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Prickle Factor in Fleeces of Performance-tested Fine-wool Rams[1,2]

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Summary

Prickle factor (PF, % of fibers > than 30 μm) is an indicator of the relative comfort of wool fabrics worn next to the skin. Fiber diameter distributions were measured (with an Optical Fibre Diameter Analyser) in three consecutive years on core samples of unskirted fleeces from 524 fine-wool rams completing a central performance test. These measurements were used to establish PF, average fiber diameter (AFD), SD, and CV in fleeces produced under the unfavorable (from a wool fineness and uniformity perspective) test conditions and to determine relationships among PF and fiber fineness and variability. As part of the normal performance test routine, AFD, SD, and CV were measured on side and britch samples for each fleece. The AFD of side samples was used in the index of overall merit and AFD of side and britch samples constituted an independent rejection criteria for ram certification. Core sample PF, AFD, SD, and CV averaged 5.5%, 22.3 μm, 4.4 μm, and 20.0% and ranged from 0.4 to 25.3%, 17.3 to 26.8 μm, 3.1 to 6.4 μm, and 15.2 to 28.6%, respectively. The PF, SD, and CV did not differ among years ($P \geq 0.05$). It has been suggested that only wools having low PF (< 2%) be used in apparel worn next to the skin. Only eighteen percent of the fleeces were in this category. Stepwise multiple regression analysis was used to predict PF using all measured variables plus AFD squared (AFD^2) and differences between side and britch AFD resulted in core AFD^2, core AFD, britch SD, core SD, side CV, and core CV entering the equation. No other variable met the 0.01 significance level for entry into the model. Partial r^2 values for the first three variables were 0.82, 0.10, and 0.03, respectively. This result was essentially unchanged when fleeces (349) having core, side, and britch AFD > 23.6, 24.9, and 27.8 μm, respectively (i.e., from coarse, uncertifiable rams) were excluded from the analysis. Most of the variability in PF can be accounted for by core data alone, i.e., $PF = 199.57 + 0.46*AFD^2 - 19.33*AFD + 6.01*SD - 1.01*CV$, $r^2 = 0.94$.

Key Words: Prickle factor, Wool, Ram performance testing

Introduction

In a survey conducted in the U.S. several years ago (Margerum, 1984), 30% of consumers polled claimed to be allergic to wool while 70% considered wool to be too "scratchy" for apparel intended to be worn next to the skin. These types of perceptions caused wool researchers in Australia to focus on the causes of fabric prickle and attempt to quantify the effects and relative importance of fiber, yarn, and fabric properties on skin comfort. Because lightweight apparel is a potentially substantial and lucrative market for wool, numerous studies were initiated over the past 15 yr to try and understand this problem. Garnsworthy et al. (1985; 1988a and b) concluded that the prickle sensation (also referred to as "itchy" and "scratchy") experienced by some people when wearing some fabrics next to the skin is caused by a mechanical triggering of pain nerve sensors which are situated close to the surface of the skin. The nerves are triggered when stiff fiber ends exert a force > 0.00017lbf (75 mgf) on soft skin. When the mechanical stimuli (stiff fiber ends) are removed or reduced, the prickle problem disappears. Meticulous studies have shown that skin temperature and moisture, length of fiber protruding above the fabric surface, and fiber diameter (but not fiber type; Naylor, 1992 a and b) are key factors in causing prickle sensations (Mayfield, 1987;

1 This article reports research conducted by the Texas Agricultural Experiment Station, The Texas A&M University System.

2 Financial support from the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture under agreement number 99-34148-7417 is gratefully acknowledged.

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Kenins, 1992). Although the critical fiber diameter (26 to 32 μm) associated with skin discomfort is dependant to some degree on fabric type (worsted, woolen, woven, or knitted, etc.), percentage of fibers > 30μm, but not the distribution of these coarse fibers, is a reasonable indicator of the relative skin comfort of different wools (Naylor and Hansford, 1999).

Reducing the percentage of wool fibers > 30 μm (the coarse edge) in the diameter distribution will improve skin comfort or reduce discomfort. In principle, this can be achieved by reducing the average fiber diameter or by decreasing the distribution (coefficient of variation of fiber diameter) both options being possible in sheep selection programs. In some areas, time of shearing might also be adjusted to achieve a reduction in coarse fiber ends (Naylor and Hansford, 1999). Theoretically, zero fibers > 30 μm would be required for "absolute" skin comfort in fabrics worn next to the skin. In practice, < 5% of fibers > 30 μm in single jersey knitted fabrics has been found to reduce prickle intensity to a level that will not be perceived as skin discomfort by most (80 - 90%) people under normal conditions (Garnsworthy et al., 1988a; Naylor, 1992b). Some experienced fabric judges can consistently distinguish between fabrics containing 1 and 2% fibers > 30 μm (Naylor, 2000). Consequently, a lower level (2%) has also been suggested for ram selection (Lupton et al., 1999). Because prickle factor has become so important to manufacturers of wool apparel, it is now reported in the annual central ram performance test (Waldron and Lupton, 2000). We began to study and measure prickle factor in ram fleeces in 1994 with the following objectives: 1) to determine PF in rams completing the test; 2) to establish mathematical relationships among PF and other fiber traits currently being measured; and 3) to determine if PF should be added to the index equation currently used to asses the overall merit of these fine-wool rams.

