SPACE AND TIME RELATIONS IN THE COAT OF THE NEW ZEALAND ROMNEY LAMB.

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A.

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B.

The Prenatal Development of the Coat of the Romney Lamb.

C.

Relative Abundance of Fibres of the Halo-Sickle Group on Different Body regions.

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SECTION A :

THE DISTRIBUTION OF THE FIBRE TYPE ARRAYS OVER THE BODY OF THE NEW ZEALAND ROMNEY LAMB.

INTRODUCTION:

In a recent paper Dry (4) gives an account of the fibre type arrays - the result of an action of two forces - the prenatal check and the reducing of inherent coarseness acting on an undefined substratum which occur on the back (4) of the New Zealand Romney Lamb.

Preliminary observations by Dr. Dry and myself suggested that orderly relations existed between the fibre type arrays on the back and britch positions. These observations were extended and a comparative study of the fibre type arrays occurring over the dorsal and dorso-lateral portions of the coat of the Romney Lamb has been made. Their distribution, as one was prepared to find, has proved orderly.

Following naturally on this investigation came a study of the proportions of precurly-tip to curly-tip and histerotrich fibres.

MATERIAL AND METHODS.

The Romney Lambs used for this work were fifteen of Dry's (5) experimental animals. For the purpose of general comparison four Southdown and four Ryeland lambs from the Massey Agricultural College stud flocks were sampled in the same way as the Romney lambs. Numerous odd samples were taken casually from a greater number of Romney, Southdown and Ryeland lambs.

Samples were taken from the following positions and were conveniently named :- see Fig. 2.

(1) Poll — on the mid-dorsal line between the ear and horn positions.

(2) Neck base — on the mid-dorsal line dorsal to the point of the shoulder.

(3) Shoulder point — on the point of the right shoulder bone

(4). Withers: on the mid-dorsal line level with the fifth rib.

(5). Fifth Rib. on the right fifth rib, ventro-lateral to the withers in a line with the lateral aspect of the shoulder point and superior to the elbow.

(6) Elbow. on the elbow joint of the right forelimb.

(7) Back: on the mid-dorsal line level with the last rib.

(8) Side: on the right side, ventro-lateral to the back at the distal end of the last rib.

(9) Superior ileum. on the mid-dorsal line at the superior angle of the ileum.

(10). Thurl: on the junction of the femur and pelvic bones (acetabulum) and ventro-lateral to the superior angle of the ileum.

(11). Superior flank: Midway and slightly anterior to an imaginary line drawn between stifle and thurl.

(12). Britch: immediately posterior to the stifle joint and midway across the thigh.

Note that only dorsal and dorso-lateral positions have been regularly studied. Odd samples have, however, been taken from the positions on the mid-ventral line. These positions were the brisket and on the mid-ventral line level with the shoulder point position - named ventral neck position.

The gradients figured do not take these samples into account but it may be mentioned that from the observations made it appeared that an array on the mid-ventral line was a little more depressed - that is a little more severely checked - than an array on the mid-dorsal line in the corresponding positions.

In reference to the dorsal and dorso-lateral portions of the coat - samples were not taken from all of the positions shown on Fig. 2 for every animal, for from preliminary examinations, it was found that britch, superior ileum, back, side, withers, shoulder point, and poll samples were sufficient to show the orderliness of distribution and the gradient of the depression on most sheep. From a few sheep ~~had~~ samples were taken from all the positions figured.

The method of examining samples was simple ; the fibre tips were protected from the weather by coats of water-proof material (3) the lambs being covered before the halo-hairs commenced shedding.

Samples were taken from the positions figured and were stored in envelopes to be sorted in the laboratory on pieces if black velvet. Blunt tipped forceps with a good grip were used for sorting the samples.

THE DISTRIBUTION OF THE FIBRE TYPE ARRAYS:

Before giving an account of the distribution of the fibre type arrays it is necessary to describe an array that so far has not been found on the back.

Escarpment: A New Fibre-Type Array:

Figure 1.

This new array is, on the one hand, similar to the Plateau array in that it has no sickle-fibres and has coarse halo-and sub-halo hairs and super-sickle fibres; on the other hand, however, it is closely akin to the Plain array in that immediately following along the array it has fine super-sickle-fibres succeeded by fine checked curly-tip ones; these checked curly-tip fibres are succeeded along the series by curly tip fibres exhibiting ~~no~~ no increase in coarseness. This array therefore has no coarse curly-tip fibres and the only transition from early to late fibres is by way of the fine super-sickle and checked curly-tip fibres to the fine curly-tip ones of the series. Compare Fig. 1 with the Plateau and Plain arrays of Dry (4).

To date an Escarpment array has only once been found on any position other than the poll - this was on the britch of a very dense Romney. From this animal only britch and back samples were preserved; the array on the back was Plain.

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than the most depressed Plain array. It is also not unlike a Plateau array in which the precipice is unusually early.

Toldt (13) describes three forms of hairs - Leithaare - Grannenhaare and Wollhaare as present in a typical coat - the types not being sharply separated from one another but the forms are distinct and do not grade into one another.

Dry (2) working on the coat of the mouse found that on the back there are no transitional fibres connecting the Zigzags and Hairlets. Transitional fibres do occur between Zigzags and Auchenes but are not plentiful. This absence of all transitional fibres between Zigzags and Hairlets further suggests that "breaks" may be of usual occurrence in Mammalian coats.

In the sheep in some arrays we find a precipice occurring in the curly-tips. Precipice is the term given to the sudden change along the array from coarse to fine curly-tip fibres without intermediate fibres.

We may suppose therefore that the precipice in the array in the coat of the sheep may be correlated with the "break" between Zigzags and Hairlets in the mouse coat of Dry (2) and with the lack of connecting fibres referred to by Toldt (13).

Further, when we consider the small number of transitional fibres connecting different fibre types it is not unreasonable to suppose that these connecting fibres are incidental to the main fibre types and may be due to the development of a comparatively small number of follicles being either accelerated or delayed. This lack of transitional fibres has been noticed particularly between the halo-hairs and super-sickle fibres in most arrays and between the small-ended sickle-fibres and the curly-tips of Ravine arrays.

To allow for such "breaks" between fibre types we must assume that the development of the coat takes place in a series of "jerks". Prenatal observations suggests that such may be the case - "breaks" occurring between the trio stage

and the first follicles and between the trio and nine stages. It is possible that other smaller "breaks" may occur, for example between the trioing of the X and the trioing of the Y follicles. It must be remembered, however, that there are additional follicles coming in all the time.

If such breaks be of usual occurrence the interpretation of the Escarpment array may be that in the Escarpment there is a break between the super-sickle and curly-tip fibres - such a break being analogous if not homologous with the "precipice" of other arrays - and may be due to either a period when no follicles are laid down or to delayed growth of a follicle laid down or to differences in follicle arrangement.

