

Some Biological Characteristics and Prediction of Sheep Productivity at Different Variants of Breed Selection

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Abstract: The paper presents the findings on the morpho structural diversity of sheep placenta, depending on such factors as age, exterior and physique characteristics, breeds, ewes prolificacy that are fundamental in assessing progeny viability. The experiment involved the ewes of the Caucasian and North Caucasian meet-and-wool breeds inseminated by the rams of the same breeds as well as the Texel, Poll Dorset, Edilbay and their progeny. The biomaterial for the research was the placenta and blood of the experimental animals. Ewes aged 2.5 and 3.5 years had the lightest placenta – 165 and 172 gr, ewes aged 4.5 and 5.5 years had the heaviest placenta – 230 and 247 gr. It has been also determined that the most favourable age for gestation in ewes is 4.5-5.5 years. Interrelation of the placenta morphostructural parameters (placenta weight, the number and size of cotyledons) and the lambs live weight and productivity has been established. This allows us to view placenta as a bioscopic material for assessing and prediction of future sheep productivity at early age.

Keywords: Ewe, Viability, Mother Organism, Progeny, Placenta, Correlation

Introduction

Obtaining viable, healthy young farm animals, sheep included, with high genetic potential remains one of the topical issues of modern agricultural science and practice.

Low viability of lambs and consequently low efficiency of sheep breeding is due to a number of factors. One of them is insufficient information on the diversified processes across pregnancy in ewes.

Despite numerous data (Gorlov *et al.*, 2014; Karagodina *et al.*, 2014; Kolosov *et al.*, 2013; 2015; Jitendra *et al.*, 2013) the role of a mother organism in the "mother-newborn" system has not been completely determined. The age of females, ewes in particular, when their reproductive potential is fully realized has not been clarified yet.

The general idea is that obtaining progeny both from very young animals and those in their old age is unacceptable. Scientists are convinced that an animal in its physiological senility, despite its outstanding reproductive indices at early age, can no longer realize its genetic potential in future progeny (Noor *et al.*, 2001).

Scientists consider it possible that for forming the essence of a female morphostructural mutation associated with age a notion such as "biological age" is necessary (Raghavendra *et al.*, 2014). But since different organs and systems of any living organism do not develop equally due to individual timing, the general idea is that there exist critical and favorable periods for forming and functioning of a mother organism reproductive system (Pasricha, 2012; Sapna *et al.*, 2015).

Selection by age does not replace or exclude any of the procedures used in breeding animals since parents age affects not only a number of productivity and progeny viability indices, but is also of general biological significance for the parents themselves during their practical use (Sumit, 2013). This seems particularly important in the light of the discussion on the advantages of the practical use of ewe lambs and tugs at first insemination (Udainia and Jain, 2001).

The uniqueness of a mother organism, culmination of development of which is having progeny, is that as soon as the egg is implanted there develops pregnancy dominant that is two functionally interconnected systems

are being formed: The Functional System of a Mother (FSM) and the Functional System of a Fetus (FSF) (Noor *et al.*, 2001; Raghavendra *et al.*, 2014). Integration of the mechanisms of the functions performed belongs to placenta (Karagodina *et al.*, 2014; Kolosov *et al.*, 2013; Gorlov *et al.*, 2017).

Placenta structure and functions are constantly changing during the life of an animal. Its structure and form are in the first place dependent on a mother organism state and needs of a fetus itself insuring tolerance in the mother-placenta-fetus system for the birth of viable progeny (Jitendra *et al.*, 2013; Udainia and Jain, 2001).

In this connection our aim was to study morphometric parameters of uneven-aged ewes placenta and optimize timing of prediction of young animals viability and potential productivity.

Materials and Methods

The research was made at the experimental station of State Scientific Institution Stavropol Animal Husbandry and Fodder Production Research Institute of the Russian Academy of Sciences, now Federal State Budget Scientific Institution "All-Russian Sheep and Goat Breeding Research Institute", on Stavropol Krai sheep breeding farms.

