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RELATIONSHIP BETWEEN GUARD HAIR DIAMETER AND TAUTNESS IN THE ANGORA RABBIT FLEECE.

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Abstract

Investigations on guard hair diameter and its relationship with tautness were undetaken in a French strain of angora rabbit. Bristle diameter and other fleece characteristics: total fleece weight, weigth of quality 1A, homogeneity, down and bristle lengths, lock structure, compression and resilience have been measured on 17 males and 66 females born in 1988. Measurements were made at each harvest, every 14 weeks, from the third harvest (8-month old) to the thirteen one. In parallel tautness was subjectively evaluated by an expert.

Bristle diameter differed significantly between animals according to its sexe, age and birth season and between harvest seasons. Females produced coarser guard hair than males. Maximum bristle diameter was observed in females from the third to the fifth harvest. The finest guard hair were found in does born in autumn or in fleeces harvested in winter.

Bristle diameter is a component of tautness and bristly fleeces had coarser guard hair than woolly ones. For an objective evaluation of tautness, bristle diameter as well as fleece weight, bristle length or lock structure and resilience have to be taken into account. Further investigations on bristle or fleece characteristics will have to be undertaken to improve objective evaluation of tautness.

Introduction

Angora wool, a high class fibre produced by angora rabbit, is a mixture of two types of medullated fibres: long and coarse guard hair and fine and short down which are fifty more numerous. The angora rabbit fleece harvested at 3-month intervals is used without any dehairing in the production of luxury yarns for hosiery and knitting because of its fineness, softness, ligthness and thermal power. Quality of an angora rabbit fleece is determined by the length and the proportion of the different types of fibres, cleanness and absence of felt. Thus different categories of wool are defined: clean and long bristly wool, clean and long woolly wool, clean and short bristly wool, clean and short woolly wool, felt wool and dirty wool. This classification, has been recently proposed by (Vrillon and Thebault, 1992) as an international standard.

Angora rabbit bred in France have a specific kind of fleece with well differenciated guard hair (Rougeot, 1986). Such bristly fleeces are valued because of their aptitude to produce a fluffy yarn used for certain luxury knit products. In order to take account this feature Thebault and Rochambeau (1988) put forward 3 others quality criteria: homogeneity which is the ratio between the weight of bristly wool and total fleece weight, structure which is the ratio between down length and bristle length and tautness which is subjectively evaluated by handling the fleece. This latter criterion which characterizes the roughness of a fleece need to be objectiveley evaluated. The aim of this paper was to study the diameter of bristles and its relationship with tautness and others fleece characteristics.

Materials and methods.

Experimental work

Studies were made on the wool production of the 66 angora does and 17 angora buck born in 1988 at the angora rabbit experimental farm of Institut National de la Recherche Agronomique.

At birth, young rabbits were sexed, most of the males were eliminated and litter size were reduced to less than six rabbits. Weaning take place four weeks later. Rabbit were plucked the first time at the age of 8 weeks, 13 weeks later for the second time and at 14 week intervals thereafter.

From the third to the thirteenth harvest and at each harvest the following variables were recorded :

- total fleece weight,
- weight of each of the five different qualities constituting the fleece:
    - quality 1A includes long (down length ≥ 6 cm) and bristly wool,
    - quality 1B includes long and woolly wool,
    - quality 2 includes short wool (down length ≤ 6 cm),
    - clean felt wool,
    - dirty wool,
- down and bristle length measured on two locks plucked respectively on the back and the britch.
- compression which is the height of a 10g-lock subjected to a 3kg-pressure inside a smooth wall cylinder of 43mm-diameter,
- resilience the height of the same lock inside the same cylinder when the pressure was removed.

These measured variables were used to calculate two fleece criteria: homogeneity as the ratio of the weight of quality 1A to total fleece weight expressed as a percentage, and structure as the ratio of down length to bristle length expressed as a percentage. Structure has been calculated for both the back and the britch.

Tautness, the third quality criterion was appreciated by fingering the fleece on the back and the side where bristly wool is found and a value ranging from 1 (bristly) to 5 (woolly) which indicates the roughness of the fleece was given by an expert.

In addition mean diameter of guard hairs taken from a lock plucked on the back was determined by measuring on 60 bristles the profile of 1mm-section lengths cut at 2 cm distance away from the base of the lock. The measurements have been made under a microscope coupled to a digitizer, a display device and a computer with a vision software package, Visilog (Noesys, France). An adaptating program in the C language has been developped in the Visilog environment in order to automate measurements and recording.

