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# The Improvement of Meat Production at the Carpathian Goat Breed through Crossbreeding with Boer Breed

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**Abstract:** ***The researches were made on 3 lots of male kids which were fattened with granulated mixed fodder and Lucerne hay. The lots were made as follows: 1. R1 hybrids – 13 heads; 2. F1 hybrids – 17 heads; 3. Kids of Carpathian breed – 11 heads. The fattening lasted for 100 days until the kids reached the body weighs between 29-36 kg. There were determined the speed of growing and the specific consumption per lot. The speed of growing at the R1 and F1 hybrids was significantly bigger than at the Carpathian breed. So, at the R1 hybrids the daily average increasing rate was higher with 39,8% (p < 0,01), and at F1 hybrids the daily average increasing rate was higher with 21,5% (p < 0,05) comparatively to the Carpathian kids. Also, at the R1 hybrids the efficiency of the fodder conversion was higher with 16% and at the F1 hybrids with 7,6% besides the contemporaries of Carpathian breed. The slaughter output at the hybrids was bigger besides the Carpathian kids, the differences being significant only in the case of the R1 hybrids. Regarding the development of the muscles of the gigot through the muscularity indicator of the thigh (IMC) the differences were significant at the R1 and F1 hybrids besides the Carpathians but also between R1 against F1. Regarding the tissue structure of the carcasses it was revealed that the R1 and F1 hybrids had significantly more meat and fewer bones in the carcass comparatively to the contemporaries of Carpathian breed.***

**Keywords:** UNC, PBD, Carpathian, gigot, hybrid, crossbreeding

## 1. Introduction

The production of meat at goats depends on the number of the weaned kids that per goat, the body weights, the rate of weigh increase, the slaughter output and the carcass indicators.

The Carpathian breed of goats is spread on the whole territory of Romania, being predominant. It is tardive, it has carcasses that are less good, they have a heavier skeleton than the other goat breeds for meat. In the literature of specialty there are many papers regarding the capacity of Boer breed to improve the meat production through crossbreeding at a series of local breeds of goats from various areas on earth, the presented data being sometimes in contradiction.

An experiment was made by Machen R.V. and collaborators [4] and there were fattened 3 lots of wethers of 50 heads each of Spanish breed and 2 types of hybrids: 50% Boer – 50% Spanish and 25% Boer – 75% Spanish.

The average daily increasing rate in weight at the hybrids which had had in their genome 50% genes from Boer was of 219 g/head being bigger with 50% besides those that had in their genome 25% genes from Boer and with 75% bigger than those of Spanish breed.

The slaughter output was of 49,76% at the hybrids that had 50% blood of Boer, 48,55% at the hybrids which had 25% blood of Boer and 48,83% at those of Spanish breed.

The surface of the section of *Longissimus Dorsi* muscle was 14,51 $cm^2$ at the hybrids with 50% blood from Boer, 10,13 $cm^2$ at the hybrids with 25% Boer blood and 10,45 $cm^2$ at those of Spanish breed. The obtained results recommend the hybridization with Boer breed as method of increasing the production of meat at goats.

In other paperwork, L.A. Gonewardene and collaborators [2] from Alberta, Canada used for fattening the wethers of Alpine breed and hybrids of F1 Boer x Alpine, F1 Alpine x Spanish, F1 Alpine x Saanen, F1 Boer x Spanish and F1 Boer x Saanen.

The best rate of weigh increase was that of the hybrids of F1 Boer x Alpine with 124 g per head and per day, being followed by F1 Alpine x Spanish with 103 g per head and per day, the hybrids of F1 Boer x Saanen with 101 g per head and per day, the hybrids of F1 Boer x Spanish with 96 g per head and per day, the he-goats of Alpine breed with 94 g per head and per day and the hybrids of F1 Alpine x Saanen with 87 g per head and per day. Regarding the slaughtering output, it was ranged between the limits of 47,89-48,16%, the differences between the 6 lots being insignificant.
Also, the surface of the section of *Longissimus Dorsi* muscle was between the limits of 8,2-10,5 $cm^2$ the differences between lots being insignificant.

M.R. Cameron and collaborators [1] had a research that had the purpose to establish the performances of the hybrids of F1 Boer x Spanish, F1 Boer x Angora comparatively to Spanish breed.

