Effect of genotype on the development pattern of muscles and muscle groups in steers at the age of 18 months

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Abstract. The development patterns of carcass muscles were studied on Simmental and Black-Spotted steers and their hybrids of the 1st generation. At the age of 18 months, a control slaughter of 3 steers of different genotypes was carried out: Group I - purebred Simmental steers; Group II - hybrids of ½ Simmentals x ½ Red Stepp steers; Group III - hybrids of ½ Simmentals x ½ Black-Spotted steers. To study the muscle groups and individual muscles development according to anatomical regions, the left half-carcasses were prepared, taking into account the methodological instructions, and to facilitate the analysis of the material, the muscles were grouped according to the joints associated with them and the topographic location, using the generally accepted scheme. The muscles development was studied on the basis of the absolute mass indices of individual muscles and muscle groups. It was established that steers of Group III had the following advantages over the animals of the same age in Groups I and II: in the total muscle mass of the spinal column the advantage was 217-772 g (1.43-18.30%), in the total muscle mass of the shoulder girdle - 1.45-0.51 kg (9.78-3.51%), the thoracic limb - 231-660 g (14.37-41.04%), the pelvic limb - 3.16-1.11 kg (9.78-3.45%) and in general for the entire half-carcass of the recorded muscles - 6.62-2.33 kg (9.79-3.44%).

1. Introduction

Intensification of beef productivity is closely associated with an increase in muscle tissue mass. Therefore, the study of the growth characteristics of the musculature of steers of various genotypes is of considerable scientific and practical interest [1-8]. The knowledge of the muscle tissue growth and development peculiarities makes it possible to determine more objectively the level of meat productivity of young animals by the age of slaughter, taking into account that the nutritional value and structure of muscles that perform different functions in the body differ to a great extent, with the relative growth rate of individual muscles being also different. Hence, a detailed study of individual muscles, their growth and dynamics development is highly important for the correct assessment of meat qualities of steers of different genotypes [9-11].

2. Problem statement

The problem of meat production increase demands the comparative studies of muscle tissue mass growth and development in beef cattle. Hence, in the course of our studies we studied the growth and development patterns and characteristics of individual muscles, muscle groups and, in general, the...
musculoskeletal system of young animals of the Simmental breed and its crosses with animals of the Red Steppe and Black-Spotted cattle breeds.

3. Research questions
To study muscle groups and individual carcass muscles of Simmental steers and their hybrids of the first generation.

4. Purpose of the study
The aim of the research work was to give a morphometric assessment of development of steers belonging to different genotypes.

5. Research methods
For the comparative study of muscle tissue development in young animals of the studied genotypes, three groups of steers were formed: Group I - purebred Simmental steers; Group II - hybrids of ½ Simmental x ½ Red Steppe steers; Group III - hybrids of ½ Simmental x ½ Black- Spotted animals. The year-round stable system was used for intensive keeping of the young animals of all groups, up to one and a half years of age, under the conditions of a standard feedlot. When the steers reached 18 months of age, a control slaughter of 3 animals from each group was performed according to the experimental scheme using the method of VASKHNIL, VIZH, VNIIMP.

Due to the fact that when sawing the carcass, the integrity of the soft tissues is not damaged, the left sides of the carcass were dissected, and its right sides were subjected to conventional deboning. The half-carcasses were prepared in accordance with the methodological instructions [3].

The muscles were assigned to the following groups: Group I - muscles of the spinal column – the longest muscle of the back - m. longissimus dorsi, semi-awned head - m. semispinalis capitis, spinous and semi-awn chest and neck - m. Spinalis et semispinalis thoracis et cervicis, patch muscle - m. spelenius, small lumbar - m.psoas minor, large lumbar - m. psoas major, multifidus muscle - m. longissimus capitis; Group II - muscles connecting the shoulder girdle with the body - deep pectoral muscle - m. Pectoralis superficialis, dentate ventral muscle - m. serratus ventralis, the broadest muscle of the back - m. latissimus dorsi, - rhomboid muscle - m. rhomboids, trapezius muscle - m.trapeczius, brachiocephalic muscle - m. brachiocephalicus; Group III - muscles of the pectoral limb - a) including the area of the scapula - preexisting muscle - m.supraspinatus, abdominal muscle - m. subscapularis; b) including the shoulder area - triceps brachii - m.triceps brachii, biceps brachii muscle - m.biceps brachii; Group IV - muscles of the pelvic limb - a) including the area of the pelvic girdle - deep gluteus muscle - m. Glutaeus profundus, - lumbar - iliac muscle - m. psoas iliacus, adductor muscle - m. Adductor femoris, gluteal middle muscle - m. Glutacus medius; b) including the thigh area - scallop muscle, quadriceps femoris muscle - m. guadriceps femoris, biceps femur - m. biceps femoris, semimembranosus muscle - m. semimembranosus, semitendinosus muscle - m. semitendineus, slender muscle - m.gracilis, tenor of the broad fascia of the thigh - m. tensor fasciae latae, sartorius muscle - m.sartoris, square psoas muscle - m.guadratus lumborum, c) including the shank area - gastrocnemius muscle - m. gastrochomius.

