Productive characteristics of beef cattle of various ecogenetic groups

S S Jaimysheva, V I Kosilov and S A Miroshnikov

Federal Research Centre of Biological Systems and Agrotechnologies, RAS, Orenburg, Russia

E–mail: saule–zhaimysheva@mail.ru

Abstract. The paper presents the study of peculiarities of the muscle development of the carcasses of Simmental, Kazakh Whiteheaded heifers and their cross breeds of the I generation. The control slaughter of 3 heifers of different genotypes was carried out at 18 months of age: I – Simmental, II – Kazakh Whiteheaded, III – 1/2 Kazakh Whiteheaded x 1/2 Simmental. To evaluate the development of a set of muscles and individual muscles, left semi–carcasses were prepared along the anatomical regions. The paper presents the analysis of the set of muscles in relation with their joints and topographic location. The development of muscles is described in terms of the absolute weight of individual muscles and the muscle sets. The paper states the advantage of crossbred heifers over their herdmates in the development of spinal muscles by 6.30–33.07 %, the weight of shoulder muscles – by 5.96–11.29 %, the entire thoracic limb – by 5.97–5.65 %, the weight of muscles of the entire pelvic girdle – by 22.13–17.19 %.

1. Introduction
Undoubtedly, the increase in cattle meat productivity is associated with the increase in the muscle tissue weight. Therefore, the evaluation of the muscle growth features of the bodies of different genotypes seems quite relevant from scientific and practical perspective. The knowledge of the growth and development patterns of the muscle tissue will allow determining the degree of expression of meat productivity of animals more objectively, since food advantages and the structure of muscles, which perform different functions in the body, is different, as well as the relative growth rate of individual muscles [1–4]. Therefore, a comprehensive study of individual muscles, their level of development and the nature of growth is essential for correct assessment of meat qualities of the heifers of different genotypes. The quantitative yield of the muscle tissue as the most valuable part of the carcass, which contains vital proteins and amino acids, as well as the complex of vitamins and mineral compounds, becomes particularly important.

2. Problem statement
The continuous growth of the consumer demand for meat quality contributed to the assessment of individual muscles and valuable junctures. But the earlier works and the obtained results representing significant scientific and practical value do not fully reflect the pattern, which individual muscles or their sets hold in the carcass. Besides, there is not enough data on the period of life of animals of different genotypes, which is characterized by the highest activity of the muscle tissue growth and to what extent its growth as a whole and certain morphologically connected muscle sets of different body
regions are affected by the genotype during the period of intensive growth of young cattle in accordance with accepted skeleton division [5–7].

3. Materials and methods

3.1. Research object

Heifers of Simmental, Kazakh Whiteheaded breeds and their first generation cross breeds.

All animal services and experimental studies were carried out in accordance with instructions and recommendations of the Russian Regulations, 1987 (Order No. 755 of 12.08.1977 the USSR Ministry of Health) and The Guide for Care and Use of Laboratory Animals (National Academy Press Washington, D.C. 1996).

3.2 Scheme of the experiment

Three groups of heifers of Simmental, Kazakh Whiteheaded breeds and their cross breeds of the I generation (15 heads each) were formed.

In order to study the development of the muscle system at the age of 18 months, a control slaughter was carried out with regard to 3 heifers of different genotypes: I – Simmental, II – Kazakh Whiteheaded, III – 1/2 Kazakh Whiteheaded x 1/2 Simmental. The study of the development of muscle sets and individual muscles in anatomical regions included the preparation of left semi–carcasses taking into account the methodological instructions. In order to facilitate the analysis of the material, the muscles were grouped according to the characteristics of their joints and topographic location.