The overlapping of the two forces - the prenatal check and the reduction of inherent coarseness at the precipice - will prevent the later portion of the array becoming coarse.

Thus we may account for the Escarpment Array as being due to a prenatal check acting upon the early fibres, a break analogous to the precipice followed by an overlapping of the two forces, the prenatal check and the reduction of inherent coarseness, causing all fibres later than the precipice to be fine.

The Fibre Type Arrays:

Before describing the distribution of the arrays it is necessary to state that the variation in the arrays is due to the action of two variables (a) the intensity of the pre-natal check and (b) the reducing of inherent coarseness. The result of this action of variables is termed a depression. When it is considered that each of these variables can differ considerably in its time of onset, its period of duration and its intensity, it is not unlikely that one will find variation in the fibre type arrays occurring on different animals. Dry (4) finds considerable variation from sheep to sheep in arrays occurring on the back. This action of forces, as far as can now be judged, is a local phenomenon (4). This point is discussed on p. 16 but it is useful to note here

that fibre type arrays vary from position to position on the same animal, thus supporting this theory.

Dry (5) found the fibre type arrays naturally fell into the following order :

Plateau least depressed.
Saddle
Ravine
Valley
Plain and Escarpment - most depressed.

This order is due to the changes in intensity of the prenatal check and the extent of the reducing of the inherent coarseness. In the Plateau array the prenatal check is very nearly if not entirely non-existent. The noticeable effects of the reduction of inherent coarseness ~~do~~ are not ~~take place~~ apparent till about half way along the curly tip portion of the array . The precipice does, however, vary from position to position; this is discussed elsewhere. The Saddle array is due to a non-intense pre-natal check and a late reduction of inherent coarseness. This reduction takes place at about the same time in both Saddle and Plateau arrays. The prenatal check in the Ravine array is often intense but is of fairly short duration, there always being a rise in coarseness in the post-ravine sickle-fibres. The reduction in inherent coarseness is still later than the rise in coarseness due to the removal of the prenatal check. In the Valley array the prenatal check is intense and of long duration while the reduction in inherent coarseness more nearly approaches the time when the prenatal check has ceased to function. In the Plain arrays the prenatal check and the reduction in inherent coarseness overlap and there is no increase in coarseness along the array. The Escarpment arrayis similar to the Plain except that it lacks sickle-fibres. Both these arrays have a severe prenatal check but in the Plain array it does not appear that overlapping with the reduction in inherent coarseness takesplace until after the formation of sickle fibres. In the Escarpment the reduction of inherent coarseness is exceptionally early and in conjunction with the prenatal check depressed all follicles later than super-sickle

ones to checked curly-tip ones. It is therefore difficult to say whether the Escarpment is more depressed than the Plain array so they have been considered to be equally affected.

We thus can suggest that the order of the fibre type arrays is due to an increase in the intensity of the prenatal check together with an earlier reduction of the inherent coarseness.

Each of these arrays passes gradually into the next; all variety of arrays intermediate between these arrays have been encountered both from animal to animal and over the same animal.

The Distribution:

As has been stated elsewhere preliminary examinations showed that different fibre type arrays occurred on back and britch positions. It was known that fibre type arrays pass gradually from one to the other - see above. From these two facts it was suspected that all fibre type arrays separating the array on the back from the array on the britch would be encountered somewhere on the area intervening between these two positions. This was found to be true. Further, knowing that the arrays on the back and britch positions differed it was suspected that the arrays on the positions anterior to the back would differ from those on the back; this surmise was also found to be correct. As well as revealing that fibre type arrays on back and britch positions differed the preliminary examination indicated that orderly relations existed between back and britch - the array on the back never being less intensely depressed than the one of the britch.

More detailed work involving the study of the fibre type arrays occurring over the bodies of various Romney lambs demonstrates that orderly variation from position to position is the rule for the distribution of fibre type arrays over the body of the Romney lamb.

See Figs. 3, 4, 5, 6, 7 and Graphs 1, 2, 3, 4, 5, 6, and 7.

This orderliness in variation is mainly due to less depressed arrays being posterior to more depressed ones, though, as explained later, some elaboration of this general statement is required.

From these statements it is apparent that the gradual increase in the depression caused by the action of the prenatal check and the reduction of inherent coarseness from posterior to anterior regions results in a general posterior-anterior, or britch - poll fibre type array gradient.

See Graphs 1, 2, 3, 4, 5, 6 and 7.

Besides the britch-poll gradient there must be kept in mind the subsidiary gradients due to the lessening of the depression as one passes from superior to inferior positions of the dorsal and lateral regions of the coat of the Romney lamb.

See Fig. 3, 4, 5 and Graphs 1, 2, 3, 4, 5, 6 and 7. Returning now to the description of the general gradients we find that these vary in steepness from animal to animal. Fine even coated lambs and their opposites the very coarse coated animals have very slight britch-poll gradients. See Graphs 1 and 2 - Sheep No. 755 and No. 618. Figs. 3 and 4. These two lambs resemble one another in that both exhibit slight britch-poll gradients, but they are unlike in that No. 618 (Graph 2) shows an even gradient due to a heavy depression - the result of intense prenatal checking and early reducing of the inherent coarseness, while No. 755 (Graph 1) has been very slightly affected by the prenatal check and the reducing of inherent coarseness has been comparatively late. These two animals show gradients on different planes; it is necessary to find more varied animals to connect the two planes. These two animals also vary in the evenness of length of the fibres comprising the fibre type array. No. 618 (Graph 2) shows little variation in the length of its fibres as one passes along the array, while No. 755 shows marked variation in fibre length as one passes along

the series - those fibres later than the precipice being very much shorter than the earlier ones.

These two sheep - No. 618 and No. 755 - do not exhibit gradients such as are found in the coats of lambs more typical of the breed but are indicative of the wide extremes of coarseness and fineness occurring in this breed of sheep; they are also indicative of the extremes in fibre type arrays one finds on the sheep intermediate between these two extreme types.

The lambs more typical of the Romney breed have a marked gradient from britch to poll. See Fig. 5 and Graphs 3, 4, 5, 6 and 7. These graphs show general posterior-anterior gradients due to slight depressing on the britch passing to a deep depression on the poll.

To give some idea of the variations in fibre type array found over the body it is now necessary to touch upon the details concerning the distribution of these arrays. It is simpler to describe first the distribution on those lambs more characteristic of the Romney breed.

No. 628 - Graph 3, did not have a poll or base of neck specimen stored but the other samples examined were sufficient to show that a marked posterior-anterior gradient is present. This particular animal was the only lamb of those examined to show a more depressed fibre type array on the back than on the side. All the other animals examined were inclined to be slightly more depressed on the back than on the side but the depression was not sufficiently greater to cause a difference in array. This difference in array between back and side illustrates the inferior-superior fibre type array gradients.