The experiment involved the ewes of the Caucasian (C) and North Caucasian meet-and-wool (NC) breeds inseminated by the rams of the same breeds as well as the Texel (T), Poll Dorset (PD), Edilbay (E) and their progeny.

The biomaterial for the research was the placenta and blood of the experimental animals. Placenta samples were taken immediately after its removal from the birth canal. Herewith its colour, shape, consistency as well as presence of pathological signs (infarction, hemorrhage, thrombosis, calcification, etc.) were estimated. On counting cotyledons, determining their shape, consistency, size, spacing the placenta was weighed. Micromorphometric parameters were measured with a standard eyepiece micrometer MOB-1-16 which scale was calibrated with a standard stage micrometer graduated in 0.01 mm. For histologic examination placental tissue 1.5×0.8 cm in size were sampled and 8% neutral formalin-fixed paraffin-embedded. 5-6 mm thick sections were stained with hematoxylin-eosin for the tissue structure general assessment and counting capillary number in the villus. Epithelial-to-connective tissue ratio was obtained by comparing the stained sections.

Blood samples for laboratory tests were taken from jugular vein in the morning before feeding. Standard, conventional methods of analysis were used in studying ontogenetic peculiarities of forming lambs physiological, biochemical and immune status. The influence of the age of the queens on the morphometric parameters of the placenta was established using single-factor analysis of variance. The dependence of the morphometric parameters of the placenta and the live weight of lambs on the fertility of the queens and sex of the lambs was established using two-factor analysis of variance.

Findings and Discussion

Formation of placenta as an organ, its adaptive and homeostatic reactions cannot but depend on a mother organism age. The general idea is that there exist critical and favorable age periods for a female to form a full-fledged in a morphostructural sense placenta (Kolosov *et al.*, 2015; Sumit, 2013; Noor *et al.*, 2001). However, there is no general agreement as to the most efficient age periods for predicting whether a mother organism reproductive capacity will be fully realized.

A set of experiments performed on the Caucasian ewes (n = 90) aged 2.5 (I group), 3.5 (II group), 4.5 (III group), 5.5 (IV group) and 6.5 years (V group), which were equally handled and fed, showed that placental morphological parameters changed with age (Table 1).

Ewes aged 2.5 and 3.5 years had the lightest placenta – 165 and 172 gr, ewes aged 4.5 and 5.5 years had the heaviest placenta – 230 and 247 gr. Fewer cotyledons in placenta, smaller cotyledon area, but looser cotyledon spacing was registered in the placenta of the youngest ewes (2.5 years) compared to older ones (3.5, 4.5, 5.5, 6.5 years); the difference in cotyledon count being 14.3, 26.2, 37.4, 25.5% respectively, the difference in average cotyledon area being 8.1, 37.8% and cotyledon spacing being more than 1.5 times thinner. The greatest Fetoplacental Ratio (FPR – placenta-to-fetus weight ratio) was registered in young ewes; the average difference between FPR in young ewes and FPR in older ones being 33.5%.

On considering interrelation of placental morphostructural parameters and ewes age there has been ambiguity of these interrelation revealed, expressed as correlation coefficient in connection both with the characteristics in question and ewes age (Table 2). Direct positive interrelation of placenta weight and cotyledon count and size and negative interrelation of placenta weight and cotyledon spacing is to be noted in the first place.

The discovered interrelation pattern is characteristic for all observed age groups, but it was more distinct between placenta weight and cotyledon count, between placenta weight and FPR in placenta of ewes aged 4.5, 5.5 and 6.5 years and equaled $IR = 0.41, 0.58, 0.49$ and $IR = 0.38, 0.44, 0.40$ against $IR = 0.32, 0.36$ and $IR = 0.19, 0.21$ – in ewes aged 2.5 and 3.5 years. Below, with the plus sign, there has been established interrelation of placenta weight and placental blood supply ratio (PBSR - interrelation of total cotyledon area and vascular tissue area), the discovered interrelation being stronger in ewes aged 4.5-6.5 years ($IR = 0.22-0.20$) than in ewes aged 2.5-3.5 years ($IR = 0.15-0.18$).

