

BEHAVIOUR AND GROWTH INTENSITY OF DAIRY SHEEP LAMBS RAISED IN NURSERIES

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ABSTRACT

The raising of lambs in nurseries is an effective way to breed lambs of dairy sheep. The aim of the study was to characterize selected ethological manifestations in lambs ($n = 31$) during the stay in the nursery. Lambs were gradually let out of the nursery to the group of mothers. During the settled 5 min interval several traits were recorded. "Beginning of suckling after opening the nursery" (BS) was significantly affected by genotype of mother ($P < 0.05$) and age of lambs ($P < 0.001$). The trait "number of suckling" was significantly affected by litter size ($P < 0.001$). Single lambs suckled 3.81 times at average, whereas twins suckled 2.78 times. The trait "total time of suckling" (TTS) was significantly affected by genotype of mother ($P < 0.05$), litter size and age of lambs as well ($P < 0.001$). TTS of single lambs was 152.29 seconds on average, whereas TTS of twins was 117.35 seconds ($P < 0.05$). The interest in suckling the mothers and, also other ewes, decreased with increasing age of lambs. As a rule, lambs with later BS ended suckling later ($r = 0.405+++$). Lambs suckling more often suckled a shorter period of time as a rule ($r = -0.527+++$). TTS was negatively correlated with the weight of lambs ($r = -0.190$; $P < 0.05$) and average daily gain ($r = -0.211$; $P < 0.01$). The lighter and lower growth intensity lambs were, the longer interest in suckling was shown and, also, the longer period of time for suckling was needed. The correlation between the trait "number of attempts to suckle non-own mother" and average daily gain was non-significant i.e. no differences in growth intensity for lambs-thieves and lambs which suckle only own mothers were observed.

Key words: dairy sheep; rearing of lambs, ethological manifestations, growth intensity

INTRODUCTION

The rising of lambs in dairy or multipurpose sheep breeds has a significant influence on the economics of sheep breeding. Research aimed at identifying the appropriate ways of the rising of lambs, which do not decrease ewe's milk yield and lamb's growth intensity, has been conducted throughout the world (Folman et al., 1966; Gargouri et al., 1993; McKusick et al., 2001; Dickmen et al., 2007). In Slovakia, the rising of lambs under the mothers is done until the age of 30-40 days (sometimes during a longer period), mostly using a system of nurseries (Margetin et al., 2003). In this system, lambs

are separated from mothers and are allowed to leave the nursery and access mother's mammary glands in regular intervals for a limited period of time. When nurseries are appropriately organized, positive results can be obtained. The experience shows that high growth intensity both before and after weaning that is not accompanied with a decrease in weight of lambs, and good preparation of ewes for milking can be observed (Margetin et al., 2004). Although advantages of nurseries were reported, only few papers were aimed at revealing the causes of positive results obtained. Moreover, papers that analyse the behaviour of lambs and mothers in nurseries are very few. Knowledge of both lamb and mother behaviour,

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however, enables the technology of rearing the lambs to be improved and optimized (Horák and Novák, 1979; Dwyer and Lawrence, 2005; Everet-Hincks et al., 2005; Nowak and Poindron, 2006).

From the breeder's point of view, knowledge of factors affecting relationship between lamb and mother in the post-natal period is crucial. These factors are responsible for the occurrence of such phenomena as orphan lambs and false progeny, and can result in economic losses. The care of mothers after the lambs decreases with increasing age of lambs (Hinch et al., 1997). Smell perceptions that enable to recognize own lambs are not indispensable in sheep (Ferreira et al., 1998), and can be replaced with acoustic manifestations and visual perceptions. Behaviour of lambs during suckling period and changes in both number and length of suckling were found interesting. Mandiki et al. (1989) reported that ewes were suckled more often during a day than at night, with increasing numbers of suckling in the morning. Both frequency and length of suckling decreased with increasing age of lambs. Mandiki et al. (1989) also reported identical frequencies of suckling between singles and twins, however, average and total time of suckling were higher for twins than for singles. Within 24-hour interval, numbers of suckling were about 90, 30 and 15 on first, fourth, seventh and eight week after lambing. Hinch et al. (1987) reported that average time necessary to recognize the mothers tended to decrease for older lambs. Ewes tended to seek their lambs mainly within first four weeks after parturition, acoustic manifestations were found to occur in later weeks. Most papers reported ethological manifestations in meat sheep with lambs on pasture and were summarized by Dwyer and Lawrence (2005). Contrariwise, ethological manifestations in dairy sheep drew less attention throughout the world and in Slovakia as well.

