SAMPLING FROM FLEECES FOR ASSESSMENT OF WOOL QUALITY

By

B. MARUTIRAM*, U.G. NADKARNI AND T.B. JAIN

I.A.S.R.I., New Delhi-110 012

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SUMMARY

The variations in the quality of wool within a fleece and between fleeces of sheep present considerable difficulties in getting a representative sample for estimating the mean of any quality character. In this paper, the results based on the studies made at I.A.S.R.I. on the regional sampling procedure and three composite sampling procedures to get an estimate of a fleece character are discussed. The sample-sizes for regional sampling and composite sampling procedures with 5 per cent standard error of the mean are given for the two important characters *viz.*, fibre diameter and crimps/cm.

1. INTRODUCTION

Indian wools, in general, have great variation in quality characters due to differences among breeds and between regions within a sheep. These variations present considerable difficulties in getting a representative sample for estimating the mean of any quality character. Another difficulty felt in sampling is the major physical source of bias, *viz.*, the natural tendency on the part of the sampler to draw longer or finer fibres more oftener than shorter or coarser ones. A method of sampling which would give an unbiased and efficient estimate is, therefore, to be forged.

An earlier study (1955) conducted at Sheep Breeding and Wool Research Laboratory, Poona was confined to only 6 pure-bred Deccani and 6 cross-bred sheep. Even though the above work yielded sufficient data on sampling from fleeces for assessment of the quality of individual sheep, it did not provide very dependable information on the magnitude of variation between sheep and within

* Present address : Asstt. Director General (Statistics), P & T Directorate, Dak Tar Bhavan, New Delhi-110 001.

region (on the body of sheep). As the quality characters were found to vary over regions, it was mentioned by Seth and Amble (1958) that proper weightages need to be given while getting the estimates of the quality characters for a sheep. The object of this study undertaken is to standardise the procedure of sampling for assessing wool quality of a single fleece as well as that of fleeces from a group of sheep so as to provide a basis for all scientific studies on fleece quality.

In pursuance of this objective, data collected on various quality characters of a single fleece *viz.*, fibre-diameter, crimps/cm, fibre-length, staple-length, medullation percentage and fleece density of different pure-breds and crosses of sheep have been statistically analysed. The results of this study are discussed in the following paragraphs.

2. Sampling Plans

In all, four sampling plans were tried for getting a representative sample, one regional and three composite.

(*i*) As per regional sampling plan twenty four ewes of each breed or type were selected at random from the available stock of two or four teeth age groups, in equal numbers for both age groups, except for Chokla breed where number of ewes for 2 and 4 teeth age groups were 10 and 12 respectively. The six anatomical regions, *viz.*, neck, shoulder, side, back, britch and wither were demarcated on both sides of each selected sheep.

On one side, selected at random, twenty locations each of side 1 cm. were selected in such a way that there were at least two locations in each region and at the same time the 20 locations were well-spread over the length and breadth of the half fleece so as to cover the entire area. The samples from an area of 1 sq. cm. were shorn from each of the 20 locations. Each of these samples is called a 'cut'. Two samples of approximately 100 fibres were drawn at random from one randomly selected cut from each of the regions. Further, one bunch of approximately 100 fibres, was drawn from each of the 14 remaining cuts. The total number of sub-samples per sheep were thus 26.

The number of cuts taken from neck, shoulder, side, back, britch and wither regions of both age groups were 2, 4, 4, 4, 4 and 2 respectively at Tamil Nadu and 2, 4, 5, 4, 3 and 2 respectively in the case of cowes at Rajasthan.

In addition to these 26 sub-samples obtained by regional sampling, two composite samples by each of the following three

methods were also drawn from the side other than the one utilised for obtaining regional samples.

(*ii*) **Method I :** A net was put on the anlmal and locks of wool were taken out at random from all the regions, except britch, the number of locks being proportional to the amount of wool grown in that region.

