

## GENETIC PARAMETERS AND TRENDS OF THE THIGH MUSCLE VOLUME IN PANNON WHITE RABBITS

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### ABSTRACT

Genetic parameters and genetic trends for average daily weight gain between the age of 5 and 10 weeks (ADG) and thigh muscle volume (TMV) were analyzed for 19751 and 2602 Pannon White rabbits, respectively, reared in 3093 litters and born between 2003 and 2007. Rabbits with higher daily weight gain than the average of their kindling batch were chosen (based on individual ADG performances), thereafter CT (computerised tomography) scanning was performed on these rabbits measuring thigh muscle volume. Estimated heritabilities were moderate for average daily gain ( $0.27 \pm 0.02$ ) and moderately low for thigh muscle volume ( $0.21 \pm 0.03$ ). Litter effects were low for both traits ( $0.14 \pm 0.01$  and  $0.14 \pm 0.02$ , respectively). Genetic correlation coefficient estimate between average daily gain and thigh muscle volume was low ( $0.14 \pm 0.08$ ). Applying BLUP the estimated selection response was 0.0879 g/year-month (i.e. 1.05 g/year) for average daily weight gain; 0.3341 cm<sup>3</sup>/year-month (i.e. 4.01 g/year) for thigh muscle volume.

**Key words:** Rabbit, Average daily gain, Computer tomography, Thigh muscle volume, Selection response.

### INTRODUCTION

An efficient breeding programme of any population requires the constant monitoring of performance for selection. The breeding objectives in domesticated animals generally target the improvement of reproduction performance in maternal lines, growth and/or slaughter value in paternal lines. Using conventional methods, performance of breeding candidates for slaughter traits can only be evaluated by sib or progeny test. Because of its unfavourable properties (high costs, long generation interval) in rabbit breeding progeny test was only carried out by Varewyck *et al.* (1986). However, body composition of live animals can be estimated through the application of computerized tomography (CT). Ten years after the first application of CT methodology in domesticated species (Skjervold *et al.*, 1981) a special digital imaging centre was installed in 1990 at the University of Kaposvár (Hungary) utilizing CT for animal science, human diagnostics and research. In rabbit breeding CT-aided selection is exclusively applied at Kaposvár and so far about 6000 rabbits were scanned in vivo. Application possibilities of CT system in rabbit research are summarised by Romvári (2005). CT-aided selection has been continuously applied at the Kaposvár University since 2001 to improve the slaughter value of Pannon White rabbits. Estimated genetic parameters for the average cross-sectional area of the muscle Longissimus dorsi and dressing out percentage were reported by Nagy *et al.* (2006). From 2004 selection criteria changed to thigh muscle volume (summing the surface of 11-12 CT scans) and genetic evaluation using BLUP methodology was also introduced. The Pannon White rabbit population at Kaposvár has been selected for average daily gain for about 15 generations. Although the efficiency of the breeding program was evaluated several times (e.g. Garreau *et al.*, 2000; Szendrő *et al.*, 2004), so far the genetic trend in thigh muscle volume has not been examined.

The objective of the present study was therefore to estimate the efficiency of the CT-aided selection of the Pannon White rabbits for average daily gain and thigh muscle volume.

## MATERIALS AND METHODS

The present analysis was based on data from 19751 Pannon White rabbits born from 2003 to 2007 at the rabbit farm of the University of Kaposvár. The evaluated animals were reared in 3093 litters and the total number of the pedigree file was 21161. Descriptive statistics are presented in Table 1.

**Table 1:** Descriptive statistics for the traits

Trait	Number of records	Mean	S.D.	Min	Max
Average daily gain (g/day)	19751	42.86	6.45	15.3	81.9
Thigh muscle volume (cm <sup>3</sup> )	2602	334.8	37.72	221	533.6

Growing rabbits were kept in a closed rabbit house, in fattening cages (2-3 rabbits per cage). After weaning at 5 weeks of age they were fed a commercial pelleted diet. In the winter the rabbit house was heated to a minimum temperature (16°C), during summer the temperature occasionally reached levels as high as 28°C.

The selection of growing rabbits was performed in two-step procedure. The first was the daily weight gain between 5 and 10 weeks of age (ADG), and the next one was the thigh muscle volume (TMV) obtained from the CT scanning. From any kindling batch the proportion of the selected female and male rabbits on average were 34% and 20%, respectively. From the CT-scanned individuals on average 40% and 21% of the female and male rabbits were selected.