The growth and development of muscle tissue was studied by the parameters of the absolute mass of individual muscles and muscle groups in a comparative aspect, both within individual muscle groups and between the muscle mass indices of the compared genotypes.

Most of the data obtained in the course of studies was processed using the “Statistica 10.0” software package [Star Soft Inc., USA], the reliability was determined using the Student's test.

6. Findings
The analysis of the spinal column individual muscles development, regardless of the animal genotype, shows that the main share in the total muscle mass is occupied by the longest muscle of the back and the group of spinal and semi-spinal muscles of the back, head and neck (table 1).
Comparative analysis of intergroup differences in the absolute mass parameters of individual muscles of the spinal column indicates that the highest level of indices was observed in steers of Group III, with the exception of the multifidus muscle, with the advantage being gained by the steers of Group I. At the same time, the smallest mass, both of individual muscles and in the whole muscle group, was observed in hybrid steers of Group II.

Table 1. Mass of individual muscles of the spinal column, g (X ± Sx).

| Muscles                                      | Group I              | Group II             | Group III             |
|----------------------------------------------|----------------------|----------------------|-----------------------|
| The longest muscle of the back               | 5651±144.33          | 5108±150.28          | 5813±194.51           |
| Semi-spinal muscle of the head               | 1809±66.48           | 1161±35.77           | 1859±77.25            |
| Spinal and semi-spinal muscle of back and neck | 1800±56.17          | 1418±50.31           | 1838±61.97            |
| The longest muscle of head and neck          | 1316±37.25           | 1143±25.93           | 1379±39.43            |
| Plaster muscle                               | 1125±27.54           | 1006±65.20           | 1207±70.08            |
| Small lumbar muscle                          | 416±16.33            | 370±22.83            | 445±32.35             |
| Large lumbar muscle                          | 1252±83.56           | 1125±53.95           | 1296±142.68           |
| Multifidus muscle                            | 1558±177.90          | 1014±67.52           | 1307±41.39            |
| Total for the group                          | 14927±179.82         | 12372±339.54         | 15144±388.77          |

Thus, the hybrid steers of Group III surpassed those of the same age of Groups I and II respectively: in the mass of the longest muscle of the back - at 162-705 g (2.79-12.13%); in the semi-spinal muscle of the head - at 50-698g (2.70-37.55%); spinal and semi-spinal muscles of the back and neck at 38-420g (2.07-22.85%); the longest muscle of the head and neck - at 63-236g (4.57-17.11%); the plaster-like muscle - at 82-64g (6.79-5.30%); the small lumbar muscle - at 29-75g (6.52-16.85%); the large lumbar muscle - at 44-171g (3.40 - 13.19%).

At the same time, the advantage of steers of Group I in the mass of the multifidus muscle over steers of the same age in group II was - 544 g (34.92%) and in group III – 251 g (16.11%). Nevertheless, the hybrids of Group III surpassed those of Group II at 293g (22.42%).

In general, in terms of the total mass of the spinal column muscles, the general pattern of intergroup differences was preserved. Thus, the advantage of steers of Group III over those of the same age of Groups I and II was 217-2772g (1.43 - 18.30%).

Analysis of individual muscles of the shoulder girdle development, regardless of the genotype, shows that the proportion of the ventral dentate muscle in the total muscle mass is the highest and it is followed by the deep pectoral one (table 2).

The rhomboid muscle had the smallest mass in this muscle group. The growth and development parameters of the superficial pectoral, broadest back, trapezoidal and the brachiocephalic muscles, belonging to the same anatomical section of the half-carcass were very close to each other. Nevertheless, the intergroup differences in the parameters of individual muscles and muscle groups mass, despite some similarities, were clearly manifested.

