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THE PATTERNS OF LINEAR SKELETAL GROWTH OF THE CROSSBRED SHEEP

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Abstract:

While creating crossbred sheep breeding, a large number of breeds and pedigrees of stud rams and females were used, which then needed a complex evaluation of morpho-biological features. To investigate this issue, sheep lambs were produced from crossing stud rams of Romney Marsh breed, North-Caucasian meat-wool breed and Precoce with fine-wooled and coarse-wooled females in the conditions of the distant pasture and mountain husbandry of the North Caucasus, from 2008 to 2016. Five rams from each group at the age of 4, 8, 13 and 18 months were butchered. It was found that the growth rate of calvaria after birth is lower than in the spine, as a result of this the relative length of the calvaria in comparison with the newborn decreased on average by 3.67%, and the spine, on the contrary, increased by same value. In the postembryonic period, the calvaria developed more intensively in length than in the depth, and the width of angle in the jaw took the first place by the intensity of growth, then the height of the angle and length. During 18 months of life of the experimental youngsters, the mass of the spine and its sections increased by an average of 8.22 - 9.20, and the increase of length was from 2.32 to 2.69. In the embryonic period, the spine more intensively developed in length than in the mass, and at the birth moment it was 37.1 - 43.1% of the length spine of 18 months age.

Keywords: *hybrids, crossbreeds, skeleton, calvarias, embryonic period, spine, postembryonic period.*

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INTRODUCTION:

In Russia, due to severe natural and climatic conditions, sheep breeding has always been an important branch of agriculture, providing the needs of the population and light industry for food and specific types of animal raw materials. In some cases, sheep are the only species of animals that can use the available natural resources [1].

In modern conditions, the development of sheep breeding, increasing its competitiveness is largely due to its meat production. Lamb meat is one of the most valuable types of meat products and enjoys high demand in the world market. The best meat is that of lambs of 6-8 months age. In the world lamb consumption per capita is 1.29 kg, in Russia 1.0 kg [2].

In order to increase the efficiency and competitiveness of this industry, based on world experience, it is necessary to use meat productivity of sheep more fully, and for this it is necessary to have breeds and types with high early maturity and meat productivity. The most important method of increasing meat productivity is crossing [3,4]. In recent years, the development of early mature meat and meat-wool sheep breeding has become increasingly important [3,5]. In the same direction, work is being done in the North Caucasus [3,6,7,8]. While creating crossbred sheep breeding, we used a significant number of breeds and breed groups of stud rams and females, which offspring also needed a comprehensive assessment of productivity and morpho-biological features.

Particularly, it is poorly known about the formation of the bone system during the postembryonic period of life. The bone system is the supporting skeleton of the body. The skeleton determines the size and shape of the body. The bony system performs important functions in the body: mechanical and biological. The first include the functions of supporting and movement of the body, in addition, the bones protect the internal organs and systems from external damage [9].

Taking this into account, the aim of the study is to establish the growth patterns of the axial skeleton's bones in hybrid sheep for the development of scientific bases for the production of high-quality meat raw materials. In addition, in order to learn the diverse essence of the growth processes, to penetrate deep secrets of the principles of these processes, and to learn how to control the development of organisms, means to increase the productivity of animals, reduce the cost of production, and, finally, in a great measure to increase the consumption of people's foodstuffs and raise the general people's welfare in our country [10,11,12,13,14,15,16,17].

MATERIAL AND METHODS:

To investigate this issue we used lambs, produced from crossing stud rams of Romney Marsh breed (RM x FC), North-Caucasian meat-wool breed (NC x FC) and Precoce (P x FC) with fine-wooled and coarse-wooled females at the State Republican Agricultural Enterprise "SANIBA" in Prigorodny District of North Ossetia-Alania, in the period from 2008 to 2017. Five rams from each group at the age of 4, 8, 13 and 18 months were butchered. In these age periods, the dimensions of the skull (the length and depth of calvaria, the length of the spine and its sections: cervical, thoracic, lumbar, sacral and caudal) are taken into account.

RESULTS AND DISCUSSION:

The total length of the axial skeleton is composed of the length of the calvaria and the spine, the results of that are shown in Table 1.

