DIVERGENT SELECTION FOR TOTAL FLEECE WEIGHT IN THE ADULT ANGORA RABBIT: DIRECT RESPONSE TO SELECTION ON TOTAL FLEECE WEIGHT AT FIRST AND SECOND HARVEST

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ABSTRACT

In order to explore genetic variability of wool production and other quantitative traits, an 8-cohort divergent selection experiment for total fleece weight (TFW) was carried out in French Angora rabbits. Studies were made on the wool production of a total of 669 female rabbits born between 1994 and 2001 and having produced wool from first to 12th harvests. The aim of the selection experiment was to obtain two divergent lines (low and high) on TFW. From preliminary analysis, the dataset was separated into three subsets according to the harvest number: one for each of the first two harvests and one for the third to the 12th harvests. In this paper, wool production data of the first and second harvests were analysed separately. Response to selection for total fleece weight at 3-12 harvest (TFW3-12) on this trait at first and second harvest was the aim of this paper. The second objective was to study the possibility of using the first or second harvest for estimation of breeding value and selection of total fleece weight in French Angora rabbit. Data were preliminary analysed for non genetic factors by SAS GLM procedure. Then genetic parameters and breeding value estimates were carried out using a BLUP animal model using with ASReml. A linear mixed model for a bivariate analysis of total fleece weight at first or second harvest and TFW3-12 was used. Heritability estimates of total fleece weight at first and second harvest, 0.36 and 0.38 respectively, were similar to that observed at later harvests (0.35). Genetic correlation between TFW3-12 and fleece weight at first harvest was close to zero indicating that wool production at first harvest is a different trait from that of following harvests. Genetic correlation estimates observed at second harvest was high, 0.76, and response to selection at second harvest was similar to that observed for TFW3-12. These observations confirm that total fleece weight at first harvest is a different trait from TFW3-12. In French Angora rabbits the high genetic correlation between TFW3-12 and total fleece weight at second harvest proposes the possibility of selection at this harvest for TFW3-12.

Key words: Angora, Divergent selection, Heritability, Rabbit, Fleece.

INTRODUCTION

The Angora rabbit is exploited to produce a fleece, which is then valued by the textile industry. The genetic improvement and the breeding of this animal have been studied by INRA (*Institut National de la Recherche Agronomique*) for more than thirty years. To analyze the efficiency of selection on the total fleece weight and the correlated response on the other traits, an experiment of divergent selection began on 1994. From preliminary analysis, the dataset was separated into three subsets according to the harvest number: one for each of the first two harvests and one for the third to the 12th harvests. With drawing the histogram of fleece weight it has been observed that the first two harvests are different from the rest of the data set. Also, previous studies showed this distinction. The result of third to 12th harvests has been published before (Rafat *et al*., 2007a, 2007b, and 2007c). These results showed that selection for high and low total fleece weight was successfully performed and a

divergence of three genetic standard deviations was observed between the high and low lines after eight years of selection (Rafat *et al*., 2007a). Selection for total fleece weight significantly increased bristle length, the secondary to primary follicle ratio and comfort factor and decreased compression, resilience, bristle diameter, and average fibre diameter. These changes resulted from moderate to high genetic correlations between total fleece weight and bristle length, and between fibre dimensions and secondary to primary follicle ratio, comfort factor, compression and resilience (Rafat *et al*., 2007b). Thus, selection for increasing total fleece weight results in an increase of both quantitative and qualitative traits of wool production in the French Angora rabbit. Measurement of total fleece weight is simple and easy at the farm level. Selection for this trait has positive effects on fleece characteristics such as bristle length, follicle population and fibre diameter.

The number of the harvest is important (at least at the first harvest) for all rabbit strains and for the second and third harvests in French strains. In French Angora, the young rabbits still produce woolly fur, even after depilation at seconds and third harvests. The total weight of wool harvested in the French breed increase rapidly up to the fifth harvest. Total fleece weight at the first harvest is about five times lower than that observed at the fourth or fifth harvest. Previous studies have been shown that total fleece weight in first and second harvests is a different trait from higher harvests. In this paper, fibre data of the first and second harvests were analysed separately. The objective of this paper is to find a response to these questions: what is the response of selection for total fleece weight at 3-12 harvest on this trait at first and second harvest? Is it possible to utilise the first or second harvest for estimation of breeding value of total fleece weight in French Angora rabbit?

