8th World Rabbit Congress – September 7-10, 2004 – Puebla, Mexico

PROCEEDINGS

Genetics – Short papers

GENETIC AND PHENOTYPIC RESPONSES ON WOOL PRODUCTION AND FLEECE COMPONENTS IN TWO DIVERGENT LINES SELECTED FOR TOTAL FLEECE WEIGHT IN ANGORA RABBITS

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ABSTRACT

This paper described a divergent selection experiment for total fleece weight in the French Angora rabbit breed. A high line and a low line were made up in 1993 with 80 females and 10 males each one. From 1994, the renewal after selection was composed each year of 36 females and 5 males, alive at the second harvest in each line. The last experimental year on 2001, 80 females and 20 males in each line were procreated. The selection criterion was the total fleece weight of the does for 3rd and latter harvests but different other wool production traits and fleece components were recorded at each harvest. The aim of this paper was to describe the production traits which have been recorded and the genetic and phenotypic trends observed between the two divergent lines. Genetic values and genetic parameters were estimated with a BLUP applied to an animal model. Heritability of total fleece weight was 0.29. After eight years of a divergent selection experiment, a difference of 3.1 genetic standard deviations on total fleece weight was observed between the two lines. In response to selection, a positive difference of 3.0, 0.7, 0.6 and 0.9 genetic standard deviation were observed for weight of long-angora jarreux quality (WAJ1 with many bristles), weight of long-angora woolly quality (WAW1 with a few bristles), fleece homogeneity and bristle length respectively. No correlated response was observed on down length while negative differences of 0.9, 0.9, 1.1 and 0.4 genetic standard deviations were observed on lock structure, compression and resilience and live bodyweight respectively. Other fleece components such as fibre diameter, proportion of each fibre type and hair follicle density remain to be determined in this experiment. Such measurements will give more information about the evolution of the structure and the composition of the fleece in response to selection for total fleece weight.

Key words: Angora rabbit, divergent selection, total fleece weight, correlated response, fleece components.

INTRODUCTION

The French Angora rabbit breed has a specific kind of fleece with well differentiated guard hair (ROUGEOT and THÉBAULT, 1984) and long and bristly wool is produced. Such bristly fleeces are valued because of their aptitude to produce a fluffy yarn used for certain luxury knit products. Information about genetic parameters of wool production and live body weight on the Angora rabbit and more especially in the French Breed is known (ALLAIN *et al.*, 1999). In order to explore genetic variability of wool production and other quantitative traits in the angora rabbit, a divergent selection experiment on total fleece weight was undertaken (ROCHAMBEAU *et al.*, 2000). This divergent selection experiment which began in 1994 was followed in 2001, by the creation of two large cohorts issued from the high and low lines. The aim of this paper was to describe the production traits which have been recorded and the genetic and phenotypic trends observed between the two divergent lines.

MATERIAL AND METHODS

The data were collected in the Angora experimental rabbit farm at Le Magneraud. Young rabbits were defleeced for the first and second time at 8 and 21 weeks respectively. Thereafter, they were defleeced every 14 weeks. Studies were made on wool production of a total of 815 Angora rabbit females from the French breed born between 1994 and 2001 and having produced altogether a total of 5037 wool harvests. The animals were raised in a naturally lighted building almost open to the air. There was no heating and no forced ventilation. Animals were raised in individual cement hutches on straw beds, which were completely replaced once a month. Each had a creep feeder and an automatic drinking bowl. Rabbits received a pellet commercial mixed food. ALLAIN *et al.* (1999) provided a more complete description of the breeding system.

