Influence of steer genotypes on the features of muscle development in the postnatal period of ontogenesis

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Abstract. The study of the carcass muscles development was carried out on Simmental and Kazakh White-Headed steers and their first generation hybrids. At the age of 18 months, the control slaughter of 3 steers of different genotypes was carried out: I - Simmental, II - Kazakh White-Headed, III - 1/2 Kazakh White-Headed x 1/2 Simmental. To study the development of muscle groups and individual muscles by anatomical regions, the left half-carcasses were prepared, taking into account the methodical instructions. To facilitate the analysis of the material, the muscles were grouped according to the relevant joints and the topographic location by the generally accepted pattern. The muscles development was studied using the data on the absolute mass of individual muscles and muscle groups. It was established that the steers of group III surpassed those of groups I and II in the total muscle mass of the spinal column, which was 1.28-0.45 kg (10.85-3.56%), the total muscle mass of the shoulder girdle - 1.45-0.51 kg (9.78-3.51%), thoracic limb - 0.72-0.25 kg (9.77-3.43%), pelvic limb - 3.16-1.11 kg (9.78-3.45%) and, in general, throughout the half-carcass of the muscles considered - 6.62-2.33 kg (9.79-3.44%).

1. Introduction
The results of a comparative assessment of genetic characteristics of the development of individual muscles and muscle groups in anatomical regions are indicative of the different growth intensities of absolute muscle tissue mass [1-3]. Moreover, these differences are due to unequal muscle growth energy under the conditions of maximum possible realization of their potential capabilities and genotypic features. Moreover, it should be noted that it is the parameters of these data that make it possible to be aware of the features and intensity of muscles growth and development in the period of ontogenesis of young cattle with different genotypic peculiarities and performance trends [4-5].

2. The problem definition
There is no doubt that the increase of cattle beef productivity is associated with an increase in muscle tissue mass [6]. Therefore, the study of muscles growth and development peculiarities in young Simmental cattle fed the Vetosporin-Active feed additive is of significant scientific and practical interest. The knowledge of the muscle tissue growth and development pattern will make it possible to
determine more objectively the level of meat productivity of young animals, depending on the consumption of the Vetosporin-Active feed additive as well as to develop the methods of using the above feed supplement in growing and fattening of animals of other genotypes on the basis of the positive results obtained.

3. Materials and methods

The object of the study

The Simmental, Kazakh White-Headed steers and their crosses of the first generation were included in the experiments.

The animals care and maintenance as well as the experimental studies were conducted in conformity with the instructions and recommendations of the Russian Regulations, 1987 (Order No. 755 of 08/12/1977, the USSR Ministry of Health) and the Guide for Care and Maintenance of Laboratory Animals (National Academy Press Washington DS 1996).

The scheme of the experiment

3 groups of Simmental, Kazakh White-Headed steers and their hybrids of the first generation, including 15 animals in each group, were formed.

To study the development of the muscular system of steers at the age of 18 months, the control slaughter of 3 animals of different genotypes was carried out: I - Simmental, II - Kazakh White-Headed, III - ½ Kazakh White-Headed x ½Simmental. To study the development of muscle groups and individual muscles in anatomical regions, the left half-carcasses were prepared in accordance with the methodical instructions. To facilitate the analysis of the material, the muscles were grouped by the relevant joints and topographic location.

The following groups of muscles have been studied:

Group I - muscles of the spinal column - the longest muscle of the back - m. longissimus dorsi, the semispinal muscle of the head - m. semispinalis capitis, spinous and semi-axial muscles of the breast and neck - m. spinalis et semispinalis thoracis et cervicis, plastrer muscle - m. spelenius, small lumbar muscle - m. psaas minor, large lumbar - m. psoas major, multiple muscle - m. longissimus capitis;

Group II - muscles connecting the shoulder girdle with the body - pectoralis muscle - m. pectoralis superficialis, dentoveentral muscle - m. latissimus dorsi, rhomboid muscle - m. rhomboides, trapezius muscle - m. trapezius, brachiocephalic muscle - m. brachiocephalicus;

Group III - muscles of the thoracic limb - a) including the area of the scapula - precarious muscle - m. supraspinatus, anisis muscle - m. subscapularis; b) including the shoulder area - the triceps of the shoulder - m. triceps brachii, biceps muscle of the shoulder - m. biceps brachii;