(*iii*) **Method II :** After drawing the samples by the above method, the wool for each region was clipped separately and cleaned wool yield was spread on the table and a quadrant placed on it. Bunches of fibres were picked up at random as per method stipulated by the I.S.I. (raw wool standard).

(*iv*) **Method III :** The wool from the entire fleece was mixed together and subjected to the process of halving, one-half being discarded at random till a small sub-sample of about 1 gm. was obtained.

Besides these sampling procedures used for estimating averages, the prevailing procedure of taking one sample per sheep from the mid-side region alone for estimating the mean was also adopted. This was done for only Chokla and Polworth × Rampur Bushair crosses.

The method of determination of various attributes were those stipulated in I.S.I. standards for determination of wool quality.

3. Experimental Data

As per sampling plan 26 sub-samples per ewe were obtained from each of 12 ewes of 2 teeth and of 4 teeth age groups of Nilgiri and Nilgiri × Romney Marsh sheep maintained at Sheep Breeding Research Station, Kamrajsagar, Ootacamund and also from village flocks of Nilgiri sheep. Similarly from each of 10 ewes of 2 teeth age group and from 12 ewes of 4 teeth age group of Chokla breed maintained at C.S.W.R.I., Avika Nagar, Rajasthan and from 12 ewes from both age groups separately of Polworth × Rampur Bushair maintained at Pashulok, Uttar Pradesh, 26-sub-samples were obtained through the technique explained above. Also two composite samples one by each method were obtained for each of these sheep. The samples for Nilgiri and Nilgiri × Romney Marsh Crosses were analysed at the Wool Analysis Laboratory at Kamrajsagar, Ootacamund and of Chokla and Polworth × Rampur Bushair Crosses at C.S.W.R I., Avika Nagar for different characters. Fleece density (only for regional samples) was also calculated for each sheep by the usual method.

4. Procedure For Sample Size

It was found from the analysis of variance that, for some breeds in one or both age groups, region to region variation was significantly high for some characters. This entailed determination of sample sizes for each region separately. In the field, however, the quality of a fleece is being determined for a fleece as a whole and therefore in the following paragraphs the sample sizes are obtained by considering overall averages obtained from regional sampling.

The sample sizes were obtained from the formula for the estimate of average value of each character. Suitable estimates were devised first to get a consistent estimate. Overall average values of different characters by regional sampling were obtained separately by—

(*i*) Without weighting the regional values.

(*ii*) Weighting regional averages by estimated number of fibres in each region.

(*iii*) Weighting with regional wool yield the regional averages.

(*iv*) Considering each region as a stratum.

As these estimates did not differ much from each other in mean and coefficient of variation, expression (vide ref. 1970, 1973) under method (*iii*) was used for estimating sample sizes.

Also as the analysis of variance of composite samples did not show any significant variation over between methods component, the sample sizes were estimated by that method for which the coefficient of variation was least.

(*a*) *Regional sampling* : The number of sheep to be selected to estimate the mean with desired degree of accuracy was obtained by using the formula

$$n=\frac{s_b'^2+\frac{1}{N}\sum_{i=1}^{n}\frac{M_i^2}{\frac{\Lambda^2}{M}}\left(\frac{1}{m_i}-\frac{1}{M_i}\right)s_i'^2}{(0.05\bar{y}_w)^2+\frac{s'^2_b}{N}}$$

wherein :

N=number of sheep in the population.

n=number of sheep to be randomly selected.

