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A STUDY OF THE CARCASS TRAITS OF DIFFERENT RABBIT GENOTYPES

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Abstract: The aim of this experiment was to study the carcass traits of rabbits when the same maternal stocks were mated with bucks of two well-known hybrids selected for growth traits or with Pannon White bucks selected for carcass traits by CT (computerised tomography). Three experiments were carried out at the same time. Experiment 1: Pannon White (P) or Hycole terminal (H) males were crossed with Pannon White (P) does (n = PP: 60, HP: 59). Experiment 2: Pannon White (P), Hycole terminal (H) or Zika terminal (Z) bucks were crossed with Hycole (H) parent does (n = PH: 60, HH: 52 and ZH: 58). Experiment 3: Pannon White (P) or Zika terminal (Z) males were crossed with a Maternal line (M) stock (n = PM: 60, ZM: 58). In all the experiments, hybrid males increased their body weight. Mating the same maternal stock with hybrid or Pannon White bucks, the body weight of the offspring of hybrid males was higher than that of the offspring of Pannon White bucks (Experiment 1: PP and HP: 2644 and 2758 g, $P<0.001$; Experiment 2: PH, HH and ZH: 2611, 2671 and 2890g, $P<0.001$; Experiment 3: PM and ZM: 2534 and 2677 g, $P<0.001$). The most important carcass traits differences were found in rabbits originated from Pannon White males. Genetic origin influenced the dressing out percentage, which was 0.5% higher in PP rabbits compared to the HP group in Experiment 1 (60.6 and 60.1%, resp.; $P=0.092$); 1% higher in PH and ZH genotypes compared to HH animals in Experiment 2 (in PH, ZH and HH: 59.6, 59.7 and 58.7%; $P=0.008$), and 1.5% higher in PM than in ZM rabbits in Experiment 3 (61.0 and 59.5%, resp.; $P<0.001$). The ratio of the *m. Longissimus dorsi* to reference carcass weight was also higher in rabbits derived from P males in Experiments 2 and 3 (Experiment 2: PH: 11.2, HH: 10.8, ZH: 10.5%, $P<0.001$; Experiment 3: PM: 11.5, ZM: 10.6%, $P<0.001$), while it did not differ in Experiment 1. Significant difference in fat deposit was found only in Experiment 3, progeny of Pannon White males had higher weight (22.3 *vs.* 16.6g, $P=0.002$) and ratio of perirenal fat (1.65 *vs.* 1.25%, $P=0.003$) compared to offspring of Z males. Results of the dressing out percentage and the ratio of *m. Longissimus dorsi* proved that the selection based on CT (Pannon White genotype) was successful.

Key words: rabbits, genotypes, carcass traits, computerised tomography.

INTRODUCTION

Carcass traits are influenced by the adult weight and the maturity of rabbits at the age of slaughter (Pla *et al.*, 1996; Piles *et al.*, 2000). Szendrõ *et al.* (2004) showed that the selection for carcass traits based on X-ray computerised tomography (CT) is an effective tool. In our former experiment, the carcass traits of Hyplus hybrid, purebred Pannon White rabbits and their crossbreds were compared; in this comparison the dressing out percentage of Pannon White × Hyplus female genotype was the highest (Metzger *et al.*, 2004).

The aim of these experiments was to compare the hybrid male lines (Hycole or Zika) selected for weight gain with Pannon White males selected for carcass traits, when crossed with different maternal stocks (Pannon White, Hycole or a Maternal line).

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MATERIAL AND METHODS

Animals and rearing conditions

Three experiments were carried out at the same time.

Experiment 1: Pannon White (P) or Hycole terminal (H) males were crossed with Pannon White (P) does (n = PP: 60, HP: 59).

Experiment 2: Pannon White (P), Hycole terminal (H) or Zika terminal (Z) bucks were crossed with Hycole (H) parent does (n = PH: 60, HH: 52 and ZH: 58).