Group IV - muscles of the pelvic limb - a) including the area of the pelvic girdle - deep GLUTUS maximizing - m. glutaeus profundus, lumbar iliac muscle - m. psoas iliacus, adductor muscle - m. adductor femoris, glutaeus medius muscle - m. glutaeus medius; b) including the thigh area - scallop muscle, quadriiceps femoris - m. quadriiceps femoris, two-headed muscle of the thighs - m. biceps femoris, semi-membranous muscle - m. semimembranosus, semitendinosus muscle - m. semitendineus, slender muscle - m. gracilis, tensor of the wide thigh fascia - m. tensor fasciae late, tailor muscle - m. sartoris, square lumbar muscle - m. quadratus lumborum, c) including the shin area - calf muscle - m. gastrochomius.

Muscle development was studied using the absolute mass parameters of individual muscles and muscle groups. Due to the fact that the integrity of soft tissues had not been damaged in the process of carcass dissection, only the left half-carcasses were dissected, while its right ones were subjected to the usual deboning, with their bones having been removed and weighed and their mass summed with the mass of the same bones of the right half carcass. The half carcasses were prepared in conformity with the guidelines. After preparation, all muscles were identified in accordance with the International
Veterinary Anatomical Nomenclature (1979). To facilitate the analysis of the material, the muscles were grouped according to the corresponding joints and the topographic location by the generally accepted scheme.

**Equipment and hardware**

The muscles were weighed separately with an accuracy of 1 g on the Acom JW-1-300 balance.

**Statistical processing**

The basic material obtained in the course of studies was processed, using the Statistica 10.0 software package (Star Soft Inc., USA); the reliability was determined using Student's criterion.

### 4. Results and Discussion

The analysis of the spinal column muscles development indicates that animals of Group III were characterized by the highest mass, while the animals of the same age in Group I had the lowest mass of the above muscles (Table 1).

| Name of individual muscles | Group I (X ± Sx) | Group II (X ± Sx) | Group III (X ± Sx) |
|----------------------------|------------------|-------------------|-------------------|
| Musculus longissimus dorsi | 4.76±202.31      | 5.09±212.42       | 5.27±222.45       |
| Musculus semispinalis capitis | 0.96±28.23    | 1.03±27.14        | 1.07±29.28        |
| Musc.spinai-semispinalis dorsi cervisis | 1.56±64.28 | 1.67±63.02        | 1.73±66.40        |
| Longissimus capitis cervisis | 1.18±38.22      | 1.26±48.30        | 1.31±51.50        |
| Plaster-like muscle | 0.90±35.12       | 0.97±38.88        | 1.00±38.33        |
| Musculus psoes minor | 0.37±20.23       | 0.39±22.01        | 0.41±23.63        |
| Musculus psoas major | 1.08±41.42       | 1.16±66.20        | 1.20±80.04        |
| Musculus multifidus | 0.98±61.33       | 1.05±60.11        | 1.09±68.28        |
| Total in the group | 11.80±180.32     | 12.63±301.82      | 13.08±321.88      |

The steers of Group II occupied an intermediate position. Thus, the steers of Group III surpassed those of the same age in Groups I and II in the mass of musculus longissimus dorsi at 0.515-0.181 kg (9.77-3.43%), and the difference between steers of Groups I and II in favor of young animals of Group II was 0.33 kg (6.56%).

Correspondingly, intergroup differences were also observed concerning the mass of the following muscles: musculus semispinalis capitis - 0.10-0.04 kg (9.76-3.47%) and 0.07 kg (6.51%); m. spinalis and semispinalis dorsi cervisis - 0.17-0.06 kg (9.77-6.41%) and 0.11 kg (6.59%) and 0.08 kg (6.58%); the plaster-like muscle 0.10-0.03 kg (9.78-3.49%) and 0.06 kg (6.52%); m. psoas minor 0.04-0.01 kg (9.9-3.62%) and 0.03 kg (6.52%); m. psoas major 0.12 - 0.04 kg (9.82-3.49%) and 0.07 kg (6.56%) and, in general, the total muscle mass of the spinal column was 1.28-0.45 kg (10.85-3.56%) and 0.83 kg (6.57%).