A selection experiment was undertaken from 1993 in order to obtain two divergent lines on total fleece weight and to increase our experience of management of a population of Angora rabbit under selection (ROCHAMBEAU *et al.*, 2000). A high line and a low line were made up in 1993 with 80 females and 10 males each one. The generations were overlapping. From 1994, the renewal after selection was composed each year of 36 females and 5 males, alive at the second harvest in each line. In 2001, the last year of the experiment, 80 females and 20 males in each line were procreated. The selection criterion was total fleece weight of the does for 3rd and latter harvests. At each harvest from the beginning of the experiment, the following variables were recorded: the *total fleece weight* (TFW) as well as the *weight of the five qualities* (WAJ1: wool angora jarreux with long fibres, WAW1: wool angora woolly with long fibres; WAJ2: wool angora jarreux with short fibres; WAF: clean felted angora wool; WAS: soiled angora wool) constituting the fleece of the French breed (VRILLON and THÉBAULT, 1992), *the length of bristles and downs,* measured on two locks respectively taken from the back and the haunch, and c*ompression and resilience*. These two measurements based on those used for objective measurement of quality in sheep wool have been already described (ALLAIN *et al.*, 1999). These parameters values are used to calculate the fleece quality criteria: homogeneity and structure. The homogeneity is equal to the ratio of the weight of quality WAJ1 to the total weight of the fleece. The structure is equal to the ratio of the length of down to the length of the bristles.

On animals born on 2001 and issued from the last selected cohort, additional biological samples were made. Wool samples were taken at each harvest in order to determine fineness and proportion of each fibre type within the fleece according to the OFDA and

Cross section methodology (ALLAIN *et al.*, 2000). Skin samples were made 4 weeks after the fourth and the sixth harvest in order to determine hair density, primary to secondary hair follicle ratio within the hair follicle group. All animals were blood sampled once for further investigations about detection of QTL or genes involved in wool production.
Genetic parameters for different variables including total fleece weight were firstly estimated by using REML VCE, a multivariate multimodel restricted maximum likelihood variance component estimation program (GROENEVELD, 1997) with an animal model. Then genetic value estimates of the different traits were obtained as solutions of the last covariance matrices at convergence. There were 3 fixed effects: reproduction with 2 levels (yes or not), the year of harvest (22 levels because one considered all the performances and the genealogies since the creation of the strain) and finally an effect dialing the season and the number of harvest (24 levels). There were 2 random effects: the animal and the permanent environment for harvests of a rabbit. There were a total of 3661 animals in the pedigree file and 10561 performances in the data file.

RESULTS AND DISCUSSION

Phenotypic and genetic evolution of total fleece weight

The evolution of the total fleece weight for adult harvest which has a harvest number higher than four was given in Figure 1. Mean total fleece weights of the two lines for each harvest were always statistically different after 1994. But it was curious to note that, in the high line the wool production did not progress after 1995 while it was mainly decreasing in the low line. However this evolution confirmed the observations made on the genetic values shown in Figure 2. Mean genetic values of the two lines were always statistically different after 1994 and after 8 years of a divergent selection experiment on total fleece weight, a difference of 3.1 genetic standard deviations was observed between the two lines. But the genetic trend was slightly different. The genetic values in the low line decreased sharply from 1995 to 1997, were stable between 1997 and 1999 and then decreased again. The evolution of the high line was different. It increased sharply until 1995, then slightly up to 2001. An asymmetric answer is often observed in divergent selection experiments (FALCONER, 1989). The coefficient of regression of the difference between the lines was equal to 10.7 grams per year between 1993 and 2001. But this value was slighter lower than the expected value (14.8g) determined earlier (ROCHAMBEAU *et al.*, 2000).

Genetic parameters estimates

Heritability estimate (Table 1) for total fleece weight was high (0.29). Repeatability estimate obtained in this experiment was 0.41. These estimates were slightly different from values set in the current selection experiment, 0.35 and 0.51 respectively (ROCHAMBEAU *et al.*, 2000), but were in agreement with earlier results (ALLAIN *et al.*, 1999).

Table 1. Estimates of heritability (bold on diagonal)**, genetic correlations** (above diagonal) **and phenotypic correlations** (below diagonal) **of total fleece weight and other wool production traits.**