Experiment 3: Pannon White (P) or Zika terminal (Z) males were crossed with a Maternal line (M) stock (n = PM: 60, ZM: 58).

The adult weight of the genotypes (does: body weights after kindlings; bucks: body weight at one year of age) was P♂: 4.8 ± 0.26 kg; P♀ : 4.4 ± 0.22 kg; H♂: 5.5 ± 0.27 kg; H♀: 4.2 ± 0.20 kg; Z♂: 5.6 ± 0.29 kg; M♀: 4.2 ± 0.20 kg (mean ± SD). H and M females are characterised by high prolificacy and early maturity, while H and Z males by fast growth but late maturity. Pannon White rabbits are selected for body weight gain and for carcass traits with the help of CT on the basis of the cross-sectional area of the *m. Longissimus dorsi* (Romvári *et al.*, 1996; Szendrõ *et al.*, 2004).

Experiments were carried out at the University of Kaposvár and at the farm of Olivia Ltd. At the University of Kaposvár P and M does were divided randomly into two groups. Half of the P does were inseminated with semen from P bucks, and the other half with semen from H bucks (Experiment 1). Half of the M does were inseminated with semen from P bucks, and the other half with semen from Z bucks (Experiment 3). At the farm of Olivia Ltd. the H does were divided randomly into three groups and were inseminated with semen from P, H or Z bucks (Experiment 2). Semen was collected from P bucks at the rabbit farm of the University of Kaposvár, while that of the H and Z bucks was collected at the rabbit farm of Olivia Ltd. The same males were used in all cases, since semen was collected on the same day and the pooled semen was divided into two (H and Z) or three parts (P). Does were inseminated on the same day in all of the 3 experiments. Therefore, rabbits of experiments 1 and 3 were born in Kaposvár, while those of experiment 2 were born in the Olivia farm at the same time. Intra–group standardisation to 9-10 kits per litter was carried out on both farms. After weaning at 5 weeks of age, all the kits were transported to the rabbit farm of Olivia Ltd.; thus, all the rabbits of the 3 experiments were reared in the same building under the same conditions. Rabbits were housed in groups (7-9 rabbits/cage, littermates together) in open-topped cages of 0.64 m^2 basic area (with a wooden gnawing stick provided in each). Rabbits were fed *ad libitum* (10.3 MJ DE/kg; crude protein: 15.6%; crude fibre: 16.7%; ether extract: 2.6%), drinking water was also available *ad libitum* from nipple drinkers.

Slaughtering and dissection procedure

At 12 weeks of age all rabbits were weighed. In all 3 experiments, 60 rabbits (divided equally between males and females) of the average ± 0.3 kg body weight were selected from each group. Selection within the average ± 0.3 kg weight category was random. Animals were slaughtered without fasting at the slaughterhouse of Olivia Ltd. Rabbits were weighed before slaughter then were bled after electric stunning. Carcasses were placed in a cooling room at 4 ^{o}C for 24 hours. The chilled carcasses were then weighed (with head, heart, lungs, liver, kidneys, periscapular and perirenal fat). The carcass dissection procedure was performed as suggested by Blasco and Ouhayoun (1996). The head was separated and the carcass was split between the 7th and 8th thoracic vertebrae and between the 6th and 7th lumbar vertebrae. Carcass parts (fore-, mid- and hind part) and perirenal fat were weighed; meat from the mid part (*m. Longissimus dorsi* – MLD) and the hind legs (HL) were removed and weighed.

Statistical analysis
In all 3 experiments, data were evaluated by one-way analysis of variance using the SPSS 10.0 programme package (SPSS for Windows, 1999). The effect of gender was not taken into consideration in the statistical analysis. When evaluating carcass traits, the body weight was included in the model as a covariate: $Y_{ij} = \mu + S_i + b_1(x_{ij} - z) + e_{ij}$; where: μ = population mean, S_i = effect of sire (i=1-2; 1-3 and 1-2 in experiment 1, 2 and 3, resp.), b_1 = regression coefficient, x_{ijk} = individual body weight, z = mean body weight, e_{ij} = error. In experiment 2, the sires were compared by means of the LSD test.