M_{ij}=total number of cuts in jth region in ith sheep (estimated by total wool weights upon mean wool weight per cut).

m_{ij}=number of cuts taken in jth region in ith sheep.

y_{ijk}=value of quality character in kth cut in jth region of ith sheep.

w_{ij}=wool yield of the jth region in ith sheep

$$w_i = \sum_{j=1}^{6} w_{ij} = \text{wool yield of } i\text{th sheep} \; ; \; w'_{ij} = \frac{w_{ij}}{w_i}$$

$$M_i = \sum_{j=1}^{6} M_{ij} \; ; \; m_i = \sum_{j=1}^{6} m_{ij} \; ; \; \bar{M} = \frac{1}{N} \sum_{i=1}^{N} M_i \; ; \; \hat{\bar{M}} = \frac{1}{n} \sum_{i=1}^{n} M_i$$

$$\bar{y}_{i(m_i)} = \sum_{j=1}^{6} w'_{ij} \bar{y}_{ij} \; ; \; \bar{y}_w = \frac{\sum_{i=1}^{n} M_i \bar{y}_{i(m_i)}}{\sum_{i=1}^{n} M_i} \; , \; \bar{y}_{ij} = \frac{\sum_{k=1}^{m_{ij}} y_{ijk}}{m_{ij}}$$

$$s_b'^2 = \frac{1}{(n-1)} \sum_{i=1}^{n} \frac{M_i^2}{\hat{\bar{M}}^2} (\bar{y}_{i(mi)} - \bar{y}_w)^2$$

$$s_i'^2 = \sum_{j=1}^{6} s_{ij}'^2 \; w_{ij}'^2 \text{ and}$$

$$s_{ij}'^2 = \frac{1}{(m_{ij}-1)} \sum_{k=1}^{m_{ij}} (y_{ijk} - \bar{y}_{j(mi)})^2$$

The bias in the variance due to the estimated values of M_{ij} is assumed to be negligible.

The number of sheep to be sampled were calculated for 5%, 2% and 1% levels of S.E. of mean separately for different flock-sizes ranging from 20 to 500 with 20 cuts per sheep. Also for observed flock-sizes these were estimated with 6 and 18 cuts per sheep.

(*b*) *Composite sampling* : The number of sheep to be sampled were obtained for different flock sizes ranging from 20 to 500 with 2 sub-samples per composite sample and also for observed flock-sizes with 2 and 4 sub-samples per composite sample by the formula.

$$n = \frac{s_b^2}{(0.05\,\bar{y}_c)^2 + \frac{s_b^2}{N} - \frac{1}{mN}\,\bar{s}_w^2}$$

wherein

M=total number of composite samples per sheep (very large),

m=number of composite samples per sheep=2,

y_{ij}=value of quality character in jth sample in ith sheep.

$$\bar{y}_c = \frac{1}{mn}\sum_{i=1}^{n}\sum_{j=1}^{m} y_{ij} \; ; \quad \bar{y}_i = \frac{1}{m}\sum_{j=1}^{m} y_{ij}$$

$$\bar{s}_w^2 = \frac{\sum_{i=1}^{n} s_i^2}{n}$$

$$s_i^2 = \frac{1}{(m-1)}\sum_{j=1}^{m}(y_{ij} - \bar{y}_i)^2$$

$$s_b^2 = \frac{1}{(n-1)}\left[\sum_{i=1}^{n}\bar{y}_i^2 - n\bar{y}_c^2\right]$$

5. Comparison Of Sampling Procedures

It is found from earlier studies (1968) that coefficient of correlation between medullation percentage and fibre diameter was very high and fibre diameter and crimps per cm. are the important characters which determine the quality of a fleece. In the following paragraph, therefore, the sample sizes for only these two characters are discussed.

Tables 1 and 2 give the averages of fibre-diameter and crimps per cm. obtained by each of the sampling procedures, for ewes of both age groups of each breed. The tables show that there is no uniformly efficient sampling procedure for all the breeds and age classes, as judged by the estimated values of C.V. The reduction in C.V. of fibre diameter was considerable due to regional sampling in four teeth farm flocks of Nilgiri, Nilgiri × Romney Marsh and Chokla breeds. In the case of crimps/cm. such a reduction was large in both age groups of Nilgiri farm flocks, in two teeth age group of Nilgiri × Romney Marsh and in four teeth age group of Nilgiri village flock. For both these characters the estimates built on using regions as strata at the second stage of selection of cuts were of the same order as other overall averages and did not show any significant reduction in C.V. (vide ref. 1973).