Comparative analysis of biochemical and immunological indices showed that the blood of young animals from ewes aged 4.5-5.5 years had a greater number of erythrocytes (8-11%), higher haemoglobin content (9-13%), reliably higher level of serum protein (11-14%), of albumins (7-11%), of globulins (8-13%), a greater number (11-16%) of immunocompetent cells (T-, B-lymphocytes).

Table 1: Placental morphometric parameters in uneven-aged ewes

Parameters	Age, years				
	2.5 I (n = 18)	3.5 II (n = 21)	4.5 III (n = 21)	5.5 IV (n = 16)	6.5 V (n = 14)
Placenta weight, gr*	165±4.6	172±5.7	230±5.4	247±7.2	219±5.9
Cotyledon count, pc*	61.0±3.4	69.7±5.1	77.0±2.4	83.8±1.2	76.6±3.1
Average cotyledon area, cm ² *	3.7±0.8	4.0±0.5	5.1±0.6	6.3±0.9	5.9±0.9
Spacing of cotyledons, cm*	5.9±1.1	4.8±0.9	4.3±0.6	3.7±0.6	4.6±0.8
Fetoplacental Ratio (FPR)*	23.0±2.1	23.2±3.1	18.6±2.4	18.6±4.5	16.0±3.8

*statistically significant differences between group means as determined by one-way ANOVA ($p < 0.05$)

Table 2: Interrelation of placental morphostructural parameters in uneven-aged ewes (IR)

Interrelated parameters	Ewes age, years				
	2.5	3.5	4.5	5.5	6.5
Placenta weight cotyledon count	0.32	0.36	0.41	0.58	0.49
Placenta weight cotyledon size	0.17	0.26	0.3	0.36	0.33
Placenta weight spacing of cotyledons	-0.18	-0.21	-0.26	-0.29	-0.24
Placenta weight Fetoplacental Ratio (FPR)	0.19	0.21	0.38	0.44	0.4
Placenta weight Placental Blood Supply Ratio (PBSR)	0.15	0.18	0.22	0.24	0.2

In herd qualitative improving such a selection technique as interbreeding is of no small importance. To increase meat production ewes of fine wool and half-fine wool breeds are commonly inseminated by stud rams of meat breeds (Texel - T, Poll Dorset - PD, Edilbay-E) (Gorlov *et al.*, 2014). Comparative analysis of placental morphometric parameters in ewes inseminated by rams of different breeds showed that dynamics of the placenta parametric variation depended on the breed of both rams and ewes.

Placenta weight, cotyledon count, cotyledon size were reliably higher in the placenta of the North Caucasian meat-and-wool and Caucasian breeds inseminated by rams of meat breeds, these placental parameters in E×NC and E×C ewes being much higher (14.5, 8.3, 22.7%) than those in T×NC and T×C ewes (14.0, 6.8, 15.0%), spacing of cotyledons being reliably 0.33 and 1.5 times thinner respectively (Table 3).

When we examined how the identified relations affected the progeny it was found that the progeny birth weight was heavier (8.3-9.8%). It was the progeny of ewes from breed selection variants where placenta was heavier and the cotyledons count was greater but with less space between them (T×NC, E×NC, T×C, E×C). Due to this parameter the progeny had superiority by the age of 9 months (7.6-16.7%). The much value of preslaughter and slaughter mass of this animals provided a greater slaughter yield (9.8% averagely).

The identified relation is probably connected with the role of placenta morphostructural form at the birth of viable progeny that has well high potential to breeding productivity in the future. It is confirmed by the representative differences in fetoplacental index value, placenta blood supply index of lambs from breed selection variants E×NC and E×C (23.8 and 24.6; 7.94 and 8.34) vs 18.6 and 21.2; 4.74 and 4.25

that has the progeny secured from the mating NC×NC and C×C, respectively.

