

STAPLE STRENGTH IN CROSSBRED WOOL: THE SENSIBLE SOLUTION

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SUMMARY

Two methods for measuring staple strength in crossbred wool are compared. One measures the force to break a staple with a cross-sectional area at the point of break equivalent to 2 ktex linear density (Method 1). The other measures the force to break a weight of wool (Method 2). Covariate analysis between breeds with very different wool characteristics suggests that fibre diameter and medullation may bias staple strength depending on the measurement technique, yet differences in loose wool bulk at a common diameter create no such bias. The small differences in these characteristics which exist between lines of New Zealand Romney sheep selected on the basis of staple strength, (using Method 1), do not appear to bias the measurement. It is proposed that strength measured by cross-sectional area should be referred to as "staple tenacity" and that "staple strength" should be reserved for strength measured using the weight of wool.

Keywords: staple strength, staple tenacity, medullation, fibre diameter, bulk.

INTRODUCTION

The units of staple strength are N/ktex; the peak force, measured in Newtons (N), to break a staple measured in grams of clean dry wool per metre length (ktex). Therefore, to measure staple strength, we need to obtain estimates of N, m and g. A logical approach is thus to measure staple length and weight, and the force to break that staple. This is approximately what is measured by ATLAS (Automated Testing of Length and Strength), and gives satisfactory results in comparison with accurate measurements made on an Instron tensile tester (Ranford *et al.* 1986). The atlas machine is more accurate with "blocky" staples than with the "tippy" staples of crossbred, because length can be measured more accurately and the staple gripped more securely in the former (Ranford *et al.* 1986). Staples of crossbred wool exhibit marked changes in diameter and medullation along their length. For example, when fed to maintain constant liveweight over a 14 month period, New Zealand Romney ewes produced a three-fold change in weight of wool produced from a clipped patch (Geenty *et al.* 1984), a two-fold change in fibre diameter (Woods and Orwin 1988), and a three-hundred-fold change in medullation from winter to summer (Scobie *et al.* 1993). These changes can be more pronounced when the animals are grazed at pasture and subject to the reproductive cycle (Fitzgerald *et al.* 1984). For staples from such animals, weighing the whole staple would over-estimate the linear density of wool at the point of break, and therefore under-estimate its strength at that point.

For a selective breeding program established in 1986 to improve staple strength of New Zealand Romney wool, an alternative technique was used. The method decided upon was that of Baumann (1981), which measures linear density at the point of break by measuring cross-sectional area of the staple at that point. Orwin *et al.* (1987) established the validity of the technique in Romney and Corriedale wools, and the method has since been used routinely within the selection program. Large differences in mean strength now exist between the lines, but other wool characteristics such as fibre diameter and bulk also differ (Bray *et al.* 1992), and it became important to re-examine the technique.

The experiments reported here compare the technique of measuring the linear density at the point of break outlined by Baumann (1981) (Method 1) with those made on the same fleece samples by measuring weight between the jaws (Method 2). The first experiment was conducted on 6 breeds, chosen to provide a wide range of fibre diameter, medullation and bulk, in an effort to determine the effect of major shifts in wool characteristics on measurements made using Methods 1 and 2. The second experiment compares these methods, in lines of Romney sheep selected for and against staple strength using Method 1.

MATERIALS AND METHODS

Greasy midside wool samples were conditioned at 20°C and 65% R.H. for 24 hours. Five staples were selected from each sample and the point of break determined in a sixth staple. The linear density of the staples was adjusted to 2 ktex at the point of break using a 6 mm wide Caffin clamp (Caffin 1976). Each staple was placed between jaws of an Agritest staple breaker set at 40 mm, and positioned so that the point of break lay in the centre. The staple was then clamped and extended at 15 mm/sec, broken, and the peakforce to break recorded (Method 1). Following this, the wool was cut from between the jaws of

the staple breaker and the greasy weight determined. Since the distance *between* the jaws was set at 40 mm, linear density was estimated using clean wool yield (%) from full length staples and the greasy weight of the portion between the jaws (Method 2).

