Small Ruminant Research 91 (2010) 193–199

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Phenotypic associations with fibre curvature standard deviation in cashmere

B.A. McGregor[a,*], K.L. Butler[b]

[a] *Livestock Production Sciences, Future Farming Systems Research Division, Department of Primary Industries, Attwood, Victoria 3049, Australia*
[b] *Biometrics Unit, Future Farming Systems Research Division, Department of Primary Industries, Werribee, Victoria 3030, Australia*

ARTICLE INFO

Article history:
Received 18 January 2010
Received in revised form 18 March 2010
Accepted 22 March 2010
Available online 24 April 2010

Keywords:
Crimp
Mean fibre diameter
Farm
Fibre testing
Fibre classing
Selection

ABSTRACT

Cashmere fibre curvature (crimp) impacts on the softness and quality of cashmere textiles, the efficiency of cashmere processing and cashmere production. This study investigated the relationship between cashmere fibre curvature standard deviation (FCSD) and other fleece attributes, and how this relationship differs with animal and farm attributes, for 10 commercial cashmere flocks in Australia. Data was analysed using general linear model analysis. Nineteen parameters were recorded for 1168 goats. Following log transformation, the best model for FCSD included farm, goat age, mean fibre diameter, fibre curvature, fibre diameter standard deviation, cashmere yield, cashmere staple length and live weight and the interactions between these terms. The percentage variance accounted for was 82%. Mean fibre diameter and fibre curvature accounted for 55% of the variation in FCSD and farm accounted for 41% of the variation. Cumulatively mean fibre diameter, fibre curvature and farm accounted for 75% of the variation existing in FCSD. For the other terms, age added 2% and the remaining measurements a further 5% to variation accounted for by the best model. Environmental (farm-effects) on FCSD are large and may explain the difficulties cashmere growers experience when they evaluate cashmere goats. Increasing the fibre curvature of cashmere was associated with an increase in cashmere FCSD, but for some combinations of farm and MFD the increase in FCSD was $\approx 35^{\circ}$/mm while with other combinations the increase was $\approx 5^{\circ}$/mm as fibre curvature increased. At a given fibre curvature the response of FCSD to mean fibre diameter differed substantially between farms, from strong negative to strong positive. Increasing cashmere yield from 20 to 55% was associated with decline in FCSD. Increasing fibre diameter SD from 3 to 5 μm increased FCSD by 6°/mm, increasing staple length and live weight were associated with small declines in FCSD. There was strong evidence of an age effect that differed with farms, but there were few clear cut trends in FCSD with increasing age. The results suggest that farm based influences are affecting the point at which fibre keratinisation is completed and thus influencing the variation in FCSD. We conclude that, because the differences between farms in the relationship been fibre curvature standard deviation, mean fibre diameter and fibre curvature are great, it is unlikely that crimp rate and crimp definition will be good indicators of cashmere fineness across farms.

1. Introduction

Cashmere exhibits single fibre crimping, which can be reliably measured as fibre curvature. The relationship between crimp frequency and fibre curvature of cashmere is quite strong, even though it covers a different range of

* Corresponding author. Current address: Deakin University, Geelong, Victoria 3217, Australia. Tel.: +61 3 52 273 358.
E-mail address: bruce.mcgregor@deakin.edu.au (B.A. McGregor).

0921-4488/$ – see front matter.
doi:10.1016/j.smallrumres.2010.03.014

Table 1
State, climate zone and number of does and wethers of each age for each farm, that were included in the analyses.