Animals were kept on a straw litter in individual cement hutches located under a naturally lighted building almost open to air without heating or force ventilation. A standard diet of angora rabbit pellets supplying 10.1 Mj digestible energy, 140 to 150 g crude protein, 110 to 120 g digestible protein, 150 g crude fibre, 20 g lipid and 7 g sulphur amino-acid per kg dry matter was applied. In order to prevent formation of trichobezoard, animals were fed 6 days a week (Rougeot and Thebault, 1977) throughout the 3-month pelage growth. Thus each doe received each non-fasted day 200 g during summer or 230 g during winter the first month following plucking, 180 g the second month and 130 g the third month. A few days preceeding plucking a depilatory treatment with a Lagodendron (Proval Company, France) dose was applied. Water was available ad libitum.

Analysis model

In order to analyze the seasonal effect of harvest and birth, 4 levels were fixed:

- winter from January 15 to April 14,
- spring from April 15 to July 14,
- summer from July 15 to October 14,
- autumn from October 15 to January 14.

The influence of different factors on guard hair diameter was measured by fixed effect variance analysis using the GLM procedure of the SAS software.

The different models were as follows:

(i) For males and non-lactating females from the third to the sixth harvest :

$$Y_{ij} = \mu + SX_i + E_{ij}$$

where Y_{ij} is the variable measured on the jth rabbit,

μ is the general mean,

SX_i is the effect of sexe (i = 1, 2),

E_{ij} is the residual.

(ii) For non-lactating does whose harvest number was three or more:

$$Y_{ijklm} = \mu + BS_i + HS_j + HN_k + T_l + E_{ijklm}$$

where Y_{ijklm} is the variable measured on the *m*th non lactating doe,

μ is the general mean,

BS_i is the effect of birth season (i = 1, 4),

HS_j is the effect of harvest season (j = 1, 4),

HN_k is the effect of the harvest number (k = 1, 8) (class k = 8 comprises harvest whose number is 10 and more),

T_l is the effect of tautness (l = 1, 3) (class l = 1 comprises fleeces sorting 1 and 2; class l = 2 comprises fleeces sorting 3 and class l = 3 comprises fleeces sorting 4 and 5),

E_{ijklm} is the residual.

Pairwise comparisons of least-square means were made. The proportion of total variance explained by the model used is given by the coefficcient R^2.

The best linear prediction of tautness using the different variables measuring fleece weight and fleece characteristics was undertaken by using the LOGISTIC procedure of the SAS software which is a linear logistic regression using maximum likehood method. Predicted probabilities associated to an event response were calculated.

Results

1 - Non-genetic variation factors of guard hair diameter.

Sex

A sex difference in bristle diameter has been observed ($p < 0.001$). The mean guard hair diameter as measured in the 17 males and the 66 females from the third to the sixth harvest is significantly higher in females ($p < 0.001$) than in males, respectively 54.1 and 49.5 μ (table 1).

Table 1: Variance analysis and least-square means of bristle diameter for males and females whose harvest number ranging from 3 to 6.

		N	Bristle diameter	critical probability
Mean		253	53.1	
Sexe				
	male	55	49.5 [a]	
	female	199	54.1 [b]	
	F		46.5	0.0001
R^2			0.16	
Residual Sd			4.4	

R^2 Proportion of total variance explained by the model

[a b] within a column, least-square means not bearing a common superscript differ significantly ($p < 0.05$)

Harvest number

There are harvest number differences on mean bristle diameter ($p < 0.001$). The highest diameter is observed from the third to the fifth harvest, and the lowest from the seventh harvest. Bristle diameter observed at the sixth harvest is intermediate. The difference between the extreme classes is approximately one residual standard deviation (table 2).

Seasonal effects

There is a birth season effect ($p < 0.001$) on the diameter of guard hair. The highest diameter is observed in does born in winter and the difference between the extreme seasons is approximately 0.75 standard deviation (table 2).

An effect of the harvest season has also been observed ($p < 0.001$). The lowest diameter is observed in fleece harvested in winter. The difference between the extreme seasons is 0.90 standard deviation (table 2).

2 - Relationship between bristle diameter and tautness.

There is a significantly difference ($p < 0.05$) on guard hair diameter between a bristly fleece and a woolly fleece. The highest diameter is observed for fleeces sorting 1 or 2 and the difference between the extreme classes is greater than an half standard deviation (table 2).

Table 2: Variance analysis and least-square means of bristle diameter for non lactating does from the third harvest.

	N	Bristle diameter	critical probability
Mean	313	52.9	
Birth season			
winter	81	54.0 [a]	
spring	63	53.2 [ab]	
summer	75	52.4 [b]	
autumn	94	51.1 [c]	
F		7.32	0.0001
Harvest season			
winter	84	50.4 [a]	
spring	82	52.8 [b]	
summer	82	54.0 [b]	
autumn	65	53.5 [b]	
F		11.86	0.0001
Harvest number			
3	49	54.8 [a]	
4	65	54.6 [a]	
5	52	54.9 [a]	
6	33	52.8 [b]	
7	25	50.7 [b]	
8	25	51.0 [b]	
9	29	51.5 [b]	
10	35	51.1 [b]	
F		7.55	0.0001
Tautness			
2	28	53.9 [a]	
3	213	52.7 [a]	
4	72	51.4 [b]	
F		3.92	0.02
R^2		0.28	
Residual Sd		4.0	

R^2 Proportion of total variance explained by the model

[abc] within a column, least-square means not bearing a common superscript differ significantly ($p < 0.05$)

3 - Prediction of tautness.