The animals were weighed at 5 and 10 weeks of age, to calculate the daily weight gain. Rabbits showing the best weight gain (based on individual ADG performances) (30-40%) were subjected to CT examination at 10.5 weeks of age. The rabbits, three at once, were fixed in stretch position, lying flat in a specially designed "container" during examination, without anesthesia and after eight hours of feed deprivation. The CT scanning was performed by a Siemens Somatom Plus 4 Expert spiral scanner of the Institute of Diagnostic Imaging of the Kaposvár University. The CT scans (pictures) were adjusted to take 10 mm thick imaginary slices, from the thigh muscle with total overlapping (slice: 10 mm, feed: 10 mm) providing direct volumetric information.

The CT examination started with a top-view picture (topogram) to determine the interval of the cross-sectional scans (tomograms) to be taken. The first of these scans moved across the *crista iliaca* and the last one across the *extremitas distalis*. Approximately 10-11 scans were taken from each container, then pixel density data were collected from each of the scans with the "Mepp software" separately from the examined rabbits. The picture-forming pixels of the images are in fact small prisms (voxel) with a defined volume (approx. 10 mm<sup>3</sup>) and a characteristic X-ray density value on the Hounsfield (HU) scale. Since in the hind legs the muscle tissue represents a well defined area on this scale (40-120 HU value), the direct determination of the total muscle volume was possible. Using the data based on the second step of the selection procedure the daily gain between the age of 5 and 10 weeks and CT-based thigh muscle volume were evaluated with the REML and BLUP procedures in order to estimate genetic parameters and breeding values. The applied softwares were PEST (Groeneveld *et al.*, 1990) and VCE 5 (Kovac and Groeneveld, 2003.) A bivariate animal model was applied (Table 2). Means of breeding values of animals measured in the same year-month were calculated for ADG and TMV (measured between 2004-2007). These values were then linearly regressed on the consecutive year-seasons (SAS, 2002-2003) to calculate selection responses.

## RESULTS AND DISCUSSION

The estimates of heritability and random litter effect can be seen in Tables 3 and 4. Heritability estimates were moderate for ADG and low for TMV. Present heritability estimate for ADG was very similar with the value reported by Nagy *et al.* (2006). The heritability of the cross-sectional area of the muscle Longissimus dorsi (L value) however highly exceeded that of the TMV. This phenomenon can be explained by the different number of CT scans taken for the L value (2) and TMV (10-11). Random

litter effect is an environmental effect primarily manifested through the milk production of the doe. Generally the importance of the random litter effect is decreasing with the increasing age of the growing rabbits. The magnitude of this effect was low for both traits.

**Table 2:** Bivariate animal model for the Pannon White breed

Factor	Type <sup>a</sup>	Level	Trait	
			Average daily gain	Thigh muscle
Sex	F	2	X	X
Year-month	F	46	X	-
Animal	A	21282	X	X
Litter	R	3093	X	X
Body weight at CT-measurement	C		-	X
Year-month of CT	F	33	-	X
Rabbits age at CT measurements	F	2	-	X
Pixel	F	3	-	X

<sup>a</sup> Types of factors: C, covariable; F, fixed factor; R, random factor; A, random additive genetic effect

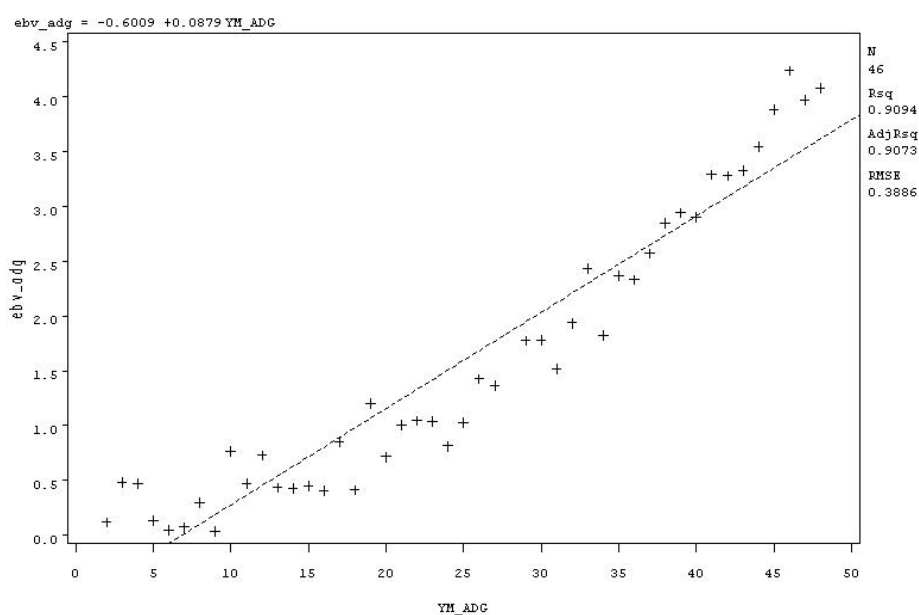
**Table 3:** Estimates of heritability (diagonals) and genetic correlation (off-diagonals). Standard errors of estimates are given in brackets

