ANGORA RABBIT WOOL PRODUCTION: MALE AND FEMALE HERITABILITIES AND GENETIC CORRELATIONS FOR WOOL QUANTITY AND DIFFERENT FLEECE CHARACTERISTICS*

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Abstract - Data on 1204 and 6523 fleece harvests produced by 350 adult males and 1014 adult females respectively, were analyzed in order to study the extent of genetic variability between sexes. These animals of the French breed were defleeced every 14 weeks from the third harvest. The following variables were recorded at each harvest: total fleece weight, the weight of the five different qualities constituting the fleece, the length of bristles and downs as well as the structure of the lock on the back and the haunch, tautness, compression and resilience. The live weight was measured nine weeks before each harvest.
Female traits were more heritable than the male counterparts. Heritability estimates ranged from 0.01 and 0.25, and 0.09 to 0.25 for males and females traits respectively. Genetic correlations between sexes were high and ranged from 0.70 to unity. These sex differences in the extent of genetic variability are discussed.

INTRODUCTION

Few information is available on genetic variability for economically important traits in the Angora rabbit. ALLAIN *et al.* (1996) have recently reported heritabilities, genetic and phenotypic correlations for quantity of wool produced and several fleece characteristics in the adult doe. However in the Angora rabbit, there are large variations on phenotypic expression of fleece weight, due to the sex and the age of the animal.
An important sex effect is observed in the Angora rabbit. Bucks produce less wool than does. This sex difference ranges between 5 and 20% depending upon the breed, and it appears that the higher the average production, the higher is the difference between buck and does as recently reviewed (ROCHAMBEAU and THEBAULT, 1990). Wool production in males increases when the influence of androgen hormones decreases. But only a part of this sex variability is due to androgens hormones. Castrated bucks produce more than entire males but less than females (SCHLOLAUT and LANGE, 1983). Furthermore, males have a different fleece than females, a lower proportion of bristly wool in the total fleece, longer downs and shorter bristles (ROCHAMBEAU *et al.*, 1991). As an other explanation, such variation in the phenotypic expression of wool production and fleece characteristics between males and females could be due to differences in genetic variability. Furthermore, a knowledge of these correlations between sexes could be important in determining rates of progress as up to now selection indices derived from genetic parameters for females are applied to males.
This paper reports results from the estimation of variance components and genetic parameters of angora wool production according to the sex when analysing data in the adult Angora rabbit of the French breed.

MATERIAL AND METHODS

Data

The data available were from the angora rabbit farm of Institut National de la Recherche Agronomique at Le Magneraud, BP 52, Surgères, France. Studies were made on wool production of a total of 1014 angora does and 350 angora bucks which have made at least one wool harvest from the third harvest and born between 1 January 1983 and 31 November 1995. The young rabbits were sexed at birth and most of the males were eliminated. In this way the size of the litters were reduced to less than six rabbits just after birth. The young rabbits were

* The authors dedicate this paper to Gabriel Blanié, technician of the experimental herd, who recently died.

weaned four weeks later. At the age of eight weeks, the young rabbits were weighed and defleeced for the first time. At the age of 21 weeks, rabbits were weighed and defleeced a second time. Thereafter, they were defleeced every 14 weeks. The liveweight was measured nine weeks before each harvest. At each harvest, several variables were recorded: the total fleece weight, the weight of the five qualities constituting the fleece of the French breed, homogeneity, the length of down and bristles, and staple structure on both the back and the haunch, tautness rating (roughness) before defleecing, compression and resilience as previously described (ALLAIN *et al.*, 1996).
Management, feeding and housing conditions of the experimental population were previously given more exactly (ALLAIN *et al.*, 1996).
Characteristics of the data structure are summarized in table 1.

Table 1: Characteristics of the data structure.

No. records in data	7727
No. animals in total	2055
with own records	1364
No. Sires	200
with own record	146
with progeny in the data	163
No. dams	398
with own record	272
with progeny in the data	322

Analysis model

The estimates of variance components for different variables were obtained by using REML VCE, a multivariate multi model restricted maximum likehood variance component estimation (GROENEVELD, 1995) with an animal model.
Earlier investigations using fixed models of variance analysis have shown that in angora rabbits, five fixed factors were considered to be important: harvest number, birth season, harvest season, year of harvest and reproduction (ROCHAMBEAU *et al.*, 1991).
The random part of the model consisted of a genetic effect, related to the individual animal and a permanent environmental effect as up to 26 performances have been recorded on the same animal.

The general model is :

$$Y = Xf + Za + Qc + e$$

where

. Y is a vector of animal records,
. f is a vector of fixed effects consisting of:
  . year of production (13 levels),
  . harvest number-birth season- harvest season composite effect (24 levels; 1 to 4: birth season effect at the third harvest; 5 to 8: birth season at the fourth harvest; 9 to 24: birth season and harvest season at harvest which number is more than four) and,
  . reproduction in females (2 levels: females which had litters or not).
. a is a random vector of direct additive genetic effects of animals,
. c is a random vector of permanent environmental effects of animals,
. e is a random vector of residuals.

X, Z and Q are known design matrices which connect a, f and c with Y. X and Z depend on the trait considered because of missing values and because each fleece trait was treated as a sex-limited trait.
By using a set of 13 bivariate model analyses, heritabilities in each sex, and genetic and phenotypic correlations between sex have been estimated on a total of 13 different traits. In each bivariate model, it was assumed that each fleece trait was treated as a sex-limited trait.

