Pakistan J. Sci. Ind. Res., Vol. 19, Nos. 3-4, June-August 1976

STUDIES ON THE DIFFERENT PARTS OF THE FLEECE OF HASHTNAGRI SHEEP
Part II. Variation in Diameter and Medullation from Root to Tip End of Wool Fibre

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(Received June 20, 1975; revised January 28, 1976)

Abstract. Variation in fibre and medulla diameter of fully medullated and true fibres of the three segments, i.e. root, middle and tip portions obtained from six distinct parts of Hashtnagri sheep were determined. The C.V. (%) of these portions for the three segments were also calculated. It was observed that fibre and medulla diameter decrease from root to tip-end in the various portions. But in majority of the cases the fibre from the middle part in the back poration shows greater fibre and medulla diameter than those from the root-end. However, there was no change in the fibre diameter of true wool in the three segments. The possible causes of these variation, for example climatic condition and nutrition, were discussed in detail.

In Pakistan most of the wool from the indigenous breeds contain medullated fibres. The presence of a certain percentage of medullated fibres play an important part in making ideal yarn for carpet, blanket and woollen cloth,[1,2] variation in the diameter of the the fibre may result in the unevenness of the yarn produced, which affects the final product. Moreoever, due to unevenness in the medulla, nonuniformity of dyeing also occurs in the yarn and also affects the final product.[3]

It is a general belief that fibre diameter decreases from root to tip-end. Recent work on Indian wools, shows that both medullation and diameter increase from root to tip-end of the fibre.[4] The increase in diameter may be ascribed to some extent to the increase in medullation from root to tip-end. Therefore, it was necessary to clarify this discrepancy.

No work seems to have been done in Pakistan on the variation of fibre and medulla diameter along the length of the fibre. Most of the work done so far is confined to the percentage of medullated and true fibres in various wools.[5,7] However, some work has also been done recently on the correlation of fibre diameter and medulla diameter.[8,9] Earlier work on medullation includes the relationship of medullation with mechanical properties, felting, and amino acids. [10,12].

The objective of the present study is to establish the variation in fibre and medulla diameter of the whole fibre as well as that of the three segements, i.e. root, middle and tip-end of the six distinct parts of the Hashtnagri sheep. The C.V. (%) of the whole fibre together with that of the three segments were also determined. The possible causes of these variation, which include climatic condition and nutrition, were discussed in detail.

Materials and Methods

Wool Samples. The wool samples were collected from the Hashtnagri breed kept on a sheep farm in these laboratories. The samples were collected in October 1970 from the following parts of the ten sheep: back wool, body wool, belley wool, shoulder wool, neck wool, and britch wool.

The above samples were purified by Soxhelt extraction with ethyl ether, followed by soaking in ethanol and finally washed with distilled water.

Method

Aboute 10 fibres each from fully medullated and true fibres were withdrawn at random from the above six parts. The fibres were cut into 3 equal parts, i.e. root, middle and tip portions. Slides were made separately for each portion, by securing the fibre with glycerine on the slide and covering with a cover slip. The direction of the fibre was from root to middle end then to tip-end. Diameter thickness and the corresponding medulla thickness were noted at equal intervals for each segment at a magnification of $\times$ 500 employing a lanameter. About 100 readings were recorded for each segment. The volume of the fibre occupied by the medulla was also determined as described elsewhere.[13] The coefficient of variation (C.V.%) of the three segments as well as of the whole fibre were calculated by the Repid method[14]. The maximum and minimum temperatures were recorded at 5 p.m. each day between 15th April 1970 to 15th October 1970 (i.e. for the time of growth of the wool fibre).