Out of 20 cases, in 11 cases C.V. by regional sampling was less than that due to composite sampling. The difference was less than 1% in 7 cases, between 1 to 2 per cent in 3 cases and between 2 to 3 per cent in one case. This indicates that gain due to regional sampling was not of a very high order, if region to region variation is to be

TABLE 1

Average values of fibre diameter (in microns) with their standard errors

Source	*Breed*	*Age group*	*Overall regional*		*Composite Method*			*From mid-side region cut*
					I	*II*	*III*	
Farm flocks	Nilgiri	2-teeth	Av.	24.36	24.26	24.91	25.66	
			S.E.	0.820	0.882	0.848	0.811	
			C.V.	3.37	3.63	3.40	3.16	
		4-teeth	Av.	25.45	25.06	26.74	26.04	
			S.E.	0.417	0.518	0.824	0.749	
			C.V.	1.64	2.07	3.08	2.88	
Farm flocks	Nilgiri × Romney Marsh	2-teeth	Av.	25.09	25.06	26.03	26.15	
			S.E.	0.454	0.554	0.486	0.500	
			C.V.	1.81	2.21	1.87	1.91	
		4-teeth	Av.	25.28	25.12	25.85	26.52	
			S.E.	0.216	0.332	0.361	0.334	
			C.V.	0.85	1.32	1.40	1.26	
Village flocks	Nilgiri	2-teeth	Av.	25.73	24.34	24.92	25.22	
			S.E.	0.516	0.485	0.476	0.496	
			C,V.	2.00	1.99	1.91	1.97	
		4-teeth	Av.	28.47	29.54	29.60	29.56	
			S.E.	0.795	0.283	0.360	0.183	
			C.V.	2.79	0.96	1.22	0.62	
Farm flocks	Chokla	2-teeth	Av.	31.50	30.38	32.45	32.14	29.73
			S.E.	0.764	0.623	0.780	0.873	0.788
			C.V.	2.42	2.05	2.40	2.72	2.65
		4-teeth	Av.	30.55	29.04	32.23	30.86	28.73
			S.E.	0.538	0.690	1.034	0.754	0.511
			C.V.	1.76	2.38	3.21	2.44	1.78
Farm flocks	Polworth × Rampur Bushair	2-teeth	Av.	19.71	18.57	20.56	20.82	19.81
			S.E.	0.309	0.336	0.462	0.438	0.384
			C.V.	1.57	1.81	2.25	2.10	1.94
		4-teeth	Av.	24.06	21.43	23.16	21.31	23.71
			S.E.	0.731	0.625	0.700	0.516	0.859
			C.V.	3.04	2.92	3.02	2.42	3.62