It may be mentioned here that certain lambs showed a higher percentage of medullation on the back than on the side. This is contrary to the results obtained by Elphick (7) when working on older sheep. Here it may be mentioned that in some work of Dry's (5) he finds that medullation is better

sustained basally on the side than on the back; Rudall (11) in his shearing experiments has the same experience.

With Nos. 641, 745 and 638 (Graphs 4, 5, and 7) No. 628 (Graph 3) illustrates the down limb gradients of the inferior-superior gradients mentioned. The hind limb inferior-superior gradient is usually marked but the fore limb one is not so obvious. The elbow position is however usually more severely depressed than the fifth rib and one is able to detect an elbow-wither inferior-superior gradient. The elbow is usually about as intensely depressed as the superior ileum position.

The curly-tip fibres of this sheep were unusual; their tips were very fine and long but basally they showed a marked increase in coarseness, most of the fibres showing some medullation. The average amount of medullation over the body estimated by a method evolved by McMahon of applying the Benzol test was 52 per cent. The positions tested were all those from which samples were taken for the fibre type array gradient work.

Footnote by P. R. McMahon on a method of estimating the medullation revealed in Benzol.

When comparing samples the average percentage of fibre material affected by medullation may be taken as an index of the degree of the hairiness revealed by the Benzol test.

The following technique was evolved to obtain such a figure :

1. The staple is teased out to a standard thickness of 300 fibres to each inch of width by comparison with a standard staple obtained by direct counting.

2. The staple is immersed in benzol and with the aid of a photograph of a lock in benzol spread to the same thickness and shewing zones where 10.....90% of the fibres are medullated, estimations of the percentage fibres affected are made at ¼" intervals.

3. Taking these figures as representative, the average percentage of medullated fibre over the lock is calculated and expressed as one figure.

The technique is slow and cumbersome but has been shown to be reasonably accurate for normal samples of wool. In the case of lambs wool, however, the accuracy is considerably reduced by rapid changes in hairiness from one level in the staple to another, and also by the parallel placing of the fibres which hinders accurate teasing. Differences of 7% would be significant

The second of these more characteristic Romneys to be

described is No. 745 Graph 4. In this lamb the fibre type array on the fifth rib position is more depressed than that on the withers. The actual difference in arrays is however not so marked here as it is between the back and side positions of No. 628, Graph 3. No. 745 was interesting in that there was noticeable variation from array to array in the distance along the series where the precipice came. The precipice was on the whole earlier in No 745 than in most sheep but even so on the anterior regions the precipice occurred noticeably earlier than on posterior ones. This suggests a gradient in the position of the precipice similar to that drawn for the fibre type arrays. The precentage of medullation was high - about 54%.

No. 641 Graph 5, Fig. 5, the next of the more typical Romney lambs figured has a gradient very similar to that of No. 745 (graph 4); the exceptions just mentioned being the outstanding points of difference. This lamb though not so hairy as No. 628 or No. 745 was by no means free of medullation. Medullation was approximately 28 per cent.

The fourth animal of the five lambs graphed as most characteristic of the Romney lambs studied is No. 763, Graph 6. This lamb, with the exception of the britch, is a comparatively fine woolled animal. The britch has coarse early fibres, halo-hairs and super-sickle and curly-tip fibres, which are of the long waving type, but early in the curly-tip fibres there is a sudden change from the coarse long waving fibres to the fine shorter ones of the curly-tip portion of the series. This sudden change - the precipice - was unusually early in this animal. The very fine fibres succeeding such an early precipice were able to be compared with the fine fibres occurring elsewhere on this generally fine coated sheep. Elsewhere the coat was fine and of even length. The medullation percentage was low - about 10 per cent. Graph 6 reveals a steep britch

to thurl gradient while the thurl to poll gradient is slight - Ravine to Plain. The Ravine on the thurl has a very slight increase in coarseness in the post-ravine sickle-fibres, making the Ravine on the thurl more closely approaching the more rather than the less depressed arrays which it is intermediate between.

No. 638 - the last of the five more typical Romney lambs studied is a comparatively fine even coated lamb having a slight posterior-anterior gradient from the side to the poll. From the britch to the side, however, the variations were obvious. The percentage of medullation was low - approximately 5 per cent.

The five sheep just described - Nos. 628, 745, 641, 763 and 638 - Graphs 3, 4, 5, 6 and 7 respectively - are animals exhibiting fibre type array gradients more or less characteristic of the New Zealand Romney lamb. These five sheep, however, are found to separate themselves into three classes, a coarse and a finer one with an intermediate one connecting the other two. This is more apparent when the gradients for all the animals studied are to be seen. In the coarser class may be placed the first three described - Nos. 628, 745, 641 - Graphs 3, 4, and 5, and in the finer class is No. 638 - Graph 7. No. 763 is representative of the intermediate class. From the sheep figured one might imagine that more lambs fell into the coarser class but in reality the numbers for each class are approximately equal for the animals examined - those representative of the fine class not being figured so often owing to the smaller amount of variation found among the finer coated animals.

The finer class - as represented by No. 638, Graph 7, is seen to approach the extreme fine type No. 618, Graph 2. Those of the intermediate class - No. 763 Graph 6 for example - do not exhibit such a regular distribution of arrays as the finer class but are far less irregular than those of the coarser group. The animals of the coarser class - Nos. 628, 745, and 641 - Groups 3, 4 and 5 - approximate the extreme coarse type No. 755, Graph 1.

Further substantiation of this grouping into classes is

to be found by comparing the percentages of medullation found in the different coats. These will be found to group themselves in the same way and though not indicative of the fineness they do suggest that medullation does not occur to any extent in the absence of coarseness.

COARSE CLASSS Graphs 1, 3, 4 & 5	INTERMEDIATE CLASS Graphs 6.	FINE CLASS. Graphs 2 & 7.
Extreme type No.755 No. 755 80% medullation	No. 763 11% medullation	Extreme type No. 618
No. 628 52% medullation		No. 618 5% medullation
No. 745 54% medullation		No. 638 5% medullation
No. 641 28% medullation		

From this it will be gathered that the Romney Lambs investigated divided themselves into three classes - a coarse, an intermediate, and a fine one. They divide themselves thus both by their varying percentage of medullation and their fibre type arrays gradients. The occurrence of th ree such classes together with such widely divergent gradients as those of No. 618 Graph 2, and No. 755 Graph 1, suggests that the Romney is a very unevenly bred sheep with wide divergence in the coat characteristicsof two animals belonging to the same breed.

In marked contrast with the irregular distribution of arrays found on the lambs more typical of the Romney breed were the comparatively regular ones found on the extreme types Nos. 755 and 618 Graphs 1 and 2.