The kids have been fattened for 112 days with mixed fodders with 25% raw protein.

From this experiment it clearly results that the hybrids are superior to Spanish breed. Thus, they did higher weigh increasing rates of 154-161 g per head and per day besides

only 117 g per head and per day at the kids of Spanish breed, the differences being significant.

The efficiency of the conversion of the consumed fodders in weigh increasing rate was of 261-263 g/kg at the hybrids besides 235 g at the kids of Spanish breed.

The slaughter output was of 46,3-47,0% at the hybrids comparatively to 47,3% at the Spanish breed.

The area of the section of *Longissimus Dorsi* muscle was of 10,2-11,6 $cm^2$ at the hybrids comparatively with 10,2 $cm^2$ at the kids of Spanish breed.

The dissection of the carcasses shows significant differences between lots for the bones' proportion, the hybrids of F1 Boer x Spanish having in their carcass 26,1% bones comparatively to 28% at the hybrids of F1 Boer x Angora and 28,9% at the kids of Spanish breed.

The conclusion was that the hybrids with Boer breed are superior to Spanish breed regarding the weigh increasing rate and the conversion of fodder.

In a research that has been done in Brazil by E.J. Medeiros and collaborators [5] the male kids from the following variants of crossbreeding: R1 (75% Boer x 25% local breed), F1 (50% Boer x 50% local breed); F1 (50% Anglo Nubian x 50% local breed) and Boer breed were subject to fattening process.

The fattening was done with a mixture of fodders with 17,1% raw protein and lasted until the kids reached the average body weight of 27 kg (65-84 days ).

The best weight increase was that of Boer kids with 165,6 g per head and day being followed by the R1 hybrids with 157,6 g per head and day, F1 hybrids (50% Anglo Nubian x 50% Local Breed) with 139,9 g per head and day and the F1 hybrids (50% Boer x 50% Local Breed) with 126,5 g per head and day.

The best slaughter output was that of F1 hybrids (50% Anglo Nubian x 50% Local Breed) with 49% being followed by the F1 hybrids (50% Boer x 50% Local Breed) with 48,8%, Boer kids with 46,3% and and the R1 hybrids with 46%.

In an experiment did in USA by F. Pinkerton and collaborators. [7] 5 lots of wethers were subject to fattening process for 120 days: a lot of Tennessee breed (meat breed) and one lot each of F1 hybrids of Boer x Spanish, F1 Boer x (Nubian x Tennessee), F1 Boer x (Nubian x Alpine) and F1 Boer x Nubian.
The highest speed of growing was that of the hybrids of F1 Boer x Spanish with 208 g per head and day besides 132-159 g per head and day at the other 4 lots.

Regarding the consumption of fodders expressed in kilograms of fodders consumed for 1 kg of weight increase, the F1 hybrids of Boer x Spanish had the best value, 5,24 kg besides 7,76 kg-9,50 kg at the other 4 lots.

The best slaughter output was that of Tennesseee breed with the value of 53,5%, being followed by the F1 hybrids of Boer x Spanish with 48,1%, hybrids from the other 3 combinations having the output between the limits of 45,3-47,1%, not being significant differences between lots.

The data from the paperwork show the superiority of F1 hybrids of Boer x Spanish regarding the speed of growing and of the consumption of fodders besides of the other combinations and meat breed of Tennessee.

In other experiment made by N.H. Casey and W.A.Van Niekerk [6] in South Africa, they compared the wethers of Boer breed with wethers from 4 breeds of South-African breeds (Merino of Meat, Merino, Dorper and Pedi).
From the researches it resulted the wethers of Boer breed did daily weight increasing rates smaller than those obtained by the wethers from the breeds of Merino of Meat, Merino and Dorper (182-194 g per head and day 260-287 g per head) but bigger as sheep breed Pedi (131-156 g per head).

The output at slaughter at Boer wethers was of 48,3% being similar to Dorper breed that had the highest value, that of 48,5%.

Also, at the wethers of Boer breed, the proportion of muscles-bones had the value of 4,7:1 besides Dorper breed which had the best proportion, that of 4,8:1.

All the information gathered in the specialty literature show the improving effect of Boer breed by crossbreeding with local goat breeds, the obtained hybrids having the growing speed significantly higher and better conversion of fodders comparatively to the contemporaries from local goat breeds.

