This preference did not change over time. The authors believed that the selection of side in the milking installation is a stable characteristic of every animal and that large individual differences can be found. The same authors suggested that the side preference of the milking parlour may come from major factors related to how individual animals differ in their ability to adapt their behavior to environmental changes. A possible reason for choosing the left or right side of the milking installation is based probably on the previous experience of the animals when allowed to select between two positions. Such an experience would make them to select either the more attractive side or avoid the more unacceptable one based on an "animal feelings" approach (Grandin et al., 1994; Hosoi et al., 1995).

Conclusions

The results of our research give us a reason to claim that the Lacaune ewes are well adapted to the breeding conditions, and the evidence for this are: (a) stable hierarchical order was built, which was manifested by the high index values (668.62) for entry order throughout the whole lactation period; (b) the established preference for the side (69.38%) of the milking installation was not accompanied by a preference for a specific site for milking that may aid the milking process; (c) the level of productivity did not affect the entry order or the preference for a particular side of the milking installation. Data for IEMI showed that the values increased with advancing lactation and reach a maximum at the end of lactation. The mean values ranged from 385.16 to 424.85 and there were no statistical differences between the stages of lactation.

References

Agrostatistics, (2018). Ministry of Agriculture, Food and Forestry, Department: Agrostatistics, Source: Farm Animals in Bulgaria, Sofia (Bg).

Barłowska, J., Szwajkowska, M., Litwinczuk, Z. & Kr´ol, J. (2011). Nutritional value and technological suitability of milk from various animal species used for dairy production. *Comprehensive Reviews in Food Science and Food Safety*, *10*, 291–302.

Bryson, T. (1984). The Sheep Housing Handbook. Pub. Farming Press, Ipswich.

Dimitrov, I., Stancheva, N., Staikova, G., Peeva, J., Vasilev, V. & Apostolov, A. (2012). Assessment of level of fear suscepti-

bility during machine milking in dairy sheep of different ages and temperament. *Bulgarian Journal of Agricultural Science*, *18*, 482–486.

Donaldson, S.L., Albright, J.L., Black, W.C., Ross, M.A. & Barth, K.M. (1967). Relationship between entrance order and social dominance in dairy goats. *American Zoology*, *7*, 807.

FAO, (2014). Statistical yearbook 2014. Food Agric. Organisation, UN, Hungary, Budapest.

Fraser, A.F. & Broom D.M. (1990). Farm Animal Behaviour and Welfare, Balliere Tindall, London.

Gadbury, J.C. (1975). Some preliminary field observations on the order of entry of cows into herringbone parlours. *Applied Animal Ethology*, *1*, 275–281.

Gorecki, M.T. & Wojtowski, J., (2004). Stability of milking order in goat over a long period. Archv-fur-Tierzucht *47*, 203–208.

Grandin, T., Odde, K.G., Schutz, D.N. & Behrns, L.M. (1994). The reluctance of cattle to change a learned choice may confound preference tests. *Applied Animal Behaviour Science*, *39*, 21-28.

Graser-Herrmann, C. & Sambraus, H.H. (2001). The social behavior of East Friesian dairy sheep in large group. *Archiv Tierzucht, Dummerstorf*, *44*, 4, 421-433.

Grasso, F., De Rosa, G., Napolitano, F., Di Francia, A. & Bordi A. (2007). Entrance order and side preference of dairy cows in the milking parlour. *Italian Journal of Animal Science*, *6*, 187–194.

Hopster, H., Van der Werf, J.T.N. & Blokhuis, J. (1998). Side preference of dairy cows in the milking parlour and its effects on behaviour and heart rate during milking. *Applied Animal Behaviour Science*, *55*, 213–229.

Hosoi, E., Rittenhouse, L.R., Swift, D.M., Richards, R.W. (1995). Foraging strategies of cattle in a Y-maze: influence of food availability. *Applied Animal Behaviour Science, 43*, 189-195.

Keszthelyi, T. & Maros K. (1992). Moving order in different group sizes of milking ewes. *Applied Animal Behaviour Science*, *35*, 181–188.