Trait	Average daily gain (g/day)	Thigh muscle volume (cm <sup>3</sup> )
Average daily gain (g/day)	0.27 (0.02)	0.14 (0.08)
Thigh muscle volume (cm <sup>3</sup> )		0.21 (0.03)

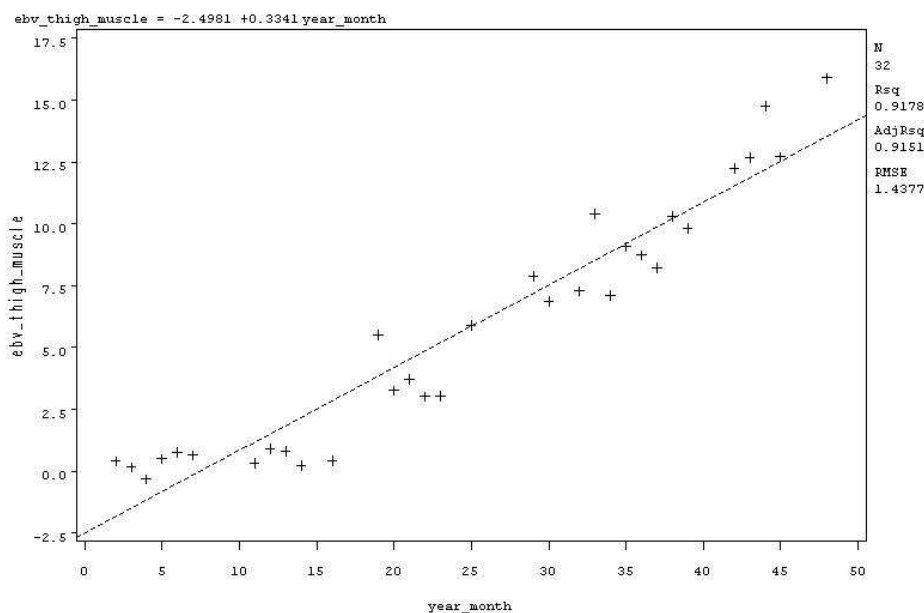
**Table 4:** Estimates of random litter effect (diagonals) and correlation (off-diagonals). Standard errors of estimates are given in brackets

Trait	Average daily gain (g/day)	Thigh muscle volume (cm <sup>3</sup> )
Average daily gain (g/day)	0.14 (0.01)	0.06 (0.05)
Thigh muscle volume (cm <sup>3</sup> )		0.14 (0.02)

The estimated selection response was 0.0879 g/year-month for average daily gain; 0.3341 cm<sup>3</sup>/year-month for thigh muscle volume (Figure 1 and 2), which is equivalent to 1.05 g/year and 4.01 cm<sup>3</sup>/year, respectively. Other authors (Garreau *et al.*, 2000; Estany *et al.*, 1992; Moura *et al.*, 1997; Piles and Blasco, 2003) found similar selection (0.45-1.23 g/d) responses for ADG to the reported values of this study. These favourable results justify the efficiency of the CT-aided selection which was also demonstrated by a divergent selection experiment (Szendrő *et al.*, 2008).



**Figure 1:** Linear regression of mean breeding values for average daily gain (ebv\_adg) of rabbits born in the same year-months (YM\_ADG) on the successive year-month periods (selection response)



**Figure 2:** Linear regression of mean breeding values for thigh muscle volume (ebv\_thigh\_muscle) of rabbits born in the same year-months (year\_month) on the successive year-month periods (selection response)

## CONCLUSIONS

These favourable results justify the efficiency of the applied selection program of the Pannon White rabbit breed. As a consequence of the applied selection (for two traits) the rabbits show increasing average daily gain with the simultaneous improvement of carcass traits (total muscle yield).

## ACKNOWLEDGEMENTS

Financial support of OTKA F048355 is gratefully acknowledged.

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