Table 1. Length of Bones of the Axial Skeleton (acc. to average data)

Age, month	Overall length, mm	Including length			
		Calvaria		Spine	
		mm	%	mm	%
At birth	639.2	123.6	19.34	515.6	80.66
4	1220.2	191.4	15.69	1028.8	84.31
8	1294.2	203.0	15.69	1091.2	84.31
13	1403.7	229.8	16.37	1173.9	83.63
18	1523.0	238.6	15.67	1284.4	84.33

The data show that at birth, on average, calvaria accounts for about a fifth of the total length of the axial skeleton and tends to decrease with age, since its growth rates noticeably lag behind the growth rates of the spine (Table 2). For the suckling period, due to a higher increase in the length of the spine, the proportion of calvaria decreased by 3.67%. With age, this ratio has remained almost unchanged, although there is a slow but steady increase in the absolute length of both sections of the axial skeleton. During 18 months of youngster's life, the growth rate of the spine exceeded that of calvaria by 1.5.

Table 2. Intensity of linear growth of the axial skeleton's bones (according to average data)

Index		Age, month					Per 18 months
		at birth	4	8	13	18	
Growth rate	skeleton, total	1	1.909	1.061	1.085	1.085	2.383
	including calvaria	1	1.549	1.061	1.132	1.038	1.930
	spine	1	1.995	1.061	1.076	1.094	2.491
Early maturity, %	skeleton, total	41.51	80.12	84.98	92.17	100	
	including calvaria	51.80	80.22	85.08	95.93	100	
	spine	40.14	80.10	84.96	91.40	100	

The main growth in the length of calvary occurred during the fetal period, since its length at the time of birth was more than half of the 18-month index (51.8%) (Table 2). Despite the high growth rates of the spine in length, the latter still lagged behind in early maturity of calvary. As for the origin of the young, it did not have a significant effect on the linear dimensions of the skull and the spine. Thus, at the time of birth the experimental lambs were virtually indistinguishable along the length of the calvary and the spine (Table 3), the difference was 1.7-3.3 in absolute length, and 0.1-0.4% in relative length. At the time of weaning, the length of calvar was also the same for all groups of animals and speaking about the length of the spine, the fine-wooled lambs exceeded crossbreds by only 0.5-1.9%. In the following age periods, the intensity of growth of the skeletal sections was low, and without the advantage of the animals of any group (Table 4), but in 18 months of growth crossbred youngsters have surpassed fine-wooled ones by the length of both sections by an average from 2.4 to 3.5%.

Table 3. The Length of the Axial Skeleton's Bones of the Experimental Youngsters (in % of the total length of the axial skeleton)

Age, month	Group	Overall length, mm	Including			
			calvaria		spine	
			mm	%	mm	%
At birth	RM x FC	646.6	125.8	19.5	520.8	80.5
	NC x FC	635.5	121.6	19.1	513.9	80.9
	P x FC	635.7	123.5	19.4	512.2	80.6
4	RM x FC	1208.6	191.4	15.8	1017.2	84.2
	NC x FC	1232.5	191.4	15.6	1032.1	84.4
	P x FC	1228.4	191.4	15.6	1037.0	84.4
8	RM x FC	1319.2	203.9	15.5	1115.7	84.5
	NC x FC	1310.5	205.2	15.7	1105.3	84.3
	P x FC	1252.5	199.8	16.0	1052.7	84.0
13	RM x FC	1366.9	231.3	16.9	1135.6	83.1
	NC x FC	1467.0	234.8	16.0	1232.2	84.0
	P x FC	1377.2	223.3	16.2	1153.9	83.8
18	RM x FC	1541.6	241.7	15.7	1299.9	84.3
	NC x FC	1532.6	240.8	15.7	1291.8	84.3
	P x FC	1494.0	233.5	15.6	1261.5	84.4

At the same time there were no regular differences by the relative length of the calvaria and the spine between animals of different groups. It should be noted that by the developing of both sections of axial skeleton, the youngsters which were produced from the rams of the North Caucasian meat-wool breed, were much closer to adults than their coevals. (Table 5).