No. 755 Fig. 3 Graph 1 - the extreme coarse type - has similar fibre type arrays - Plateau - on all positions posterior to the withers region. Anterior to the withers the prenatal check exerts slight influence but not even on the poll does it become very intense, the finest array being

a Ravine. The percentage of medullation was high - approximately 80 per cent. This animal, despite its high percentage of medullation and the large number of Plateau arrays did not have very stiff coarse halo-hairs. Halo, sub-halo hairs, super-sickle and curly-tip fibres were long and waving but show a marked increase in medullation a short distance from the tip. These long waving fibres resembled the Lincoln type of coarse fibre. This sheep was interesting in that although it was difficult to detect any increase in the intensity of the prenatal check, until after the withers region was reached the second variable - the reduction in inherent coarseness- causing the precipice in the curly-tip portion of the array, came into operation earlier, in the arrays on the anterior regions than in those on the posterior ones. It would thus be possible to draw a gradient from britch to neck base showing the precipice taking place earlier and earlier along the array. The increase in intensity of the prenatal check on the poll tends to mask this tendency of the precipice to appear earlier on this region. No. 755 is the least depressed arrayed animal on which I have studied all positions, but another sheep for which only back, side, britch and poll specimens were available, had a Plateau array on the poll as well as on the other three more posterior positions (4).

No. 618, Graph 2 - the extreme fine type - is very regular in the distribution of its arrays. Unlike No. 755 where any irregularities of distribution occurred anteriorly, the irregularities of No. 618 are posteriorly placed. The fibre type array gradient of No. 618 very closely approaches those found on the Ryeland and Southdown lambs. Graphs 8, 9, 10, 11 Figs. 6 and 7. The percentage of medullation was low - about 5 per cent - but the distribution was unusual - most of it occurring on the superior ileum position; the britch had more medullation than any position other than the superior ileum; it had, however, only about a quarter of the amount on the superior ileum, Elphick (7). No. 618 was unusual in that very few of the early fibres of the fibre type array series were present; halo-hairs were

non-existent and sickle-fibres very scarce. This lamb was the progeny of a no-halo-hair ewe mated to a no-halo-hair ram. In addition to the fact that very few early fibres were present, the coat was very fine and even, very little variation from fibre to fibre taking place on any region but the britch where the early curly-tip fibres showed a slight increase in coarseness. The greater percentage of medullation on the superior ileum was due to a large number of fibres being slightly medullated rather than to a few coarse ones being very hairy.

Minor Fibre Type Array Variations :

So far all observations have had to do with the major variations, due to the action of the two variables the prenatal check and the reduction of inherent coarseness causing different fibre type arrays. Little attention, bar reference to the change in the position of the precipice in Nos. 745 and 755, has been given to the gradual gradients within the arrays themselves. Animals such as No. 755 No. 641 and No. 618 have similar fibre type arrays on a large number of the regions examined but because the fibre type array is the same it does not mean there is no variation between say, a Plain array on the superior ileum and a Plain array on the Poll. It is found that there are marked differences in the extent to which these two arrays that are technically the same, are depressed. Therefore, for such sheep as No. 618, No. 641 and No. 755 where most of the positions have the same fibre type arrays more detailed graphs showing the changes within arrays can be drawn; this gradient is a very gradual one, emphasising the gradual change from one fibre type array to the next. See Graph 12, a detailed graph of Nos. 641, & 755. We find, therefore, that in nearly all sheep there is a gradient from britch to poll - if not one due to change in fibre type array there is one due to the changes within the array the anterior regions being more depressed than the posterior ones. The most noticeable changes from posterior to anterior regions are the changes in the position of the precipice and the lessening of the coarseness of the halo-hairs, supersickle and curly-tip fibres as one passes anteriorly.

Summary:

The first animal discussed was a fine even-coated lamb No. 618 Graph 2, exhibiting little variation from britch to poll. This animal not only showed slight variation from position to position but little variation from fibre to fibre within the array.

On the other hand No. 755 Graph 1 Fig. 3 was a coarse coated animal with little variation in the types of arrays occurring from britch to poll but within the arrays is exhibited marked variation from fibre to fibre.

Intermediate between these two types are three classes - a coarse, a fine and an intermediate one. The coarse class approaches the extreme coarse type, while the fine one approaches the extreme fine type; the intermediate class connects the two. The lambs of these three classes show different degrees of variation both in the fibre type arrays over the body and from fibre to fibre within the array according to how closely they approximate either the coarser or finer extreme type.

The Prevalence of the Several Fibre Type Arrays on the Various Positions :

The following table gives an idea of the proportion of fibre type arrays found on the different positions. These are from a number of samples taken at random from different Romney animals :

Positions: Fibre type arrays in proportion to one another.

TABLE 1:

	No. sheep examined	Plateau:	Saddle:	Ravine:	Valley:	Plain & escarpment
Britch	100	30	45	13	9	infrequent
Thurl	39	3	6	26	3	infrequent
Superior ileum	30	1	5	18	4	2
Back) (4) Side)	100	infrequent	4	35	42	18
Withers) Fifth Rib)	46	infrequent	infre-quent	4	21	18
Shoulder point	44	"	"	2	19	20
Poll	35	"	"	infre-quent	3	30

On the britch among the sheep examined it was found that Plateau was far more common than at first suspected. Dry (4) however, working on animals with no halos on the back found that these animals very rarely have a britch array so little depressed as a Saddle. Two of the Plateau arrays had few halo- and sub-halo-hairs but a large number of super-sickle-fibres and coarse chalky tipped curly-tip ones. Chalky is the term used to describe that white opaque look of medullated fibres. Plain and Escarpment are the most common arrays on the poll - Plain being more often found than Escarpment.

From the above table it can be seen that the arrays occurring most often on the different regions are

Britch	-	Saddle then Plateau
Thurl	-	Ravine
Superior Ileum	-	Ravine
Back and side	-	Valley then Ravine
Withers and fifth rib	-	Valley and plain
Shoulder point	-	Plain and Valley
Poll	-	Plain then Escarpment.

From this it can be seen that there is a general tendency for the more anterior positions to have more depressed arrays than the posterior positions.

From the summary of the commonest arrays found on the different positions, a graph (Graph 12) for an imaginary lamb typical of the animals studied can be drawn and it will be seen that this graph (Graph 13) is very similar to the graphs drawn for the animals considered more or less characteristic of the Romney breed - - Nos. 628, 745, 641, 763, 638. Compare graphs 3, 4, 5, 6, and 7 with Graphs 13.

From the graph it can be seen that in the lambs more characteristic of the Romney breed there is a marked fibre type array gradient from britch to poll. Also it will be remembered that there is often considerable variation from fibre to fibre comprising the array series.