The aim of the study was: (a) to analyze the ethological manifestations of lambs with respect to the genotype of mothers and non-genetic factors that can affect these manifestations, and (b) to analyze the influence of ethological manifestations on growth intensity of lambs raised in the nursery.

MATERIAL AND METHODS

Investigations were performed at the Sheep Station of the Animal Production Research Centre Nitra. Purebred Improved Valachian (IV) lambs and crossbreeds of IV with Lacaune (LC) and East Friesian (EF) breeds were included in the experiment. Lambs (either singles or twins) and mothers (either at first or higher parities) were kept in the nursery system under the same conditions since lambing till weaning. Totally 20 ewes and 31 lambs

were included: 11 purebred IV ewes (of whose five were mothers of twins and six were mothers of singles; three were at first parity and eight were at higher parities) and 9 crossbred ewes either IVxLC with 50 and 75% portion of LC or (IVxLC)xEF with 50% portion of EF and 25% portion of LC (of whose six were mothers of twins and three were mothers of singles; three were at first parity and six were at higher parities). Lambs and mothers were marked immediately after parturition to be easily identified during the experiment.

The nursery system was designed according to modified methods reported by Margetín et al. (2003). The lambs were allowed to leave the nursery in accordance with the time schedule proposed. In the beginning of the experiment, the nursery was opened the whole night for two weeks. Later, the nursery was closed at night since 11 p.m. Ethological observations started at 7.15 a.m. The nursery, in which lambs were kept, was of dimensions 5 x 2.5 m. The group pen, in which ewes were kept, was of dimensions 10.5 x 2.5 m. Behaviour of lambs and mothers after opening the nursery and during suckling were observed in week intervals. Control measurements (one within each control day: 21.2.; 28.2.; 7.3.; 14.3.; 21.3.) were done in the early morning. The average ages of lambs at first, second, third, fourth and fifth control measurement were 13.4, 20.4, 27.4, 34.4 and 41.4 days. The lambs were allowed to access the mothers in groups of three to five; singles first, twins later. Sibs were allowed to leave the nursery at the same time. Each evaluator followed ethological manifestations of one lamb. The lambs were allowed to spend five minutes with mothers and, afterwards, were closed in the nursery again. Weight of lambs was measured in week intervals; three days after ethological observations.

Data were processed by general linear model (SAS/STAT, 1999/2001, GLM procedure). Effects of the genotype of mother, litter size, sex and control measurement on the following traits were investigated within the settled 5 min interval:

- beginning to suckle i.e. time necessary for lambs to recognize the mothers after leaving the nursery till beginning of suckling – BS (s),
- number of attempts to suckle own mother i.e. number of sucklings – NS,
- number of attempts to suckle non-own mother – NSNOM,
- average time of one suckling of own mother – ATS (s),
- total time of suckling – TTS (s),
- finishing to suckle i.e. last second of suckling at last attempt to suckle own mother – FS,
- weight of lambs (kg),
- average daily gain of lambs (g).

RESULTS AND DISCUSSION

Basic statistics of ethological manifestations of lambs in the nursery is given in Table 1. The mean values of traits observed were as follows: beginning to suckle after opening the nursery (BS) was 40.61 s, number of sucklings (NS) was 3.15, total time of suckling (TTS) was 125.90 s, average time of one suckling (ATS) was 51.50 s, number of attempts to suckle non-own mothers (NSNOM) was 1.13. The lambs finished to suckle (FS) at 205.7 s at average. According to mean values of TTS, the lambs were able to empty the udder in about 2 min. The mean value of FS was about 3.5 min (of 5 min interval in which the lambs were allowed to access the mothers) as after this time there was no attempt to suckle. ATS ranged from 8.3 to 275 s with the mean value of about 51 s. BS ranged from 3 to 239 s with coefficient of variation almost 120 %. Within 5 min interval, the lambs suckled own mothers 7 times at maximum. TTS ranged from 20 to 303 s. NSNOM was of highest variation (coefficient of variation almost 161 %), ranging from 0 to 10 times.