RESULTS AND DISCUSSION

Basics statistics (mean and standard deviation) of the different traits are given in table 2. Estimates of additive genetic parameters for each trait in each sex are given in table 3. Heritability estimates for male traits were low and ranged from 0.01 to 0.25. Female traits were more heritable than the male counterparts, especially for total fleece weight and the weight of Quality WAJ1 (0.23 and 0.23 *v.s.* 0.06 and 0.02 respectively). Repetability estimates were also lower in males than in females but in a lesser extent than for heritability. As expected, there were a large between sex variation in the extent of genetic variability on the quantity of wool produced. About the other fleece characteristics, differences in heritability estimates between sexes were lower. Between sex

differences in heritability estimates have been shown on body weight in Romney sheep (PARRAT *et al.*, 1989) and turkey (CHAPUIS *et al.*, 1996). Genetic correlations between sexes were high, ranged from 0.70 to unity and thus would suggest that genetically there were no difference between a male trait and a female trait.

Table 2 : Mean and standard deviation of the different traits in male and female angora rabbits

	Male			Female		
	Number of records	Mean	Standard deviation	Number of records	Mean	Standard deviation
Fleece weight (g)	1204	176.1	37.1	6523	235.1	45.2
Weight of Quality WAJ1 (g)	1204	95.5	49.0	6523	157.2	41.3
Homogeneity (p. 1000)	1204	532.6	240.1	6523	663.3	101.7
Back bristle length (mm)	931	101.2	8.9	5517	101.1	8.1
Back down length (mm)	931	67.3	6.5	5517	63.1	7.3
Back lock structure (p. 1000)	931	667.4	71.0	5517	625.5	68.7
Haunch bristle length (mm)	929	105.5	8.2	5406	103.7	8.1
Haunch down length (mm)	929	69.3	5.6	5408	65.6	5.9
Haunch lock structure (p. 1000)	929	659.3	51.7	5406	634.3	55.8
Compression (mm)	930	27.8	2.1	5522	26.9	2.0
Resilience (mm)	930	64.0	5.5	5521	64.0	5.3
Tautness	950	4.0	0.8	5526	3.1	0.6
Live weight (g)	1025	3649.5	396.3	6369	3902.9	441.5

Table 3 : Heritability, repetability, and genetic and phenotypic correlations of fleece traits within and between sex in Angora rabbit.

	Heritability		Repetability		Genetic
	male	female	male	female	correlations
Fleece weight (g)	0.06	0.23	0.29	0.40	1.00
Weight of Quality WAJ1 (g)	0.02	0.23	0.23	0.33	1.00
Homogeneity (p. 1000)	0.13	0.18	0.23	0.24	0.70
Back bristle length (mm)	0.20	0.25	0.21	0.26	0.87
Back down length (mm)	0.09	0.17	0.09	0.20	0.99
Back lock structure (p. 1000)	0.04	0.17	0.04	0.21	0.83
Haunch bristle length (mm)	0.13	0.25	0.22	0.30	0.90
Haunch down length (mm)	0.06	0.15	0.14	0.17	1.00
Haunch lock structure (p. 1000)	0.01	0.09	0.05	0.16	1.00
Compression (mm)	0.21	0.19	0.27	0.23	0.97
Resilience (mm)	0.17	0.12	0.17	0.14	0.92
Tautness	0.02	0.10	0.14	0.15	1.00
Live weight (g)	0.25	0.37	0.61	0.57	1.00

The results suggested that genetic variances can and will vary between sexes. The genetic bases for these differences could be simple (chromosomal) or complex (cytoplasmic, inheritance, sex by environment interactions including sexual hormones, epistasis). As we expected these differences do exist, up to now only selection indices derived from genetic parameters for females are applied to males. However for genetic improvement and as male fleece traits are recorded, it would be more efficient to take account these sex differences when determining breeding values, by using multivariate models.

Acknowledgements - The authors gratefully acknowledge the assistance of Mr. M. BONNET, G. BLANIE, G.AUVINET, B. BAYLE and J.C. MUSSEAU, who managed the experimental farm and recorded all the different parameters of the Angora fleece characteristics during the whole conduct of this study.

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Production de poil chez le lapin Angora : héritabilités mâles et femelles, et corrélations génétiques relatives à la quantité de poil et à différentes caractéristiques de la toison - Nous avons analysé 1204 et 6523 récoltes de poils, produites respectivement par 350 mâles adultes et 1014 femelles adultes dans le but d'étudier la variabilité génétique en fonction du sexe. Ces animaux de souche française sont dépilés toutes les 14 semaines. Nous avons mesuré à chaque récolte le poids total de la toison, celui des cinq qualités, la longueur des jarres et des duvets ainsi que la structure sur le dos et la hanche, la dureté ainsi que la compression et la résilience d'une mèche. Les animaux ont été pesés 9 semaines avant chaque récolte.

Les héritabilités sont comprises entre 0,01 et 0,21 chez les mâles et entre 0,09 et 0,25 chez les femelles. Les caractères femelles sont plus héritables que les caractères mâles équivalent, en particulier en ce qui concerne le poids total de la toison. Les corrélations génétiques entre le caractère chez le mâle et le même chez la femelle sont élevées et comprises entre 0,70 et 1. Nous discutons ces différences de variabilité génétique dues au sexe.