MATERIALS AND METHODS

Animals and experimental design

Data were obtained from the Angora experimental rabbit farm of INRA at Le Magneraud, France. The experiment took place in a naturally lighted semi-open building with no heating and no forced ventilation. Studies were made of the wool production of female Angora rabbits born between 1994 and 2001 under a divergent selection experiment that was initiated in 1994. The aim of the selection experiment was to obtain two divergent lines on total fleece weight. A high line and a low line were made up of 80 females and 20 males each. Rabbits were distributed between the lines in order to have the same demographic structure and the same distribution of genetic values. Generations were overlapping. The renewal after selection was composed each year of 36 females and 5 males, alive at the second harvest in each line. The selection criterion was the total fleece weight of the does measured for the third and later harvests. During the selection experiment, genetic values were estimated with a BLUP applied to an animal model. The evaluation of the animals was done each year. Twenty does and five bucks having the highest and the lowest genetic values in the high and the by 2001, two large cohorts were available from the high and low lines.

Statistical Analysis

Data from total fleece weight at the first and the second harvest were separately analysed. In a first step the significance of fixed effects was determined using the least square means method with the GLM procedure. Then analyses for genetic parameters and breeding values were carried out with ASReml.

The following linear mixed models for a bivariate analysis of total fleece weight at first (TFW1) or second harvest (TFW2) and total fleece weight at 3-12 harvests (TFW3-12) were used:

$$\mathbf{Y}_i = \mathbf{X}i\,\boldsymbol{\beta}_i + \mathbf{Z}_i\,\mathbf{a}_i + \mathbf{W}_i\,\mathbf{p}_i + \mathbf{e}_i$$

Where:
N is the total number of animals,
N_i is the number of animals measured for the i^{th} trait,
$\mathbf{Y}_i$ (N_i) is a vector of animal records for the i^{th} trait at the first or the second harvest,
$\boldsymbol{\beta}_i$ (f_i) is a vector of fixed effects for the i^{th} trait consisting of:

- Year (8 levels) from 1994 to 2001,
- Harvest number (10 levels) from the third to the twelfth harvest for TFW3-12,
- Birth season effect (4 levels),
- Harvest season effect (4 levels) for TFW3-12,
- Reproduction (3 levels: females which had litters and females which had been inseminated or not) from the third harvest onwards for TFW3-12,

$\mathbf{a}_i$ (N) is a random vector of direct additive genetic effects of animals for the i^{th} trait,
$\mathbf{p}_i$ (N_i) is a random vector of permanent environmental effects of animals for the i^{th} trait.
Breeding values for all the traits were obtained as solutions from the best linear unbiased prediction analysis of the ASREML package. Then the means of the estimated breeding values (EBV) for all traits were calculated per cohort of animals born the same year and per selected line.

RESULTS AND DISCUSSION

Means and standard deviations (SD) for TFW1, TFW2 and TFW3-12 are shown in Table 1. Significance levels of fixed effects for fibre traits and 9LW are shown in Table 2.

Table 1: Number of records (N), mean and standard deviation (SD) for the studied traits: total fleece weight at first harvest (TFW1), total fleece weight at second harvest (TFW2), total fleece weight at 3^{rd} to 12 harvests (TFW3-12)

Trait	Unit	N	Means	SD
TFW1	g	762	31.31	8.56
TFW2	g	669	143.80	34.02
TFW3-12	g	3351	214.3	57.20

Table 2: Significance levels of fixed effects for the studied traits: total fleece weight at first harvest (TFW1), total fleece weight at second harvest (TFW2), total fleece weight at 3^{rd} to 12 harvests (TFW3-12)

Traits	Fixed effects				
	Year	Harvest number	Birth season	Harvest season	Reproduction
TFW1	***	-	***	ns	-
TFW2	***	-	***	ns	-
TFW3-12	***	***	***	***	***

