ORTHO-PARA CORTICAL DIFFERENTIATION IN "ANOMALOUS" MERINO WOOL

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Summary

"Anomalous" or "doggy" Merino wool appears to be an increasing problem in Australian woolgrowing. The pattern of the ortho-para cortical differentiation of the straighter-fibred anomalous growth has been compared with that of normal wool. It was found that demarcations of ortho- and paracortex typical of much coarser fibres, may be present in the fine fibres of anomalous growth. In general, doggy wool is coarser than the normal flock mean and has a higher percentage occurrence of paracortex in the cross section.

I. Introduction

Bilateral cortical effects have been recognized by a number of workers (McMurtrie 1886; von Bergen 1935; Hirabayasha 1938; O'Hara 1938) but Horio and Kondo (1953) recognized that there are two cortical components in the form of approximate hemi-cylinders wound round each other helically in phase with the fibre crimp. The two components differed in dyeing, swelling in alkali, and in birefringence after exposure to alkali. Fraser and Rogers (1953, 1954) showed that the outer bilateral component of the crimp wave had an affinity for basic dyes and was less resistant to thioglycollate digestion. Fraser, Lindley, and Rogers (1954) attributed the cause of the appearance in segmentation to the difference in the amino acid composition, in cystine, proline, and dicarboxylic acids. Other evidence of a difference in physical and chemical properties has been given by Race (1946), Woods (1953), Dusenbury, Mercer, and Wakelin (1954), Mercer, Golden, and Jeffries (1954), and Golden, Whitwell, and Mercer (1955). The basophilic component has been called orthocortex or S (soft) and the other, the paracortex or H (hard).

Fraser and Rogers (1953) noted that in wool of 64's quality wherein the cortex was differentiated on the basis of basophilic dyeing, there was no gradation of properties near the boundary. The paracortex was the lesser in area and the segmental line lay along the major axis of the fibre cross section. From examination of coarser wool, Fraser and Rogers (1955) made the following suggestions:

(i) In wool less than 25 μ in diameter, the segments are discrete.

(ii) Between 25–35 μ, the demarcation is less sharp and the uptake of dye variable. Frequently ortho- surrounded by paracortex and vice versa are evident.

(iii) Above 35 μ, the division between ortho- and paracortex is no longer justifiable, on the basis of staining methods. There is a marked tendency for the paracortex to become concentrated around the periphery in the coarser fibres, leaving a central core of orthocortex.

The disappearance of segmentation appears to be a function of fibre diameter.

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A Merino woolgrowing problem of some standing in Australia is that typically well-crimped flocks may show a proportion of "anomalous", "doggy", or "rough" Merino fleeces, in which the crimp has a longer wavelength than would have been expected and a shiny staple appearance, causing the adoption of the colloquial description "doggy". When a number of these samples, chosen by experts in several Australian States, was received for study, one aspect examined was the cortical response to basic dyeing. The results were unexpected enough to report separately.

II. Materials and Methods

(*a*) *Dyeing Technique*

After degreasing in petroleum ether and warm distilled water, the samples were dehydrated in ethyl alcohol and then air-dried. Fine wools were dyed with 0·08 per cent. methylene blue, but, for adequate dyeing, the doggy wool required 0·08–0·12 per cent. Dyeing was carried out in 0·03M potassium dihydrogen phosphate buffer of pH 7·4 at 100°C for 30 min with a wool/liquor ratio of 0·1 g per 30 ml.

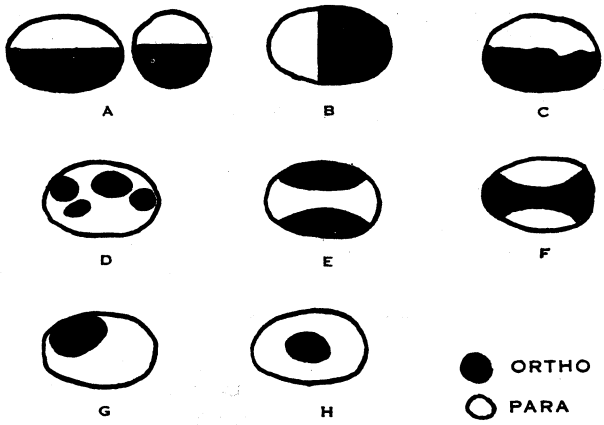

Fig. 1—An arbitrary classification of types of bilateral cortical segmentation.