The muscles were classified into the following groups:

I group: spinal column muscles – m. longissimus dorsi, m. semispinalis capitis, m. spinalis et semispinalis thoracis et cervicis, m. spelenius, m. psoas minor, m. psoas major, m. longissimus capitis;

II group: muscles connecting the shoulder belt to the body – m. pectoralis superficialis, m. serratus ventralis, m. latissimus dorsi, m. rhomboides, m. trapezius, m. brachiocephalicus;

III group: thoracic limb muscles a) including areas of the blade – m. supraspinatus, m. subscapularis; b) including shoulder area – m. triceps brachii, m. biceps brachii;

IV group: pelvic limb muscles a) including pelvic belt region – m. glutaeus profundus, m. psoas iliacus, m. adductor femoris, m. glutaeus medius; b) including hip areas – m. quadriceps femoris, m. biceps femoris, m. semimembranosus, m. semitendineus, m. gracilis, m. tensor fasciae latae, m. sartoris, m. quadratus lumborum, c) including gaskin areas – m. gastrocnemius.

The muscle development was studied according to the absolute weight of individual muscles and muscle sets. Due to the fact that during carcass splitting the integrity of soft tissues is not damaged, the left semi–carcasses were prepared, and the right ones were subjected to standard dissection thus taking bones for weighing, which was then summed with the weight of the same bones of the right semi–carcass. The semi–carcasses were prepared, after which all muscles were identified according to the International Veterinary Anatomical Nomenclature (1979). To facilitate the analysis of the material, the muscles were grouped according to their joints and topographic location.

3.3 Equipment and technical means

The muscles were weighed separately with an accuracy of up to 1 g using Acom JW–1–300 electronic scales. A Wilkens caliper and a measuring tape were used to determine the linear dimensions of bones.

3.4 Statistical processing

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

4. Results and discussion

The comparative analysis of the development of the spinal column muscles of the heifers of different genotypes at the age of 18 months according to the indicators of their absolute weight shows that the crossbred heifers (III group) had the largest weight, while the heifers of the Kazakh Whiteheaded
breed (II group) had the smallest, except for several muscles, such as m. semispinalis capitis, m. psaas minor, m. psoas major, which were slightly bigger than those of their herdmates of the Simmental breed (I group) holding the average position in other muscles (Table 1).

| Muscles                                      | Simmental     | Kazakh Whiteheaded | ½ Kazakh Whiteheaded x ½ Simmental |
|----------------------------------------------|---------------|--------------------|-----------------------------------|
| m. longissimus dorsi                         | 4965±180.42   | 3894±190.34        | 5278±192.03                      |
| m. semispinalis capitis                      | 933±30.12     | 1115±45.16         | 992±46.06                        |
| m. spinalis et semispinalis thoracis et cervicis | 1538±52.12    | 1211±50.48         | 1636±60.13                       |
| m. longissimus capitis et cervicis           | 1173±32.23    | 1432±52.14         | 1248±38.12                       |
| m. spelenius                                 | 875±30.12     | 434±28.24          | 931±22.72                        |
| m. psaas minor                               | 388±18.50     | 402±20.00          | 413±21.32                        |
| m. psoas major                               | 1148±38.39    | 1158±42.13         | 1221±82.82                       |
| m. longissimus capitis                       | 1070±60.12    | 1017±52.11         | 1138±63.64                       |
| Total vertebral muscles                      | 12090±209.14  | 9663±201.90        | 12857±212.17                     |

Thus, the advantage of the III group heifers over their herdmates in the I and II groups made accordingly: in the weight of m. longissimus dorsi – 313–1384 g (5.93–26.22 %), and the difference between the purebred heifers in favor of the herdmates of the I group makes 1071 g (2.57 %); in the weight of m. spinalis et semispinalis thoracis et cervicis – 98–425 g (5.99–25.98 %) and 327 g (21.26 %); in the weight of m. longissimus capitis et cervicis – 75–816 g (6.0–65.39 %) and 741 g (63.17 %); in the weight of m. spelenius – 56–497 g (6.02–53.38 %) and 441 g (50.40 %); in the weight of m. longissimus capitis – 68–121 g (5.98–10.63 %) and 53 g (4.95 %); in the weight of muscles in general of this group – 767–3194 g (5.97–24.84 %) and 2427 g (20.07 %). Besides, the heifers of the Kazakh Whiteheaded breed were characterized by highest indicator in the weight of m. semispinalis capitis. Their advantage over the herdmates of the I and III group was 182–123 g (16.32–11.03 %). At the same time, the crossbred heifers exceeded the Simmental herdmates by 59 g (5.95 %). The purebred crossbred heifers were also characterized by the smallest weight of m. psaas minor. Thus, their advantage over the herdmates of the I and II groups made 2.5–11g (6.05–2.66 %).