## 2. Material and Method

3 lots of male kids were subject to control fattening with Lucerne hay and granulated concentrated fodders, as follows:
1) R1 hybrids – 13 heads;
2) F1 hybrids – 17 heads;
3) Kids of Carpathian breed– 11 heads.

The fattening of kids lasted for 100 days until the kids reached the average weight of cca-29-36 kg/head.

The consumptions of fodders for each lot were daily recorded.

In the end of fattening the average weight increasing rates and consumptions of fodders were established at each of the 3 lots that had been subject to fattening. On the living animal the indicators of compactness and muscularity of the gigot were established according to the formula:

$$I_{cj} = \frac{\text{width at cox femoral articulations}}{\text{length of gigot}} \text{ x } 100 \quad (1)$$

After the formula of E. Laville [3]

$$I_{mj} = \frac{\text{perimeter of gigot}}{\text{length of gigot}} \text{ x } 100 \quad (2)$$

After the formula of G.P. Vicovan, 2014, unpublished data.

Width at coxofemoral articulations was measured with the compass in cm.

Length of gigot was measured with the ribbon on the interior of the thigh between the ischio - pubic and tibia-metatarsal articulations.

Perimeter of gigot was measured with the ribbon in the superior third passing over knee and buttock's point.

From each lot, 3 kids were slaughtered having almost similar body weights (35,2 kg/head at R1 hybrids, 35,83 kg/head at the F1 hybrids and 33,3 kg/head at the Carpathians). The outputs (yield) at slaughtering were determined as follows:

$$\text{yield}\,1 = \frac{\text{weight of cooled carcass}}{\text{living weight}} \text{ x } 100 \quad (3)$$

$$\text{yield}\,2 = \frac{\text{weight of cooled carcass}}{\text{empty living weight}} \text{ x } 100 \quad (4)$$

The empty living weight was established by diminishing the living weight with the weight of the content of the digestive tube.

The cooled carcasses were cut 3 regions as follows: gigot, scapula and rest of carcass, proceeding then to the dissection of the carcasses by separating the muscular tissue from bones and from fat (covering and inter-muscular fat) establishing their weighting.
The surface of the thigh's section (at half of the femur) and the surface of the section of *Longissimus Dorsi* muscle between the thorax vertebras 12 and 13 were measured, and also the big and small diameter of the muscle eye.

To establish the areas of the said sections a computer with Auto CAD software was used. On the gigot, the indicator of muscularity of the thigh was calculated. The indicator of muscularity of thigh (IMC) was calculated after Purchas' formula, quoted by [3]:

$$\text{IMC} = \frac{\sqrt{\frac{G}{L}}}{L} \quad (5)$$

G = the weight of thigh's muscles in grams* (g).
L = the length of the femur in centimetres (cm).
* The thigh's muscles: M. rectus femoris; m. vastus lateralis; m. vastus; m. vastus intermedius; m. sortorius; m. semimembranosus; m. adductor; m. pectineus; m. gracilis; m. semitendinosus; m. gluteo-biceps.

The weighing of the carcasses and of the tissues that had been separated from them was done with an electronic balance with a precision of ±5 g. All obtained data were processed and statistically interpreted by Fisher test.

**Abbreviations**

- R1 – hybrids that have in their genome 75% genes from Boer breed and 25% genes from Carpathian;
- F1 – hybrids that have in their genome 50% genes from Boer breed and 50% from Carpathian;
- Yield – output at slaughtering;
- PBD – Digestible Raw Protein;
- UNC –Nutritive Meat Units;
- Ef – efficiency of fodders conversion.

$$\text{Ef} = \frac{\text{the average daily increasing rate in grams}}{\text{daily swallowed dry substance in kilograms}} \quad (6)$$

## 3. Results and discusions

### 3.1. Weight increasing rate

In table 1 the weight increasing rates and the differences between genotypes are presented.