Results and Discussion

Table I shows the fibre diameter and the corresponding medulla diameter of the whole fibre, root, middle and tip-end of the six parts of Hashtnagri fleece. Each reading represents the mean of 10 fibres. It is clear that, in general, the fibre diameter and medulla diameter decrease from root to tip-end. But in the case of wool from back portion, the fibre diameter and medulla diameter of the middle portion are greater than those of the root-end. The decrease in the diameter from middle to tip portion is greater than from root to middle end in all the portions. Table 2

shows the percent volume occupied by the medulla which is an indication of medullation. It produces the same picture as given in Table 1.

Table 3 gives the fibre and medulla diameter of root, middle and tip portions of the individual fibre of the back wool. The fibres are arranged in the descending order of diameter. It is evident that in the case of fibre Nos.1 to 4, the diameter and medulla decrease from root to middle and then to tip-end. However, in the case of fibres Nos. 5 to 10, the diameter and medulla incrase from root to middle end and then decrease in the tip portion. In the former case the diameter of the fibres is greater than that in the latter case. It is thus clear that all the fibres in the back wool wool do not behave in the same manner. These results are contrary to the recent work of Chatterjee and Bumb[4] who showed that medulla and diameter increase from root to tip-end of the fibre. They have further found the difference between the extent of medullation and the diameter of root, middle and tip portions to be statistically significant.

In the case of true wool (Table 4) it is clear that there is a negligible difference in diameter of the root, middle and tip portions. This is in agreement with the result of earlier work on Rambouillet breed.[4]

The level of coefficient of variation (C.V.%) for diameter and medulla is very important in assessing the uniformity of the fibre. The C.V. (%) of medulla is greater than that of fibre diameter in the whole fibre, root, middle and tip portions. (Table V) It is also evident that in the middle portion the variation is the lowest. The C.V. (%) in medulla is greatest in the tip portion. The C.V. (%) in diameter of true wool (Table 4) is the same as that in the case of medullated wool but in the former case the variations are less. Table 6 gives the maximum and minimum temperatures of the period of growth of tip, middle and root-end.

It may be noted that the diameter of all the tip portions in the various parts becomes less, especially in the shoulder, neck and britch portions. The medulla reduces to such an extent that the fibre becomes almost true. This happens in the tip portion of the above parts only, but not in the back, body and belly wool. The transition from continuous to fragumental medulla occurs in the range 30-40 μ, but in the majority of the fibres, the transition occurs at 35μ. Earlier Shah *etal.* have stated that below a diameter $32 \pm \mu$ all the fibre are expected to be true.[9] They have further shown that in most of the fibres the process of medullation initiates at this diameter and approaches completion at a diameter of $51+15\eta$. It has further been observed that as the fibre diameter increases, medulla diameter also increases. Thus the present study confirms the earlier work as quoted.

There are a number of factors which are responsible for the variation in fibre diameter and medulla diameter along the length of the fibre, but the effects of climatic conditions and nutrition are considered as the main factors. We take into account the effect of temperature first and suppose that the growth of the wool fibre is uniform and this is the basis for dividing the whole fibre into equal thirds. However, data for diameter in Table 1 shows that fibre growth was not uniform and because of the correlation between length and diameter, it is most probable that a greater length of the fibre was produced during growth of the root than while the tip portion was growing. Thus on the assumption of uniform growth of the wool fibre, the period of growth for the tip portion is from 15th April to 15th June, that of the middle portion is from 16th June to 15th August and that of the root end is from 16th August to 15th October. It is evident from Table 6 that the growth of wool in the middle portion takes place during the hottest months (i.e. min. 79.8°F; max. 105.6 F). Next comes the tip portion in which the minimum is 65.5°F and maximum 105. 1°F. The temperature at which the root portion grows is the lowest, i.e. min. 69.0°F; max. 95.1 F). It has been established that tthe narrowing and loss of medulla in the double coated British mountain breeds occurs in winter.[15] This has also been confirmed by Doney and Smith who have shown that in the Scottish Blackface primary fibres narrow proportionally more than the secondaries in the winter mainly because of the loss of medulla.[16] Therefore, if we take only the effect of temperature, the fibre diameter and medulla diameter in the present study should be the highest in the middle portion and the least at the root-end.