Table 4. Coefficient of Linear Growth of the Axial Skeleton's Bones of the Experimental Young Animals

Skeleton	Group	Age, month				Per 18 months
		4	8	13	18	
Axial, Total	RM x FC	1.869	1.092	1.036	1.128	2.384
	NC x FC	1.925	1.071	1.119	1.045	2.112
	P x FC	1.932	1.020	1.100	1.085	2.350
including calvaria	RM x FC	1.521	1.065	1.134	1.045	1.921
	NC x FC	1.574	1.072	1.144	1.026	1.980
	P x FC	1.550	1.044	1.118	1.046	1.891
spine	RM x FC	1.953	1.007	1.018	1.145	2.496
	NC x FC	2.018	1.071	1.025	1.098	2.514
	P x FC	2.025	1.015	1.095	1.093	2.463

Table 5. Early Maturity of the Axial Skeleton's Bones, %

Section	Group	Age, month			
		at birth	4	13	18
Calvaria	RM x FC	52.0	79.2	95.7	100
	NC x FC	50.5	79.5	97.5	100
	P x FC	52.9	82.0	95.6	100
Spine	RM x FC	40.1	78.3	87.4	100
	NC x FC	39.8	79.9	95.4	100
	P x FC	40.6	82.2	91.5	100

The skull consists of calvaria and the mandible, which takes into account the length, the depth, the width and the height of the angle (Table 6). In spite of the fact that a partial table is already given an estimate of the linear growth of calvaria, it is necessary to add to this evaluation its development in depth. As can be seen from the data in Table 7, at the moment of birth lambs calvaria was better developed in depth than in length (in % to adults), but in the suckling period they switched places, since its length at this time increased faster than the depth (the coefficient of growth of 1.549 against 1.504).

Table 6. Skull Sizes of the Experimental Youngsters (according to average data)

Age, month	Calvaria		Lower jaw		
	length	depth	length	width of angle	height of the angle
At birth	123.6	57.5	86.2	15.6	28.7
4	191.4	86.5	134.0	38.4	53.3
8	203.0	94.8	148.5	43.6	59.4
13	229.8	103.8	161.7	47.4	65.4
18	238.6	108.3	174.0	51.9	70.0

In the period from the weaning to the age of 18 months, the growth's intensity of the length and depth of the calvaria alternated in each subsequent period, their early maturity changed identically, but as a result, over the 18 months the calvaria developed more intensively in length than in depth. At birth and at the age of 4 months the experimental animals had approximately the same indices on the length and depth of the calvaria (Table 8), but starting from the age of 8 months, the crossbred youngsters slightly exceeded the fine-wooled peers in developing of calvaria.

The lower jaw of experimental animals, regardless of origin, turned out to be a late-ripening part of the skull. In the embryonic period, it developed more slowly than calvaria (Table 7), but after birth, their growth rate was higher than that of calvaria. In the fetal period, its length developed better than the width and height of the angle, and after birth, especially in the suckling period, on the contrary, we noted the high growth of the latter. For 18 months, the first place by the intensity of growth was the width, then the height of the angle and, the jaw's length had the slowest changes. It should be noted that although the differences between the animals of different groups were small, there is still a slight but regular superiority of crossbred youngsters.

Table 7. The Intensity of Growth of Skull Bones (according to average data)

Index			Age, month					Per 18 months
			at birth	4	8	13	18	
Growth ratio	calvaria	length	1	1.549	1.061	1.132	1.038	1.930
		depth	1	1.504	1.096	1.095	1.043	1.883
	lower jaw	length	1	1.554	1.108	1.089	1.076	2.019
		width of angle	1	2.462	1.135	1.087	1.095	3.327
		height of the angle	1	1.857	1.114	1.101	1.070	2.439
Early maturity, %	calvaria	length	51.8	80.2	85.1	96.3	100	
		depth	53.1	79.9	87.5	95.8	100	
	lower jaw	length	49.5	77.0	85.3	92.9	100	
		width of angle	30.1	74.0	84.0	91.3	100	
		height of the angle	41.0	76.1	84.9	93.4	100	