		LBW	TFW	WAJ	WAW	BBL	BDL	BLS	COM	RES	HOM
Live body weight	(LBW)	**0.39**	0.11	0.01	0.19	-0.14	-0.11	0.02	0.12	0.19	-0.24
Total fleece weight	(TFW)	0.32	**0.29**	0.93	0.64	0.33	0.35	0.08	-0.09	-0.21	0.17
Weight of quality WAJ1	(WAJ)	0.25	0.88	**0.23**	0.41	0.25	0.41	0.22	-0.23	-0.35	0.51
Weight of quality WAW1	(WAW)	0.17	0.38	0.05	**0.10**	0.09	0.02	-0.07	0.22	0.17	-0.42
Back bristle length	(BBL)	-0.02	0.17	0.15	0.00	**0.23**	0.54	-0.39	0.01	-0.04	-0.10
Back down length	(BDL)	-0.05	0.13	0.13	-0.03	0.44	**0.14**	0.56	-0.19	-0.29	0.29
Back lock structure	(BLS)	-0.04	0.00	0.03	-0.03	-0.29	0.73	**0.14**	-0.22	-0.29	0.42
Compression	(COM)	0.00	-0.10	-0.11	0.02	0.03	-0.01	-0.04	**0.18**	0.89	-0.44
Resilience	(RES)	0.03	-0.08	-0.08	0.03	0.03	-0.11	-0.15	0.62	**0,11**	-0.50
Homogeneity	(HOM)	0.01	0.22	0.64	-0.49	0.04	0.07	0.05	-0.07	-0.04	**0.12**

Figure 1. Total fleece weight (g) of adult doe harvests for each line (harvest number higher than 4).

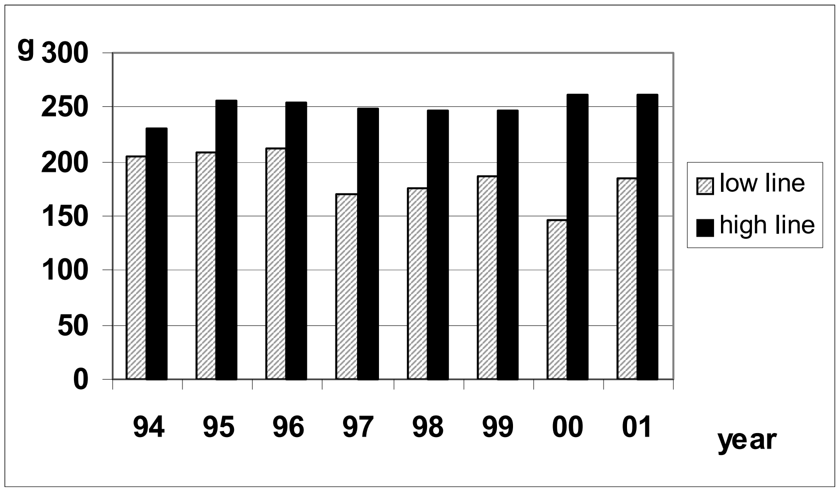
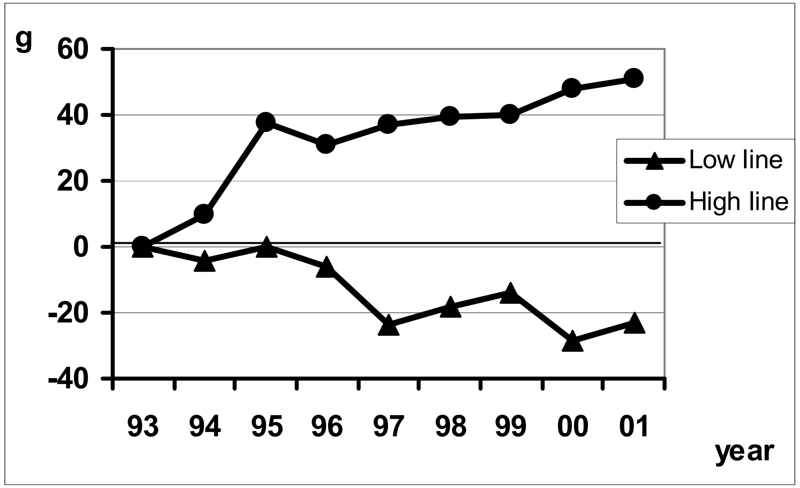


Figure 2. Mean genetic value for total fleece weight in grams for each line.