As it can be seen from the table data, the highest muscle mass indices were observed for the musculus longissimus dorsi and for the group of spinalis and semispinalis dorsi cervisis muscles in the steers of all the groups. Such muscles as the m. semispinalis capitis, m. longissimus capitis, the plaster-like muscle, the m. psoas major and the m. multifidus were also distinguished by the level of their development. All of them, forming a group, had almost the same properties, determining the high quality of beef along the spinal column as a whole.

The analysis of the shoulder girdle muscles development showed that the animals of Group III had the highest mass, those of Group II had the lowest mass, while steers of the same age were characterized by an average level of muscle development parameters of this group (Table 2)
Table 2. Development of muscles of the shoulder girdle, kg (X ± Sx)

| Name of individual muscles       | Group I     | Group II     | Group III    |
|----------------------------------|------------|--------------|--------------|
| M. profundus pectoralis          | 3.39±280.28| 3.63±202.44  | 3.76±292.49  |
| M. superficialis pectorali       | 1.14±43.48 | 1.22±55.28   | 1.27±58.19   |
| M. denticulatus ventralis        | 4.73±320.22| 5.06±318.40  | 5.24±353.02  |
| M. latissimus dorsi              | 1.82±78.08 | 1.94±72.62   | 2.01±79.00   |
| M. rhomboides                    | 0.49±38.12 | 0.53±42.19   | 0.35±48.53   |
| M. trapezius                    | 1.00±54.28 | 1.07±79.18   | 1.11±88.38   |
| M. brachilis capitus             | 0.81±50.81 | 0.87±28.08   | 0.90±80.93   |
| Total for the group              | 13.40±328.33| 14.35±401.20| 14.86±423.33|

Thus, the steers of Group III exceeded the same age ones of the first and second groups in the mass of the m. profundus pectoralis by 0.36-0.13 kg (9.78-3.46%), and the differences between the steers of the first and second groups in favor of those of Group II was 0.24 kg (6.55%). The intergroup differences in mass of other muscles were as follows: m. superficialis pectoralis - 0.12 - 0.04 kg (9.77-3.48%) and 0.08 kg (6.53%); m. denticulatus ventralis - 0.513-0.18 kg (9.78-3.45%) and 0.33 kg (6.56%); m. latissimus dorsi - 0.20-0.07 kg (9.7-3.43%) and 0.13 kg (6.58%); m. rhomboids - 0.05-0.09 kg (9.78-3.44%) and 0.03 kg (6.57%); m. trapezius - 0.11-0.31 kg (3.79-3.41%) and 0.07 kg (6.58%); m. brachilis capitus - 0.09-0.03 kg (9.76-3.44%) and 0.06 kg (6.54%), with the total muscle mass of the shoulder girdle (cingulum extremitatis superioris) being - 1.45-0.51 kg (9.78-3.51%) and 0.941 kg (6.56%).

Among the muscles of the shoulder girdle, irrespective of the group, the mass of m. denticulatus ventralis was the highest and the m. profundus pectoralis followed it in terms of its mass. The latissimus dorsi muscle was the third in absolute weight in this group. Relatively close mass indices were observed in superficialis pectoralis and trapezius muscles. The lowest mass parameters were registered in the brachilis capitus and rhomboids muscles.

It is obvious that the development of muscles of this group, characterized by their specific capacity of musculature formation under optimal conditions of feeding and keeping young cattle is to result in their purposeful improvement, which should be taken into account in the process of creating new cattle breeding technologies.

The results of analysis of the thoracic limbs development demonstrated that this topographic region of muscle tissue was characterized by the same pattern of intergroup differences as the development of muscles of the spinal column and those of the shoulder girdle (Table 3).

Table 3. Development of the thoracic limb muscles, kg (X ± Sx)

| Name of individual muscles         | Group I     | Group II     | Group III    |
|------------------------------------|------------|--------------|--------------|
| M. prespinalis thorasis            | 0.95±45.53 | 1.02±39.20   | 1.06±63.42   |
| M. retrospinalis thorasis          | 1.44±91.22 | 1.54±88.10   | 1.59±112.40  |
| M. subscapularis                   | 1.03±8.33  | 1.10±70.28   | 1.14±91.20   |
| Scapular regions, total            | 3.42±168.92| 3.66±153.23  | 3.79±301.22  |
| M. triceps brachialis              | 2.49±92.92 | 2.67±64.20   | 2.76±120.21  |
| M. biceps brachialis               | 0.76±62.62 | 0.82±40.90   | 0.85±65.80   |
| Shoulder regions, total            | 3.25±190.20| 3.48±172.33  | 3.61±202.60  |
| Thoracic limb, total               | 6.68±308.20| 7.15±312.42  | 7.40±352.92  |

The steers of Group III were distinguished by the highest mass parameters of individual muscles of the thoracic limb, the lowest mass indices were observed in steers of Group I, and steers of the same age of Group II occupied an intermediate position in the development of muscles of this half-carcass region. Thus, the Group III steers exceeded those of Groups I and II in the mass of the m. prespinalis.
by 0.10-0.04 kg (9.74-3.40%), and the difference between steers of Groups I and II in favor of steers of Group II was 0.07 kg (6.65%).