TABLE 2

Average values of crimps per cm. with their standard errors

Source	*Breed*	*Age group*	*Overall regional*		*Composite Methods*			*From mid-side region cut*
					I	*II*	*III*	
Farm flocks	Nilgiri	2-teeth	Av.	2.08	1.88	1.92	1.92	
			S.E.	0.077	0.109	0.103	0.103	
			C.V.	3.70	5.80	5.36	5.36	
		4-teeth	Av.	2.10	2.07	2.01	2.03	
			S.E.	0.121	0.165	0.167	0.169	
			C.V.	5.76	7.97	6.31	8.32	
Farm flocks	Nilgiri × Romney Marsh	2-teeth	Av.	1.61	1.47	1.50	1.40	
			S.E.	0.040	0.059	0.060	0.049	
			C.V.	2.48	4.01	4.00	3.50	
		4-teeth	Av.	1.54	1.42	1.42	1.43	
			S.E.	0.035	0.044	0.041	0.037	
			C.V.	2.27	3.10	2.89	2.59	
Village flocks	Nilgiri	2-teeth	Av.	1.75	1.86	1.70	1.66	
			S.E.	0.056	0.061	0.055	0.047	
			C.V.	3.20	3.28	3.23	2.83	
		4-teeth	Av.	1.98	1.94	1.94	1.82	
			S.E.	0.084	0.117	0.118	0.102	
			C.V.	4.24	6.03	6.08	5.60	
Farm flocks	Chokla	2-teeth	Av.	2.19	2.06	1.81	1.71	2.17
			S.E.	0.130	0.105	0.065	0.070	0.146
			C.V.	5.94	5.10	3.59	4.09	6.73
		4-teeth	Av.	1.45	1.77	1.61	1.55	1.50
			S.E.	0.050	0.084	0.069	0.056	0.065
			C.V.	3.45	4.74	4.28	3.61	4.33
Farm flocks	Polworth × Rampur Bushair	2-teeth	Av.	3.79	3.33	3.12	3.11	3.85
			S.E.	0.169	0.150	0.135	0.122	0.273
			C.V.	4.46	4.50	4.33	3.92	7.09
		4-teeth	Av.	2.99	2.95	2.68	2.63	3 07
			S.E.	0.144	0.144	0.129	0.123	0.140
			C.V.	4.82	4.88	4.81	4.68	4.56

ignored while considering the quality. The fleece is generally taken as a whole in manufacturing process. The composite sampling procedure is, therefore, preferred for objective reasons in sampling from a fleece. From the estimates based on mid-side region cuts for Chokla and Polworth × Rampur Bushair, it was observed that C.V. by this method was small and comparable with that due to other methods and the difference exceeded 3 per cent only in the case of crimps/cm. for sheep of 2 teeth age group of Polworth × Rampur Bushair. The method of composite sampling which is based on well mixing of the material to make it homogeneous is more representative, sound and economic than regional sampling. From the physiological angle mid-side region cut may not be representative. It may also be noted that C.V. for fibre-diameter was smaller than those for crimps/cm. in all cases and consequently the sample sizes required for crimps/cm. were larger than those required for fibre-diameter.

6. Number of Sheep to be Selected

In the following paragraphs sample sizes for 5% standard error of the mean alone are discussed. Since fibre-diameter and crimps per centimeter are important quality characters, the discussion is confined to only these two characters.

(*A*) Regional Sampling : (*i*) *Nilgiri and Nilgiri × Romney Marsh.*

As the number of sheep to be selected did not differ over the flock size, the estimated sizes are given for each breed only in Table 3.

TABLE 3

Number of Nilgiri and Nilgiri × Romney Marsh Sheep (for all flock sizes)

	Nilgiri		*Nilgiri × Romney Marsh*		*Nilgiri (Village)*	
	Fibre diameter	*Crimps/ cm.*	*Fibre diameter*	*Crimps/cm*	*Fibre diameter*	*Crimps/ cm.*
2-teeth	7	8	3	5	2	6
4-teeth	2	18	1	5	4	10

The number of sheep required are less for fibre-diameter than for crimps/cm. and that required for Nilgiri are more than those required for Nilgiri × Romney Marsh.

For observed flock strength, the number of sheep required to estimate mean fibre-diameter by taking 6 and 18 cuts per sheep were same for each age group *viz.*, 6 and 2 for Nilgiri, 3 and 1 for Nilgiri × Romney Marsh farm flocks and 2 and 3 for Nilgiri village flock. In the case of crimps/cm. these were as in Table 4.

TABLE 4

Number of Nilgiri and Nilgiri × Romney Marsh sheep for crimps/cm. (observed flock size)

	Nilgiri		*Nilgiri × Romney Marsh*		*Nilgiri (Village)*	
Age group \ No. of cuts/ region	1	3	1	3	1	3
2-teeth	8	7	6	4	6	5
4-teeth	15	15	5	4	10	9

Though the number of sheep to be selected were of the same order for 1 cut and 3 cuts per region, those required for Nilgiri breed were more than those required for Nilgiri × Romney Marsh.