III. Results

(*a*) *Types of Segmentation*

It was necessary to establish an arbitrary classification for the various types of segmentation. This was made as follows:

Type *Description* (see Fig. 1)

A Clear demarcation, approximately along the major axis of the elliptical section. If fibre circular, then included in *A* if demarcation clearly defined.

B Clear demarcation approximately along the minor axis of the elliptical section.

C Demarcation not well defined, due to a gradation in staining.

D When the orthocortex was gathered in two or more separated groups, usually being of smaller total area than the paracortex. This was of rare occurrence.

TABLE 1

NORMAL MERINO WOOL: MEASUREMENTS ON SECTIONS FROM THREE ADJACENT STAPLES FROM THE SAME FLEECE

Staple	Section	Para-cortex (%)*	S.D.	Mean Thickness (μ)	Types of Segmentation		Mean Thickness of *B* (μ)
					A (%)	*B* (%)	
I	1	39·6	9·2	20·6	86	14	19·8
	2	40·7	7·9	20·6	86	14	20·6
	3	39·6	7·4	20·8	93	7	18·0
	4	37·7	9·1	21·1	84	16	19·6
II	1	41·8	7·7	21·6	92	8	20·3
	2	40·7	8·0	22·1	88	12	21·4
	3	37·0	7·8	21·5	90	10	21·2
	4	37·4	8·0	22·3	84	16	20·8
	5	40·0	7·2	21·9	89	11	19·0
	6	40·4	7·0	21·6	89	11	19·3
III	1	41·9	6·9	22·6	93	7	22·0
	2	37·2	6·4	22·5	92	8	21·6
	3	41·6	7·6	23·5	94	6	22·7
	4	40·4	8·2	21·8	83	17	21·5
	5	41·1	8·8	21·8	84	16	21·5
	6	44·5	8·2	22·4	94	6	17·6

* Mean = 40·1 per cent. Standard error of mean = 1·96 per cent.

TABLE 2

PERCENTAGE TYPES OF SEGMENTATION IN NORMAL MERINO WOOL

Values are arranged in order of increasing mean thickness

Sample No.	Para-cortex (%)*	S.D.	Mean Thickness (μ)	Types of Segmentation (%)†						
				A	*B*	*C*	*D*	*E*	*F*	*G*
N3	35·5	5·9	15·8	76	24					
N2	38·1	5·4	18·1	76	24					
N5	35·5	6·2	19·2	80	20					
N1	42·7	5·9	19·6	85	15					
N11	37·3	8·5	19·6	64	36					
N4	31·3	5·8	22·0	80	20					
N9	31·3	5·1	22·3	74	24	2 (33)				
N12	36·4	7·7	22·3	60	38					2 (17)
N13	37·8	6·8	22·3	66	34					
N14	40·1	5·5	22·7	72	28					
N10	38·2	6·3	22·8	66	24	2 (26)			8 (27)	
N7	37·2	6·3	23·9	90	10					
N8	36·5	8·4	27·5	84	14					
N6	45·3	9·2	35·9	18	2	68 (36)	4 (41)	8 (46)		

* Mean = 37·3 per cent. † Mean thickness of the group is given in parentheses.

E Resembling *D*, but with two separate occurrences of orthocortex situated peripherally and diametrically opposed, leaving a channel of paracortex centrally across the fibre.

F *E* with ortho- and paracortex reversed in position.

G A single, small, circular occurrence of orthocortex at the fibre periphery.

H A single circular occurrence of orthocortex at the fibre centre.