It was now necessary to ascertain whether some more even breed of sheep exhibited fibre type array gradients similar to those of the New Zealand Romney.

COMPARATIVE STUDIES IN TWO FINER WOOLLED BREEDS THE RYELAND AND SOUTHDOWN BREEDS.

A small number of samples were taken from Southdown and Ryeland lambs - nine samples from four sheep of each breed and less from others, with the idea of determining the fibre type array gradients for purposes of comparison with the Romney lambs.

Southdown Lambs:

The Southdown coat when compared with that of the Romney is very much finer and more uniform - Graphs 8 and 9 Fig. 6.

Among the lambs examined smokiness Rudall (12) Elphick (7) was found to be of common occurrence but medullation was unusual. The lambs studied were very free from halo-hairs; a few had some on the poll region while a slightly greater number had them on their britch margins and briskets; on many, however, there were none at all.

The arrays showed a very even distribution with very little gradient in the array depression. On only two of those examined did Valley array occur on the Britch (Graph 8)the others exhibiting Plain arrays on the britch - Graph 9. In the two Valley arrayed britches it was possible to pick out some chalky sickle-ends of sickle-fibres by means of the Benzol test (Elphick) (8). These chalky ended ones, however, did not comprise the greater number of sickle-fibres far more very fine non-medullated ones occurring. Some of these very fine sickle-fibres are shed but I did not find any of those with medullated ends shed; as well as fine sickle-fibres some of the fine curly-tip ones are also shed.

The other Southdown britches examined had Plain arrays Graph 9. Those with Plain arrays on the britch did not have very many fibres with medullated sickle-ends. Sicklefibres were numerous but were extremely fine and were very easy to

miss in sorting samples.

On the two animals with Valley array on the britch it was found that the more dorsal positions rapidly changed to Plain arrays. On none of the sheep examined was an array less depressed than a Plain found anterior to the superior ileum position.

On one animal an Escarpment array was found on the poll. This animal had halo- and sub-halo-hairs - short stout kemp fibres - and very fine super-sickle-fibres succeeded by checked curly-tip ones; the halo- and sub-halo hairs were shed.

The Southdowns examined are from one flock only and do not represent the extremes of coarseness or fineness it may be possible to find in the breed. They can, however, be compared with those Romneys more characteristic of the breed. The Southdown gradients are not unlike the gradient of the extreme fine type of Romney lamb No. 618 Graph 2, but they are generally far more even in array distribution than those more typical Romney lambs - Graphs 3, 4, 5, 6 and 7.

The Ryeland Lambs:

In many ways the wool of the Ryeland lambs was not unlike that of the Romney - Graphs 10, 11, Fig. 7.

In the Ryeland the sickle-fibres are like those of the Southdown but are perhaps a little coarser; sickle- fibres with medullated ends are by no means restricted to the posterior regions. The sheep examined had fewer halo-hairs than the Romney and they were not so long. They were not, however, so free of these fibres as the Southdown lambs were. Shedding of fine sickle-fibres but to a lesser extent - takes place as in the Southdown.

In the curly-tip fibre portion of the array the resemblance to the coat of the Romney is quite marked. A considerable amount of medullation was present in some cases and in most there were traces of it. Compared with the curly-tip portion of the Romney however the Ryeland curly-tip fibres presented a more even series and exhibited less variation in length from fibre to fibre within the array; peak curly-tips (5) were not found. The fibres

as a whole were somewhat shorter than those of Romney lambs of the same age.

A Plain array was not found on the Ryeland britches studied but Valley was common; Ravine arrays were found on two of the britches examined but nothing less depressed was seen. The distribution of the arrays on these Ryeland lambs resembled the distribution of the array on the lambs belonging to the fine class of New Zealand Romneys - Graph 2 and 7 but there is apparently far less variation in the fibre type arrays occurring on different positions on the more average Ryeland lambs than there is in the more characteristic Romney ones; the Southdown, however, shows less variation still than the Ryeland does.

As in the Southdown examples the Ryeland lambs sampled are from one flock - and are therefore not indicative of possible extremes of either coarseness or fineness.

Though the numbers of sheep of these breeds examined are small the observations made indicate that in both these breeds the distribution of fibre type array is far less variable than in the Romney and their coat is generally finer with less variation in fibre length. The coat is shorter than the Romney especially in the case of the Southdown. Medullation is more common in the Romney lamb, but is not uncommon in the Ryeland lamb; the Southdown has very little of it but those examined were inclined to show a considerable amount of smokiness (12) (7).

Of the two studied the Ryeland breed is the more closely allied to the Romney one when judged by wool characters alone.

SHEDDING OF FINE FIBRES.

Both Ryeland and Southdown lambs exhibit a marked tendency to shed their finer sickle-fibres. Coarse super-sickle-fibres and halo-hairs were shed in a manner similar to the shedding of coarse fibres in the Romney breed. The Southdown also sheds a few early fine curly-tip ones. This shedding of fine sickle-fibres is in marked contrast to the shedding of

these fibres as it occurs in the Romney where shedding of all but baby and infant sickle-fibres is to be regarded as an expression of vigour, Dry (5). Roberts (10) and Darling (1) in their papers on the Welsh mountain and the Scottish ~~Mountain~~ Blackface breeds, respectively, mention that shedding of fine fibres does occur and dissociate it from the shedding of Kemp. In their work on the Blackheaded Persian of South Africa. Duerden and Boyd make reference to a spring shedding of wool fibres as distinct from kemp fibres. In the Blackheaded Persian, however, all fibres of the coat are apparently shed. In the Southdown and Ryeland it is only the early fibres of the fibre type array - the sickle- and early curly-tip ones that shed. In the Welsh Mountain Breed (10) from the accounts given the shedding is apparently similar to that of the Romney. In the Romney (5) shedding of kemp fibres is common. In addition to this, however, there is "smoky" shedding due to the damaging of fibres (12). Further in one animal examined by Mr. Rudall it is found that there is shedding of the histerotrich fibres. The manner of shedding of these differs from that of the early kemp fibres. Here the shed fibres do not have a bulb-like swelling forming a sheath round the brush nor do they have a smoky swelling as in fibres where the shedding is caused by the damaging of the follicles. The brush is small and the proximal end of the fibre very thin. The shedding in the ~~Mountain~~ Scottish Blackface of the fine fibres is apparently more nearly related to the shedding in the Blackheaded Persian than to that in the Romney breed.

The fine shed fibres of the Southdown and Ryeland are the early fibres of the array - the fibres that might form kemp in more hairy breeds. They are shed in a manner similar to that of the kemp of the Romney; each fibre having a bulb-like sheath about its brush - the bulb swelling being visible to the naked eye when sorting on black velvet; these fibres are not infant or baby sickle-fibres though infant and baby shed sickle-fibres are found in both the Southdown and Ryeland breeds. Some of the shed curly-tip fibres of the Southdown had smoky

swellings but not all, some being shed in the normal way.