Following the values given in Table 2, BS was significantly ($P < 0.05$) and highly significantly ($P < 0.001$) influenced by the genotype of mother and control measurement. At first control measurement, the lambs were able to recognize own mothers in 94.76 s, whereas at fifth control measurement, the lambs were able to recognize own mothers in 22.26 s (see Table 3 for

comparison). These findings agree with findings of Hinch et al. (1987). The effects of litter size and sex on BS were statistically non-significant ($P > 0.05$). However, singles and males were able to recognize own mothers earlier than twins and females.

NS was highly significantly ($P < 0.001$) influenced by litter size (Table 2). Singles were able to suckle 3.81 times, whereas twins were able to suckle 2.78 times (Table 3). This is probably caused by the fact that mothers are not able to produce more milk. Mandiki et al. (1989) reported that, within first weeks of life, twins suckle more often (sum of all sucklings) than singles. Four-five weeks after birth no differences in NS between singles and twins were observed. With increasing age of lambs, the decrease in NS tended to be the same for singles and twins. O'Connor et al. (1989) found singles to be more active; they lied down less and were of more attempts to suckle than twins. NS was non-significantly ($P > 0.05$) influenced by the genotype of mother, sex and control measurement. Differences between females (3.47 times) and males (3.11 times) were relatively important and corresponded to findings of Mandiki et al. (1989).

TTS (Table 2) was significantly or highly significantly influenced by the genotype of mother ($P < 0.05$), litter size ($P < 0.001$) and control measurement ($P < 0.001$). On average, crossbred IVxLC ewes with 50 % proportion of LC were suckled the least (121.51 s; Table 3). Purebred IV ewes were suckled 126.95 s. Three-bred

Table 1: Basic statistics of chosen ethological manifestations of lambs in the nursery

Trait	BS (s)	NS	TTS (s)	ATS (s)	FS (s)	NSNOM
Number of observations	153	153	153	153	153	153
Mean	40.61	3.15	125.90	51.50	207.50	1.13
Standard deviation	48.652	1.689	64.517	41.058	77.137	1.820
Coefficient of variation	119.79	53.61	51.24	79.72	37.18	160.94
Minimum	3	1	20	8,3	37	0
Maximum	239	7	303	275	364	10

BS: beginning to suckle; NS: number of attempts to suckle own mother; TTS: total time of suckling; ATS: average time of one suckling of own mother; FS: finishing to suckle; NSNOM: number of attempts to suckle non-own mother

Table 2: The influence of the analyzed effects on chosen ethological manifestations of lambs in the nursery

Source of variance	BS (s)	NS	TTS (s)	ATS (s)	FS (s)	NSNOM
Genotype of mother	+	ns	+	ns	++	Ns
Litter size	ns	+++	+++	ns	++	Ns
Sex	ns	ns	ns	ns	ns	Ns
Control measurement	+++	ns	+++	+++	+++	+++

BS: beginning to suckle; NS: number of attempts to suckle own mother; TTS: total time of suckling; ATS: average time of one suckling of own mother; FS: finishing to suckle; NSNOM: number of attempts to suckle non-own mother;

+ $P < 0.05$; ++ $P < 0.01$; +++ $P > 0.001$; ns: non-significance

(IVxLC)xEF ewes were suckled most (163.53 s). TTS for singles was 152.29 s, whereas TTS for twins was only 117.35 s. This is probably a result of mother's milk abilities. In spite of the fact that mothers of twins produce more milk (by 30-40 %) than mothers of singles, it could be possible that singles had more milk at disposal or twins were able to suckle milk faster. The lowest value of TTS was found for lambs at first control measurement (106.25 s); the highest value of TTS was found for lambs at second control measurement (184.38 s). From second control measurement, the decrease of TTS was observed, with the lowest value at fifth control measurement (108.68 s). Maybe, with increasing time from birth, the lambs used to consume roughage and concentrates and, also, heavier lambs used to suckle the udder milk faster.

