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Variation in the whiteness and brightness of mohair associated with farm, season, and mohair attributes

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ABSTRACT

This work aimed to quantify factors affecting the reflectance attributes of Australian white mohair sourced from five different farms and to evaluate the effect of season and year on mohair grown by goats of known genetic origin in a replicated study. For the season study the mohair was harvested every three months for two years. All goats and their fleeces were weighed. Mid-side samples were tested for fibre diameter attributes, clean washing yield (CWY), staple length (SL) and for tristimulus values X, Y, Z and Y-Z. For the farm study (n = 196), linear models, relating Y, Z and Y-Z were fitted to farm of origin and other objective measurements. For the season and year study (n = 176), data were analysed by ANOVA and then by linear analysis. The variation accounted for by farm alone was: X, 22%; Y, 24%; Z, 12%; Y-Z, 30% (P < 0.001). Once farm had been taken into account, the regression models for X, Y and Z had similar significant terms: mean fibre diameter (MFD), CWY, SL and fibre diameter CV; and correlation coefficients (057–0.65). For Y-Z, in addition to farm only MFD was significant ($P = 1.8 \times 10^{-9}$). While X, Y, Z and Y-Z were significantly associated with clean fleece weight (CFwt), CFwt was not significant in any final model. Season affected mohair Y ($P = 2.5 \times 10^{-24}$), Z ($P = 2.3 \times 10^{-20}$) and Y-Z ($P = 6.8 \times 10^{-22}$). Autumn grown mohair had higher Y and Z, and summer grown mohair had lower Z than mohair grown in other seasons. This resulted in summer grown mohair having the highest Y-Z and winter grown mohair having the lowest Y-Z than mohair grown in other seasons. The differences between years in Y, Z and Y-Z were significant but not large. When Y, Z and Y-Z were modeled with season and other mohair attributes, MFD, CWY, CFwt, incidence of medullated fibre (Med) and sire were also significant terms. This model accounted for 62.1% of the variance. Over the range of Med (0.3–4.2%), Y-Z increased by 11 T units. Increasing CFwt 0.5 kg was associated with a decline in Y-Z of 7.5 T units. The variation in Y, Z and Y-Z associated with sire effects were respectively 2.66, 3.77, and 1.04 T units. In the farm and the season studies increasing MFD was associated with lower Y and Z and higher Y-Z. The extent of the differences in tristimulus values between seasons and years, were unlikely to be of commercial importance. The extent of the differences between farms, and to variations in MFD and Med were large enough to be of commercial importance. Clean mohair colour was artefactually biased by MFD.

1. Introduction

Mohair forms the long lustrous coat of the Angora goat. Mauersberger (1954), von Bergen (1963), Evans (1984) and Hunter (1993) have described the evolution of mohair in world textile trade since about 1920. The most important commercial attribute of mohair is its mean fibre diameter, which explains over 50% of the variation in auction prices (McGregor and Butler, 2004). Other fibre attributes of commercial importance include staple length, style, freedom from contaminants such as vegetable matter and the incidence of medullated fibres.

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Mohair is famed for its natural lustre which can be measured objectively by visible light reflectance at a range of observation angles, although there is some debate about the best methods (Hunter, 1993). The main explanation given for the high lustre of mohair is the relatively large surface cuticle scales, and the low cuticle scale edge height relative to other animal fibres, which results in a lustre peak reflection. However, lustre and yellowness of mohair may be correlated to the extent that processes which lead to yellowing are also associated with declines in lustre (Strydom, 1975). Lustre is not measured prior to commercial sales of mohair or wool. The reflectance properties of wool are assessed prior to sales using international standards (IWTO-14, 2005d). These methods describe the colour of an object in terms of tristimulus values (T units), where X refers to reflected red light, Y refers to reflected green light and Z refers to reflected blue light. Higher Y values indicate greater brightness (or lightness). Lower differences between the Y and Z values (Y-Z) indicate greater whiteness and higher differences greater yellowness. Perfectly white fibre would have Y = 100 and a Y-Z = 0 (Wood, 2002; Hatcher et al., 2010). White mohair is preferred by processors, as it can be dyed to a greater range of colours. Millington (2006a,b) provides comprehensive reviews of factors affecting photodegradation of wool, factors which are likely to affect mohair. Exposure to UV light present in sunlight causes photo-bleaching, followed by progressive photo-yellowing and after a few months, the wool undergoes photo-tendering, characterized by reduced tensile strength.

While Taddeo et al. (2000) examined the variation in Y and Y-Z across the mohair fleece, no reports on factors associated with variation in colour attributes of white mohair have been located. As the variation in the colour attributes of white Merino of wool is of commercial importance (Woolcheque, 2012), investigations into factors affecting the colour attributes of white mohair are warranted. The present work aimed to quantify the on-farm factors which affect the Y, Z and Y-Z of white Australian mohair.