Experiment 1

Ten ewe hoggets of each of 6 breeds (Merino, New Zealand Halfbred (English Leicester x Merino), Poll Dorset, Romney, English Leicester and Drysdale) were obtained from farms in February 1992 and run as 1 mob in a non-pregnant condition until shearing in October 1992. Midside samples were collected at shearing, and 5 staples from each animal were broken and N/ktex estimated using Methods 1 and 2. Subsamples were measured for clean wool yield, fibre diameter using an Optically-based Fibre Diameter Analyser (OFDA), bulk using a WRONZ Bulkometer and medullation using a WRONZ Medullameter. An analysis of covariance was conducted on the data using GENSTAT5 (Rothamsted Agricultural Research Institute).

Experiment 2

Ewe hoggets (n = 206) from 3 lines of New Zealand Romney sheep selected on the basis of staple strength (using Method 1), were grazed as 1 mob from lamb shearing until hogget shearing in November 1992. Midside wool samples were collected from these animals at shearing, and a subsample measured for clean wool yield and fibre diameter. Methods 1 and 2 were used to measure N/ktex on 5 staples from each animal. The overall correlation between each measure of staple strength was determined, and the 3 selection lines compared by analysis of covariance using GENSTAT5.

RESULTS

Experiment 1

Breed means for staple strength measured by both Method 1 and 2 increased with fibre diameter (Table 1), with one exception for each method. For Method 1 this was the highly medullated Drysdale wool, and the Halfbred wool for Method 2. The weight of greasy wool and clean wool between the jaws was inversely related to mean fibre diameter and staple strength, apart from the anomalous value for Halfbreds. The average weight of greasy wool between the jaws was similar for the Poll Dorset, Romney and English Leicester animals, despite large differences in bulk. Covariate analysis revealed significant differences between breeds, in slope ($P < 0.001$) and intercept ($P < 0.001$) of the relationship between Methods 1 and 2.

Table 1. Fibre diameter (FD), loose wool bulk, percentage of medullated fibres, N/ktex by cross-sectional area (Method 1), greasy weight of wool between the jaws (GWT), yield and N/ktex by weight (Method 2) of six breeds of sheep

	FD (μm)	Bulk cm^3/g	Medulla (%)	Method 1 (N/ktex)	GWT (mg)	Yield (%)	Method 2 (N/ktex)
Merino	19.6	29.6	0.0	43.9	155	80.1	28.6
Halfbred	30.6	24.6	0.0	46.5	111	78.3	42.9
Poll Dorset	38.2	30.3	5.0	45.9	137	70.4	39.1
Romney	37.9	20.4	2.8	47.0	138	70.0	39.7
English Leicester	39.2	17.9	2.9	57.9	132	72.1	49.0
Drysdale	42.8	24.2	38.9	49.8	119	74.6	52.8
LSD (5%)	1.6	2.0	3.0	8.1	23	5.4	9.0

Experiment 2

The average strength of 5 staples for individual animals, estimated using both Methods 1 and 2 are displayed in Figure 1. Clearly there was close relationship between the results of the 2 methods ($r = 0.966$). Furthermore, covariate analysis revealed no difference between the staple strength selection lines in either slope ($P < 0.927$) or intercept ($P < 0.088$) of the individual fitted lines. The slope of the overall regression line (0.750 ± 0.018) differed significantly from 1 ($P < 0.001$).

The average weight of greasy wool between the jaws over all lines was 131 mg, and the average weight of clean wool calculated using individual yields was 104 mg, there being no significant difference between the lines. Theoretically, a 40 mm section of clean wool of 2 ktex linear density should weigh 80 mg, and weight measurements therefore indicate that more wool was present than estimated by cross-

sectional area. Table 2 provides the selection line means for the measured characteristics, with fibre diameter and strength by either method being significantly different between the lines ($P < 0.001$).