From this we can say that the shed fibre types of the Southdown and Ryeland lambs are of the same type as those fibres that constitute the kemp of the Romney - Halo-hairs, and coarse super-sickle-fibres when present and fine super-sickle and sickle-fibres, and as in the Romney occasional curly-tip ones. The shedding of the curly-tip fibres of the Southdown is more usual than the shedding of coarse curly-tip ones of the Romney which usually takes place to any extent only in Plateau and occasional Saddle and Ravine arrays.

In a personal communication Dry reports that one fine woolled Romney lamb exhibited shedding of fine sickles in a manner similar to that of the Southdown and Ryeland. This was accompanied by the shedding of coarse Kemps as well. In this animal as in the Southdown and Ryeland, shedding is in all probability primarily due to some factor other than vigour.

The shedding of histerotrichs, mentioned as occurring in one Romney, may be hunger shedding; such shedding was not seen in the Southdown and Ryelands studied. The method of shedding in these two breeds is similar to that of the Kemp of the Romney - a thinning of the fibre succeeded by a brush in a sheath forming a bulblike swelling. Smoky shedding occurs in all three breeds.

SUMMARY and DISCUSSION OF THE DISTRIBUTION OF THE FIBRE TYPE ARRAY.

Britch-Poll gradient:

From the foregoing account it is apparent that in the New Zealand Romney the extent to which the fibre type arrays are depressed varies over the dorsal and dorso-lateral regions of the body giving a general gradient from britch to poll - that is a posterior-anterior gradient; this gradient is gradual - no sudden transitions such as Plateau on the britch to plain on the superior flank position taking place.

Subsidiary Gradient:

Subsidiary to this general posterior-anterior gradient

but occurring with it are the gradients down the sides of the body. These subsidiary gradients are most noticeable down the limbs. In these gradients we find that the array on the inferior position limits the array on the superior position - See Graphs 1, 2, 3, 5 and 7.

The Limiting Power of Posterior and Inferior Positions:

We therefore find that the finer the arrays on the posterior or inferior positions - the more limiting their effect upon the arrays on the anterior or superior positions. If the array on the posterior or inferior position is little depressed its limiting power is negligible.

From this it can be seen that the britch array limits the arrays occurring on the other positions of the body.

We can now say that the array on any position both posterior and inferior to another position limits the array on the anterior-superior position to being no less depressed than the array on the posterior-inferior position. This statement may be further elaborated to read thus - every position either posterior or inferior to another position in a straight line has an array no more depressed than that on the anterior or superior position; further every position either anterior or superior to another position in a straight line has an array no less depressed than that on the posterior or inferior position.

Therefore it can be seen that if the array of either a posterior or inferior position is known it is possible to make a fairly accurate surmise as to the array on either an anterior or inferior position.

To determine the possible limits of variation over the body it is of no use examining the anterior positions first as these, though they are indicative of the greatest depression are no guide as to how little depressed a posterior position may be. On the other hand the depression of the britch position array limits the arrays on any other position of the dorsal or dorso-lateral portion of the body to being no less depressed

than the britch.

Orderly Variation:

We thus see that the distribution of the fibre type arrays is orderly owing to orderly variation in the depression causing the arrays. This depression is caused by the action of two variables - the prenatal check and the reducing of inherent coarseness on an undefined substratum.

Discussion of the possible methods of operation and the cause is given in the summary of section B.

Variation in fibre length :

As well as the variation in array there is the variation in fibre length of the fibres comprising the array series. This also varies from anterior to posterior end of the body in accordance with the fibre type array variation. Variation in fibre length being less in the more depressed arrays Plain and Valley - than in the less depressed ones - Plateau and Saddle. We therefore find the change in fibre length variation coinciding with the fibre type array gradient.

Comparison with Ryeland and Southdown Breeds:

Examination of the Ryeland and Southdown lambs reveals that orderly variation in the fibre type array gradients is not a prerogative of the Romney lamb but also occurs in the more even breeds of sheep. The variations in these finer more even coated breeds is not so extreme as in the more unevenly bred Romney.

Shedding:

The differences between the Romney and the finer breeds in regard to the matter of shedding are very interesting. Shedding in the Romney is due - except in the case of infants and baby-fibres - to vigour; in the Southdown and Ryeland stout halo hairs and super sickle fibres are shed - which may be due to vigour (5) - but in addition a number of fine sickle fibres are shed - whether this is due to vigour or not is still to be determined, but it is thought it is more likely to be due to some other unknown factor.

These fibres are not able to be correlated with the shedding histerotrichs, nor is this shedding to be compared with the shedding of the wool coat of the Blackheaded Persian (7) or the Scottish Blackface because the shed fibres of the Southdown and Ryeland are comparable with the birthcoat kemp fibres of these animals and not the wool coat.

Medullation :

Medullation was not found to be important in the Southdown breed. It was of more general occurrence in the Ryeland breed and very common in the Romney. The Romney breed showed marked individual differences - some showing very nearly no medullation while others were nearly all hairy fibres. The greater power to sustain hairiness basally (5) is an interpretation of the fact that while many lambs are equally or even more hairy on the back than on the side, the older animals are less hairy (7) on the back than on the side.

Ventral gradient of the Romney Breed.

We have seen that there is a gradual posterior-anterior gradient over the dorsal and dorso-lateral regions of the Romney lamb due to gradual change from coarser to finer arrays as we pass from britch to poll, with a corresponding change in the depression caused by the action of the two variables - the prenatal check and the reduction in inherent coarseness. This same gradient, however, does not apply to the ventral and ventro-lateral region for which another gradient would have to be drawn. No detailed work has been done on the ventral surface but a few examinations indicate that the fibre type arrays become coarser as one passes from the anterior to the posterior end of the body. Further they indicate that the fibre type array on a position on the mid-ventral line is inclined to be slightly more depressed than one on a corresponding position on the mid-dorsal line. This is not very obvious on sheep more characteristic of the Romney breed on positions anterior to the shoulder point position. It is suspected that the posterior-anterior gradient for the

ventral surface is similar but a little less steep than that for the dorsal surface.

We thus find that the lamb has more depressed arrays anteriorly than posteriorly and is more depressed on the mid-dorsal and mid-ventral lines than on the lateral or inferior regions. We can therefore state that the array on any position either posterior or inferior to another position in a straight line limits the array on either the anterior or superior position to being no less depressed than the array on either the posterior or inferior position. Hence the array on the britch limits the arrays on the rest of the body to being no less depressed than the britch array and we may therefore determine the extreme limits of the coarseness of the arrays over the body by determining the britch array.