(*ii*) *Chokla and Polworth × Rampur Bushair.*

As in the case of Nilgiri sheep, the number of sheep required to be selected for fibre-diameter remained constant over flock size. These were 5 and 4 for Chokla breed and 2 and 8 for Polworth × Rampur Bushair for the two age groups respectively. In the case of crimps/cm., however, the number to be selected did vary with flock size and are given in table 5.

TABLE 5

Number of Chokla and Polworth × Rampur Bushair sheep for crimps/cm. (for different flock sizes)

Breed	*Age group*	*No. of sheep per flock*								
		20	*40*	*60*	*80*	*100*	*200*	*300*	*400*	*500*
Chokla	2-teeth	12	18	21	23	24	27	29	29	30
	4-teeth	8	10	11	12	13	13	13	13	13
Polworth ×	2-teeth	10	13	14	15	16	17	17	18	18
Rampur Bushair	4-teeth	10	14	16	17	18	19	20	20	20

Though the number of sheep for flock size of 20 differ widely from those rcquired for flock size of 500, the sample size remains almost constant for larger flock sizes.

For observed flock-strength of Chokla sheep the number required were 9 and 7 for 6 cuts per sheep for the two agc groups respectively and were 4 and 3 for 18 cuts per sheep. In the case of Polworth × Rampur Bushair the required number of sheep were 3 and 7 with 6 cuts while it was 2 and 7 when 18 cuts per sheep were taken.

(*B*) **Composite Sampling :** (*i*) *Nilgiri and Nilgiri × Romney Marsh.*

It was found that in the case of fibre-diameter, C.V. was least under III composite sampling method in 2 teeth sheep of Nilgiri farm flocks, 4 teeth sheep of Nilgiri × Romncy Marsh farm flocks and Nilgiri village flocks. Whereas C.V. was least by I method in 4 teeth Nilgiri farm flocks and by II method in 2 teeth age group of Nilgiri × Romney Marsh farm flocks and in Nilgiri village flocks. In the case of crimps/cm., III method gave least C.V. in all cases except in 4 teeth Nilgiri farm flocks, wherein I method was the best.

The number of sheep required for fibre-diameter did not differ over flock size and are given in table 6 for the two age groups.

TABLE 6

Number of sheep of Nilgiri and Nilgiri × Romney Marsh sheep for fibre diameter (for all flock sizes)

Age group	*Farm flocks*		*Village flocks*
	Nilgiri	*Nilgiri × Romney Marsh*	*Nilgiri*
2-teeth	6	3	2
4-teeth	2	1	1

In the case of crimps/cm. the sample sizes varied over the flock strength and are given in Table 7,

TABLE 7

Number of sheep of Nilgiri and Nilgiri and Nilgiri × Romney Marsh sheep for crimps/cm. (for different flock sizes)

	Age group	No. of sheep per flock								
		20	*40*	*60*	*80*	*100*	*200*	*300*	*400*	*500*
Farm flock	Nilgiri 2-teeth	10	13	14	15	16	17	17	18	18
	4-teeth	13	19	23	26	28	32	34	35	35
	Nilgiri × Romney Marsh 2-teeth	6	8	8	9	9	9	9	9	9
	4-teeth	5	6	6	6	6	6	6	6	6
Village flock	Nilgiri 2-teeth	4	4	4	4	4	4	4	4	4
	4-teeth	9	12	14	15	15	16	17	17	17

The number of sheep to be sampled may differ with number of sub-samples taken. These numbers, in the case when two or four sub-samples are taken, were estimated for the observed flock strength in the case of each breed, and are given in table 8.