RESULTS

Experiment 1
In this experiment significant differences between progenies were found only in a few cases. Body weight of rabbits from Hycole males was 114 g higher (*P*<0.001) than that of the progeny of Pannon White bucks (Table 1). Dressing out percentage of PP genotype was 0.5% higher compared to HP rabbits, however, this difference was significant at *P*=0.092 (Figure 1). Weight of the hind part of the carcass was 11 g higher in PP rabbits compared to HP ones (*P*=0.014; Table 1). A similar result was found in the weight of the hindleg meat, being the 12 g of difference significant (*P*=0.005; Table 1). The ratio of hindleg meat to reference carcass weight was 0.8% higher in PP rabbits (*P*=0.002; Figure 2). In the other traits, the two genotypes had similar results (Table 1, Figure 3).

Table 1: Body weight and carcass traits of rabbits (mean ± SE) when Pannon White maternal stock was mated with Pannon White or Hycole terminal males (Experiment 1).

Maternal genotype:	Pannon White		
Males' genotype:	Pannon White	Hycole	
Progenies' genotype:	PP	HP	*P*-value
Number of rabbits	60	59	
Body weight (BW) and weight of body parts, g			
BW at slaughter	2644 ± 15.9	2758 ± 22.2	<0.001
Chilled carcass	1634 ± 5.31	1621 ± 5.35	0.089
Reference carcass	1389 ± 5.51	1375 ± 5.56	0.080
Head	147 ± 1.13	148 ± 1.14	0.475
Liver	59.3 ± 1.02	58.5 ± 1.03	0.618
Heart and lungs	20.8 ± 0.31	21.0 ± 0.31	0.666
Kidneys	17.8 ± 0.28	18.2 ± 0.28	0.254
Fore part	399 ± 2.19	399 ± 2.21	0.964
Mid part	436 ± 2.93	433 ± 2.95	0.544
Hind part	530 ± 2.93	519 ± 2.96	0.014
Perirenal fat	24.9 ± 1.38	23.9 ± 1.39	0.603
m. Longissimus dorsi	160 ± 2.02	159 ± 2.04	0.761
Hindleg meat	370 ± 2.97	358 ± 2.99	0.005
Ratio to reference carcass weight,%			
Fore part	28.7 ± 0.14	29.0 ± 0.14	0.156
Mid part	31.3 ± 0.14	31.5 ± 0.14	0.277
Hind part	38.1 ± 0.16	37.8 ± 0.16	0.112
Perirenal fat	1.79 ± 0.10	1.72 ± 0.10	0.630

BW at slaughter was involved into the model as covariate (2700.5 g)

Experiment 2

Body weight was affected by the males (P<0.001). ZH rabbits had the highest body weight (2890 g) which differed significantly from PH and HH genotypes (Table 2). Both the chilled and the reference

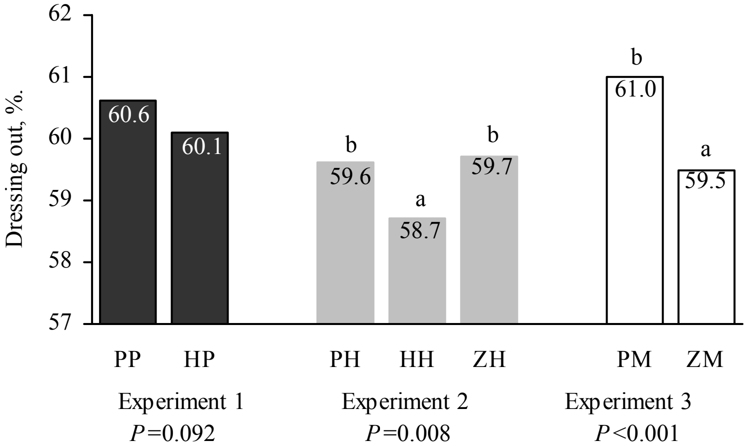

Figure 1. Effect of crossing on dressing out percentage.

