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Relationship between Stress-Strain Parameters and Fibre Characteristics in Wools

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Regression of stress-strain parameters, like hookean slope, yield slope, and breaking stress and strain, on fibre characteristics, like diameter, CV of diameter, area and CV of area has been studied. It is observed that it is not possible to obtain a single linear regression equation for pure and medullated wool fibres.

It has long been recognized that wools from various breeds of sheep differ in physical characteristics. In general, previous studies have revealed significant variations in stress-strain characteristics of wools from various breeds of sheep[1-4]. It was shown that the breaking properties improve with increase in fibre diameter. However, not much work is reported about wools of Indian origin. In the present work, an attempt has been made to find out the relationship between some stress-strain parameters and fibre dimensional variables, particularly for obtaining a common relationship for pure and medullated wool fibres.

Materials and Methods

Wool samples from Rambouillet, Chokla and their halfbred sheep were collected from the flocks being maintained at this institute from the spring clip of 1976. The fibres were separated into pure and medullated groups by dichlorobenzene test[5]. At random, 22 fibres from each breed were selected: Rambouillet (22 pure), Chokla (22 pure and 22 medullated) and halfbred (22 pure and 22 medullated). Single fibres were mounted on microscopic slides and 35 measurements of diameter were made along a 30 mm long fibre. The fibres were extended at a constant rate of elongation of 16% per min on Instron and the load elongation curves were obtained with a chart to cross-head speed ratio of 10:1, so that the three regions of the curves were clear. All the measurements were made in air at $65 \pm 5\%$ RH and $27 \pm 2°C$. Each curve was converted to stress-strain curve using the average area of each fibre and stress-strain parameters were worked out. The statistical analysis of the regression of four stress-strain parameters, viz. hookean slope, yield slope, breaking stress and breaking strain, on the fibre dimensional variables, viz. diameter, cross-sectional area and their coefficients of variations, were calculated by standard procedures[6,7].

Results and Discussion

The average values of the fibre and curve characteristics for pure and medullated fibres are given in Table 1. The regression coefficients of stress-strain parameters on fibre characteristics are given in Table 2.

The values of stress-strain parameters are high in pure fibres, except for the value of breaking strain which is high for medullated fibres (Table 1). Data presented in Table 2 reveal that stress-strain parameters regress positively on diameter for pure fibres and negatively for medullated fibres. This may be true, because pure fibres tend to be structurally stronger with increase in diameter[6]. In the case of medullated fibres, increase in diameter increases the medulla, resulting in poor elasticity.

The regression of stress-strain parameters on coefficient of variations of diameter and cross-sectional area are negative for both pure and medullated fibres. This is in conformity with the results reported by Shah

Table 1—Average Values of Fibre and Stress-Strain Curve Parameters

Parameter	Pure fibre	Medullated fibre
No. of fibres	66	44
Diameter, μ	24.0	51.9
CV of diameter, %	19.5	16.9
Area, μ^2	520.2	2361.3
CV of area, %	24.2	22.6
Hookean slope, kg/mm^2	0.0349	0.0244
Yield slope, kg/mm^2	0.00278	0.00146
Breaking stress, kg/mm^2	0.00154	0.00105
Breaking strain	0.268	0.301

Table 2—Regression Coefficients of Stress-Strain Parameters on Fibre Characteristics

Curve parameter	Fibre character	Pooled		Total	
		Pure	Medullated	Pure	Medullated
Hookean slope	Diameter	0.2047	−0.3422†	0.2236	−0.4442†
	CV of diameter	−0.1811	−0.0537	−0.1347	−0.1071†
	Area	−0.0116	−0.0370	0.0989	−0.4307†
	CV of area	−0.3129*	−0.0022	−0.1869	−0.1308
Yield slope	Diameter	0.0451	−0.1675	0.0080	−0.3346*
	CV of diameter	0.1614	−0.1267	0.1275	−0.0749
	Area	0.0105	−0.1556	−0.1855	−0.3107
	CV of area	−0.0555	−0.0614	−0.0626	−0.0922
Breaking stress	Diameter	0.3608†	−0.3407*	0.2758*	−0.1360
	CV of diameter	−0.1036	−0.2048	−0.0872	−0.1599
	Area	−0.0830	−0.3480*	−0.0760	−0.1538
	CV of area	0.0088	−0.1664	−0.0288	−0.1418
Breaking strain	Diameter	0.1754	−0.1480	0.0402	0.2096
	CV of diameter	−0.0177	−0.4777†	−0.2308	−0.0077
	Area	0.0544	−0.1259	0.0481	0.2142
	CV of area	0.0176	0.0214	−0.1282	0.0700

*Significant at 5% level.
†Significant at 1% level.

and Whiteley[4]. Such results are expected for medullated fibres owing to their poor elasticity. For pure fibres, the coefficients of variation are comparatively high and this increases the chances for the fibre to have thinner places, resulting in low stress-strain values. It is evident from Table 1 that medullated fibres harbour nearly two times the diameter of pure fibres, whereas its coefficient of variation is not that significantly low compared to pure fibres. Therefore, stress-strain parameters regress negatively on coefficient of variation.

The values of regression coefficient of stress-strain parameter on cross-sectional area are not consistent. This could be because of the effect of variations due to genetic groups comprising the fibre groups. For example, the value of regression coefficient of breaking stress on cross-sectional area for Rambouillet fibres is +0.446, which is significant, whereas all other breeds have shown a negative value. The average cross-sectional area and its coefficient of variation are minimum in Rambouillet fibre; consequently, the regression coefficient is positive.

Significance tests on regression coefficients (Table 2) indicate that it is not possible to pool both pure and medullated fibre group values to obtain a single regression equation. F-tests for homogeneity of regression lines were carried out to further examine the possibility of pooling the five fibre groups to obtain a single regression equation. This test has shown the possibility of obtaining a regression equation for pure and medullated fibres separately, but has failed to show a single regression equation for all the fibre groups.

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