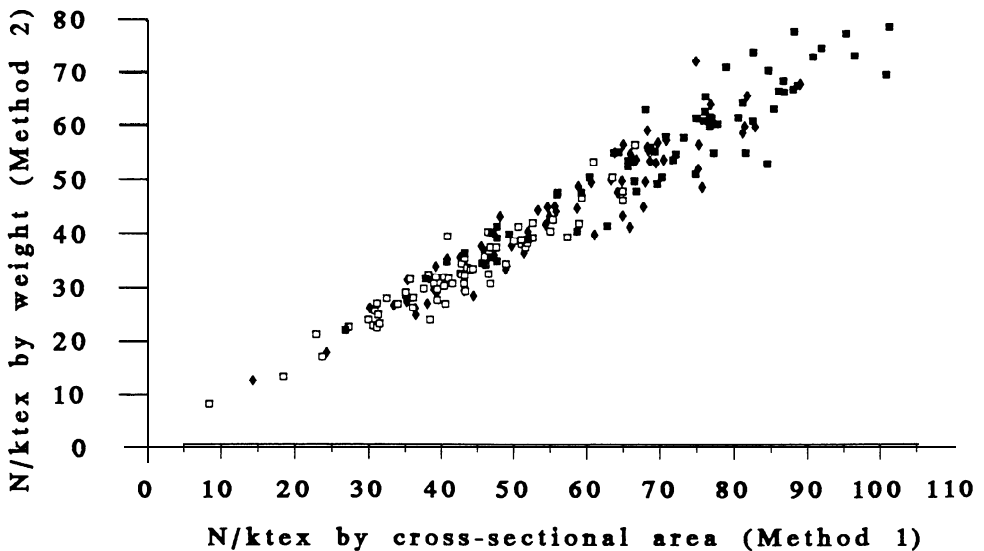


Figure 1. The relationship between staple strength (N/ktex) measured either by cross-sectional area or by weight of wool, for Romney ewe hoggets from lines selected for High (closed squares) or Low (open squares) staple strength, and a randomly selected Control (closed diamonds)

Table 2. Fibre diameter (FD), N/ktex by cross-sectional area (Method 1), greasy weight of wool between the jaws (GWT), yield, clean weight of wool between the jaws (CWT) and N/ktex by weight (Method 2) of three lines of Romney sheep selected on the basis of Method 1

	FD (μm)	Method 1 (N/ktex)	GWT (mg)	Yield (%)	CWT (mg)	Method 2 (N/ktex)
Low strength	32.4	43.0	133.1	79.7	105.8	32.7
Control	35.0	55.7	131.1	80.5	105.3	42.8
High strength	34.7	70.6	130.1	79.4	103.1	55.2
LSD (5%)	0.6	4.9	4.9	1.3	3.0	3.9

DISCUSSION

There were major discrepancies between linear density estimated by Method 1 and measured by Method 2 on wool from different genotypes kept in the same environment. These differences in weight of wool between the jaws suggests that mean fibre diameter and medullation affect the estimation of linear density using Caffen jaws. High or low bulk (Poll Dorset and English Leicester respectively) at similar average diameter, does not appear to greatly influence the estimate of linear density relative to the Romney. However, English Leicester staples exhibited higher strength than the Romney and Poll Dorset, which may reflect a real breed difference and warrants further investigation.

For the staple strength selection lines, the similarity of the slope and intercept of the individual regression lines, shows that it is unlikely that the between selection line within breed differences in fibre diameter ($2\mu\text{m}$) (Bray *et al.* 1992), medullation (2 %) (Scobie unpublished) or any other characteristics

bias the measurements. Results from Method 1 are therefore as suitable as those from Method 2 for use as selection criteria.

Some of the disagreement between Method 1 and Method 2 may be explained as follows. The gauge length (40 mm) represents approximately 3 months of wool growth for these animals and therefore one and a half months either side of the point of break. Based on published seasonal changes of fibre diameter (Woods and Orwin 1988), average diameter could change 20% over this period, and therefore cross-sectional area of the staple could increase 44%. The calibration of the Caffin jaws has been tested theoretically and experimentally, and staples average 2 ktex of clean wool at the point at which they break. In theory, a staple 2 ktex in the centre of the jaws could reach 2.88 ktex at the edge of the jaws, and average approximately 2.44 ktex (98 mg) overall. This is reasonably close to the average weight of clean wool between the jaws which was measured in Experiment 2 (104 mg or 2.6 ktex).

The strong correlation between the estimates of N/ktex obtained using Methods 1 and 2 suggests that within breeds we can convert between the 2 methods, at least for the 40 mm test length. The inter-conversion is made using the assumptions that the density of the staple is constant and cross-sectional area is uniform along its entire length. These assumptions do not hold for full length staples with seasonal variations in fibre diameter and medullation, and can be expected to give rise to errors where differences in these characteristics are substantial, such as between breeds. The sensible solution is to adopt the term "staple tenacity" (Hunter *et al.* 1983), for measurements by Method 1, and for the units to be "N/ktex at the point of break", to describe the strength of wool per unit cross-sectional area at the point of break.

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