At the same time, the heifers of the I group outnumbered the herdmates of the I group by 14 g (3.48 %). A similar pattern was observed in the weight of m. psoas major. Thus, the advantage of crossbred heifers over the herdmates of the I and II groups was 73–63 g (5.98–5.16 %). Besides, the heifers of the I group lagged 10 g (0.86 %) behind their herdmates of the II group.

Irrespective of the genotype the main specific weight in the total weight of spinal muscles is held by m. longissimus dorsi and the group of m. spinalis et semispinalis thoracis et cervicis.

The comparative analysis of the development of the shoulder muscles of the heifers of different genotypes at the age of 18 months according to the indicators of their absolute weight confirms that the crossbred heifers (III group) had the largest weight, while the heifers of the Kazakh Whiteheaded breed (II group) had the smallest, except for several muscles, such as m. pectoralis superficialis, m. rhomboideis, m. trapezius, which were slightly bigger than those of their herdmates of the I and II groups (Table 2).

Thus, the advantage of the III group heifers over the I and II group herdmates was as follows: in the weight of m. pectoralis profundus 255–1157 g (6.82–30.93 %), and the difference between purebred heifers in favor of the I group herdmates was 902 g (25.88 %); in the weight of m. pectoralis superficialis – 74–62 g (5.96–4.99 %), at the same time the herdmates of the I group lagged behind their herdmates of the II group by 12 g (1.025); in the weight of m. serratus ventralis the crossbred heifers outnumbered the herdmates of the I and II groups by 275–518 g (5.96–11.22 %), the heifers of the II group lagged behind the herdmates of the I group by 243 g (5.60 %); in the weight of m. latissimus dorsi the crossbred heifers outnumbered the herdmates of the I and II group by 275–518 g (5.96–11.22 %), and the heifers of the II group lagged behind the herdmates of the I group by 243 g (5.96–11.22 %), and the heifers of the II group lagged behind the herdmates of the I group by 243 g (5.96–11.22 %).
(5.60 %); in the weight of m. latissimus dorsi the crossbred animals exceeded the herdmates of the I and II groups by 119–308 g (5.96–15.42 %).

### Table 2. Development of shoulder muscles in heifers of different genotypes at the age of 18 months, g (x±Sx)

| Muscle Group               | Simmental        | Kazakh Whiteheaded | ½ Kazakh Whiteheaded x ½ Simmental |
|----------------------------|------------------|--------------------|-----------------------------------|
| m. pectoralis profundus    | 3486±90.92       | 2584±104.13        | 3741±115.28                       |
| m. pectoralis superficialis| 1168±38.02       | 1180±40.14         | 1242±41.00                        |
| m. serratus ventralis      | 4341±329.11      | 4098±304.70        | 4616±308.78                       |
| m. latissimus dorsi        | 1879±70.73       | 1690±68.67         | 1998±72.12                        |
| m. rhomboideus             | 540±42.04        | 774±45.15          | 574±48.12                         |
| m. trapezius               | 1104±61.02       | 1497±70.14         | 1140±78.39                        |
| m. brachiocephalicus       | 908±36.82        | 842±30.03          | 966±48.93                         |
| Total shoulder muscles     | 13426±600.02     | 12665±733.14       | 14277±780.80                      |

At the same time, the difference between purebred heifers in favor of the animals of the I group made 189 g (10.06 %); in the weight of m. rhomboideus the heifers of the II group surpassed their herdmates of the I and III groups by 234–200 g (30.23–25.84 %) and the difference between the heifers of the I and III groups in favor of the III group made 34 g (5.92 %).