TABLE 8

Number of Nilgiri and Nilgiri × Romney Marsh sheep for crimps/cm. (observed flock sizes)

	Nilgiri flock				*Nilgiri × Romney Marsh*				*Nilgiri (Village)*			
	Fibre diameter		*Crimps/ cm*		*Fibre diameter*		*Crimps/ cm*		*Fibre diameter*		*Crimps/ cm*	
Sub-Samples	*2*	*4*	*2*	*4*	*2*	*4*	*2*	*4*	*2*	*4*	*2*	*4*
2-teeth	5	3	14	8	2	1	7	4	2	1	4	2
4-teeth	2	1	23	14	1	1	5	3	1	1	14	8

The table shows that, for estimating fibre diameter, a single sheep was sufficient with two or four sub-samples in 4-teeth age group of Nilgiri × Romney Marsh farm flock and Nilgiri village flock and with four sub-samples in the case of Nilgiri farm flock. Only in the case of 2-teeth sheep of Nilgiri farm flock, 5 and 3 sheep were required with 2 and 4 sub-samples per sheep respectively. In all the remaining cases 2 sheep were enough. The number of sheep to be selected for estimating fibre diameter was thus always less than 5. However, it can be seen from the table that the number of sheep required for crimps/cm. ranged from 3 in four teeth age group with 4 sub-samples of Nilgiri × RomneyMarsh to 23 with 2 sub-samples in the same age group of Nilgiri farm flock.

(*ii*) *Chokla and Polworth × Rampur Bushair*

In the case of fibre diameter, the first composite sampling method in both age groups of Chokla and in 2-teeth age group of Polworth × Rampur Bushair gave least C.V. and the III method in 4-teeth age group of Polworth × Rampur Bushair. In the case of crimps/cm. the III method gave least C.V. in both the age groups of Polworth × Rampur Bushair and 4-teeth age group of Chokla breed. The II method gave the least C.V. in the case of 2-teeth age group of Chokla.

The estimated number of sheep to be selected for fibre-diameter did not vary over the flock size. These were 5 and 4 for the two age groups of Chokla breed and 2 and 8 respectively of Polworth × Rampur Bushair. In the case of crimps/cm. however, the sample sizes did not remain constant in all cases. These sample sizes are given in table 9.

TABLE 9

Number of sheep of Chokla and Polworth × Rampur Bushair sheep (for different flock sizes)

Age group		*No. of sheep per flock*								
		20	*40*	*60*	*80*	*100*	*200*	*300*	*400*	*500*
Chokla	2-teeth	12	18	21	23	24	27	29	29	30
	4-teeth	8	10	11	12	12	13	13	13	13
Polworth × Rampur-	2-teeth	10	13	14	15	16	17	17	18	18
Bushair	4-teeth	10	14	14	17	18	19	20	20	20

It is seen that in 4 teeth age group, as the flock size increases the sample size gradually reaches a constant value.

It is found that the number of sheep required by regional sampling were more than those required by composite sampling in all the cases. For observed flock size the number of sheep required to be selected with 2 and 4 sub-samples are as in table 10.

TABLE 10

Number of Chokla and Polworth × Rampur Bushair sheep (observed flock sizes)

Sub-samples	*Chokla*				*Polworth × Rampur Bushair*			
	Fibre diameter		*Crimps/cm*		*Fibre diameter*		*Crimps/cm*	
	2	*4*	*2*	*4*	*2*	*4*	*2*	*4*
2-teeth	2	1	6	4	1	1	9	5
4-teeth	4	2	8	5	4	2	11	5

As in earlier cases, the number of sheep required to be selected for crimps/cm. is considerable more than that for fibre diameter. It can be seen that, except in the case of sheep of 4 teeth age group of Polworth × Rampur Bushair for crimps/cm., the total number of samples to be analysed by increasing the number of sub-samples to four is always greater than or atmost equal to those when two sub-samples are taken. This indicates that increasing the number of sub-samples is not economical.

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