Macuhova, J., Tancin, V., Kraezl, W.D., Meyer, H. & Bruckmaier, R.M. (2002). Inhibition of oxytocin release during repeated milking in unfamiliar surroundings: the importance of opioids and adrenal cortex sensitivity. *Journal of Dairy Research*, *69*, 63–67.

Mačuhová, L., Tančin, V., Mačuhová, J., Uhrinčať, M., Hasoňová, L. & Margetínová J. (2017). Effect of ewes entry order into milking parlour on milkability and milk composition. *Czech Journal of Animal Science*, *62*, 392–402.

Margetinova, J., Broucek, J., Apolen, D. & Mihina, S. (2003). Relationship between age, milk production and order of goats during automatic milking. *Czech Journal of Animal Science*, *48*, 257–264.

Marie-Etancelin, C., Manfred, E., Aurel, M. R., Pailler, F., Arhainx, J., Ricard, E., Lagriffoul, G., Guillauet, P., Bibe, B. & Barillet, F. (2006). Genetic analysis of milking ability in Lacaune dairy ewes. *Genetics Selection Evolution*, *8*, 183-200.

Moatsou, G., Samolada, M., Katsabeki, A. & Anifantakis, E. (2004). Casein fraction of ovine milk from indigenous Greek breeds. *Lait*, *84*, 285–96.

Ojeda, E. (1978). Comportement de la brebis manchega en vue de la traite mécanique. In: Inra-Itovic (eds.), 2ème Symposium Internacional sur la Traite mécanique des petits ruminants, Paris (France), pp. 141–145.

Paranhos Da Costa, M.J.R. & Broom, D.M. (2001). Consistency of side choice in the milking parlour by Holstein-Friesian cowsand its relationship with their reactivity and milk yield. *Applied Animal Behaviour Science, 70*, 177-186.

Park, Y.W., Juárez, M., Ramos, M. & Haenlein, G. F. W. (2007). Physico-chemical characteristics of goat and sheep milk. *Small Ruminants Research*, *68*, 88–113.

Polikarpus, A., Grasso, F., Pacelli, C., Napolitano, F., Arney, D. & De Rosa, G. (2014). Milking behaviour of buffalo cows: entrance order and side preference in the milking parlour. *Journal of Dairy Research*, *81*, 24–29

Polikarpus, A., Kaart, T., Mootse, H. & De Rosa, G. (2015). Influences of various factors on cows' entrance order into the milking parlour. *Applied Animal Behaviour Science*, *166*, 20–24.

Stefanowska, J., Plavsic, M., Ipema, A. & Hendriks, **M.M.** (2000). The effect of omitted milking on the behaviour of cows in the context of cluster attachment failure during automatic milking. *Applied Animal Behaviour Science*, *67*, 277–291.

Tancin, V., Macuhova, J., Jackuliakova, L., Uhrincat, M., Antonic, J., Macuhova, L. & Jilek, **F.** (2015). The effect of social stress on milking efficiency in dairy ewes differed in milk flow kinetic. *Small Ruminant Research*, *125*, 115–119.

Varlyakov, I. (1989). Ethological evaluation of two perspective technologies for free housing of dairy cows, Ph.D. thesis, Trakia University, Stara Zagora, Bulgaria, 236 (Bg).

Varlyakov, I. (2011). Animal welfare – theoretical and practical aspects, Monograph. Printed in Bulgaria, ISSN – 978-954-914296-9, p. 246 (Bg).

Varlyakov, I. & Ivanov, I. (1994). Significance of some behavioural reactions during the machine milking for determination type of hygher nervous activity of ewes. XXIV Annual Meeting of ESNA, September 12-16, Varna, Bulgaria, 46.

Varlyakov, I., Slavov, T., Radev, V., Nedeva, I. & Nikolov, G. (2018). Milking behaviour of Saanen goats. *Bulgarian Journal of Agricultural Science*, *24* (1), 109–118.

Villagra, A., Balasch, S., Peris, C., Torres, A. & Fernandez, N. (2007). Order of sheep entry into the milking parlour and its relationship with their milkability. *Applied Animal Behaviour Science*, *108*, 58–67.

Wasilewski, A. (1999). Demonstration and verification of a milking order in airy sheep and its extent and consistency. *Applied Animal Behaviour Science, 64*, 111-124.