*** $P<0.001$; ns: non-significant

Results of bivariate analysis for TFW1, TFW2 and TFW3-12 are shown in Table 3. Heritability of TFW at first and second harvest was similar to values observed at harvests of 3-12. Genetic correlation between TFW3-12 and TFW1 is close to zero and indicates that wool production at first harvest is a different trait from that of following harvests. Similar to our results, genetic correlation between birthcoat and clean fleece weight in superfine Merino sheep was found to be zero and the authors concluded that birthcoat do not increase economic gains when included in the selection criteria. In French Angora rabbits the high genetic correlation between TFW3-12 and TFW2 suggests the possibility to use TFW2 as a selection criterion.

Response to selection on TFW1 and TFW2 are shown in Figure 1. There is no response to selection at first harvest while a difference of 2.54 genetic standard deviation was observed between the two divergent lines. This response to selection at second harvest was similar to that observed for harvests 3 to 12. These observations confirm that TFW1 is a different trait, as could be expected from the fact that hair follicle development in the rabbit is not complete at 8 weeks of age when occurs the first harvest. Studying the development of the coat in the growing Angora rabbit from birth indicated that the number of derived hair follicle per hair follicle group increased in the growing animal from 10-12 at birth to 50-70 at the age of 20 weeks when occurs the second harvest. They concluded that the multiplication of derived hair follicles was independent of age but occurs up to a weight of 2 kg which was reached between 8 and 14 weeks depending on the growing potential of animals.

Table 3: Estimates of heritability, genetic and phenotypic correlations (± standard deviations) from bivariate analysis between total fleece weight at harvests 3-12 (TFW3-12) and first (TFW1) or second (TFW2) harvest

Trait 1	Trait 2	h2 Trait 1	h2 Trait 2	rg 1	rp1
TFW3-12	TFW1	0.35±0.05	0.36±0.08	0.01±0.11	0.14±0.03
TFW3-12	TFW2	0.33±0.05	0.38±0.08	0.76±0.10	0.34±0.03

[1] r_g: genetic correlation; r_p: phenotypic correlation

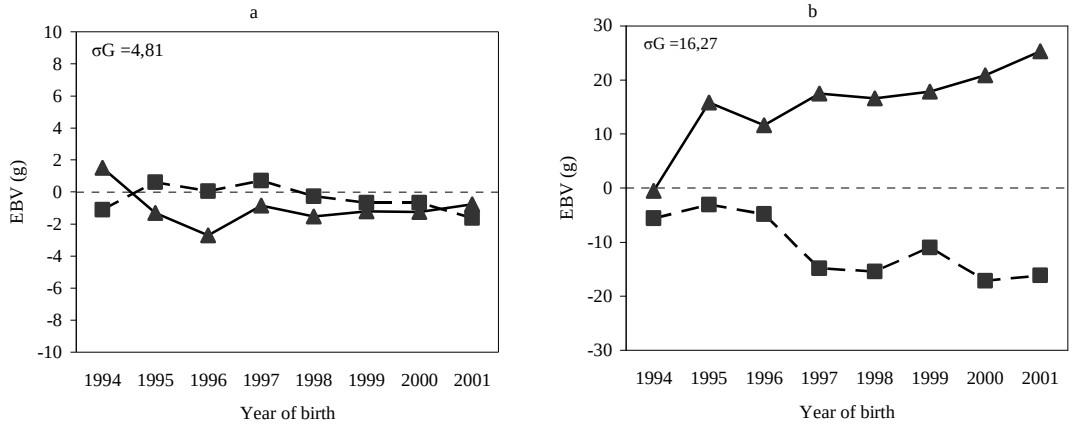

Figure 1: Change of mean breeding value estimates (EBV) of total fleece weight at first harvest (a) and second (b) harvests over the eight years of selection for both the high (▲) and low (■) lines. Genetic standard deviation (σ_G) is given

CONCLUSIONS

Our results obtained in French Angora rabbits show i) a high genetic correlation between total fleece weight at 3-12 harvests and total fleece weight at second harvest and ii), a significant response to selection for total fleece weight in the adult animal at the second harvest. Therefore, we propose the possibility of selection for wool production at the second harvest.

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