The spine plays an important role in the skeleton of animals, so studying its length with age and depending on the origin of the animals is of some interest. First of all, we will analyze the linear growth of the length of the entire vertebral column and its sections regardless the origin of the youngsters. It was established that the spine developed considerably faster in the embryonic period than its mass. At the time of birth, its length was 40.1% of the adult index, while its mass reached only 11.7%. At a later age (13 months), it was better formed in length (91.4%) than in mass (88.5%), although the growth rate of the mass (growth ratio 8.548) over 18 months of life was significantly faster than linear growth rates (growth ratio 2.491). Newborn lambs had a better developed coccygeal section of the spine (in relation to the total length), then the thoracic, cervical and lumbar spine (Table 9).

Table 8. Skull Size of the Experimental Youngsters, mm

Age, month	Group	Calvaria		Lower jaw		
		length	depth	length	width of angle	height of the angle
At birth	RM x FC	125.8	57.2	87.6	16.5	29.6
	NC x FC	121.6	56.8	84.9	16.9	27.9
	P x FC	123.5	58.6	86.1	13.4	28.7
4	RM x FC	191.4	88.1	134.1	39.1	53.2
	NC x FC	191.4	86.5	134.5	41.0	53.8
	P x FC	191.4	84.8	133.4	35.1	52.9
8	RM x FC	203.9	96.3	148.6	42.7	60.7
	NC x FC	205.1	95.8	152.0	45.0	60.0
	P x FC	199.8	92.4	145.0	43.1	57.5
13	RM x FC	231.3	103.0	160.3	47.0	67.1
	NC x FC	234.8	107.0	163.2	51.2	65.5
	P x FC	223.3	101.5	161.7	44.0	63.5
18	RM x FC	241.6	107.3	175.4	54.0	70.6
	NC x FC	240.8	108.4	176.4	52.4	70.7
	P x FC	233.5	109.3	170.2	49.3	68.7

Later, this ratio underwent small changes. The largest linear growth of the spine sections occurred in the suckling period (Table 10), with the best increase in the development of the caudal vertebrae, in which the total length increased 2.085 times, which increased their relative length by 1.6%. On the second place was the lumbar spine, which retained its part in the total length of the entire spine. The ratio of the remaining parts of the spine for the suckling period decreased due to low rates of linear growth.

With age, the rates of linear growth of the spine sections changed. After weaning, a relatively higher length gain was preserved in the lumbar and cervical spine, which allowed them to take the first places in absolute increments over the 18 months. In the remaining sections, the proportion to the total length of the spine decreased. This decrease is explained by the fact that the caudal, sacral and thoracic parts of the spine in the embryonic period were formed (in % to adults) earlier than the lumbar and cervical spine, that is, the length of the lumbar and cervical spine turned out to be the late-ripening part of the spine.

Table 9. The Length of the Spine and Its Sections (according to average data, in % of total length)

Index		Age, month				
		at birth	4	8	13	18
Length of spine, total	mm	515.6	1028.8	1091.2	1173.9	1284.4
Including: cervical spine	mm	95.8	182.8	206.2	226.0	257.3
	%	8.6	17.8	18.9	19.2	20.0
Thoracic spine	mm	130.9	255.7	273.1	294.0	319.6
	%	25.4	24.8	25.0	25.0	24.9
Lumbar spine	mm	79.3	159.4	183.4	192.5	214.0
	%	15.4	15.5	16.8	16.4	16.7
Sacral spine	mm	41,1	79.5	83.4	91.7	95.3
	%	8.0	7.7	7.6	7.8	7.4
Coccygeal	mm	168.5	351.4	345.1	369.7	398.2
	%	32.6	34.2	31.6	31.5	31.0

The origin had a definite effect on the length of the spine sections (Table 11). In the length of the cervical spine, crossbred lambs, both at birth and at an older age, excelled fine-wooled ones. At the age of 18 months, the difference by absolute length was 6.3-12.8%, and by relative - 0.27-1.80%. At the same time, the lumbar spine is better developed in fine-wooled lambs and its ratio in the overall length was significantly higher than in crossbreds. By the length of the sacral spine, the differences between the groups are inessential.