PP, HP, PH, HH, ZH, PM, ZM: see in Tables 1, 2 and 3 .

a, b: P<0.05.

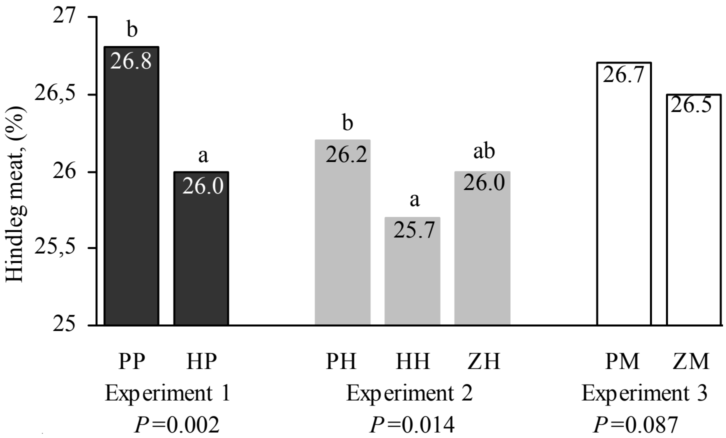

Figure 2. Effect of crossing on Hindleg meat (HL) to reference carcass ratio, %.

PP, HP, PH, HH, ZH, PM, ZM: see in Tables 1, 2 and 3 .

a, b: P<0.05.

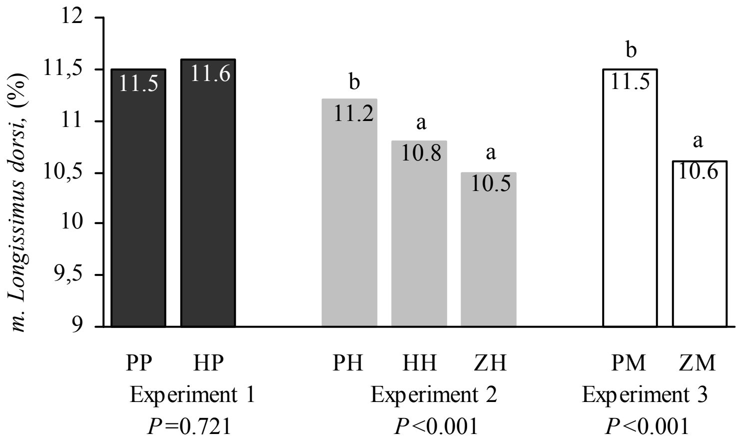

Figure 3. Effect of crossing on *m. Longissimus dorsi*, (MLD) to reference carcass ratio, %.

PP, HP, PH, HH, ZH, PM, ZM: see in Tables 1, 2 and 3 .

a, b: P<0.05.

Table 2: Body weight and carcass traits of rabbits (mean ± SE) when Hycole maternal stock was mated with Pannon White, Hycole or Zika males (Experiment 2).