In order to take account the harvest number effect on bristle diameter, relationships between guard hair diameter and tautness and distribution of tautness evaluation for the third harvest, three different models of logistic linear prediction of tautness have been used.

Table 3. *Association between tautness grade given by an expert and predicted* value.

Tautness observed values	Tautness predicted values			number of observations
grade	2	3	4	
2	1 *	27	0	28
3	2	201	10	213
4	0	39	33	72

* frequency of associated value / tautness grade.

The best linear prediction of tautness is observed by entering in the model the following significant variables ($p < 0.10$): resilience, total fleece weight and lock structure on the britch for the third harvest, bristle length on the britch, resilience, total fleece weight and bristle diameter for harvest ranking from 4 to 5, and weight of quality 1A, bristle diameter and lock structure on the britch for harvest number 6 and more. The other variables we have introduced in the different models were not significant.

In each model the highest probability of an event response has been defined as the best predicted value of tautness. The rate of association between tautness grade given by the expert and these predicted values were 3.6 %, 94.4 % and 45.8 % respectively for fleeces grading 2, 3 and 4 (table 3). Correlations between predicted and observed values is 0.46 ($p < 0.001$).

Discussion

1 - Non-genetic variation factors of the guard hair diameter.

In angora rabbit fleece, the mean diameter of bristles is finer in the male than in the female. These result is agree with others observed earlier (Kettner, 1962; Marinucci et al, 1989). This sexual difference observed in angora rabbit is an exception as it is opposite to that observed in most other species including sheep (Brown et al, 1966, 1968) and goat (Shelton, 1981) bred for fibre production.

In angora rabbit, the diameter of guard hair decreases with the harvest number and consequently with age. Bristle diameter remains high from the third to the fifth harvest and decreases thereafter. No similar observations have been made earlier in angora rabbit. In other species bred for fibre production an opposite effect has been reported as fibre diameter increases with age in sheep (Brown et al, 1966, 1968), angora goat (Shelton, 1981) and cashmere goat (Restall and Pattie, 1989).

Both the harvest season and the birth season have an effect on bristle diameter. The finest bristles are found in fleeces harvested in winter or in does born in autumn. About the harvest season effect, our results are in contradiction with those reported earlier (Rougeot and Thebault, 1983). However Haberbosch (1955) has found similar results to ours and Kettner (1962) has reported contradictory results between different breedings. The birth season effect on bristle diameter we observe can explain these contradictory results. As a consequence of such a birth season effect, an observed seasonal effect is the result of both the harvest season and birth season effects when the harvest number is constant. Unfortunately neither Rougeot and Thebault (1983) or Haberbosch (1955) or Kettner (1962) have mentionned anything about the season of birth of animals they have studied. Moreover by comparing our results and those observed earlier in the same French strain (Rougeot and Thebault, 1983), the decrease of guard hair diameter with age from the sixth harvest we observe may be an other explaination. In this latter study variations in guard hair diameter have been observed during 4 consecutive harvests from the age of 10-12 month, so between the fifth and the eighth harvest.

A birth season effect on fibre production in adult angora rabbit has been yet demonstrated as well on total fleece weight as on fibre length and compression (Rochambeau et al 1990). Our results on bristle diameter complete this previous work and confirm the hypothesis that rabbit mothers control pelage development of their offsprings by transferring information about daylength prenatally as it has been yet demonstrated in the vole (Lee and Zucher, 1988).

2 - Prediction of tautness and its relationship with bristle diameter.

Bristle diameter is a component of tautness as guard hairs are coarser in bristly fleeces than in woolly ones. In a preceeding work on the same French strain, Rochambeau et al (1990), by studying other fleece characteristics have shown that bristly fleeces are heavier, compress more and relax less than woolly fleeces. By entering these different variables which characterizes a bristly fleece, in the prediction models of tautness, most of them have a significant influence. However variability of tautness explained by the models remains low. Correlation between the predicted value and the observation is 0.46 and only a small proportion of bristly fleeces (grade 2) have been well predicted. Therefore tautness as subjectively evaluated by fingering the fleece must include other components. These fleece roughness felt by handling would be the result of a general sensation concerning the guard hair characteristics:

diameter, proportion of coarse bristle, cross section shape, lock structure and total fleece weight which can influence bristle straightness. We have initiated work describing bristle population and the shape of guard hair cross section to complete studies on tautness.

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