Farm	State	Climate zone	Rainfall (mm)		Sex	Age of goat (years)								
			2002–2003[a]	Mean[b]		1	2	3	4	5	6	7	8–10	11–13
2	Vic	Wheat-sheep	364	443	Doe	9	10	9	8	10	11	–	–	–
					Wether	9	–	–	–	–	–	–	–	–
3	NSW	High rainfall	507	688	Doe	–	16	20	20	–	–	–	–	–
4	WA	Wheat-sheep	282	332	Doe	–	51	42	–	–	–	–	–	–
5	Vic	Wheat-sheep	261	551	Doe	–	307	–	–	–	–	–	–	–
					Wether	–	4	–	–	–	–	–	–	–
6	Qld	High rainfall	611	807	Doe	–	41	25	13	5	4	3	–	–
7	NSW	High rainfall	951	1302	Doe	20	25	16	10	–	–	–	–	–
8	NSW	High rainfall	477	848	Doe	–	23	16	21	–	–	–	–	–
9	NSW	High rainfall	478	694	Doe	–	31	45	28	25	–	–	–	–
10	NSW	High rainfall	902	1290	Doe	19	21	27	2	11	7	12	2	–
					Wether	26	4	5	–	–	–	–	–	–
11	Vic	High rainfall	463	811	Doe	34	21	9	19	10	4	–	2	7
					Wether	31	6	6	3	2	1	–	–	–

[a] For the 12-month period July 2002 to June 2003.
[b] The long-term mean rainfall (all locations > 50 years).

values to those that have been observed in wool. Raw cashmere of different origins exhibits different fibre curvature and fibre crimp forms. Eleven different forms of cashmere fibre crimp, including straight fibres, have been described and the occurrence of these crimp forms vary with the origin of the raw cashmere (McGregor, 2000, 2001, 2007).

The amount of fibre curvature of Merino wool has commercial importance although less important than mean fibre diameter, staple length and clean washing yield (Anon., 1973). Fibre curvature affects the textile processing and performance of cashmere and wool knitwear (McGregor and Postle, 2002, 2004, 2007, 2008, 2009; Wang et al., 2006). In cashmere, lower fibre curvature has been associated with reduced efficiency of textile processing and the production of shorter cashmere (McGregor and Butler, 2008a) and with increased softness, as measured by reduced resistance to compression, in dehaired cashmere (McGregor, 2000, 2001, 2004).

Fibre curvature standard deviation (FCSD) is a measurement that has only become available since the commercialisation of the OFDA100™ and Sirolan Laserscan™ computer operated fibre testing equipment, and is frequently not measured. However, in Merino wool, FCSD has been shown to affect two important properties of the wool. Firstly, increasing the variation of fibre curvature (higher FCSD) has been shown to be negatively correlated with staple crimp definition. In other words, wool staples with good crimp definition have low variation in fibre curvature (Swan, 1994). Staple crimp definition is a measure of the clarity or dominance of a particular crimp waveform within the staples. “These effects are thought to be mediated through fibre entanglement, the poorer definition wools being in a sense being more entangled which predispose them to further entanglement during scouring” (Swan, 1994). Secondly, at a given mean fibre diameter, an increase in FCSD is associated with a reduction in felting propensity (Greeff and Schlink, 2002).

Hynd et al. (2009) indicated that crimp is the result of two different factors which can override each other. They concluded that fibre crimp is caused predominantly by asymmetric cell division in follicles that are highly curved and then modulated by the point at which keratinisation is completed. This means that even highly asymmetric follicles may produce a straight fibre if keratinisation is

Table 2
Mean, standard deviation (SD) and range in measured attributes of sampled cashmere goats from 10 farms ($n = 1168$).

Variables	Mean	SD	Minimum	Maximum
Age of goat (years)	2.7	1.5	1	13
Live weight (kg)				
Initial live weight, December or January	25.6	9.2	5	68.7
Final live weight, May or June	27.6	8.9	8.6	69.4
Change in live weight (Initial–Final)	+2.0	4.7	−14.7	+18.5
Greasy fleece weight (g)	397	123	112	910
Clean washing yield (%w/w)	90.0	4.4	74.0	98.7
OFDA cashmere yield (%w/w)	37.7	10.6	11.6	86.4
Clean cashmere yield (%w/w)	33.9	9.1	10.8	60.9
Clean cashmere weight (g)	137	62	31	389
Staple length (cm)	8.7	2.1	2.5	16.0
Mean fibre diameter (μm)	16.5	1.6	13.0	22.0
Fibre diameter SD (μm)	3.68	0.41	2.57	5.56
Fibre diameter coefficient of variation (%)	22.5	2.8	14.8	36.4
Fibre curvature (°/mm)	48	8.8	25	72
Fibre curvature SD (°/mm)	33	6.0	20.0	59.5