A similar pattern was observed in the weight of m. trapezius, where the heifers of the II group outnumbered the herdmates of the I and III group by 393–357 g (35.60–32.34 %) with the difference between the herdmates of the I and III group in favor of crossbred heifers being 36 g (3.16 %); in the weight of m. brachiocephalicus the crossbred animals (group III) outnumbered the herdmates of the I and II groups by 58–124 g (6.00–12.84 %) and the heifers of the I group outnumbered the herdmates of the II group by 66 g (7.27 %); in the weight of shoulder muscles all crossbred heifers outnumbered the herdmates of the I and II groups by 851–1612 g (5.96–11.29 %), while the Simmental heifers outnumbered the herdmates of Kazakh Whiteheaded by 761 g (5.67 %).

It should be noted that in this muscle group, regardless of genotype, the m. serratus ventralis, m. pectoralis profundus and m. latissimus dorsi hold the highest specific weight. The analysis of the development of this group of muscles considering their absolute weight shows that in the total weight of the semi–carcass they hold the lowest specific weight (Table 3).

### Table 3. Development of thoracic limb muscles in heifers of different genotypes at the age of 18 months, g

| Muscles                  | Simmental        | Kazakh Whiteheaded | ½ Kazakh Whiteheaded x ½ Simmental |
|--------------------------|------------------|--------------------|-----------------------------------|
| m. supraspinatus         | 1012±42.43       | 1097±40.02         | 1076±58.63                        |
| m. infraspinatus         | 1425±88.63       | 1863±84.12         | 1515±90.91                        |
| m. subscapularis         | 1021±72.16       | 1178±70.05         | 1086±74.63                        |
| blade muscles, total     | 3458±202.20      | 4111±160.34        | 3677±218.63                       |
| m. triceps brachii       | 2620±170.13      | 2388±172.14        | 2787±180.20                       |
| m. biceps brachii        | 793±66.72        | 395±65.10          | 843±70.53                         |
| shoulder muscles, total  | 3413±188.62      | 2783±170.14        | 3630±200.02                       |
| Total thoracic limb muscles | 6871±312.88     | 6894±298.52        | 7307±321.21                       |

According to our data, in the subgroup of the blade muscles, as well as individual muscles, the purebred heifers of Kazakh Whiteheaded breed were characterized by the largest weight and the purebred heifers of the Simmental breed had the smallest weight, while the crossbred heifers occupied the intermediate position. In the subgroup of the shoulder muscles, as well as individual muscles, the crossbred heifers were characterized by the largest weight and the purebred heifers of the Kazakh Whiteheaded breed had the smallest weight, while the purebred heifers of the Simmental breed occupied the intermediate position. Thus, a detailed analysis of the differences in the blade muscle set...
shows that the advantage of the heifers of the II group over the herdmates of the I and III groups was 85–21 g (7.75–1.91 %) in m. supraspinatus weight, respectively, and the difference between the herdmates of the I and III groups in favor of the crossbred animals was 64 g (5.95 %); in the weight of m. infraspinatus – 411–321 g (22.39–17.48 %) and 90 g (5.94 %); in the weight of m. subscapularis – 157–92 g (13.33–7.81 %) and 65 g (5.98 %); in the weight of the entire blade area muscles – 653,434 g (15.88–10.56 %) and 219 g (5.96 %).

A detailed analysis of the differences in the shoulder muscle set shows that the advantage of the crossbred heifer over the herdmates of the I and II groups made respectively: in the weight of m. triceps brachii – 167–399 g (5.99–14.32 %), and the differences between the herdmates of the I and II groups in favor of the purebred Simmental heifers was 232 g (8.85 %); in the weight of m. biceps brachii – 50–448 g (5.93–53.14 %) and 398 g (50.19 %); in the weight of the entire shoulder area muscles – 217–847 (5.98–23.33 %) and 639 g (18.46 %). At the same time, throughout the thoracic limb the crossbred heifers having the largest weight of muscles exceeded their herdmates of the I and II groups by 436–413 g (5.97–5.65 %). The difference between the animals of the I and II groups concerning this indicator was insignificant and amounted to only 23 g (0.33 %) in favor of the herdmates of Kazakh Whiteheaded.