Materials and Methods

Side (S) and britch (B) samples shorn directly from the animals and 32 x ½-in core

Table 1. Means, variabilities, and ranges of measured traits (N=524) for all data.

Trait	MEAN	SD	MIN	MAX
Average fiber diameter, side, μm	23.6	1.9	17.8	29.6
SD of fiber diameter, side, μm	4.0	0.6	2.8	6.7
CV of fiber diameter, side, %	17.1	2.0	13.1	24.0
Average fiber diameter, britch, μm	26.6	2.4	19.4	36.3
SD of fiber diameter, britch, μm	5.0	1.1	3.1	9.9
CV of fiber diameter, britch, %	18.8	3.21	2.9	33.0
Average fiber diameter, core, μm[a]	22.3	1.5	17.3	26.8
SD of fiber diameter, core, μm	4.4	0.5	3.1	6.4
CV of fiber diameter, core, %	20.0	2.0	15.2	28.6
Prickle factor, %	5.5	4.3	0.4	25.3

[a] Core sample of unskirted whole fleece.

Table 2. Variation among years for several measures of fiber fineness and variability and prickle factor.

Trait	1994	1995	1996
Average fiber diameter, side, μm	23.7[a]	23.3[b]	23.9[a]
SD of fiber diameter, side, μm	4.3[a]	3.8[c]	4.0[b]
CV of fiber diameter, side, %	18.3[a]	16.2[c]	16.6[b]
Average fiber diameter, britch, μm	27.0[a]	26.2[b]	26.6[a,b]
SD of fiber diameter, britch, μm	5.7[a]	4.5[b]	4.7[b]
CV of fiber diameter, britch, %	20.9[a]	17.3[b]	17.8[b]
Average fiber diameter, core, μm	22.1[b]	22.4[a]	22.5[a]
SD of fiber diameter, core, μm	4.4	4.5	4.4
CV of fiber diameter, core, %	20.0	20.0	19.8
Prickle factor, %	5.3	5.5	5.7
Britch - Side average fiber diameter, μm	3.3[a]	3.0[b]	2.6[c]

[a,b,c] Within a row, means without a common superscript differ ($P < 0.05$).

samples (C) removed from the whole, unskirted fleeces of 524 rams completing the 1994 (201), 1995 (169), and 1996 (154) Texas Agricultural Experiment Station central performance tests were measured for average fiber diameter (AFD, µm), standard deviation of fiber diameter (SD, µm), coefficient of variation of fiber diameter (CV, %) and PF (core samples only; %) using an Optical Fibre Diameter Analyser (OFDA; Baxter et al., 1992). The GLM procedure of SAS (SAS, 1996) was used to identify differences in traits among years. Simple linear regression and stepwise multiple regression analyses were used to establish relationships among PF and the measured variables plus the square of AFD (AFD^2) and differences between britch AFD and side AFD.

Results and Discussion

Core sample prickle factor (PF), average fiber diameter (CAFD), standard deviation of fiber diameter (CSD), and coefficient of variation of fiber diameter (CCV) averaged 5.5 %, 22.3 µm, 4.4 ìm, and 20.0 % and ranged from .4 to 25.3 %, 17.3 to 26.8 µm, 3.1 to 6.4 µm, and 15.2 to 28.6 %, respectively (Table 1). The PF, CSD, and CCV did not differ among years ($P > 0.05$), though all other traits did (Table 2). Fifty eight percent of all fleeces tested contained PF < 5%. Eighteen percent of the fleeces were in the (highly desirable) low (<2%) PF category. These relatively small proportions can be partially attributed to the fleeces not being skirted and to the composition and quantity of the ram's test feed not being conducive to fine fiber production. Though this ram test was designed to measure the maximum genetic potentials of the rams (in terms of weight gain, wool production, fiber fineness, staple length, etc.), it is important to remember that yearling female offspring of these rams are typically 4 µm finer under range conditions (Waldron et al., 1998). As expected by virtue of its definition, prickle factor is significantly correlated with all 3 measures of AFD (core > side > britch) and with both measures of variability (SD > CV, Table 3). Stepwise multiple regression analysis for PF versus all measured variables plus CAFD squared ($CAFD^2$) and differences between side and britch AFD resulted in $CAFD^2$, CAFD, BSD, CSD, SCV, and CCV entering the equation (Table 4). No other variable met the 0.01 significance level for entry into the model. Partial r^2 values for the first three variables were 0.82, 0.10, and 0.03, respectively. Figure 1 shows the relationship between PF and $CAFD^2$.

Table 3. Correlation coefficients and probability values for prickle factor versus other traits.