TABLE 3

PERCENTAGE PARA-CORTEX AND CLASSIFICATION OF TYPES OF SEGMENTATION IN ANOMALOUS MERINO WOOL SAMPLES

Sample size = 50 fibres. Values are arranged in order of increasing mean thickness

Sample No.	Para-cortex (%)*	S.D.	Mean Thick-ness (μ)	Types of Segmentation (%)							
				A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
D2	74	9·9	21·8	—	—	—	—	—	—	—	100
D19	59	12·0	23·0	8	—	—	—	—	—	24	68
D30	35	9·2	23·4	36	32	20	—	—	4	6	—
D28	47	8·9	24·1	46	18	12	—	—	14	8	—
D10	51	14·8	24·4	26	—	24	4	—	4	22	18
D17	47	12·5	25·8	42	—	30	—	—	4	20	4
D25	56	14·3	26·4	24	—	10	4	—	—	4	58
D20	47	13·9	26·5	16	4	40	8	2	10	20	—
D11	69	18·5	26·6	24	—	10	4	—	—	4	58
D1	85	11·9	26·7	—	—	—	—	—	—	—	100
D29	38	13·3	26·8	30	6	48	—	—	14	2	—
D15	50	11·3	27·0	40	—	28	—	2	2	10	14
D4	63	14·7	27·8	2	2	10	—	—	2	26	56
D6	60	15·6	28·0	16	—	40	2	—	—	26	14
D7	63	10·3	28·3	12	—	26	12	4	8	32	6
D9	61	11·8	28·6	8	—	16	—	—	—	24	52
D23	50	13·3	29·0	14	2	34	—	—	8	32	10
D31	46	10·2	29·0	50	10	12	2	4	10	10	2
D8	56	9·1	29·6	12	—	28	—	—	2	40	18
D14	56	17·0	30·6	16	—	32	6	—	—	14	26
D12	45	12·5	33·3	32	—	14	—	—	14	18	2
D5	53	12·5	34·2	—	—	34	26	—	—	30	10
D18	60	10·0	34·3	—	—	2	—	—	—	4	88
D3	45	11·1	34·7	8	—	22	—	4	46	14	2

* Mean = 55 per cent.

(*b*) *Dimensional and Bilateral Cortical Phenomena in Doggy Wool*

Seventeen normal wool samples were added to the group of 31 doggy or rough Merino wools, so that comparisons could be made more easily. As a guide to the repeatability of measurements on the respective areas of ortho- and paracortex in cross sections from the same staple and from adjacent staples in the same fleece, three such staples were sectioned at a number of levels after staining. Table 1 shows that the percentage of paracortex was fairly constant. Areas were assessed by copying the microprojections at 500 diameters on to millimetre graph paper, from whence the estimates were made.

It is apparent that the percentage by area of paracortex is reasonably constant in the three staples that the percentage of the cross sections in which the segmentation follows the major axis lies between 83 and 94 per cent., that the mean thickness of fibre sections with the segmentation following the minor axis tends to be slightly lower than that of the fibres with the demarcation line along the major axis, and that, as in other normal wools of like fineness, the percentage of paracortex is the lesser.