Similar intergroup differences were observed for the mass of the following muscles: the m. retrospinalis - 0.15-0.05 kg (9.73-3.39%) and 0.10 kg (6.56%); m. subscapularis - 0.11-0.04 kg (9.65-3.33%); and 0.07 kg (6.65%); the total scapular area - 0.37-0.13 kg (9.71-3.38%) and 0.24 kg (6.55%); m. triceps brachialis - 0.27-0.09 kg (9.81-3.48%) and 0.17 kg (6.54%); m. biceps brachialis - 0.08-0.03 kg (9.92-3.54%) and 0.05 kg (6.38%); the shoulder area as a whole - 0.35-0.13 kg (9.84-3.49%) and 0.23 kg (6.58%); - thoracic limb, totally - 0.72-0.25 kg (9.77-3.43%) and 0.47 kg (6.56%).

As can be seen from the table, the absolute mass of the group of thoracic limb muscles under study in steers of all the groups was the first among the muscles of the scapula region. The m. triceps brachialis was distinguished by the highest absolute muscle mass in the shoulder region.

The analysis of the pelvic limb muscles development confirms that the general patterns of differences between the studied groups manifested themselves in the same sequence as in the previously considered regions of the half-carcass (table 4).

Table 4. Pelvic limb muscle development, kg (X ± Sx)

| Name of individual muscles | I         | II         | III        |
|----------------------------|-----------|------------|------------|
| M. gluteus profundus       | 0.53±55.28| 0.57±53.22 | 0.59±60.12 |
| M. lumbosacralis           | 0.66±92.22| 0.71±90.58 | 0.73±112.43|
| M. adductor                | 1.99±202.14| 2.13±212.80| 2.19±233.23|
| M. glutus medius           | 2.85±118.48| 3.05±160.12| 3.17±188.33|
| Pelvic girdle region, total| 6.03±308.23| 6.46±393.28| 6.69±402.18|
| M. pectineus               | 0.51±43.43 | 0.55±38.28 | 0.57±45.40 |
| M. quadriceps femoris      | 4.49±220.90| 4.80±233.99| 4.98±282.65|
| M. biceps femoris          | 5.47±105.05| 5.85±88.10 | 6.06±280.14|
| M. semimembranous          | 5.62±221.12| 6.01±188.81| 6.23±263.40|
| M. semitendinosus          | 2.29±140.20| 2.45±168.07| 2.53±190.23|
| M. gracilis                | 1.10±80.58 | 1.18±68.10 | 1.22±128.33|
| M. tensor fascia vastus femoris | 1.15±80.85 | 1.23±85.20 | 1.27±133.93|
| M. sartorius               | 0.32±33.12 | 0.35±20.21 | 0.36±35.20 |
| M. quadratus femoris       | 0.41±55.40 | 0.44±40.12 | 0.46±62.11 |
| M. regio femoris, total    | 21.37±622.10| 22.87±608.92| 23.68±920.18|
| M. surae-gastrochemius     | 1.77±83.12 | 1.89±55.18 | 1.97±91.12 |
| Pelvic limb, total         | 29.18±1202.13| 31.23±1110.40| 32.34±1633.80|
| Entire half-carcass of muscles | 61.06±2240.13| 65.35±2323.19| 67.68±2830.16|

The steers of Group III were distinguished with the highest mass of individual pelvic limb muscles and their analogues of group I showed the lowest mass, while the steers of the same age showed the intermediate parameters. Thus, the young animals of group III exceeded those of groups I and II in the mass of m. glutus profundus at 0.06-0.02 kg (9.73-3.41%). Moreover, the difference between the steers of groups I and II in favor of the latter was about 0.04 kg (6.54%).