SECTION B:

THE PRENATAL DEVELOPMENT OF THE NEW ZEALAND ROMNEY LAMB.

INTRODUCTION.

The classification of fibre type arrays is based on postulated prenatal events. It is therefore desirable to study the development of the coat before birth.

MATERIAL AND METHODS.

The material consisted of a series of dated New Zealand Romney foetuses from the Massey College flock and a number of undated ones from various sources.

Macroscopic examination was carried out with the aid of a hand lens and more detailed knowledge was gained by taking snippets of skin from definite areas and mounting.

The earlier foetuses were fixed immediately they were taken from the uterus by immersion in a form-alcohol bath - 5% formalin 30% alcohol; this form-alcohol bath was changed after twenty four hours and the foetuses were stored in a second similar bath. This was found to be a satisfactory method of preserving the earlier foetuses - the animal remaining in a suitably stretched condition for taking skin snippets. The later foetuses - from 112 days - were immersed in a 7% formalin bath instead of the form-alcohol one. The foetuses were changed to a similar solution in which they were stored in the same way as for the earlier foetuses.

Skin samples were regularly taken from the following positions - Fig. 1 -

Nose: Across the bridge of the nose just anterior to the eyes.

Poll: On the mid-dorsal line between the ear and horn positions.

Neck: On the mid-dorsal line half way between the ears and the base of neck specimen.

Ventral Neck: On the mid-ventral line comparable to the base of neck position.

Base of neck: On the mid-dorsal line dorsal to the shoulder points.

Shoulder point: On the point of the right shoulder bone.

Withers:

On the mid-dorsal line level with the fifth rib.

Fifth Rib:
Ventro-lateral to the withers, on the right fifth rib, in a line with the lateral aspect of the shoulder point and superior to the elbow.

Elbow:
On the elbow joint of the right forelimb.

Back:
On the mid-dorsal line level with the last rib.

Side:
On the right side at the distal end of the last rib.

Superior ileum:
On the mid-dorsal line on the superior angle of the ileum.

Thurl:
Ventro-lateral to the superior ileum position at the junction of the femur and pelvic bones (acetabulum).

Britch
Immediately posterior to the stifle joint and midway across the thigh.

In addition skin snippets were taken from many other positions, but not from every foetus. The skin snippets were stained with borax carmine, cleared and mounted in Xylol balsam. This staining proved most effective, the follicles staining a deeper red than the skin generally.

Examination of skin snippets revealed the fact that the body naturally divided itself into regions that developed at different times. These regions were not all contiguous and for the purposes of descriptions all regions that develop at the same time have been grouped together and termed an "Area . There are six of these areas and they have been named Areas A, B, C, D, E and F, respectively - Area A including the regions that develop first - Area F those that develop last. These Areas do not include the sensory follicles round the eyes, mouth ears or nostrils, nor those on the anterior or posterior coronet regions; these are referred to by name when mentioned in the text.

The Areas include the following regions : See Fig. 9.

Area A The poll region.

Area B The anterior neck region - dorsal and ventral.

The posterior aspect of the hind limb inferior to the knee.

Area C — The dorsal and ventral portions of the posterior neck region.
The fore limb knee pads.
The posterior face of the forelimb and the large ventral region between the forelimbs extending laterally to the anterior coronet region and mid ventrally a short distance behind the navel.
The small regions either side of the external genital organs.
The dorsal surface of the tail and the posterior third of the ventral surface.
The face region.
Underneath the lower jaw.

Area D — The withers region extending laterally to anterior coronet region and mid-dorsally to a short distance anterior to the last rib.
ventral
The anterior face of the forelimb.

The lateral regions of the ventral surface as far posterior as the navel.

The britch region.

Area E — The back and side regions of the dorsal surface.
The dorsal limb regions inferior to the britch.
The ventral surface posterior to the navel and extending down the limb.

Area F — The ventral anterior two thirds of the tail.

The dorsal surface posterior to the back and side.

The bridge of the nose.

DEVELOPMENT OF THE COAT:

The development of the coat of the New Zealand Romney lamb has been found to correspond in the main with that described by Wildman (14) for certain British breeds. The idea for crown-rump measurement has been copied from this paper and is given for the foetus along with the age.

It will be noticed, however, that considerable importance is attached to the stage of development termed trio (8) (9) which Wildman (14) makes reference to but does not stress. Further reference is often made to a nine stage - a derivative of the trio stage - which has been considered of importance, equal to that of the trio stage; this stage when completed might well be mistaken for a complete trio stage - description appears later in the text. See Figs. 13 & 17. This nine stage I do not find mentioned by Wildman (14) in his

description of British breeds but along with the trio stage I find it a very satisfactory stage with which to approximately date foetuses. A discussion as to its importance will be given later.

42 Days:

The earliest dated foetus taken was a 42 day one - 6 cms crown-rump measurement - follicles were present round the eyes, nostrils and mouth - both upper and lower lips; these are presumably sensory follicles. Undated foetuses with no follicles were simple to obtain and also foetuses with follicles around the eyes alone. In the 42 day foetus the follicles round the eyes were very prominent. They appeared as large white rounded spots. No follicles were to be seen elsewhere on the body as separate from the head region.

49 Days: - Fig. 10.

On the 49 day foetus - 7½ to 8 cms. crown-rump measurement a few scattered follicles have appeared on the poll and isolated ones appear on the anterior portions of the neck. Posterior and anterior coronet regions both had follicles. With the exception of these sensory follicles mentioned as occurring in the 42 day foetus no other regions of the body as yet had follicles.

56 day foetus: Fig. 10 and 11.

The 56 day foetus - 11 cms. crown-rump measurement has isolated follicles over most of the body, but they are much more difficult to find on the E and F areas than on the other ones. On the A areas it is now possible to distinguish between first follicles of ~~the~~ two sizes - X being the term applied to the larger and older and Y to the later and smaller of the two. See Fig. 10 and 11. The follicles are numerous on the A area. The B area has a number of follicles but as yet X and Y follicles are not discernible. This area is however in advance of the other areas - the most noticeable indication being the greater size of the follicles and the greater numbers.

64 Days foetus - Fig. 10, 11 and 12.

At 64 days the foetus 14 cms. crown-rump measurement

has follicles all over the body and varying densities are quite marked; density (14) here signifying the number of follicles to a unit area. On the A area the X and Y follicles are numerous and the larger or X follicles have now two small follicles one on either side of them giving the trio arrangement mentioned previously. Fig. 12. These small follicles have been conveniently termed x and y so that the trios may be written xXx and yYy. The X and Y follicles of the A area have arranged themselves in lines. The trio grouping does not disturb this arrangement. See Fig. 12. On the B areas both X and Y follicles are apparent but no trio grouping has appeared as yet. On the C areas large X follicles and small Y ones can be seen; D areas have X follicles with Y ones just appearing; E and F areas have isolated follicles scattered over the field. The follicles on the E areas however were slightly more pronounced than those on the F one. Linear arrangement of follicles was to be seen on the A and B areas but nowhere else on the body.