ATS confirms the findings for TTS (see Tables 2 and 3 for comparison). This trait was highly significantly ($P < 0.001$) influenced by control measurement. The decrease of ATS was observed from the second control measurement with the lowest values at fourth and fifth measurement (35.87 and 42.86 s). These findings agree with the findings of Arnold et al. (1979), who considered milk amount the main determinant of relationship

between lamb and mother. The effects of the genotype of mother, litter size and sex on ATS were statistically non-significant ($P > 0.05$). However, singles suckled longer than twins and females suckled shorter than males.

FS (Tables 2 and 3) was highly significantly ($P < 0.001$) influenced by the genotype of mother, litter size and control measurement. Interest in suckling the mothers decreased with increasing age of lambs. The last seconds of suckling were as follows: 239.18, 258.13, 234.87, 195.6 and 174.94 with the highest value found at second control measurement and the lowest value found at fifth control measurement. Twins finished suckling earlier than singles. Males finished suckling earlier than females. The latter difference was, however, non-significant. The lambs of crossbred ewes (IVxLC with 75 % proportion of LC) finished suckling in 186th s, whereas the lambs of three-bred ewes finished suckling in 246th s.

NSNOM was highly significantly ($P < 0.001$) influenced by control measurement (Tables 2 and 3). This number decreased with the increasing age of lambs. Non-significant influence ($P > 0.05$) of the genotype of mother, litter size and sex on NSNOM was found.

Table 3: Least-squares means of chosen ethological manifestations of lambs in dependence on the analyzed effects

Source of variation	Group	n	BS (s)	NS	TTS (s)	ATS (s)	FS (s)	NSNOM
Genotype of mother	IV	78	43.72ab	3.51	126.95ab	45.04	209.09ab	1.44
	IVxLC (50LC)	15	68.07b	2.77	121.51a	48.98	240.07ab	0.99
	IVxLC (75LC)	25	30.00a	3.06	127.28abc	57.12	186.88a	0.53
	(IVxLC25)xEF50	35	33.55ab	3.83	163.53bc	59.10	246.62b	1.18
Litter size	Singles	45	40.88	3.81a	152.29a	51.49	238.95a	0.87
	Twins	108	46.79	2.78b	117.35b	53.64	202.38b	1.20
Sex	Females	45	49.59	3.47	139.07	51.66	226.17	1.35
	Males	108	38.08	3.11	130.56	53.46	215.15	0.72
Control measurement	1	31	94.76a	2.85	106.25a	47.13a	239.18ab	0.97abc
	2	31	39.89b	3.11	184.38b	85.51b	258.73b	2.10c
	3	30	30.73b	3.63	159.58b	51.67a	234.87bc	1.51bc
	4	31	31.54b	3.79	115.19a	35.87a	195.60ab	0.58ab
	5	30	22.26b	3.07	108.68a	42.62a	174.94a	0.01a
Total (LSM ± SE)	-	153	43.84 ± 4.370	3.29 ± 0.169	134.82 ± 5.721	52.56 ± 4.055	220.66 ± 7.208	1.04 ± 0.179

BS: beginning to suckle; NS: number of attempts to suckle own mother; TTS: total time of suckling; ATS: average time of one suckling of own mother; FS: finishing to suckle; NSNOM: number of attempts to suckle non-own mother; LSM: least-squares mean; SE: standard error;

n: number of observations; a,b,c: different letters indicate statistically significant difference in LSM

Table 4: Phenotypic correlations between respective ethological manifestations of lambs in the nursery

Trait	BS	NS	TTS (s)	ATS (s)	FS (s)	NSNOM
BS (s)	-	-0.155ns	-0.132ns	0.065ns	0.405+++	0.158ns
NS	-0.155ns	-	0.329+++	-0.527+++	0.465+++	-0.057ns
TTS (s)	-0.132ns	0.329+++	-	0.462+++	0.627+++	-0.013ns
ATS (s)	0.065ns	-0.527+++	0.462+++	-	0.138ns	0.136ns
FS (s)	0.405+++	0.465+++	0.627+++	0.138ns	-	0.111ns
NSNOM	0.158ns	-0.057ns	-0.013ns	0.136ns	0.111ns	-

BS: beginning to suckle; NS: number of attempts to suckle own mother; TTS: total time of suckling; ATS: average time of one suckling of own mother; FS: finishing to suckle; NSNOM: number of attempts to suckle non-own mother;