**Table 1:** Weight increase of kids at the control fattening and the differentiation of genotypes

| No. | Genotype | The average daily weight increasing rate | The differentiation of the weight increasing rate and the significance of differences | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | R1 besides Carpathian | | | | | |
| | | $x \pm s_x$ | ± % | significance | ± % | significance | ± % | significance |
| 1. | R1 | 172,75± 11,2682 | +39,8 | p < 0,01 | +26,6 | p < 0,01 | +22,6 | p > 0,05 |
| 2. | F1 | 150,15± 9,4182 | | | | | | |
| 3. | Carpathian | 123,56± 10,8936 | | | | | | |

From the above table it results that the hybrids R1 and F1 are superior to the Carpathian kids regarding the average daily weight increasing rate, this being higher at R1 with 39,8% and at F1 with 26,6% besides the contemporaries of Carpathian breed, the differences being statistically significant.

### 3.2. Consumption of Fodders

**Table 2** Consumption of fodders at kids depending on genotype

| No. | Genotype | Specific Consume | | | | Daily ingestion of dry substance (g/head) | Efficiency of fodders conversion |
|---|---|---|---|---|---|---|---|
| | | UNC | | PBD (g) | | | |
| | | per head and day | for 1 kg of increasing rate | per head and day | for 1 kg of increasing rate | | |
| 1. | R1 | 1,14 | 6,57 | 133 | 771 | 1036 | 167 |
| 2. | F1 | 1,09 | 7,25 | 125 | 832 | 967 | 155 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3. | Carpathian | 0,98 | 7,91 | 112 | 903 | 864 | 144 |

From the data in the above table it can be noticed that the R1 hybrids had the best consumption of fodders, that of 6,57 UNC besides 7,25 UNC at the F1 hybrids and 7,91 UNC at the Carpathian kids.

Also, R1 the hybrids had the best consumption of fodders that of 167 g of weight increasing rate for 1 kg of consumed dry substance besides 155 g at the F1 hybrids and 144 g at the Carpathian kids.

### 3.3. Indicator of conformation on living animal

**Table 3** Measurements and indicators on living animal with reference to the development of the posterior train at kids depending on genotype

| No. | Specification | Genotypes | | | The differences between genotypes ± per cent points and statistical significance | | |
|---|---|---|---|---|---|---|---|
| | | R1 | F1 | Carpathian | | | |
| | | $x \pm s_x$ | $x \pm s_x$ | $x \pm s_x$ | | | |
| 1. | Width at cox femoral articulations (cm) | 20,67 ± 0,6667 | 20,83 ± 0,9280 | 18,50±0,7638 | Between R1 and Carpathian | Between F1 and Carpathian | Between R1 and F1 |
| 2. | Perimeter of gigot (cm) | 59,67 ± 0,3330 | 53,67 ± 0,8819 | 49,33 ± 1,2019 | | | |
| 3. | Length of gigot (cm) | 24,83 ± 0,6009 | 27,00 ± 0,5774 | 27,83 ± 0,5373 | | | |
| 4. | Indicator of compactness (ICG) | 83,19 ± 0,8700 | 77,21 ± 3,6200 | 66,44 ± 2,3700 | +16,75 p < 0,001 | +10,77 p > 0,05 | +5,98 p > 0,05 |
| 5. | Indicator of muscularity (IMG) | 240,50 ± 4,8700 | 199,08 ± 7,4700 | 177,21 ± 3,3100 | +63,29 p < 0,001 | +21,87 p > 0,05 | +41,42 p < 0,01 |

From the table it results that the R1 and F1 hybrids had a bigger width at cox femoral articulations, they also had a bigger perimeter of the gigot comparatively to the contemporaries of Carpathian breed.

Regarding the length of the gigot it can be noticed that only the R1 hybrids had a shorter gigot comparatively to Carpathian.

Regarding the indicator of compactness of the gigot at the R1 hybrids, from table 3 it results that its values were significantly higher comparatively to Carpathian breed and F1 hybrids. From the same table it can be noticed that at the R1 hybrids the values of the indicator of muscularity of the gigot were significantly higher comparatively to Carpathian breed and F1 hybrids.

### 3.4.Output at Slaughtering

In table 4 it is presented the output at slaughtering, the differences between genotypes and their significance.