As far as the effect of nutrition is concerned, it has been shown that in the Australian merino there is a decrese in fibre diameter under droughty conditions.[10] There is usually little nutrition avaiable to the sheep during the hottest months, i.e. from 16th June to 15th August, which is the period of growth of middle portion which should result in a reduction of fibre diameter and medulla diameter. Therefore, it is evident that for the middle portion, due to temperature effect, the fibre and medulla diameters should increase on

TABLE 1. THICKNESS OF FIBRE AND MEDULLA (MICRON) OF WHOLE FIBRE, ROOT, MIDDLE AND TIP PORTION OF MEDULLATED FIBRE OF HASHTNAGRI FLEECE.

Parts	Whole fibre (dia)		Root (dia)		Middle (dia)		Tip (dia)	
	Fibre	Medulla	Fibre	Medulla	Fibre	Medulla	Fibre	Medulla
Back wool	68.2	56.8	71.5	61.1	76.0	66.6	56.2	42.0
Body wool	74.4	63.7	83.6	74.5	79.9	69.0	60.8	47.0
Belly wool	67.2	47.2	73.2	54.7	72.6	54.2	57.4	33.3
Shoulder wool	44.6	29.7	50.3	40.3	46.2	30.7	35.4	15.4
Neck wool	57.2	41.7	76.3	63.1	57.3	39.9	39.4	18.0
Britch wool	50.2	32.1	59.1	42.2	53.7	36.0	36.9	9.3

TABLE 2. VOLUME PERCENTAGE CM³ OF MEDULLA FOR WHOLE FIBRE, ROOT, MIDDLE AND TIP PORTION OF VARIOUS PARTS OF HASHTNAGRI FLEECE.

Parts	Whole (%)	Root (%)	Middle (%)	Tip (%)
Back wool	58.5	62.4	65.0	44.5
Body wool	73.0	79.2	74.6	59.7
Belly wool	49.3	56.8	55.6	33.4
Shoulder Wool	44.0	64.1	43.9	18.9
Neck wool	52.9	63.6	48.4	20.9
Britch wool	40.6	56.7	45.1	6.7

the one hand, but on the other hand due to nutritional effect it should decrease. The ultimate result is that there is no marked change of fibre and medulla diameters of the middle portion. As regards the root-end, the temperature in this period of growth is the lowest. As plenty of nutrition is available to the sheep during this period, the effect of nutrition seems to be dominant which has resulted in an increase in fibre as well as medulla diameter. However, the reason for the observation that the fibre and medulla diameters of the middle part of some fibres (Table 3) in the back portion are greater, may be that the back

TABLE 3. THICKNESS OF FIBRE AND MEDULLA DIAMETER OF ROOT, MIDDLE AND TIP PORTION OF MEDULLATED FIBRE OF BACK PART OF HASHTNAGRI FLEECE.

Fibre no.	Root (dia)		Middle (dia)		Tip (dia)	
	Fibre	Medulla	Fibre	Medulla	Fibre	Medulla
1	89.8	80.8	76.6	67.2	53.2	39.8
2	83.6	71.2	78.2	72.4	57.4	45.0
3	80.5	71.7	72.8	62.4	66.5	56.0
4	77.6	67.6	74.6	65.4	56.3	42.9
5	74.4	67.6	78.2	70.0	55.4	42.6
6	67.6	55.6	83.1	72.4	53.3	35.0
7	62.6	54.0	82.8	72.6	52.4	36.2
8	61.4	48.9	71.1	60.0	61.3	47.5
9	60.6	47.4	70.0	61.5	53.2	34.2
1	57.6	46.6	72.4	62.0	53.2	41.0
Mean	71.5	61.1	76.0	66.6	56.2	42.0

TABLE 4. COEFFICIENT OF VARIATION OF FIBRE DIAMETER AND MEDULLA DIAMETER OF WHOLE FIBRE, ROOT, MIDDLE AND TIP PORTION OF MEDULLATED FIBRES OF HASHTNAGRI FLEECE.