+ P < 0.05; ++ P < 0.01; +++ P < 0.001; ns: non-significance

The phenotypic correlations between respective ethological manifestations of lambs in the nursery are given in Table 4. Some of the relationships were statistically highly significant (P<0.001). For instance, the lambs which began suckling later (i.e. they needed longer time to recognize own mothers) finished suckling later,

as a rule. The correlation between BS and FS was 0.405 (P<0.001). With these lambs, we assume that relationship between lamb and mother was weaker than with lambs which were able to recognize own mothers earlier and also to begin and finish suckling earlier. The mothers of the latter group of lambs were probably of better mother's

Table 5: The influence of the analyzed effects on growth intensity traits of lambs in the nursery and least-squares means and standard errors of growth intensity traits

Source of variance	Group	n	Weight at weaning (kg)		Average daily gain (g)	
			LSM	SE	LSM	SE
Genotype of mother	IV	80	13.46a	0.148	311.7	10.86
	IVxLC (50LC)	15	13.91a	0.305	323.2	22.40
	IVxLC (75LC)	25	13.59a	0.247	286.1	18.15
	(IVxLC25)xVF50	35	12.37b	0.215	283.3	15.82
F-value			8.39+++		1.32ns	
Litter size	Singles	45	14.51a	0.192	330.7a	14.15
	Twins	110	12.15b	0.138	271.5b	10.16
F-value			112.91+++		13.11+++	
Sex	Females	45	12.70a	0.187	283.1a	13.72
	Males	110	13.97b	0.153	319.1b	11.23
F-value			30.20+++		4.48+	
Control measurement	1	31	9.31a	0.226	271.4ab	16.58
	2	31	10.88b	0.226	228.0a	16.58
	3	31	12.89c	0.226	290.8ab	16.58
	4	31	15.74d	0.226	411.0c	16.58
	5	31	17.84e	0.226	304.1b	16.58
F-value			276.20+++		19.38+++	
Total	-	155	13.33	0.125	301.1	9.22

BS: beginning to suckle; NS: number of attempts to suckle own mother; TTS: total time of suckling; ATS: average time of one suckling of own mother; FS: finishing to suckle; NSNOM: number of attempts to suckle non-own mother; LSM: least-squares mean; SE: standard error;

n: number of observations; + P < 0.05; ++ P < 0.01; +++ P < 0.001; ns: non-significance

a,b,c: different letters indicate statistically significant difference in LSM

instincts, calm individuals able to produce more milk.

The lambs which suckled more times had probably less time available for suckling. The correlation between NS and ATS was -0.527 ($P < 0.001$). With ewes which had sufficient amount of milk, we assume that the lambs suckled 1 or 2 times, although suckling took a longer period of time. The lambs which finished suckling later needed probably more time for suckling. The correlation between FS and TTS was 0.627 ($P < 0.001$). These lambs were probably progeny of ewes which had insufficient amount of milk, mainly milk located in the udder cisterns. The lambs were attempted to stimulate higher milk secretion by more often attacks on the udder (beating with the head) to be provided with needed amount of milk to become fed. When higher TTS was found, higher average ATS was recorded. The correlation between TTS and ATS was 0.462 ($P < 0.001$).

The analysis of effects influencing weight and growth intensity of lambs in the nursery showed highly significant ($P < 0.001$) influence of the genotype of mother, litter size, sex and control measurement (Table 5). The highest weight was found for lambs of crossbred IVxLC ewes with the proportion of 50 and 75 % LC (13.91 and 13.59 kg, respectively). The lowest weight was found for lambs of three-bred ewes (12.37 kg). Singles had higher (by 19.4 %) weight than twins. Males had higher (by 10 %) weight than females.

Average daily gain was used to evaluate growth intensity of lambs. The overall average daily gain from the beginning to the end of experiment was 301.1 g. This trait was highly significantly ($P < 0.001$) influenced by litter size and control measurement and significantly ($P < 0.05$) influenced by sex. The effect of the genotype of mother was non-significant. The difference between singles and twins was 21.8 %. The difference between males and females was 12.7 %. Average daily gain varied amongst individual control measurements. The highest average daily gain was found between third and fourth control measurement (411.0 g) and the lowest average daily gain was found between first and second control measurement (228.0 g). These findings are in accordance with previous findings of Margetin et al. (1995), who reported average daily gain of purebred Tsigai and Improved Valachian lambs in the nursery system within the range from 241.8 g to 358.6 g.