Table 10. Intensity of Linear Growth of the Spine (acc. to average data)

Index		Age, month				
		at birth	4	8	13	18
Growth ratio	spine, total	1	1.995	1.061	1.076	1.094
	including: cervical spine	1	1.908	1.128	1.096	1.138
	thoracic spine	1	1.953	1.068	1.047	0.087
	lumbar spine	1	2.010	1.151	1.050	1.112
	sacral spine	1	1.934	1.049	1.100	1.039
	coccygeal	1	2.085	0.982	1.071	1.077
Early maturity,%	spine, total	40.1	80.1	85.0	91.4	100
	including: cervical spine	37.3	71.0	80.1	87.85	100
	thoracic spine	41.0	80.0	85.5	92.03	100
	lumbar spine	37.1	74.5	85.7	90.04	100
	sacral spine	43.1	83.4	87.5	96.21	100
	coccygeal	42.3	88.7	86.7	92.82	100

The comparison of the intensity of weight and linear growth of the spine and its sections showed that over 18 months the mass of the spine and its sections increased by 8.22-9.20 times, while the increase in its length on averaged is by 2.32-2.69 times. Obviously, the length of the spine is more intensively formed in the embryonic period, reaching 37.1-43.1% of the length of adult animals by the time of birth, whereas this index of the mass of the spine and its sections was only 11.0-12.2%.

Table 11. The Length of the Spine and Its Sections (in% of the length of the spine)

Age, month	Group	Length of spine, total mm	Including the length of the section									
			cervical		thoracic spine		lumbar spine		sacral spine		coccygeal	
			mm	%	mm	%	mm	%	mm	%	mm	%
At birth	RM x FC	520.8	96.6	18.55	134.3	26.79	78.6	15.09	41.7	8.01	169.6	32.56
	NC x FC	513.9	97.0	18.87	127.3	24.77	75.5	14.69	40.1	7.80	174.0	33.86
	P x FC	512.2	93.8	18.31	131.1	25.59	83.8	16.36	41.5	8.10	162.0	31.63
4	RM x FC	1017.2	183.8	18.07	255.3	25.10	157.8	15.51	79.7	7.83	340.6	33.48
	NC x FC	1032.1	183.9	17.82	255.3	24.34	157.8	15.29	79.7	7.72	355.4	34.43
	P x FC	1037.0	180.7	17.42	256.4	24.73	162.5	15.67	79.0	7.62	358.4	34.56
8	RM x FC	1115.7	210.5	18.87	277.9	24.91	182.3	16.34	84.4	7.56	360.6	32.32
	NC x FC	1105.3	211.2	19.11	271.0	24.52	188.6	17.06	86.0	7.78	348.5	31.53
	P x FC	1052.7	197.0	18.71	270.5	25.70	179.3	17.03	79.9	7.59	326.0	30.97
13	RM x FC	1135.6	225.3	19.84	284.8	25.08	190.7	16.79	90.8	8.00	344.0	30.29
	NC x FC	1232.2	231.5	18.79	303.3	24.61	191.3	15.52	95.5	7.75	410.6	33.23
	P x FC	1153.9	221.3	19.18	293.9	25.47	195.5	16.94	88.7	7.69	354.4	30.71
18	RM x FC	1299.9	272.9	20.98	326.5	25.12	211.7	16.29	96.8	7.48	392.0	30.16
	NC x FC	1291.8	257.2	19.91	315.0	24.38	200.1	15.49	95.7	7.41	423.8	32.81
	P x FC	1261.5	241.9	19.18	317.2	25.14	230.3	18.26	93.3	7.40	378.8	30.02

Table 12. The Measurement of the Chest Bone of the Experimental Youngsters, mm

Measurement	Group	Age, month				
		at birth	4	8	13	18
Length	RM x FC	98.0	181.2	188.4	214.0	215.2
	NC x FC	93.5	171.4	191.8	204.4	210.0
	P x FC	100.4	172.2	178.8	190.0	203.0
On average		97.3	174.9	186.3	202.8	209.4
Width	RM x FC	18.4	27.5	30.8	35.2	39.1
	NC x FC	17.2	29.0	31.8	40.3	41.3
	P x FC	17.7	28.3	29.2	34.9	38.7
On average		17.8	28.3	30.6	36.8	39.7
Length to Width ratio	RM x FC	5.33	6.59	6.12	6.08	5.50
	NC x FC	5.44	5.91	6.03	5.07	5.08
	P x FC	5.67	6.08	6.12	5.44	5.25
On average		5.48	6.19	6.09	5.53	5.28

It should be noted that the sections of the spine differ in their growth rates: the sacral and caudal spine took the first two places in terms of the intensity of weight gain, while in terms of the intensity of elongation they were inferior to others.