Maternal genotype:	Hycole			
Males' genotype:	Pannon White	Hycole	Zika	
Progenies' genotype:	PP	HP	ZH	*P*-value
Number of rabbits	60	52	58	
Body weight (BW) and weight of body parts, g				
BW at slaughter	2611^{a} ± 26.1	2671^{a} ± 28.1	2890^{b} ± 26.6	<0.001
Chilled carcass	1622^{b} ± 6.45	1601^{a} ± 6.64	1628^{b} ± 6.91	0.011
Reference carcass	1374^{b} ± 6.29	1355^{a} ± 6.47	1378^{b} ± 6.73	0.031
Head	144^{a} ± 1.09	145^{a} ± 1.12	148^{b} ± 1.17	0.021
Liver	65.5^{b} ± 1.19	61.0^{a} ± 1.22	61.3^{a} ± 1.27	0.015
Heart and lungs	21.4 ± 0.33	21.6 ± 0.34	21.9 ± 0.35	0.534
Kidneys	17.7 ± 0.25	18.3 ± 0.26	18.2 ± 0.27	0.224
Fore part	401^{a} ± 2.78	401^{a} ± 2.86	412^{b} ± 2.97	0.015
Mid part	430^{b} ± 2.91	420^{a} ± 3.00	423^{ab} ± 3.12	0.035
Hind part	518 ± 2.81	510 ± 2.90	519 ± 3.01	0.070
Perirenal fat	24.8 ± 1.13	23.6 ± 1.16	23.1 ± 1.22	0.596
m. Longissimus dorsi	154^{b} ± 1.80	147^{a} ± 1.85	145^{a} ± 1.93	0.001
Hindleg meat	360^{b} ± 2.33	348^{a} ± 2.39	358^{b} ± 2.49	0.001
Ratio to reference carcass weight,%				
Fore part	29.2^{a} ± 0.14	29.7^{b} ± 0.15	29.8^{b} ± 0.14	0.011
Mid part	31.3^{b} ± 0.15	30.9^{ab} ± 0.16	30.7^{a} ± 0.16	0.023
Hind part	37.7 ± 0.15	37.7 ± 0.15	37.7 ± 0.16	0.964
Perirenal fat	1.78 ± 0.08	1.71 ± 0.08	1.64 ± 0.09	0.513

a. b: different superscripts mark significant differences (*P*<0.05) between genotypes.
BW at slaughter was involved into the model as covariate (2724.7 g)

carcass weight were lowest in the offspring of H males, while these traits did not differ significantly between PH and ZH rabbits (Table 2). A similar result was found in dressing out percentage (*P*=0.008). HH genotype had 1% lower dressing out percentage compared to PH and ZH rabbits (Figure 1). Both the weight and the ratio of the fore part were highest in ZH animals (412 g, *P*<0.05 and 29.8%, *P*<0.05; resp.) and lowest in the PH group (401 g, *P*<0.05 and 29.2%, *P*<0.05; resp; Table 2). Opposite results were found in the weight and the ratio of the mid part, since the highest values were found in the progeny of P bucks (430 g and 31.3%; Table 2). Comparing the weight (Table 2) and the ratio of MLD (Figure 3), similar results were found. Genetic origin had significant influence on this trait (*P*<0.001). PH rabbits had the most developed m. *Longissimus dorsi* (MLD; 154 g and 11.2%) and ZH group had the less developed (145 g and 10.5%). No significant difference was found in the weight and the ratio of the hind part (Table 2). Although, the weight (Table 2) and the ratio (Figure 2) of hindleg meat (HL) was affected significantly (*P*=0.001 and *P*=0.014; resp.), HH rabbits had 10-12 g lower HL compared to ZH and PH genotype (*P*<0.05). No difference was found in the volume of fat deposit (Table 2), while the liver weight differed significantly (*P*=0.015).

Experiment 3

Body weight of PM rabbits was 143 g lower than that of ZM genotype (*P*<0.001), while the weight of chilled and reference carcass was 43 g higher (*P*<0.001) in PM (Table 3). Dressing out percentage was

1.5% higher in PM rabbits (*P*<0.001) compared to ZM animals (Figure 1). The weight of the fore part did not differ, while its ratio to reference carcass was significantly (*P*<0.001) higher in ZM rabbits. Both the weight and the ratio of the mid part were higher in PM genotype, the 14 g and 0.6% differences were significant (*P*=0.004 and *P*=0.015, resp.). Weight of MLD was found to be 16 g heavier in PM rabbits (*P*<0.001; Table 3). A similar result was found in the ratio of MLD, which was 0.9% higher in PM genotype (*P*<0.001, Figure 3). No significant differences were found in the ratio of hind part (Table 3) and that of hindleg meat (Figure 2), although, the weight of these traits was significantly higher in PM rabbits (14 g, *P*=0.004 and 13 g, *P*<0.001; resp., Table 3). Both the weight and the ratio of perirenal fat were significantly higher in PM genotype (*P*<0.001 and *P*=0.003, resp.) compared to ZM rabbits (Table 3). The weight of the edible organs did not differ significantly (Table 3).