Heritability estimates for live body weight were high (0.39) and in agreement with previous results (ALLAIN *et al.*, 1999).
Heritability estimates for other fleece traits were low to moderate (Table 1), ranging from 0.10 to 0.23. Genetic and phenotypic correlations between the total weight of the fleece and weight of quality WAJ1 were positive and high (0.93 and 0.88 respectively). Genetic and phenotypic correlations between bristle and down length, and lock structure were high and positive. All these results were in agreement with earlier observations (ALLAIN *et al.*, 1996).
High and positive genetic and phenotypic correlations were observed between compression and resilience, two important fleece characteristics used to appreciate fleece bristlyness as it has been shown that bristly fleeces are valued because of their aptitude to produce a fluffy yarn used for certain luxury knit products, compress more and relax less than woolly fleeces (ROCHAMBEAU *et al.*, 1991).

Genetic correlated responses on other fleece traits

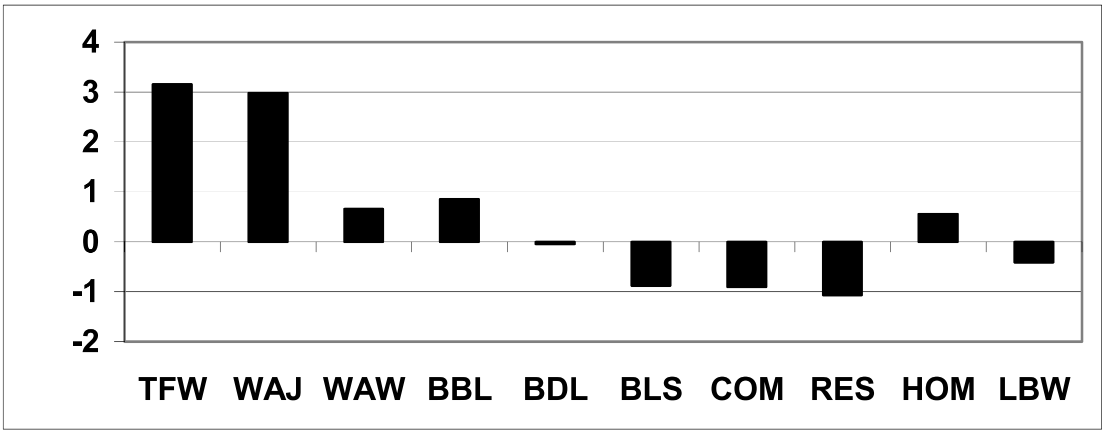


Figure 3. Genetic correlated response (in genetic standard deviation unit) on other fleece traits (TFW: total fleece weight; WAJ: weight of angora jarreux; WAW: weight of angora woolly; BBL: back bristle length; BDL: back down length; BLS: back lock structure; COM: compression; RES: resilience; HOM: homogeneity; LBW: live bodyweight) observed on the 2001 animal cohort.

Correlated responses on other fleece traits observed on the 2001 animal cohort were shown in Figure 3. In response to a divergent selection experiment on total fleece weight, positive differences of 3.0, 0.7, 0.6 and 0.9 genetic standard deviations were observed for weight of quality WAJ1, weight of quality WAW1, fleece homogeneity and bristle length, respectively. There was no effect on down length while negative differences of 0.9, 0.9, 1.1 and 0.4 genetic standard deviations were observed on lock structure, compression and resilience and live bodyweight, respectively. No other data about correlated responses to selection on total fleece weight or on fleece characteristics in angora rabbits have been published before. It is important to observe that selection for total fleece weight has a general beneficial effect on fleece quality. A high quality fleece having a good aptitude to produce a fluffy yarn was characterized by a high weight of quality WAJ1, high fleece homogeneity and long bristles with a low structure lock. All these characteristics were observed on the high line indicating that selection for total fleece weight results in an improvement of the quality of the fleece. Compression and resilience were also affected by selection and a decrease in both traits was observed. But evolution of these traits was difficult to interpret. Other fleece components such as fibre diameter, proportion of each fibre type *i.e.* bristle and down and hair follicle density remain to be determined. Such measurements will give more information about the evolution of the structure and the composition under selection for total fleece weight.

Moreover, such divergent selected lines provide an invaluable material for further investigations in functional genomics of the hair follicle as well as detection of QTL and major genes which are implied.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of Mrs. Patricia Bayle and Mr. J.C. Musseau, who managed the experimental farm and recorded all the different parameters during the whole conduct of this study.

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