TABLE 4

MEAN THICKNESSES OF GROUPS OF ANOMALOUS MERINO WOOL SAMPLES FOR EACH TYPE OF SEGMENTATION AS GIVEN IN TABLE 3

Sample No.	Mean Thickness (μ)	Mean Thickness of Group (μ) for Each Type of Segmentation							
		A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
D2	21·8	—	—	—	—	—	—	—	21·8
D19	23·0	23·1	—	—	—	—	—	22·7	—
D30	23·4	22·8	22·7	24·2	—	—	25·4	26·7	—
D28	24·1	24·2	22·3	24·3	—	—	27·2	26·2	—
D10	24·4	24·6	—	23·2	30·5	—	26·5	24·5	24·5
D17	25·8	24·6	—	25·0	—	—	27·1	27·2	30·6
D25	26·4	24·4	20·4	26·1	26·0	35·0	30·1	27·0	—
D20	26·5	25·6	22·6	26·6	—	—	24·4	27·0	27·5
D11	26·6	25·3	—	27·3	26·0	—	—	30·0	25·1
D1	26·7	—	—	—	—	—	—	—	26·7
D29	26·8	25·2	26·4	27·8	—	—	27·6	23·7	—
D15	27·0	26·2	—	26·6	—	23·7	24·9	30·5	27·8
D4	27·8	23·7	24·9	25·5	—	—	29·4	29·4	27·9
D6	28·8	29·1	—	29·0	23·7	—	—	29·1	27·1
D7	28·3	21·8	—	26·2	27·6	34·5	29·5	31·0	30·1
D9	28·6	28·0	—	28·0	—	—	—	28·4	28·8
D23	29·0	28·0	19·2	29·4	—	—	29·5	29·2	31·2
D31	29·0	25·6	26·2	30·4	45·0	38·0	36·0	29·5	40·6
D8	29·6	27·0	—	27·3	—	—	34·0	30·0	35·1
D14	30·6	25·0	—	29·5	37·2	—	—	34·0	33·0
D12	33·3	30·2	—	32·9	—	—	37·5	35·2	44·0
D5	34·2	—	—	34·6	35·5	—	—	32·0	36·0
D18	34·3	—	—	31·6	—	—	—	30·5	34·5
D3	34·7	31·4	—	33·0	—	35·5	36·0	34·7	28·3

In Table 2, the types of segmentation in 14 samples of normal wool have been noted. These demonstrate that there is a marked tendency towards the *A* and *B* types throughout all except N6, which is a coarse Corriedale wool whereas the others in the group are of Merino type. If these details are compared with Tables 3, 4, and 5, the differences between normal and anomalous wools become apparent.

IV. Discussion

While, on the average, the anomalous wools tended to be coarser than the flocks from whence they came, the real contrast lay in the types of bilateral cortical segmentation. In general, for normal wool up to 27 μ mean thickness, the segmentation revealed in the cross sections is well defined and almost wholly in the *A* and *B*

Table 5

NUMBERS OF ANOMALOUS MERINO WOOL SAMPLES FALLING INTO THE THREE THICKNESS RANGES 25μ AND UNDER, 26–35μ, AND 36μ AND OVER

Sample No.	Thickness Ranges																							
	25 μ and Under								26–35 μ								36 μ and Over							
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
D2	—	—	—	—	—	—	—	40	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—
D19	3	—	—	—	—	—	12	25	1	—	—	1	—	—	—	8	—	—	—	—	—	—	—	—
D30	16	14	5	—	—	1	1	—	2	2	5	—	—	1	2	—	—	—	—	—	—	—	—	—
D28	15	7	4	—	1	1	3	—	8	2	2	—	—	6	—	—	—	—	—	—	—	—	—	1
D10	10	—	10	—	—	—	9	6	4	—	2	2	—	1	2	4	—	—	—	—	—	—	—	—
D17	15	—	7	—	—	—	4	—	6	—	7	—	—	2	6	2	—	—	1	—	—	—	—	—
D25	6	2	11	2	—	—	3	—	2	—	9	2	1	5	7	—	—	—	—	—	—	—	—	—
D20	6	1	6	—	—	2	2	3	8	—	12	—	—	—	4	6	—	—	—	—	—	—	—	—
D11	7	—	—	1	—	—	—	16	5	—	5	1	—	—	2	13	—	—	—	—	—	—	—	—
D1	—	—	—	—	—	—	—	24	—	—	—	—	—	—	—	16	—	—	—	—	—	—	—	10
D29	5	1	6	—	—	3	1	—	10	2	16	—	—	4	2	—	—	—	2	—	—	—	—	—
D15	8	—	3	—	1	2	—	2	12	—	11	—	—	—	3	5	—	—	—	—	—	—	2	1
D4	1	1	3	—	—	—	1	6	—	—	2	—	—	1	13	21	—	—	—	—	—	—	—	1
D6	3	—	4	1	—	—	4	2	5	—	16	—	—	—	7	5	1	—	—	—	—	—	2	—
D7	5	—	7	2	—	—	4	—	1	—	6	3	2	4	7	3	—	—	—	1	—	—	5	—
D9	—	—	1	—	—	—	2	2	4	—	7	—	—	—	10	23	—	—	—	—	—	—	—	1
D23	2	1	4	—	—	—	—	—	5	—	12	—	—	3	15	5	—	—	1	—	—	1	1	—
D31	13	2	1	—	—	—	—	—	12	3	3	—	—	2	5	—	—	—	2	1	2	3	—	1
D8	1	—	4	—	—	—	4	—	5	—	10	—	—	1	15	6	—	—	—	—	—	—	1	3
D14	6	—	4	—	—	—	—	2	3	10	1	—	—	—	5	6	—	—	2	2	—	—	2	5
D12	—	1	—	—	—	—	—	1	16	—	4	—	—	2	3	—	—	—	3	—	—	5	5	1
D5	—	—	—	—	—	—	—	—	—	—	10	6	—	—	13	3	—	—	7	7	—	—	2	2
D18	—	—	—	—	—	—	—	—	—	—	1	—	—	—	2	31	—	—	—	—	—	—	13	—
D3	4	—	11	—	—	13	4	1	—	—	1	1	2	11	2	—	—	—	—	—	—	—	—	—
Totals	126	30	91	6	2	22	54	130	109	19	142	16	5	43	125	167	1	—	18	11	2	9	33	26