The ewe breeding productivity is the physiological and biological potential and is rather high in case of standards observance, animal welfare and feeding (Sapna *et al.*, 2015). Regarding to this factor and the sex of a lamb with reference to placenta morphostructural form was found that placenta minimal mass (320-340 gr) but with higher cotyledons count (76-80) with bigger size (2.5/3.0; 3.5/4.0 cm) was representative of singles where ram-lambs had advantage in examined index value (Table 4). Specifically was that with birth rate growing the placenta mass was growing too: Single ewe-lambs (from 320 gr), single ram-lambs (to 340 gr) and twin-born lambs (from 360 to 380 gr). The placenta mass of twin ram-lambs was higher than of twin ewe-lambs: 380 gr vs 360 gr, respectively.

The cotyledons count in placenta of twin-born lambs was different: In twin ram-lambs' placenta there was by 8,2% more than in twin ewe-lambs' placenta. The big-sized cotyledons under comparatively similar spacing were typical for twin ram-lambs in contrast to twin ewe-lamb.

As for placenta morphostructural index of triplets, we can say that this placenta was the heaviest (400 gr). The cotyledons were of minimum size (1,8/2,0; 1,5/2,0) but with great total number of them (102) that probably indicates an activation of mother's mechanisms adaptation, supporting the conditions for normal fetal development and progeny birth (Pasricha, 2012).

We compared the lamb live weight index at birth and at the age of two months, taking into account the sex of lambs and the breeding productivity of their mothers. It was found out that there are representative differences in compared groups (Table 5).

Table 3: Productive indices of young animals at different variants of parental breed selection

Index	Variants of breed selection, group							
	NC×NC	T×NC	PD×NC	E×NC	C×C	T×C	NC×C	E×C
	I	II	III	IV	V	VI	VII	VIII
Placenta weight, gr*	290±5.8	310±6.6	265±5.4	355±7.7	230±5.8	285±6.6	270±5.9	325±7.2
Live weight, kg: - at birth*	4.0±0.18	4.8±0.14	4.3±0.16	5.2±0.18	3.6±0.30	4.3±0.24	4.5±0.35	4.7±0.30
- 4 months*	25.8±1.77	25.1±1.29	25.5±0.89	26±1.23	20.1±0.45	23.1±0.63	21.9±0.51	23.1±0.58
- 9 months*	36.8±1.19	3±1.15	36.9±1.08	39.6±1.14	32.4±0.65	34.8±0.85	35.5±0.72	37.8±0.75
Preslaughter weight, kg*	36.7±0.31	35.7±0.28	36.2±0.33	39.2±0.36	31.8±0.40	34.1±0.45	35±0.26	37.3±0.35
Dressing weight, kg*	17.27±0.21	16.75±0.18	16.93±0.22	19.04±0.25	12.7±0.18	14.6±0.19	15.7±0.17	17.5±0.18
Dressing percentage, %*	47.1	46.9	46.7	48.6	40	42.7	44.8	46.9
FPR *	21.2±2.2	22.6±2.7	20.2±1.6	23.8±2.7	18.6±2.1	21.8±2.2	19.3±1.9	24.6±1.7
PBSR*	4.74±0.32	5.00±0.32	3.00±0.21	8.34±0.75	4.25±0.73	4.93±0.56	6.05±1.98	7.94±0.41

*Statistically significant differences between group means as determined by one-way ANOVA ($p<0.05$)

Table 4: Placenta morphometric index, ewes breeding productivity, sex of lambs, (n = 90)