From the above data it can be concluded that the parameters of the absolute weight of individual muscles and muscle sets clearly show the intergroup differences due to genotype.

In the blade area, m. infraspinatus had the largest weight. In the shoulder area, m. triceps brachii had the largest weight.

The information on the development of the muscle tissue of the pelvic limb of the carcass seems quite relevant from scientific and practical perspective, since this region is characterized by the presence of junctures, as well as rumps, butts and top side, which account for more than 30 % of the weight of the entire semi–carcass. Pelvic limb muscles make up three main groups: pelvic belt regions, hip and tibia regions. The major muscles in the structure of these groups provide for more than 95 % of the muscle tissue weight of the entire limb (Table 4).

Table 4. Development of pelvic limb muscles in heifers of different genotypes at the age of 18 months, g.

| Muscles                  | Simmental       | Kazakh Whiteheaded | ½ Kazakh Whiteheaded x ½ Simmental |
|-------------------------|-----------------|--------------------|------------------------------------|
| m. glutaeus profundus   | 523±50.28       | 1163±52.53         | 556±60.01                          |
| m. psoas iliacus        | 680±43.48       | 2053±80.53         | 723±86.12                          |
| m. adductor femoris     | 1960±192.13     | 1983±188.14        | 2084±195.41                        |
| m. gluteus medius       | 2789±192.47     | 2444±183.40        | 2966±199.71                        |
| Pelvic girdle muscles, total | 5952±382.26 | 7643±400.02        | 6329±415.22                        |
| m. pectineus            | 550±40.10       | 616±58.36          | 585±42.16                          |
| m. quadriceps femoris   | 4324±292.46     | 4184±270.90        | 4598±301.21                        |
| m. biceps femoris       | 5577±102.02     | 4240±80.88         | 5930±105.28                        |
| M. semimembranosus      | 5734±201.04     | 2953±188.90        | 60,97±212.71                       |
| M. semitendineus        | 2407±130.20     | 2664±160.05        | 2560±172.36                        |
| m. gracilis             | 1088±80.53      | 772±73.74          | 1157±102.12                        |
| m. tensor fasciae latae | 1162±80.36      | 1436±81.28         | 1236±96.34                         |
| m. sartorius            | 331±30.16       | 375±31.12          | 352±38.33                          |
| m. quadratus lumborum   | 429±53.60       | 594±42.02          | 456±44.04                          |
| Hip muscles, total      | 21602±881.14    | 18818±890.82       | 22971±914.03                       |
| m. gastrocnemius        | 1827±74.13      | 1843±73.04         | 1943±78.32                         |
| Total pelvic limb muscles | 29381±1412.20 | 28304±1414.71      | 31243±1505.42                      |

The comparative analysis of the development of this group of muscles of the heifers of different genotypes shows pronounced differences in the ratios between these muscle groups according to the absolute weight. Thus, in the weight of m. glutaeus profundus the heifers of the II group exceeded the
herdmates of the I and III groups by 640–607 g (55.03–52.19 %), and the difference between the animals of the I and III groups in favor of crossbred heifers amounted to 33 g (5.94 %).