Table 2. Development of individual muscles of the shoulder girdle, g (X ± Sx).

| Muscles                              | Group I             | Group II            | Group III           |
|--------------------------------------|---------------------|---------------------|---------------------|
| Deep pectoral                        | 3709±91.80          | 3180±171.16         | 3522±77.65          |
| Superficial chest                    | 1377±53.34          | 948±40.23           | 1608±59.37          |
| Ventral dentate                      | 5016±138.59         | 4438±112.95         | 5006±144.31         |
| Latissimus muscle of the back        | 1954±41.36          | 1800±46.20          | 2407±38.19          |
| Rhomboid                             | 596±23.65           | 494±25.03           | 1125±48.17          |
| Trapezioidal                         | 1404±54.32          | 965±79.39           | 1912±62.17          |
Thus, the advantage of purebred steers of Group I over those of the same age of Groups II and III respectively, was: by the deep pectoral muscle mass - 529 - 187 g (14.26-5.04%); by the ventral dentate muscle mass - 10-578 g (11.52 - 0.2%); by the brachiocephalic muscle mass - 53-682g (3.32 - 42.78%).

Besides, the steers of Group III exceeded those in Groups I and II, respectively in the mass of the deep pectoral muscle at 342 g (9.71%); in the mass of the ventral dentate muscle at 568 g (11.35%); in weight of the brachiocephalic muscle at 539 g (37.15%).

At the same time, the crossbred steers of Group III outweighed the hybrid animals of Groups I and II in the superficial pectoral muscle mass - at 231-660 g (14.37-41.04%); in the latissimus dorsi muscle mass - at 453-607 g (18.82 - 25.22%); in the rhomboid muscle mass at 529-631 g (46.90 - 56.09%); in the trapezoidal muscle mass - at 508-947g (26.57 - 49.53%). Meanwhile, the crossbred steers of Group II were inferior to the purebred Simmental ones, respectively: in the mass of the superficial pectoral muscle - at 429g (31.15%); in the mass of the latissimus dorsi muscle - at 154g (7.88%); in the rhomboid muscle mass - at 102g (17.11%); in the trapezius muscle mass - at 439g (31.27%).

A similar pattern of intergroup differences was observed in the value of the total muscle mass parameters. So, the steers of Group III overweighed their age animals of Groups I and II at 1381-4294g (8.11 - 25.21%), while those of Group II were inferior to their age ones in Group I at 2913g (18.6%).

As can be seen from the results of analysis of quantitative indices, characterizing the growth and development of the shoulder girdle muscle tissue in purebred and crossbred steers, the variability of the quality signs, which is quite obviously observed, does not fully fit into the logical understanding and substantiation of the data obtained.

The comparative assessment of individual pectoral limb muscles development demonstrates that among the muscles patterns of young animals of all genotypes, studied in the course of the experiments conducted, it was the muscle group of the scapula region that predominated in its absolute mass (table 3). Moreover, the extraspinal muscle was distinguished by the greatest mass in steers of all groups, the supraspinalis muscle had the smallest mass, and the subscapularis muscle occupied an intermediate position.

**Table 3. Development of individual muscles of the pectoral limb(X ± Sx).**

| Muscles             | Group I          | Group II         | Group III     |
|---------------------|------------------|------------------|--------------|
| Suprasspinalis      | 1342±100.17      | 1530±83.52       | 1532±73.71   |
| Extrapinal          | 2450±110.32      | 1836±129.32      | 2798±103.69  |
| Subscapularis       | 1530±90.36       | 1368±84.10       | 1748±111.19  |
| Scapula areas, total| 5322±150.28      | 4734±103.89      | 6078±238.13  |
| Shoulder triceps    | 3340±138.35      | 2874±141.52      | 3814±190.50  |
| Shoulder biceps     | 770±59.66        | 952±61.38        | 880±38.03    |
| Shoulder areas, total| 4110±188.93     | 3826±86.42       | 4694±176.75  |
| Total for the group | 9432±347.65      | 8560±276.27      | 10772±377.15 |

The data suggested show that in this group the greatest mass of the supraspinalis muscle was observed in crossbred steers, while purebred steers were inferior to them at 190 g (12.4%). By the mass of the extraspinal muscle, the highest indices were observed in the crossbred steers of Group III. Their advantage over their age steers in Groups I and II was - 348 - 962 g (12.44-34.38%). A similar pattern manifested itself in the mass of the subscapularis muscle, which predetermined the parameters of differences in the following proportions: 218 - 380 g (12.47-21.74%).

It should be noted that while the Simmental purebred steers were inferior in the supraspinalis muscle mass to their age steers of Group II at 188 g (12.29%), they surpassed them in the mass of the extraspinus and subcapularis muscles, on the contrary, at 614 g (25.06%) and 162 g (10.59%).
In general, in the scapula region, the intergroup differences in absolute and relative indices were 756-1344 g (12.44-22.12%).