Index	Sex of lambs, groups					
	Singles ♀ I	Singles ♂ II	Twins ♀/♂ III	Twins ♀/♀ IV	Twins ♂/♂ V	Triplets (♂♀♂) VI
Placenta weight, gr.*	320±6.6	340±5.4	380±6.2	360±6.6	380±5.1	400±7.2
Cotyledons count**	76±2.8	80±3.3	42/48±2.4	43/42±2.8	45/47±3.3	39/29/34±2.9
Cotyledons size, cm**	2.5/3.0±0.5	3.5/4.0±0.6	2.0/2.5±0.7	2.0/2.5±0.6	2.5/2.5±0.5	1.8/2.0±0.4 1.5/2.0±0.3 2.0/2.0±0.3
Spacing of cotyledons, cm**	2.0/2.5±0.4	2.0/3.5±0.3	2.0/2.5±0.2	2.0/2.5±0.2	2.5/3.0±0.3	1.5/2.0±0.2

*Statistically significant differences between group means as determined by one-way ANOVA ($p<0.05$)

**Statistically significant influence of lamb count as determined by two-way ANOVA ($p<0.05$)

Table 5: Ewe breeding productivity, newborn lambs' sex and live weight

Index	Sex of lambs, group					
	Singles ♀ I	Singles ♂ II	Twins ♀/♂ III	Twins ♀/♀ IV	Twins ♂/♂ V	Triplets (♂♀♂) VI
Live weight of lambs at birth, kg *	3.6±0.11	4.0±0.12	2.8/3.0±0.09	3.2/3.4±0.1	3.6/3.4±0.12	2.4\2.1\2.3±0.08
2 months aged lambs **	14.0±0.16	14.7±0.17	10.2/10.0±0.13	9.2/9.6±0.14	11.0/10.6±0.12	8.4\8.5\8.6±0.09

*Statistically significant influence of nest size as determined by two-way ANOVA ($p<0.05$)

**Statistically significant influence of nest size and sex of lambs as determined by two-way ANOVA ($p<0.05$)

Single lambs, both ram-lambs and ewe-lambs were born heavier (3.6 and 4.0 kg) Vs twins either homosexual twins, or heterosexual twins where ram-lambs were more common: Twin ewe-lambs (3.2/3.4 kg); twin ram-lambs (3.6/3.4 kg) and twin ewe-lambs/twin ram-lambs (2.8/3.0 kg).

The triplets were born with minimal live weight: 2.4/2.1/2.3 kg. Single ewe-lambs and ram-lambs had a dominance in live weight index both at birth and at the age of 2 months: 14.0 and 14.7 kg vs twin ewe-lambs (9.2/9.6 kg), twin ram-lambs (11.0/10.6 kg), twin ewe-lambs/twin ram-lambs (10.2/10.0 kg) and triplets (8/4/8.5/8.6 kg).

Due to the comparison of placenta age features, physiological and biological indexes, immunological status of the born breed it can be noted that the most favourable period for breeding is ewe aged 4.5-5.5 years. It was found that here is a correlation between placenta morph structural indexes (placenta mass, cotyledons count, cotyledons size) and live weight of lambs, their breeding capacity.

Conclusion

The obtained results point to the fact that the processes, occurring in female organism across pregnancy are multifaceted. Such processes are directed at the ewe internal environment uniformity preserving on the one hand and at the creation of a favourable conditions for fetal development and viable progeny birth on the other hand. Such reaction complexity of female organism is achieved by the complex of compensatory, inter-system processes, occurring in placenta. The significance of mentioned findings is that the identified relations permit to believe – placenta is valuable bioscopic material for lambs viability evaluation and future sheep productivity prediction.

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Author's Contributions

Kolosov Yuri A., Vasilenko Vyacheslav N., Klimenko Aleksander I. and Aboneev Vasili V.: Provided leadership and coordinated the implementation of research work, analyzed and interpreted the study findings, drew conclusions.

Shirokova Nadezhda V., Getmantseva Lyubov V. and Kolosov Anatoli Yu: Conducted research, compiled the literary review, analyzed and interpreted the results.

Chizhova Ludmila N., Marchenko Vyacheslav V. and Mikhailenko Antonina K.: Involved in all experiments, obtained data analyses and contributed to the scientific writing of the manuscript.

Aboneev Dmitri V.: Conducted research, compiled the literary review, analyzed and interpreted the results.

Ethics

The authors declare no conflict of interest.

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