DISCUSSION

As all rabbits were reared in the same premises after weaning in all experiments, the differences in bodyweight at slaughter were due to disparities in the growth rate of genotypes. H and Z males are selected for high growth rate, which improves the body weight at a fixed age. As a consequence of the selection for growth rate Piles *et al*. (2000) found 178 g higher bodyweight at 9 weeks of age between generations 3 and 10. Mating hybrid females with Flemish Giant or INRA 9077 males, David

Table 3: Body weight and carcass traits of rabbits (mean ± SE) when a Maternal line stock was mated with Pannon White or Zika terminal males (Experiment 3).

Maternal genotype:	Maternal line		
Males' genotype:	Pannon White	Zika	
Progenies' genotype:	PM	ZN	*P*-value
Number of rabbits	60	58	
Body weight (BW) and weight of body parts, g			
BW at slaughter	2534 ± 14.4	2677 ± 15.4	<0.001
Chilled carcass	1591 ± 7.37	1548 ± 7.52	<0.001
Reference carcass	1348 ± 7.43	1305 ± 7.58	<0.001
Head	142 ± 1.18	144 ± 1.21	0.437
Liver	61.2 ± 0.97	60.3 ± 0.98	0.568
Heart and lungs	20.5 ± 0.28	20.0 ± 0.29	0.219
Kidneys	18.1 ± 0.28	18.5 ± 0.29	0.400
Fore part	396 ± 2.90	394 ± 2.96	0.612
Mid part	417 ± 3.43	395 ± 3.50	<0.001
Hind part	513 ± 2.87	499 ± 2.92	0.004
Perirenal fat	22.3 ± 1.16	16.6 ± 1.18	0.002
m. Longissimus dorsi	156 ± 2.10	140 ± 2.14	<0.001
Hindleg meat	359 ± 2.34	346 ± 2.39	<0.001
Ratio to reference carcass weight,%			
Fore part	29.4 ± 0.14	30.1 ± 0.14	<0.001
Mid part	30.9 ± 0.15	30.3 ± 0.15	0.015
Hind part	38.0 ± 0.15	38.3 ± 0.16	0.248
Perirenal fat	1.65 ± 0.08	1.25 ± 0.09	0.003

BW at slaughter was involved into the model as covariate (2604.2 g) *et al.* (1990) also demonstrated the superiority of a male line with large body size. Similar results were found by Lobera *et al*. (2000), mating two dam lines (selected for litter size at weaning) with three sire lines (non-specialised terminal sire, standard sire and top sire).

Carcass traits are basically influenced by the adult body weight and maturity at slaughter (Dalle Zotte, 2002). Slaughtering the rabbits at the same bodyweight, later matured larger sized breeds or lines have poorer dressing out percentage than that of the smaller sized ones (Lukefahr *et al.*, 1982; Maertens, 1992; Pla, 1996; Pla *et al.*, 1996; Gómez *et al.*, 1998; Dalle Zotte and Ouhayoun, 1998). This is partly due to the different growth rate of tissues and organs (Cantier *et al.*, 1969; Deltoro and López, 1985). The skeleton and digestive tract mature earlier, the intensive growth of muscle starts later and fat is the latest. Our results confirmed literature data (Dalle Zotte, 2002), since in all 3 experiments comparing the dressing out percentage of genotypes from the same does but different males (P or hybrid /H or Z/), the P bucks had better results in all cases. This could be the effect of CT based selection (see explanation below).