Trait	r	P
Average fiber diameter, side, µm	0.80	0.0001
SD of fiber diameter, side, µm	0.56	0.0001
CV of fiber diameter, side, %	0.10	0.0183
Average fiber diameter, britch, µm	0.78	0.0001
SD of fiber diameter, britch, µm	0.55	0.0001
CV of fiber diameter, britch, %	0.25	0.0001
Average fiber diameter, core, µm	0.89	0.0001
SD of fiber diameter, core, µm	0.67	0.0001
CV of fiber diameter, core, %	-0.19	0.0001
Britch - side average fiber diameter, µm	0.25	0.0001

Table 4. Stepwise multiple regression analysis for prickle factor (all variables in model).

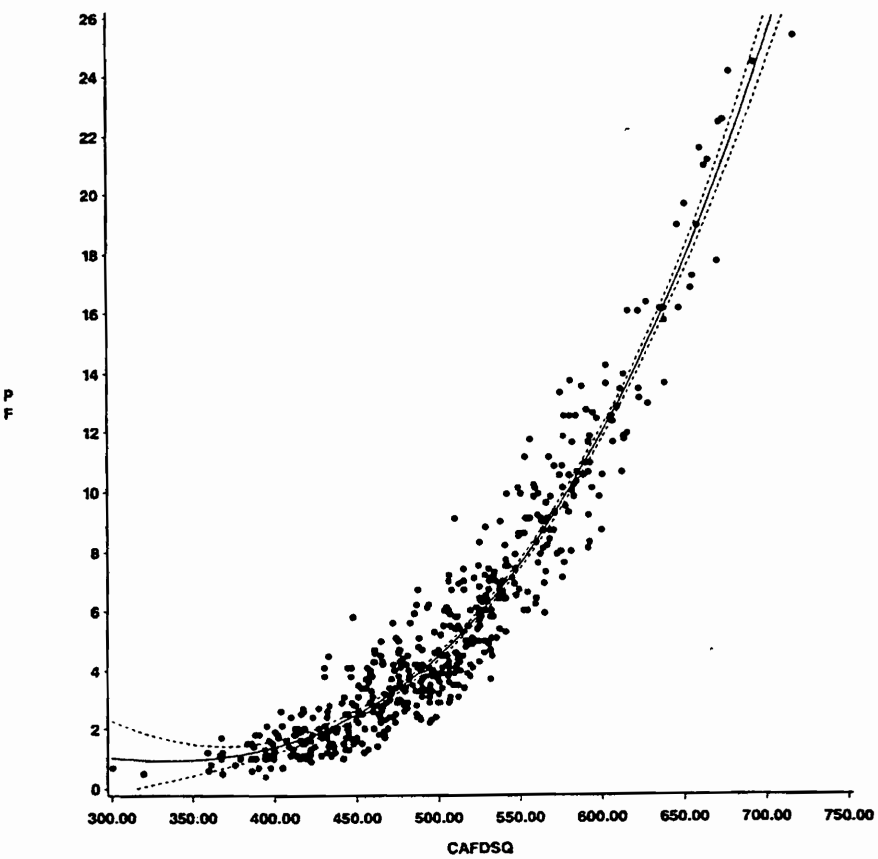
Trait	Partial r^2	P
Average fiber diameter, core, $µm^2$	0.8184	0.0001
Average fiber diameter, core, µm	0.1021	0.0001
SD of fiber diameter, britch, µm	0.0249	0.0001
SD of fiber diameter, core, µm	0.0121	0.0001
CV of fiber diameter, side, %	0.0023	0.0001
CV of fiber diameter, core, %	0.0007	0.0023
TOTAL	0.9605	—

Note: no other variable met the 0.01 significance level for entry into the model.

Table 5. Stepwise multiple regression analysis for prickle factor (core traits only in model).

Trait	PARTIAL r^2 (individual contributions)	MODEL r^2 (additive contribution)	P
Average fiber diameter, core, ìm^2	0.8184	0.8184	0.0001
Average fiber diameter, core, ìm	0.1021	0.9205	0.0001
SD of fiber diameter, core, ìm	0.0233	0.9438	0.0001
CV of fiber diameter, core, %	0.0012	0.9445	0.0009

Figure 1. Prickle factor (PF, %) versus the squared average fiber diameter of core samples (CAFDSQ, square microns)



This result was essentially unchanged when fleeces (349) having core, side, and britch AFD > 23.6, 24.9, and 27.8 µm, respectively (i.e., from coarse, uncertifiable Rambouillet rams) were excluded from the analysis. Most of the variability in PF can be accounted for by core data alone (Table 5).

i.e., $PF = 199.57 + 0.46*AFD^2 - 19.33*AFD + 6.01*SD - 1.01*CV, r^2 = 0.94$

Conclusions

1. About 92 % of the variability in PF can be accounted for by CAFD and CCV.
2. Because CAFD and CCV are currently used in the index equation for overall merit and since adding another trait would dilute the contributions of the existing traits, we concluded that PF should not be included into the index equation.

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