**Table 4** Output at slaughtering depending on genotype

| Specification | Genotypes | | | The differences between genotypes ± per cent points and statistical significance | | |
|---|---|---|---|---|---|---|
| | R1 | F1 | Carpathian | Between R1 and Carpathian | Between F1 and Carpathian | Between R1 and F1 |
| | $x \pm s_x$ | $x \pm s_x$ | $x \pm s_x$ | | | |
| Yield 1 | 50,40 ± 0,0094 | 45,50 ± 0,0057 | 42,29 ± 2,3900 | + 8,1 p < 0,05 | + 3,3 p > 0,05 | + 4,9 p < 0,05 |
| Yield 2 | 56,24 ± 0,0283 | 52,59 ± 0,0073 | 49,77 ± 1,2200 | + 6,5 P < 0,05 | + 2,8 P > 0,05 | + 3,7 P < 0,05 |

From table 4 it results that R1 hybrids had both slaughtering outputs significantly higher than both the Carpathian kids and the F1 hybrids. Between the F1 hybrids and the contemporaries of Carpathian breed the differences were insignificant.

### 3.5. Measurements of conformation on the gigot

In table 5 the weight of thigh's muscles, the length of the femur and the indicator of thigh's muscularity (IMG) are presented.

**Table 5** The weight of thigh's muscles, the length of the femur and the indicator of thigh's muscularity depending on genotype

| Genotype | Weight of thigh's muscles (g) | Length of the femur (cm) | IMG |
|---|---|---|---|
| | $x \pm s_x$ | $x \pm s_x$ | $x \pm s_x$ |
| R1 | 1251,33 ± 55,9206 | 17,03 ± 0,6670 | 0,503 ± 0,0141 |
| F1 | 1041,67 ± 31,9287 | 18,40 ± 0,1528 | 0,409 ± 0,0026 |
| Carpathian | 835,33 ± 66,3459 | 17,77 ± 0,4256 | 0,385 ± 0,0059 |

From the table it can be noted that the R1 hybrids had the biggest amount of muscles which also generated the highest value of the indicator of thigh's muscularity comparatively to the F1 hybrids and Carpathian kids.

In table 6 the differences between genotypes and statistical significance are presented.

**Table 6:** Differentiation of genotypes

| Specification | Differences ± % |
|---|---|

| | Weight of thigh's muscles | Length of the femur | IMG |
|---|---|---|---|
| Between R1 and Carpathian | + 49,80 p < 0,001 | - 4,16 p > 0,05 | + 30,65 p < 0,001 |
| Between F1 and Carpathian | + 24,70 p < 0,05 | + 3,54 p > 0,05 | + 6,23 p < 0,05 |
| Between R1 and F1 | + 20,13 p < 0,05 | - 7,45 p < 0,001 | + 22,98 p < 0,001 |

From the table it results that regarding the weight of thigh's muscles there were very significant differences between R1 hybrids and Carpathian kids and significant differences between F1 hybrids and Carpathians and also between R1 and F1.

Regarding the length of the femur, differences were only between the R1 and F1 hybrids, they being very significant. Regarding IMG it can be noticed that the differences were very significant between the genotypes of R1 and Carpathians and R1 and F1 and significant between genotypes of F1 and Carpathians.

### 3.6 Areas of sections on the carcass

In table 7 the areas of thigh's section and that of *Longissimus Dorsi* muscle are presented.

**Table 7** The area of the thigh's section and that of the muscle eye at kids depending on the crossbreeding variant

| No. | Genotype | The area of thigh's section ($cm^2$) | The area of the section of Longissimus Dorsi muscle ($cm^2$) |
|---|---|---|---|
| | | $x \pm s_x$ | $x \pm s_x$ |
| 1. | R1 | 102,89 ± 3,9893 | 12,74 ± 0,6444 |
| 2. | F1 | 93,84 ± 0,4784 | 11,08 ± 0,8377 |
| 3. | Carpathian | 84,11 ± 3,6298 | 8,58 ± 1,2281 |

It is noticed that the R1 hybrids had the highest values, those of 102,89 $cm^2$ of the area of thigh's section and 12,74 $cm^2$ of the area of the muscle eye being followed by F1 hybrids with 93,84 $cm^2$ and respectively 11,08 $cm^2$. The smallest values were those of the Carpathian kids with 84,11 $cm^2$ and respectively 8,58 $cm^2$.