Similar intergroup differences were observed, respectively, in mass of the following pelvic limb muscles: lumboiliac - 0.07-0.02 kg (9.81-3.41%) and 0.05 kg (6.63%); m. adductor - 0.21-0.07 kg (9.37-3.00%) and 0.14 kg (6.56%); m. glutus medius - 0.32-0.12 kg (10.09-0.75%) and 0.20 kg (6.59%); total in the pelvic girdle region - 0.66-0.23 kg (9.94-3.44%) and 0.42 kg (6.58%); m. pectineus - 0.06-0.02 kg (9.86-3.52%) and 0.04 kg (6.57%); m. quadriceps femoris - 0.49-0.17 kg (9.79-3.46%) and 0.32 kg (6.58%); m. biceps femoris - 0.58-0.21 kg (9.61-3.45%) and 0.38 kg (6.56%); m. semimembranosus - 0.61-0.21 kg (9.78-3.45%) and 0.39 kg (6.55%); m. semitendinosus - 0.25-0.09 kg (9.79-3.43%) and 0.16 kg (6.58%); m. gracilis - 0.12-0.042 kg (9.72-3.43%) and 0.08 kg (6.51%); m. tensor fascia vastus femoris - 0.12-0.04 kg (10.10-3.38%); additional glutal-femoral
muscle - 0.016-0.045 (3.49%) and 0.03 kg (6.54%); thigh area, total - 2.32-0.82 kg (9.78-3.45%) and 1.5 kg (6.56%); including the muscle 0.19-0.07 kg (9.77-3.46%) and 0.12 kg (6.53%); total in the pelvic limb 3.16-1.11 kg (9.78-3.45%) and 2.05 kg (6.56%) and in general throughout the half-carcass of the muscles under study - 6.62-2.33 kg (9.79-3.44%) and 4.29 kg (6.56%).

5. Conclusion

The standard muscle groups have a variety of developmental parameters. Besides, the deep muscles of the pelvic region are characterized by low absolute mass indices. Moreover, large muscles, due to their size and high growth rate, form the corresponding character of muscle development of the group as a whole.

The largest muscles of the pelvic region are the middle gluteal and adductor, which make up more than 80% of the mass of the muscle group under study.

The largest muscles of the thigh area are biceps, quadriceps, semi-membranous and semitendinous. The relatively smaller sizes are characterized by the tensor of the wide fascia of the thigh and slender muscle. The lowest indices are observed in the pectinia-form muscle, additional gluteus-femoral and tailor muscles.

In general, it is an indisputable fact that the use of the Vetosporin–Active feed additive in the diet of Simmental steers in the periods of their intensive growing, rearing and fattening is an effective way to increase the growth rate of muscle tissue and live weight as a whole.

References

[1] Duskaev G, Karimov I, Levakhin G, Nurzhanov B, Rysaev A and Dusaeva H 2019 Ecology of ruminal microorganisms under the influence of quercus cortex extract International Journal of GEOMATE 16(55) 59-66
[2] Karimov I, Kondrashova K, Duskaev G and Kvan O 2020 Evaluation of effects of rumen fluid in combination with probiotic preparations and vanillin on the luminescence of a recombinant strain E coli E3S Web of Conferences 143 02034
[3] Zhaimysheva S S, Kosilov V I, Miroshnikov S A, Duskaev G K and Nurzhanov B S 2020 Genetic and physiological aspects of bulls of dual-purpose and beef breeds and their crossbreeds IOP Conference Series: Earth and Environmental Science 421(2) 022028
[4] Nassambayev E, Akhmetaliyeva A B, Nugmanova A E and Kulbaev R M 2019 Reproductive indicators of stud bulls and bull calves of the Kazakh white breed of various genotypes Advances in Animal and Veterinary Sciences 7 (Special Issue 1) 85-87
[5] Sedykh T A, Gizatullin R S, Kosilov V I, Chudov I V, Andreeva A V, Giniyatullin M G, Islamova S G, Tagirov Kh Kh and Kalashnikova L A 2018 Adapting Australian Hereford cattle to the conditions of the southern Urals Research Journal of Pharmaceutical, Biological and Chemical Sciences 9(3) 885-898
[6] Bozymov K K, Nassambayev E, Bayakhoz A N, Upievich B Y and Sultanova A K 2015 Ultrasonography use in the reproduction of the Kazakh white-headed breed cows Biology and Medicine 7(2) BM-073-15