A similar tendency was observed with the differences in indices between muscle groups, belonging to the scapula region and the total parameters of differences between the genotypes in the shoulder area muscles, though with certain diversity peculiarities in the parameters of individual muscles. Thus, the crossbred steers of Group III had the highest parameters in the triceps muscle mass of the shoulder and they surpassed their age steers in Groups I and II at - 474-940 g (12.43-24.65%). Besides, the steers of Group II were inferior to their age steers of group I at 466 g (13.95%).

The greatest mass of the shoulder biceps muscle was recorded in the crossbred steers of Group II and they outweighed their age animals of Groups I and III at 182-72 g (19.12-7.56%). At the same time, the young animals of Group I were inferior in weight, in the above parameter, to their age steers of Group III at 110 g (12.50%).

In terms of the total muscle mass of the shoulder region, the steers of Group III exceeded their age steers of Groups I and II at 584-832 g (12.44-17.72%). Moreover, the animals of Group II were inferior to their purebred age steers at 284 g (6.91%).

In general, the hybrid steers of Group III were distinguished by the greatest muscle mass in the total pectoral limb muscles mass and they outweighed their age animals at 1340-868 g (28.55-18.49%), while the crossbred animals of Group II were inferior in these parameters to their age purebred steers at 872 g (9.25%).

The muscles of the pelvic limb consist of three main groups: the pelvic girdle region, the thigh area, and the shank area. The most significant muscles of these groups account for about 95% of the pelvic limb.

The results of the studies conducted indicate that in young animals of the experimental groups, regardless of the genotype, the main part of muscles in this region is concentrated topographically in the thigh area, then in the pelvis and, to a lesser extent, in the shank area. Moreover, in the steers of different genotypes noticeable differences in the ratios between these muscle groups have been observed, namely: the mass of muscles in the pelvic girdle region in steers of Group I was 20.43%, in Group II - 24.00%, in Group III - 23.75%; in the thigh area - 73.10%; 70.04%; 70.25%, respectively, and in the shank area - 6.47%; 5.76%; 6.00% (table 4).

### Table 4. Development of individual muscles of the pelvic limb(X ± Sx).

| Muscles                                | Group I     | Group II    | Group III   |
|----------------------------------------|-------------|-------------|-------------|
| Deep gluteus                           | 559 ± 23.80 | 803 ± 26.59 | 912 ± 32.58 |
| Lumbar-iliac                           | 750 ± 22.19 | 934 ± 95.58 | 1060 ± 113.38 |
| Adductor                               | 2185 ± 97.66 | 2060 ± 90.39 | 2338 ± 121.95 |
| Medius gluteus                         | 3032 ± 124.74 | 3775 ± 148.61 | 4197 ± 180.36 |
| Pelvic girdle areas, total             | 6526 ± 198.53 | 7572 ± 234.75 | 8507 ± 166.30 |
| Scallop                                | 513 ± 45.16 | 489 ± 21.50 | 555 ± 40.10 |
| Quadriceps femoris                     | 5046 ± 237.20 | 5516 ± 323.79 | 6263 ± 366.88 |
| Biceps femoris                         | 5913 ± 285.32 | 5752 ± 270.34 | 6530 ± 340.07 |
| Semi-membranous                        | 6054 ± 413.47 | 5019 ± 196.44 | 5698 ± 165.98 |
| Semi-membranous                        | 2628 ± 139.32 | 2540 ± 174.08 | 2884 ± 97.65 |
| Semitendinous                          | 1155 ± 58.85 | 1161 ± 63.06 | 1318 ± 117.56 |
| Slender                                | 1219 ± 86.83 | 912 ± 64.72 | 1036 ± 50.90 |
| Wide fascia lata tensioner             | 344 ± 32.10 | 327 ± 21.37 | 372 ± 38.18 |
| Tailor                                 | 473 ± 33.14 | 445 ± 38.21 | 505 ± 48.56 |
| Additional gluteal femoral             | 23345 ± 555.90 | 22161 ± 390.14 | 25160 ± 718.48 |
| Thigh area, total, including the shank area with the gastrocnemius muscle | 2065 ± 78.35 | 1816 ± 45.76 | 2150 ± 55.43 |
The comparative analysis of the pelvic limb individual muscles development demonstrated that among the muscles considered in the experimental young animals of all genotypes, the nature of both individual muscles and muscle groups formation at the site of their localization was different. Thus, crossbred steers of Group III showed the highest indices in the deep gluteus muscle mass, and they surpassed their age animals in Groups I and II at 353-109 g (38.71-11.95%), in the mass of the lumbar-iliac muscle - at 310 - 126 g (29.25 - 11.89%), in the weight of the mid. gluteus muscle - at 1165 - 422 g (27.76 - 10.06%). whereas, the young animals of Group I were inferior to their age ones of Group II in the above parameter at 249g (12.06%).