parts	Whole fibre		Root		Middle		Tip	
	Fibre dia.	C.V. (%)	Fibre dia.	C.V. (%)	Fibre dia.	C.V. (%)	Fibre dia.	C.V. (%)
Back wool	20.6	18.1	20.8	9.0	21.0	13.0	20.0	18.1
Body wool	25.6	15.3	25.6	12.0	26.2	12.0	25.4	12.0
Belly wool	19.4	14.2	19.8	10.0	19.2	10.0	19.4	14.2
Shoulder wool	26.0	11.1	25.4	7.7	26.0	7.7	26.6	11.1
Neck wool	16.6	17.6	17.0	11.1	16.4	5.8	16.2	12.5
Britch wool	27.0	18.5	26.2	11.1	27.2	5.3	27.8	11.5

TABLE 5. COEFFICIENT OF VARAITION OF FIBRE DIAMETER AND MEDULLA DIAMETER OF WHOLE FIBRE, ROOT, MIDDLE AND TIP PORTION OF MEDULLATED FIBRES OF HASHTNAGRI FLEECE.

Parts	Whole fibre (dia)		Root (dia)		Middle (dia)		Tip (dia)	
	Fibre	Medulla	Fibre	Medulla	Fibre	Medulla	Fibre	Meddulla
Back wool	17.7	26.1	9.2	9.6	7.3	8.8	10.3	17.2
Body wool	17.6	23.6	6.4	7.5	6.5	7.8	9.9	15.5
Belly wool	19.9	34.4	11.0	12.2	12.2	18.5	16.5	26.4
Shoulder wool	24.2	50.0	14.2	22.2	11.0	17.4	14.8	30.2
Neck wool	31.9	53.4	11.4	12.9	1.6	22.7	13.0	35.4
Britch wool	24.1	61.6	9.6	11.2	13.0	18.6	7.3	26.

TABLE 6. MAXIMUM AND MINIMUM (F) TEMPERATURE FROM THE PERIOD 15TH APRIL - 15TH OCTOBER 1970, WITH SUB-PERIOD; CORRESPONDING TO THE GROWTH OE TIP, MIDDLE AND ROOT PORTIONS.

Portion	Period		Min temp (F)	Max. temp (F)
Tip	15	30 April	65.5	93.0
	1	15 May	70.1	96.8
	16	31 May	75.4	103.5
	1	15 June	79.2	105.1
Middle	16	30 June	82.4	105.6
	1	15 July	80.3	101.6
	1	31 July	80.1	101.0
	1	15 August	79.8	98.9
Root	16	31 August	80.0	95.1
	1	15 September	77.3	92.1
	16	30 September	70.2	93.2
	1	15 October	69.0	90.9

portion is more exposed to the sun rays and so in this case the effect of climatic conditions may be dominant.

Conclusion

Variations in fibre diameter and medulla diameter exist along the length of the fibre in medullated wool. The fibre and medulla diameter decrease from root to tip-end, in all the portions except the wool from the back portion. In the back portion some of the fibres of the middle portion have higher fibre and medulla diameter but others have lower. However, there is no or little varition in diameter of true wool which is in conformity with earlier work.

The C.V. (%) of the medulla is greater than that of the fibre diameter for the whole fibre, root, middle and tip portions. In the middle portion the C.V(%) is lower than that of the root and tip-end. The C.V.(%) in true wool is of the same order as that of medullated fibre but the variations are less.

In the shoulder, neck and britch portions, the medulla narrows to a stage that it almost becomes a true fibre. This happens in the tip portion only. The transition from continuous to fragmental medulla occurs at about 35μ.

The increase in fibre and medulla diameter of the root-end may be due to the effect of nutrition.

The abnormal behaviour of some wool fibres in the middle portion of the back wool may be due to the predominant effect of temperature.

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