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ABSTRACT

A short divergent selection experiment was carried out on residual feed consumption. One step of selection was performed on young male rabbits from a heavy weight line. They were individually caged and measured for weight gain and feed consumption between weaning (30 days) and 65 days of age. The fatness of all the males was estimated by ToBEC measurement at 65 days of age. Their offspring were bred under the same conditions and 120 males were slaughtered at 65 days of age for estimating the correlated response on carcass traits: dressing yield, cutting parts, fatness, ultimate pH and colour. The heritability value estimated for residual feed efficiency was 0.45±0.11, which was of the same order as heritability estimated for average daily gain (0.41±0.13) and higher than heritability estimated for feed conversion ratio (0.27). Residual feed consumption was negatively correlated with hind part percentage (-0.71) and correlated positively with fore part percentage (0.54). The genetic correlations with dressing percentage and carcass fatness were very low. No significant phenotypic differences were found between offspring of high residual feed consumption and low residual feed consumption males, except for hind part percentage which was higher in the low residual feed consumption line.

Key words: rabbit, residual feed efficiency, selection, carcass composition, fatness.

INTRODUCTION

In rabbit production, feed consumption is one of the critical point: Feed costs represent over 70% of rabbit meat production (MOURA *et al*., 1997). Additionally, improving feed efficiency should improve carcass quality by decreasing carcass fatness. However, genetic determinism of feed consumption or feed efficiency has been little studied (POUJARDIEU *et al*. 1974; MOURA *et al*., 1997). Selection for growth rate is not detrimental to feed efficiency, therefore direct selection for feed efficiency has rarely been applied in selection schemes in rabbit. In addition, in alternate breeding systems, rabbits could be slaughtered at older ages and feed efficiency may be taken into account because feed conversion ratio highly increased after 11 weeks of age.

The feed efficiency concept had been suggested by BRODY (1945) to limit the feed costs by product unit. The criterion retained for estimating feed efficiency was the ratio such as product/ingested. This kind of ratio has no biological interpretation and when considered for selection can not allowed knowing the relative selection pressure made for each term of the ratio. Within the same period, the concept of residual ingested energy was proposed: energy importation and exportation compartments were related to each others. A prediction equation is settled, by multiple linear regression, between the ingestion of energy and the consumption (muscle tissue deposition, fat deposition, heat production…). This concept has been extended to the residual feed consumption for estimating genetic determinism of feed efficiency in several species (TIXIER-BOICHARD *et al*., 2002).

When using residual feed consumption, a measure of the carcass composition might be useful. For rabbit, an in vivo measurement of body fat content is available (LEVAI and MILISITS, 2002). Based on that result, when carried a short term divergent selection experiment on residual feed consumption and measured the consequences on growth, feed efficiency and carcass composition in the offspring.

MATERIAL AND METHODS

Animals

The rabbits used in the experiment were issued from a commercial line selected on growth rate. At birth, litter size was homogenised. After weaning, the males were put in individual cages. The females were bred in collective cages (6 animals per cage).

Measurements

Growth and feed consumption

The animals were weighed just after weaning. Then they were weighed at the age of 65 days on the first generation. The individual consumption was recorded between weaning and 65 days of age. The ToBEC value (Total Body Electrical Conductivity) was recorded with an EM-SCAN Sa3152 on each male, just after weighing at 65 days of age. An index was estimated based on the regression of the consumption on the weight gain, the mean metabolic weight and the ToBEC value. The residual of the regression was considered as the residual consumption. The 7 highest (high residual feed consumption line) and the 7 lowest indexes (low residual feed consumption line) were retained as bucks for the following generation. No selection was performed on the females.

The animals of the second generation were bred on the same basis as the first generation: males in individual cages, females in collective cages. They were weighed at weaning, at 56 days and at 65 or 67 days of age. Within the same period, individual consumption was measured on males, as well as average daily gain and feed conversion ratio. At 65 or 67 days of age, the ToBEC value was recorded and the animals were immediately slaughtered. A total of 120 animals were slaughtered, 59 from the high efficiency line, 61 from the low efficiency line.

Carcass and meat traits

The skin, the viscera and the carcass were weighed after exsanguination. The carcass was kept at 4°C during 24 hours. The day after slaughtering, the carcass were divided (BLASCO *et al.*, 1993) in 3 parts (hind part, back part and front part without head and heart, trachea and lungs) and weighed. The perirenal fat and the interscapular fat were removed from the cold carcass and weighed. The pH and L*a*b* color parameters (Minolta chromameter) were measured on the *Longissimus dorsi* (7^{th} lumbar vertebrae) and on the *Biceps femoris*.

Statistical analysis

The residual feed consumption was estimated with the REG procedure of SAS package (1999). The model of analysis retained for the second generation measured traits was slaughter series and lines. The interaction between these two effects was not retained in the model, because it appeared to be not significant.

The heritability values were estimated with the VCE4.2 package (NEUMAIER and GROENEVELD, 1998) using the same model as previously described for fixed effects, adding two random effects for common environment and additive genetic effects.

RESULTS AND DICUSSION

The differences between the two lines for the animals of the second generation are presented in Table 1. No significant differences were found between the two lines, except for the percentage of hind part, which was higher in the low residual feed consumption line. Two tendencies could be mentioned: the E-value was higher in the low residual feed consumption line, and the ultimate pH measured in the *Biceps femoris* tended to be lower.