The phenotypic correlations between weight of lambs (and average daily gain) and chosen ethological manifestations of lambs in the nursery are given in Table 6. Most of the relationships were statistically significant ($P < 0.05$) or statistically highly significant ($P < 0.01$; $P < 0.001$). TTS was negatively correlated with weight of lambs ($r = -0.190$; $P < 0.05$) and average daily gain ($r = -0.211$; $P < 0.01$). ATS was negatively correlated with weight of lambs ($r = -0.240$; $P < 0.01$) and average daily gain ($r = -0.189$; $P < 0.05$). The heavier and higher growth

Table 6: Phenotypic correlations between growth intensity and chosen ethological manifestations of lambs in the nursery

Trait	Weight of lambs at control measurements (kg)	Average daily gain (g)
BC (s)	-0.355+++	-0.070ns
NS	0.099ns	0.050ns
TTS (s)	-0.190+	-0.211++
ATS (s)	-0.240++	-0.189+
FS (s)	-0.332+++	-0.175+
NSNOM	-0.236++	-0.070ns

BS: beginning to suckle; NS: number of attempts to suckle own mother; TTS: total time of suckling; ATS: average time of one suckling of own mother; FS: finishing to suckle; NSNOM: number of attempts to suckle no own mother;

+ $P < 0.05$; ++ $P < 0.01$; +++ $P < 0.001$; ns: non-significance

intensity lambs were, the shorter period of time was needed for suckling i.e. the higher ability to empty the udder earlier was observed. BS was negatively correlated with weight of lambs ($r = -0.355$; $P < 0.001$). The heavier lambs were, the less time the lambs needed to recognize own mothers and begin suckling. These lambs were more active and lively than lambs which needed more time to recognize own mothers. FS was negatively correlated with weight of lambs ($r = -0.332$; $P < 0.001$) and average daily gain ($r = -0.175$; $P < 0.05$). The lighter and lower growth intensity lambs were, the longer interest in suckling was shown and, also, the longer period of time for suckling was needed. NSNOM was negatively correlated with weight of lambs ($r = -0.236$; $P < 0.01$). The heavier lambs were, the less attempts to suckle non-own mothers were observed. The correlation between NSNOM and average daily gain was non-significant i.e. no differences in growth intensity for lambs-thieves and lambs which suckle only own mothers were observed.

CONCLUSION

The nursery system for lambs is an effective way to raise dairy sheep lambs which are weaned early. The lambs are quickly adapted to their separation from ewes and to the access to mothers in regular time intervals. The findings showed that group of almost 50 lambs could be closed within 30 to 80 s. After leaving the nursery, the lambs need about 4 min to be able to empty the udder. The time significantly decreases with increasing age of lambs. The attempts to suckle non-own mothers and stole milk can occur, however, number of attempts tends to decrease with increasing age of lambs. There are no differences in

average daily gains of lambs-thieves and lambs which suckle only own mothers. Average daily gain above 300 g can be found in the nursery system organized in an appropriate way; provided that adequate feeding is available. Behaviour of lambs is mainly influenced by milking abilities of mothers. The significant differences in behaviour between singles and twins are observed. Separate raising of singles and twins seems to be more effective way of the nursery system.