According to literature data (Pla *et al.*, 1996; Gómez *et al.*, 1998), when slaughtering rabbits at the same body weight the fore part is usually lower, the mid part is similar, while the hind part is higher in breeds of lower adult weight. However, Piles *et al.* (2000) did not find any difference in the ratio of carcass parts between generations 3 and 10 within a line selected for body weight gain. In our experiments, the ratio of the fore part changed in agreement with the literature, since it was higher in rabbits from larger sized hybrid bucks in all cases. This could be explained by the fact that the fore part is the most bony part of the carcass and the bone is an early matured tissue (Cantier *et al.*, 1969; Deltoro and López, 1985).

Contrary to the results found in the literature, in our experiments significant differences were obtained both in the weight and in the ratio of the mid part. In experiments 2 and 3, the ratio of this part was higher in rabbits derived from P males. A similar relation could be obtained in the weight and the ratio of MLD. Metzger *et al.* (2004) found similar results comparing Pannon White and Hyplus genotypes. These results can be explained by the CT based selection. Pannon White breed has been selected on the basis of the cross-sectional area of the MLD for three years (Szendrõ *et al.,* 2004). The cross-sectional area of MLD, determined *in vivo* by CT between the 2nd and 3rd and between the 4th and 5th lumbar vertebrae, is positively correlated to the most important carcass traits (Szendrõ *et al.,* 1992) and its heritability is 0.41 (Szendrõ *et al*. 2004) The volume of MLD is positively correlated to the mid part and the dressing out percentage. The fact that no differences were found in the weight and in the ratio of both the mid part and MLD in experiment 1 could also be explained by the CT selection. P does are selected for carcass traits as well.

In the weight of the hind part, significant differences were obtained in experiment 1 and 2. In both cases the offspring of Pannon White males had heavier hind parts. However, no differences were found in the hind part ratio to reference carcass weight. Similar results were found both in the weight and ratio of HL. Our results confirm data in the literature (Ouhayoun, 1986; Pla, 1996) which show that there is no important difference between breeds of large and medium body size for this trait.

As a result of the selection for improving the body weight gain or the body weight, the volume of the perirenal fat decreases (Lukefahr *et al.,* 1982; Pla, 1996; Pla *et al.*, 1996; Dalle Zotte and Ouhayoun, 1998; Piles *et al.*, 2000; Gondret *et al.,* 2002). The reason for this is the later development of fat tissue (Cantier *et al.*, 1969; Deltoro and López, 1985). The results of our experiments confirmed literature data, since the volume of the fat deposit was higher in the offspring of smaller sized P bucks than in that of larger sized hybrid males. In experiment 3 the difference between the progeny of P and Z bucks was significant.

According to the results found by Maertens (1992), Pla *et al.* (1996) and Gómez *et al.* (1998), rabbits of larger body size had a larger liver. This is due to the fact that the liver is an early-maturing organ (Cantier *et al.*, 1969; Deltoro and López, 1985), thus, it is larger at the usual slaughtering age and weight in late-maturing rabbits. Our results did not confirm these literature data, since in experiment 2 PH rabbits had the largest liver, while the body weight of this group was one of the lowest, and in the other two experiments no difference was found in this trait.

Like the liver, the kidney is an early-maturing organ, thus, it is more developed in rabbits of larger body size (Deltoro and López, 1985). In our experiments, larger sized genotypes had heavier kidneys in all cases, however these differences were not significant.

CONCLUSIONS

Our results confirmed that the adult weight and the maturity at slaughter influenced most of the carcass traits (dressing out percentage, fore part or fat deposit). However, it also proved that the selection of Pannon White rabbits based on CT was successful. In the genotypes from P bucks and/or does, the weight and the ratio of the MLD improved. Thus, the weight and the ratio of the mid part and the dressing out percentage were also higher. From these results it can be concluded that the growth rate and the carcass traits could be selected in parallel, thus making it possible to increase the meat content at a younger age in the late maturing breeds.

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