2. Materials and methods

2.1. Influence of farm

Samples to test the effect of farm were obtained from commercial mohair farms which participated in a national mohair enterprise benchmarking study (McGregor, 2010; McGregor and English, 2010). The farms used in the present study (n = 5) originated from different geographical areas of Australia. Mohair farmers selected a sample of Angora goats, covering a range in ages within their herds, for regular monitoring and fleece sampling. Mohair harvested during the autumn 2006 shearing was used in this study and represents the fibre grown over the previous six-month period. Prior to shearing, all goats were weighed to the nearest 0.5 kg. At shearing, fleeces, pieces, bellies and locks and samples were weighed to the nearest 10 g to provide the greasy fleece weight. Mid-side samples were taken at shearing, identified and stored in a plastic bag. Mid-side samples were used as Taddeo et al. (2000) concluded that the mid-rib site best represented the mean Y and Y-Z values for the mohair fleece.

Staple length (SL) was determined as the mean of three staples taken from the mid-side sample and measured to the nearest 0.5 cm. Fleece samples were commercially tested for clean washing yield (CWY; %, w/w), mean fibre diameter (MFD; μm), fibre diameter coefficient of variation (CVD; %), fibre curvature (FC; °/mm) and incidence of medullated fibres (Med; %, number) (IWTO, 2005a,b,c). Samples were tested for X, Y and Z tristimulus values (IWTO, 2005d). Clean mohair production per goat (CFwt) was determined as: CWY (as a proportion) × greasy fleece weight.

2.2. Influence of season and year

Samples to test the effect of season were obtained from a replicated experiment which included three different genetic strains. The mohair assessed in this report relates only to the treatment shorn every 3 months (n = 24) between February 2004 and February 2006. Details of the allocation, management and productivity of the experimental goats have been provided by McGregor and Butler (2008). In brief, Angora wether goats (18 months of age) were grazed as one flock at Attwood, Victoria (37°40′S, 144°53′E, altitude 135 m) on annual temperate pastures. The goats were progeny of various genetic sire lines including 100% South African origin (n = 2), 100% Texan origin (n = 3), and mixed origin sires approximately 50% South African and 50% Texan (n = 4). Shelter was available in the form of covered and enclosed shedding that was always accessible and could accommodate all goats. Fleece sampling and testing was as described earlier and with assessment for staple definition (clarity of staple formation based on cross fibres), staple tip shape (staple length uniformity based on shape of the staple tip), style (number of twists along the staple), character (number of crimps along the staple) and staple fibre entanglement (degree of staple fibre entanglement and fibre adhesions) (McGregor and Butler, 2008).

2.3. Statistical analyses

Data were analysed to determine parameter means and standard deviations. Box plots are provided for Y and Y-Z showing the mean, quartiles and outliers for each farm. The effect of farm of origin (treated as a factor) and other continuous variables on X, Y, Z and Y-Z were determined using general linear analysis (GenStat 14.1 for Windows; Payne, 2011). The best models were developed independently with terms being added or rejected on the basis of Wald F-test. The observational unit in each analysis was an individual fleece sample. The original farm identifiers have been retained to enable comparison with previously published data. Standard error of differences between means (s.e.d.) and least significant differences (l.s.d.), at P = 0.05, are provided. Predicted responses of X, Y, Z and Y-Z to significant terms, after adjustment for other terms in the models, are provided (GenStat 14.1; Payne, 2011).

The effect of season and year was analysed using restricted maximum likelihood (REML, GenStat 14.1 for Windows; Payne, 2011) by assigning the terms season and year as follows: autumn, for mohair harvested in May; winter, for mohair harvested in August; spring, for mohair harvested in November; summer, for mohair harvested in February; Year 2004, for mohair grown between February 2004 and February 2005; Year 2005, for mohair grown between February 2005 and February 2006. Data from two animals have been omitted as samples were not available for the entire period. The data for season were then analysed using general linear analysis (GenStat 14.1 for Windows; Payne, 2011) to test season, year, sire and other continuous variables, with models and outputs treated as for the farm analyses.

3. Results

3.1. Effect of farm and fleece attributes

The location of the farms, their climatic zone, rainfall and the greasy mohair production of goats which provided fleece samples are provided in Table 1. The mean, s.d. and range in variables are presented in Table 2 and Fig. 1. Mohair originated from goats aged between 0.5 and 4.5 years of age. Mean attributes (range) were: live weight at shearing 30.4 kg (9.8–57.5 kg); greasy fleece weight 2.1 kg (0.5–3.8 kg); CWY, 82.6% (66.4–95.7%); SL, 11 cm (6–16.5 cm); MFD, 29.8 μm (19–41 μm); FC, 14°/mm (9–22°/mm); Y, 68 T units (60.4–75.5 T units); Y-Z, 7.6 T units (5.6–10.1 T units).

Farm alone accounted for 22% of the variation in X, 24% of the variation in Y, 12% of the variation in Z and 30% of