As stated by the results, only tendencies have been found in the experiment which may be not very encouraging for using residual feed consumption in breeding programs. The key point remains the determination of body (or carcass) fatness for living animals. In that experiment, we did not evidence a clear relationship between E-value and carcass adiposity estimated by weighing external fatty tissues. The phenotypic correlation estimated between E-value and fatness was only 0.07. Corrected for the body weight, the phenotypic correlation between residual E-value and carcass adiposity remained low (-0.26). YASUI *et al.* (1998) developed a simple formula to estimate lean body mass with the ToBEC value. By using TOBEC, they were able to assess the losses of body fat in the rabbits with cachexia at 10-day intervals. LEVAI and MILISITS (2002) demonstrated the efficiency of selection for ToBEC value on carcass composition in rabbit. However some results in small mammals recently showed that limited variations of fat were very difficult to detect with ToBEC (WIRSING *et al.* 2002).

Table 1. Estimation of differences between high and low residual feed consumption (RFC) lines; genetic parameters (heritability h², common environment c² and genetic correlation with residual feed consumption) growth, carcass and meat traits.

Traits[A]	Line effect[B]	Low RFC line	High RFC line	standard deviation	h²	c²	r_g
RFC (g)	NS	-25	26	303	0.45(0.11)	0.11(0.06)	
Body weight							
Weaning (g)	NS	969	945	92	0.09(0.13)	0.52(0.07)	0.63(0.46)
Slaughter (g)	NS	2898	2882	196	0.67(0.16)	0.26(0.07)	0.19(0.19)
ADG (g/j)	NS	58.5	58.8	4.8	0.41(0.13)	0.21(0.06)	-0.09(0.22)
E	+	2636	2552	285	0.42(0.15)	0.19(0.06)	-0.07(0.23)
FCR	NS	2.93	2.96	0.20	0.27(ne)	0.24(ne)	1 (ne)
Carcass traits							
Weight (g)	NS	1780	1767	125	0.94(0.19)	0.03(0.05)	0.24(0.23)
Liver weight (g)	NS	116	118	26	0.94(0.17)	0.02(0.03)	0.25(0.18)
Skin (%)	NS	17.9	17.8	0.9	0.83(0.11)	0.17(0.24)	-0.04(0.24)
Dressing yield (%)	NS	61.5	61.3	1.7	0.48(0.27)	0.07(0.11)	0.05(0.28)
Viscera (%)	NS	16.3	16.5	2.0	0.74(0.19)	0.02(0.05)	0.07(0.25)
Hind part (%)	**	30.1	29.4	1.0	0.87(0.24)	0.05(0.09)	-0.71(0.15)
Back part (%)	NS	16.9	17.0	0.8	0.48(0.15)	0.01(0.03)	0.08(0.24)
Front part (%)	NS	33.2	33.4	1.0	0.27(0.11)	0.01(0.02)	0.54(0.26)
Interscapular fat(%)	NS	0.54	0.57	0.12	0.77(0.16)		0.05(0.20)
Perirenal fat (%)	NS	1.62	1.69	0.33	0.24(0.11)	0.15(0.08)	0.37(0.25)
Fatness (%)	NS	2.16	2.26	0.40	0.32(0.19)	0.25(0.10)	0.15(0.32)
Meat traits							
Longissimus dorsi							
pH	NS	5.63	5.64	0.06	0.50(0.16)		0.30(0.19)
L*	NS	54.5	54.3	2.5	0.07(ne)		1.00(ne)
a*	NS	4.51	4.26	1.84	0.26(0.19)		0.32(0.28)
b*	NS	3.41	3.15	1.02	0.15(0.12)		0.19(0.30)
Biceps femoris							
pH	+	5.81	5.84	0.09	0.06(0.10)		0.23(0.56)
L*	NS	59.4	58.6	2.9	0.18(0.12)		0.11(0.31)
a*	NS	3.80	3.44	1.34	0.51(0.16)		-0.21(0.19)
b*	NS	3.99	3.60	1.44	0.28(0.12)		0.03(0.25)

[A]: RFC: Residual consumption; ADG: Average Daily Gain; FCR: Feed Conversion Ratio; E: ToBEC value; [B]: level of significance NS=non significant; +: P<0.10; **: P < 0.01

Some comparisons between lines selected on different objectives showed that lines selected for growth rate have a better feed efficiency than lines selected for reproduction traits (TORRES *et al*., 1992; FEKI *et al*., 1996). Recent results showed that selection for growth rate genetically improved feed efficiency (MOURA *et al*., 1997). In that particular experiment, direct selection for feed efficiency is less efficient than selection for growth rate for improving feed conversion ratio. This result could be explained by the heritability values of growth rate and feed conversion ratio and the high correlation found between both traits. In the literature, the genetic correlation between growth rate and feed conversion ratio may vary from medium to high negative values (–0,19 and –0,29 for MASOERO, 1974 between 20 and 74 days of age cited in MASOERO 1982; –0,41 for SZENDRÕ 1980, between 7 and 11 weeks; –0,82 for MOURA *et al.* 1997; from –0,97 to –1 for Vogt, 1979 between 56 and 84 days of age). By construction, residual feed consumption was only lowly related to average daily gain (-0.09). The heritability values estimated for average daily gain and feed conversion ratio very similar to the values presented by MOURA *et al.* (1997) (0.48 and 0.28, respectively). To our knowledge, no results on effects of selection for feed efficiency in rabbits on carcass composition are available in literature. But in other species, it is clear that improving feed efficiency reduces carcass fatness.

CONCLUSION

It has been demonstrated with estimation of genetic parameters that selection on feed efficiency is possible. The experiment failed to initiate a genetic difference between lines divergently selected on residual feed consumption, probably because of the lack of precision in using ToBEC measurement for estimating precisely in vivo carcass composition.

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