categories (Tables 1 and 2). It is obvious from Table 5 that the classifications *C-H*, which are more typical of coarser wools, are freely represented among fibres which are "25 μ and under" in thickness, as well as in the "26–35 μ" region. It would appear as though a factor, normally operating in the production of coarse fibres only, is also present in the growth of many of these anomalous or doggy wool fibres, even at a low fibre-thickness level. Some of the peculiar variants from the simple bilateral

segmentation of type *A* or *B* may well lead to explanations of peculiarities of fibre crimp form and physical response seen in these wools. Another deviation from normal growth appears to be a greater area of paracortex in the doggy samples as compared with that in normal wool growth (Tables 1, 2, and 3). In these cases 24 doggy samples averaged 55 per cent. paracortex while 14 normal samples had a mean as low as 37 per cent. These values are only indicative, as the assumption has been made that in all cases the methylene blue staining has been similar in degree and that the orthocortex has been clearly and completely defined.

V. Conclusions

Conclusions from this study are:

(i) That doggy Merino wool, in general, appears to be coarser than the normally crimped production of the flock in which it originates.

(ii) That the cortical segmentation of fine fibres from doggy wool may show characteristics normally seen only in much coarser-wooled breeds.

(iii) That the area occurrence of paracortex appears to be higher in doggy wool than in normal Merino wool.

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VII. References

von Bergen, W. (1935).—*Proc. Amer. Soc. Text. Mater.* **35** (11): 705.
Dusenbury, J. H., Mercer, E. H., and Wakelin, J. H. (1954).—*Text. Res. J.* **24**: 890.
Fraser, R. D. B., and Rogers, G. E. (1953).—*Biochem. Biophys. Acta* **12**: 484.
Fraser, R. D. B., and Rogers, G. E. (1954).—*Biochem. Biophys. Acta* **13**: 297.
Fraser, R. D. B., and Rogers, G. E. (1955).—*Aust. J. Biol. Sci.* **8**: 288.
Fraser, R. D. B., Lindley, H., and Rogers, G. E. (1954).—*Biochem. Biophys. Acta* **13**: 295.
Golden, R. L., Whitwell, J. C., and Mercer, E. H. (1955).—*Text. Res. J.* **25**: 334.
Hirabayasha, K. (1938).—*Bull. Res. Inst. Synth. Fibres, Japan* **3**: 17.
Horio, M., and Kondo, T. (1953).—*Text. Res. J.* **23**: 373.
McMurtrie, W. (1886).—"Examination of Wool and Other Animal Fibres." (Govt. Printing Press: Washington, D.C.)
Mercer, E. H., Golden, R. L., and Jeffries, E. B. (1954).—*Text. Res. J.* **24**: 615.
O'Hara, K. (1938).—*Melliand. Textilber.* **19**: 407.
Race, E. (1946).—"Fibrous Proteins Symposium." p. 69. (Soc. Dyers and Col.: Bradford.)
Woods, H. J. (1953).—*J. Text. Inst.* **26**: T93.