**Table 8** The differentiation of the areas of thigh's sections and *Longissimus Dorsi* muscle depending on genotype and significance of differences

| Specification | ± differences between genotypes | | | |
|---|---|---|---|---|
| | The area of thigh's section | | The area of thigh's section | |
| | ± $cm^2$ | ± $cm^2$ | ± $cm^2$ | ± $cm^2$ |
| Between R1 and Carpathian | + 18,78 | + 22,33 | + 4,16 | + 48,50 |
| | p < 0,05 | | p < 0,05 | |
| Between F1 and Carpathian | + 9,73 | + 11,57 | + 2,50 | + 29,14 |
| | p < 0,05 | | p < 0,05 | |
| Between R1 and F1 | + 9,05 | + 9,64 | + 1,66 | + 14,98 |
| | p > 0,05 | | p > 0,05 | |

From table 8 results that there were significant differences regarding the area of thigh's section and the area of the section *Longissimus Dorsi* muscle between R1 hybrids and Carpathian kids and between F1 hybrids and Carpathian kids.

There were no significant differences regarding the area of thigh's section and that of *Longissimus Dorsi* muscle between the R1 and F1 hybrids.

### 3.7. Dissection of Carcasses

In table 9, the tissue structure of the carcasses depending on genotype is presented.

**Table 9** Tissue Structure of the kids carcasses depending on genotype

| No. | Genotype | Proportion of tissues | | | |
|---|---|---|---|---|---|
| | | Muscles (%) | Bones (%) | Fat (%) | Meat* (%) |
| | | $x \pm s_x$ | $x \pm s_x$ | $x \pm s_x$ | $x \pm s_x$ |
| 1. | R1 | 66,72± 0,1100 | 21,02± 0,2200 | 11,92± 0,2800 | 78,64± 0,3100 |
| 2. | F1 | 62,63± 0,6100 | 23,24± 0,2300 | 14,03± 0,3500 | 76,65± 0,2800 |
| 3. | Carpathian | 61,92± 0,7300 | 25,01± 0,2500 | 13,14± 1,0500 | 75,06± 0,3300 |

*Meat represents the muscles together with covering and inter-muscular fat and the fascis afferent to each region.

It can be noted that in the carcasses of R1 hybrids the muscles had the proportion of 66,72% and the bones of 21,02% comparatively to 62,63% respectively 23,24% at

F1 hybrids and 61,92% with 25,01% at Carpathian kids, the fat being in proportion of 11,92-14,03%.

In table 10 is presented the differentiation of the proportion of tissues in the carcass depending on genotype and the significance of differences.

**Table 10** The differentiation of the proportion of tissues in carcasses of the kids depending on genotype

| Specification | Difference, ± per cent points and their significance | | | |
|---|---|---|---|---|
| | Muscles | Bones | Fat | Meat |
| R1 besides Carpathian | + 4,8 p < 0,001 | - 3,99 p < 0,001 | - 1,22 p > 0,05 | + 3,58 p < 0,001 |
| F1 besides Carpathian | + 0,71 p > 0,05 | - 1,77 p < 0,001 | + 0,89 p > 0,05 | + 1,59 p < 0,001 |
| R1 besides F1 | + 4,09 p < 0,001 | - 2,22 p < 0,001 | - 2,11 p < 0,001 | + 1,99 p < 0,001 |

From the table it results that regarding the proportion of the muscles in the carcass there were very significant differences between the R1 hybrids and Carpathians and between R1 and F1, the differences between F1 hybrids and Carpathian being insignificant.

Regarding the proportion of the bones in the carcass there were very significant differences between the R1 hybrids and Carpathian, between F1 and Carpathian but also between R1

and F1, the hybrids having lighter skeleton comparatively to the contemporaries of Carpathian breed.

Regarding the proportion of fat in the carcass from the table it can be noted that there were neither significant differences between R1 hybrids and Carpathian and nor between F1 and Carpathian, but the differences between R1 and F1 were very significant (due to the higher content of fat in the carcasses of F1 hybrids).

Regarding the proportion of the meat in carcasses of kids, from table 9 can be observed that there are very significant differences between the R1 hybrids and the Carpathian, between F1 and Carpathian but also between R1 and F1.

## 4. Conclusions

In conclusion it can be certainly stated that the hybridization of Carpathian goat breed with Boer breed is efficient, leading to the significant increase of meat production, the hybrid kids having a higher speed of growing, a lower consumption of fodder, the carcasses containing more meat and fewer bones than the kids of Carpathian breed.

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