The thoracic bone is an integral part of the axial skeleton, consisting of seven segments connected by a cartilaginous tissue. Its dimensions and mass depend not only on pedigree features, but also on the live weight and supporting functions. From the data in Table 12, it can be seen that the length of the newborns' chest bone was 5.48 times its width, but this ratio varies with age, since after birth, both measurements in length vary unequally. Over the suckling period, the length of the breast bone increased more than its width. After weaning, the intensity of the latitudinal increase in length was higher, which changed the ratio of the measured data toward the decrease. In general, for 18 months the width of the breast bone increased more than its length, but in the embryonic period it was earlier formed in length (in% to adults) than in width (Table 13).

Table 13. The Intensity of Linear Growth of the Thoracic Bone

Index		Group	Age, month					Per 18 months
			at birth	4	8	13	18	
Growth ratio	Length	RM x FC	1	1.85	1.04	1.14	1.01	2.20
		NC x FC	1	1.83	1.12	1.07	1.03	2.25
		P x FC	1	1.72	1.04	1.06	1.07	2.02
	On average		1	1.80	1.07	1.09	1.04	2.16
	Width	RM x FC	1	1.49	1.12	1.14	1.11	2.13
		NC x FC	1	1.69	1.10	1.27	1.03	2.40
		P x FC	1	1.60	1.03	1.20	1.11	2.19
	On average		1	1.59	1.08	1.20	1.08	2.24
Early maturity, %	Length	RM x FC	45.5	84.2	85.7	99.4	100	
		NC x FC	44.5	81.6	91.3	97.3	100	
		P x FC	49.5	84.3	88.1	93.6	100	
	On average		46.5	83.5	88.4	96.8	100	
	Width	RM x FC	47.1	70.3	78.8	90.0	100	
		NC x FC	41.6	70.2	77.0	97.6	100	
		P x FC	45.7	73.1	75.5	90.2	100	
	On average		44.8	71.3	77.1	92.6	100	

In animals of different groups, the breast bone is developed unequally (Table 12, 13). Fine-wooled lambs at a birth has better developed the breast bone in length, and RM x FC - in width. Crossbred lambs had the breast bone better developed after birth, so at the age of 18 months they exceeded the fine-wooled by 3.4-5.9 %. This is also confirmed by the higher early maturity of crossbred lambs along the length of the breast bone.

At the age of 18 months, crossbred youngsters had better development of the brisket bone in width, surpassing the fine-wooled by 1.0-6.7%.

The foregoing allows us to conclude that: - after birth the rate of calvaria's growth in length is lower (ratio growth is 1.93) than the spine's one (2.49), as a result of which the relative length of the first in comparison with the newborn decreased by an average of 3.67%, and the spine, on the contrary, increased by the same degree. The origin of the young had no significant effect on the length of the calvaria and the spine;- in the postembryonic period, the calvaria developed more intensively in length (growth ratio was 1.930) than in depth, but in the jaw the width of the angle (growth ratio 3,327) took the first place by the intensity of growth, followed by the height of the angle (2.439) and the length (2.019);

- over 18 months of life, the mass of the spine and its sections of the experimental youngsters increased by 8.22 - 9.20 on average and the increase in length was 2.32 - 2.69. This difference is explained by the fact that in the embryonic period the spine developed more intensively in length than in the mass, as a result of which the length of the spine at the time of birth was 37.1 - 43.1% of the spine's length at the age of 18 months. And its mass is only 11.0-12.2;

- crossbred youngsters had a better developed thoracic bone than fine-wooled ones, which is typical for sheep of meat-wool breed.

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