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REFERENCES

- ARNOLD, G. W. – WALLACE, S. R. – MALLER, R. A. 1979. Some factors involved in natural weaning processes in sheep. *Appl. Anim. Ethol.*, 1979, vol. 5, p. 43-50.
- DICKMEN, S. – TURKMEN, I. I. – USTUNER, H. – ALPAY, F. – BALCI, F. – PETEK, M. – OGAN, M. 2007. Effect of weaning system on lamb growth and commercial milk production in Awassi dairy sheep. *Czech J. Anim. Sci.*, 2007, vol. 52, p. 70-76.
- DWYER, C. M. – LAWRENCE, A. B. 2005. A review of the behavioral and physiological adaptations of hill and lowland breeds of sheep that favour lamb survival. *Appl. Anim. Behav. Sci.*, 2005, vol. 92, p. 235-260.
- EVERETT-HINCKS, J. M. – LOPEZ-VILLALOBOS, N. – BLAIR, H. T. – STAFFORD, K. J. 2005. The effect of ewe maternal behaviour score on lamb and litter survival. *Livest. Prod. Sci.*, 2005, vol. 93, p. 51-61.
- FERREIRA, G. – TERRAZAS, A. – POINDRON, P. – NOWAK, R. – ORGEUR, P. – LÉVY, F. 1998. Olfactory cues are not necessary for recognition of the lamb by the ewe. In: *Proc. 32nd Congress of the International Society for Applied Ethology*, Clermont – Ferrand, France, 1998, p. 83.
- FOLMAN, Y. – VOLCANI, R. – EYAL, E. 1966. Mother-offspring relationships in Awassi sheep. I: The effect of different suckling regimes and time of weaning on the lactation curve and milk yield in dairy flocks. *J. Agric. Sci. (Camb.)*, 1966, vol. 67, p. 359-368.
- HINCH, G. N. – LECRIVAIN, E. – LYNCH, J. J. – ELWIN, R. L. 1987. Changes in maternal-young associations with increasing age of lambs. *Appl. Anim. Behav. Sci.*, 1987, vol. 17, p. 305-318.
- HORÁK, F. – NOVÁK, J. 1979. Etologické projevy bahnic a jehňat po porodu. *Živoč. Vým.*, 1979, vol. 24, p. 213-221.
- GARGOURI, A. – CAJA, G. – SUCH, X. – FERRET, A. – CASALS, R. – PERIS, S. 1993. Evaluation of a mixed system of milking and suckling in Manchega dairy ewes. In: *Proc. 5th Int. Symp. on Machine Milking of Small Ruminants. Hungarian J. Anim. Prod., (Suppl. 1)*, 1993, p. 484-499.
- MANDIKI, S. N. M. – FOSION, M. – PAQUAY, R. 1989. Daily variations in suckling behaviour and relationship between suckling intensity and lactation anestrus in Texel ewes. *Appl. Anim. Behav. Sci.*, 1989, vol. 23, p. 247-255.
- MARGETÍN, M. – ČAPISTRÁK, A. – VALKOVSKÝ, P. – KALIŠ, M. 1995. Dependence between growth intensity in lambs and milk production in mothers during the suckling period. *J. Farm. Anim. Sci.*, 1995, vol. 28, p. 219-225.
- MARGETÍN, M. – ČAPISTRÁK, A. – APOLEN, D. – ŠPÁNIK, J. – B ULLOVÁ, M. – ŠÁNDOR, E. 2003. Ewes breeding with high milk yield in the first months of lactation. In: *Najnovšie poznatky genetického hodnotenia, výživy a technológie v chove oviec. Zborník prednášok z odborného seminára s medzinárodnou účasťou*. 1. vyd., Nitra : VÚŽV, 2003, p. 55-62. ISBN 80-88872-28-6 [in Slovak]
- MARGETÍN, M. – BULLOVÁ, M. – ČAPISTRÁK, A. 2004. Growth curves in different genotypes of lambs created on the base of Improved Valachian and Tsigai breeds. In: *Aktuálne problémy riešené v agrokomplexe*. Zborník z medzinárodného vedeckého seminára. On CD, Nitra : SPU, 2004, p. 456-461. ISBN 80-8069-488-6 [in Slovak]
- MCKUSICK, B. C. – THOMAS, D. L. – BERGER, Y. M. 2001. Effect of weaning system on commercial milk production and lamb growth of East Friesian dairy sheep. *J. Dairy Sci.*, 2001, vol. 84, p. 1660-1668.
- NOWAK, R. – POINDRON, P. 2006. From birth to colostrum: early steps leading to lamb survival. *Reprod. Nutr. Dev.*, 2006, vol. 46, p. 431-446.
- O'CONNOR, C. E. – LAWRENCE, A. B. – WOOD-GUSH, D. G. M. 1989. The influence of parity and litter size on maternal behaviour in sheep at parturition. *Appl. Anim. Behav. Sci.*, 1989, vol. 24, p. 86-87.
- SAS/STAT, 1999-2001. Version 8.2. SAS Institute Inc., Cary, NC, USA.