A somewhat different pattern of intergroup differences in this field was found out as regards the adductor muscle mass. Moreover, the advantage of Group III steers over those of Groups I and II also remained within the weight of 153-278g (6.54 -11.89%), but in this case, the steers of Group I were not inferior to steers of Group II, as noted earlier, but on the contrary surpassed them at 125g (5.72%).

In general, in the pelvic girdle region, the total indices retained the general pattern of differences. The young animals of Group III, being distinguished by the highest parameters, surpassed their age steers of Groups I and II at 1981 - 935g (23.29 - 10.99%), while the steers of Group I were inferior to their age ones of Group II at 1046g (13.81%).

Analyzing the degree of development of individual muscles in the thigh area, it should be noted that in general, for most of their mass parameters, a certain pattern of intergroup differences can be traced. Moreover, in this area, with the exception of the semimembranosus muscle and the tendon of the wide thigh fascia, the highest muscle mass indices were observed in crossbred steers of Group III. It was the animals of group III that overweighed their age animals in Groups I and II in: the scallop muscle - at 42 - 66g (7.57-11.89%); the quadriceps femoris muscle - at 1217- 747g (19.43-11.93%); biceps femoris - at 617-778g (9.45-11.91%); semitendinosus muscle - at 256 - 344g (8.88-11.93%); slender muscle (m. gracilis) - at 163-157g (12.37-11.91%); tailor muscle - at 28-45g (7.53-12.10%); accessory gluteus-femoral muscle - at 32-60g (6.34-11.88%). At the same time, the young animals of Group I exceeded their age animals of Group II in the mass of: the scallop muscle - at 24g (4.68%); biceps femoris - at 161g (2.72%); semi-membranosus muscle - at 1035g (17.10%); semitendinosus muscle - at 88g (3.35%); tailor muscle - at 17g (4.94%), though the proportion weight ratio for certain muscles in this region was inverse: the steers of Group I were inferior in weight to those of the same age in group II: in quadriceps femoris - at 470g (8.52%) and m. gracilis - at 6g.

It should be pointed out that steers of Group I were distinguished by the highest level of the m. tensor fasciae femoris development, which was confirmed by its absolute mass indices. The steers of Groups II and III of the same age were inferior to them at 307-183g (25.18-15.01%). Incidentally, the steers of Group III surpassed their age ones of Group II at 124g (11.97%).

In general, according to the obtained total indices of the thigh region muscles mass, the animals of Group III were characterized by the highest mass and outweighed their age steers in Groups I and II at 1806 – 2999g (7.18 – 11.92%). Meanwhile, the steers of Group II were inferior to their age animals of Group I in the level of this parameter at 1184g.

As for the m.gastrocnemius muscle, which is characterized by the lowest nutritional value, the intergroup differences were also standard here and corresponded to the patterns of differences between the groups noted above. Thus, the advantage of animals of Group III over their age steers of Groups I and II in absolute weight was 85 - 334 g (3.95 - 15.54%). At the same time, the steers of Group II were inferior to their age animals of Group I in the above parameter at 249g (12.06%).

Summing up the analysis of the level of pelvic limb muscles development, it should be noted that the crossbred steers of Group III, characterized by the highest weight, surpassed their age animals in Groups I and II at 3881 – 4268g (10.84 - 11.92%), while the crossbred steers of Group II were inferior to the purebred steers of the same age in Group I at 387g (1.22%).

| Total pelvic limb | 31936±1134.15 | 31549±985.70 | 35817±1072.15 |
7. Conclusion
As result of analysis of the development of individual muscles and muscle groups of steers’ carcasses, it should be noted that, in general, a certain pattern of muscle tissue formation in young animals of the studied genotypes has been manifested. The data obtained demonstrate that the level of muscle development and the existing pattern of their heterogeneity are conditioned by the unequal growth rate of standard muscles in animals of different genotypes.

To develop programs for the feasibility of outside control over the growth and development of the muscle tissue of animals in the postnatal period of their growth and development, it is necessary to continue similar studies on other genotypes.

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