A similar pattern was observed in the weight of m. psoas iliacus. Thus, the advantage of the heifers of the II group over the herdmates of the I and III groups was 1373–1330 g (66.88–64.78 %). At the same time, the herdmates of the II group exceeded the heifers of the I group by 43 g (5.95 %). In the weight of m. adductor femoris, the crossbred heifers outnumbered their herdmates of the I and II groups by 124–101 g (5.95–4.85 %), and the difference between purebred heifers in favor of the herdmates of the I group was 23 g (1.16 %). Crossbred heifers surpassed their herdmates of the I and II groups by 177–522 g (5.97–17.60 %) in the weight of m. gluteus medius, and the heifers of the I group surpassed their herdmates of the II group by 345 g (12.37 %) in the weight of the entire pelvic muscles; purebred Kazakh Whiteheaded animals surpassed their herdmates of the I and III groups by 1691–1314 (22.13–17.19 %). The difference between the heifers of the I and III groups in favor of the crossbred animals was 377 g (5.96 %). In the weight of m. pectineus, the purebred heifers of the Kazakh Whiteheaded breed exceeded their herdmates of the I and III groups by 66–31 g (10.71–5.03 %), and the difference between the heifers of the I and III groups was 377 g (5.96 %). In the weight of m. quadriceps femoris, the crossbred heifers outnumbered the herdmates of the I and II groups by 274–414 g (5.96–9.00 %), with the difference between the purebred heifers in favor of the herdmates of the I group being 140 g (3.24 %). A similar pattern was observed in the weight of m. biceps femoris. Thus, the heifers of the I and II groups were 353–1690 g (5.95–28.50 %) inferior to the herdmates of the III group, and the difference between the heifers of the I and II groups in favor of Simmental heifers was 1,337 g (23.97 %). A similar pattern was observed in the weight of m. semimembranosus. Thus, the crossbred animals exceeded the herdmates of the I and II groups in the weight of this muscle by 363–3144 g (5.95–51.57 %). The difference between the heifers of the I and II groups was 2781 g (48.50 %). In the weight of m. semitendinosus the heifers of the I and II groups by 241–88 g (20.43–3.32 %). The difference between the heifers of the I and II groups was 153 g (5.98 %). In the weight of m. gracilis, the crossbred heifers outnumbered their herdmates of the I and II groups by 69–385 g (5.96–33.28 %), and the difference between the animals of the I and II groups was 316 g (29.04 %). In the weight of m. tensor fasciae latae the heifers of the II group exceeded the herdmates of the I and III groups by 74 g (5.99 %). A similar pattern was observed in the weight of m. sartorius. Besides, the heifers of the II group outnumbered the herdmates of the I and III groups by 44–23 g (11.73–6.13 %). The difference between the heifers of the I and III groups was 21 g (5.97 %). A similar pattern was observed in the weight of m. quadratus lumborum, but with more significant differences in weight indicators. Thus, the purebred heifers of the Kazakh Whiteheaded breed exceeded the herdmates of the I and III groups by 1165–1138 g (73.09–71.40 %). The difference between the heifers of the I and III groups was 27 g (5.92 %) in favor of the crossbred animals.

In general, in the muscle group of the whole hip region, the heifers of the II group were 2784–4153 g (12.88–18.08 %) inferior to the herdmates of the I and III groups, whereas between the animals of the I and III groups the advantage of crossbred animals was 1369 g (5.96 %). In the weight of m. gastrocnemius, the crossbred animals outnumbered the herdmates of the I and II groups by 116–100 g (5.97–5.15 %). The difference between the animals of the I and II groups made 16 g (0.87 %). In the weight of the pelvic limb muscles in general, the heifers of the II group were 1077–2939 g (3.67–9.40 %) inferior to the herdmates of the I and III groups. Besides, the difference between the muscle weight of the heifers of the I and III groups in favor of crossbred animals was 1862 g (5.96 %).

5. Conclusion
Proceeding from the above it can be concluded that the standard muscle sets have a wide variety of growth rates at various stages of animal development that differ in genotypic characteristics. It should also be noted that the growth dynamics in a particular individual set is formed as a sum of the growth parameters of individual muscles that make up this set. Besides, some muscles have other growth variability than the whole set. This is especially true for small muscles. So, in the set of pelvic
muscles, deep small muscles have low growth rate. Therefore, the large muscles due to their size and growth intensity cause the corresponding growth pattern of the entire group muscles.

The largest muscles of the pelvic region – m. glutaeus medius and m. adductor femoris – make up more than 75% of the weight of the studied muscle group.

The largest muscles of the hip area are m. biceps femoris, m. quadriceps femoris, m. semimembranosus and m. semitendineus. The m. tensor fasciae latae and m. gracilis were characterized by smaller weight, while m. pectineus, m. sartorius and m. quadratus lumborum were the smallest in weight.

The absolute muscle weight of the studied group of heifers is quite different due to differences in genotypic features.

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