68 Days - Figs. 10, 11, 12 and 13.
Foetus

The 68 day foetus - 15 cms crown rump measurement - has all the follicles of the A area in trio groups xXx and yYy groups. See Fig. 13. The B, C and D areas have X and Y follicles and appear much the same as the poll did at 56 days. Fig.11. The D area is further retarded than the other two while the B area is slightly in advance of the C one. The follicles on all three areas are arranging themselves linearly. Only X follicles are apparent on the F areas while X and suggestions of Y ones are to be seen on the E areas.

72 day foetus - Figs. 11, 12, 13 and 14.

The 72 day foetus - 19 to 20 cms crown-rump measurement shows the trio arrangement disappearing on the A area. This is apparently due to the fact that at the 68 day stage X and Y follicles had completed their development and were about to commence fibre growth. When the 72 stage is

reached the x and y follicles of the trio have also nearly completed development and are about to commence fibre growth so that at 72 day all follicles of the trio - xXx and yYy look much the same. It is now impossible to detect which is an xXx trio group and which a yYy one. Grouping in threes is however still able to be detected - Fig. 14. At this stage odd new small follicles are appearing beside the follicles of the trio grouping - see Fig. 14. They do not necessarily appear close to the middle or oldest follicles of the trio group but appear indiscriminately beside either X or x or Y or y. The B areas have now reached the trio stage of development; on the C and D areas the X follicles are trioed - xXx - and on the C one most of the Y are also trioed but on the D one the Y follicles have not yet begun to trio. The number of follicles on the E and F areas has increased; the E areas now evince a linear arrangement of follicles while on the F areas there are still a number of Y ones just appearing.

At this stage the follicles round the eyes and nostrils and on the upper and lower lips are very prominent and nearly ready to burst through the skin.

<u>76 Day foetus - Fig. 11, 12, 13, 14 and 15</u>:

The next foetus was a 76 day one - 20 cms crown-rump measurement. The A areas now retain only a suggestion of the trio arrangement it being impossible to distinguish between any of the xXx or yYy follicles of the trio except by their position. Additional new follicles - x'y' are appearing (Fig.15) rapidly beside the various members of the trio. The B, C and D areas have completed their trio stage of development - on the D area, Y follicles being not quite so completely trioed as the other two - Fig. 13 and 14. The B areas have the trio stage disappearing and odd new x' and y' follicles are appearing as on the poll at 72 days - Fig. 14. The C area though not so advanced as the B one also has suggestions of the new x' and y' follicles. The E areas show trio grouping about the X follicles but not about the Y ones. Fig. 12; the F area follicles are now

linearly arranged. (Fig.11).

83 Day Foetus Fig. 13, 14, 15 and 16.

At 83 days the foetus - 22 to 23 cms. crown-rump measurement - has the fibres round the eye through the skin. The A areas on casual inspection are much the same as at 76 days but closer examination revealed further development of x' and y' follicles about the old xXx and yYy trio groups. These new follicles are arranging themselves in groups about either the X or x the Y or y follicles of the original trio group in a manner suggestive of the original trio grouping which has now completely disappeared. This is the fore-shadowing of the nine-grouping - which is due to each of the follicles of the trio group becoming the central follicle of a group of three follicles - making each trio the forerunner of a nine group. At this stage groups of seven and eight can be found. The x' follicles are still small. See Fig. 16. On the B C and D areas the trio arrangement of follicles is no longer obvious but close inspection revealed the remains of such grouping. The definition of xXx and yYy trios is no longer apparent. New x' and y' follicles are appearing, B and C areas showing groups of five and six follicles. An odd group of seven may be detected on the B areas. On the E areas the suggestion of a trio arrangement still persists but now x' and y' follicles are appearing. The F areas are in the late stage of trio development the Xx and yY follicles all approaching the same size.

90 day foetus: Figs. 14, 15, 16 and 17.

On the 90 day foetus - 29 to 30 cms crown-rump measurement - the follicles round the nostrils - on the upper and lower lips, the horn and posterior coronet regions have all burst through the skin, while the hairs round the eyes are quite long.

The follicles of the A areas are now grouped in nines each nine originating from an original trio group. We thus get three groups of three one about the X follicle of the trio

and one about each x follicle of the trio group.

This grouping x'xx' x'Xx' x'x'x' of three groups of three makes the nine group - which may very easily be mistaken for an advanced trio grouping - closer inspection however reveals the nine grouping and the origin of the group. Fig. 17. In addition new follicles are beginning to appear beside the nine stage follicles. Some of the follicles on this area are ready to burst through the skin. B C and D areas evince a further increase in the number of x' and y' follicles the B area having very nearly reached the complete nine grouping stage. On the E areas remains of the original trio arrangement can still be detected but the number of x' and y' follicles are increasing. On the F areas the suggestion of the trio arrangement still persists though it is rapidly disappearing.

97 day foetus : Figs. 15, 16 and 17.

At 97 days - 30 cms. crown-rump measurement - the foetus has quite a number of regions on which the fibres have burst through the skin. The hairs are quite long on those regions where the fibres had pierced on the 90 day foetus. The fibres on the anterior coronet region are through.

The fibres are through the skin on the A areas and are just piercing it on the B ones. The C areas show the completed nine groups though there are still a few groups of seven and eight to be completed. No complete nine groups occur on the D areas but there are a number of groups of eight; on the F areas one can still detect the remains of the trio stage but it is difficult. The E areas have a number of groups of five, si and seven follicles while the F areas have the now x' follicles appearing - groups of four and five being quite common.

Owing to the sterility of one ewe no foetus intermediat between 97 and 111 days was secured.

111 day foetus:

The next foetus was the 111 day one - 32 - 33 cms. crown-rump measurement. This one had fibres through on all areas but the E and F ones. The fibres of the A and B areas are now quite long and have commenced to curl while on the C

areas the fibres are through the skin. The D Area has the fibres just piercing the skin. The E areas are not through. The nine grouping is now complete and some of the follicles are just ready to pierce the skin. On the F areas the nine grouping is very nearly complete.

122 day foetus:

The 122 day foetus - 40 - 43 cms. crown-rump measurement is completely covered with fibres. On the early regions - the A and B areas - it is possible to distinguish the halo-hairs and sickle-fibres. On the C and D areas suggestions of sickle-fibres can be detected while on the E and F ones the fibres are short and straight. This ewe had triplets and the wool characters of the lambs were somewhat different, two having a large number of halo-hairs while the third had very few.

127 day foetus :

The 127 day foetus - 47 - 50 cms. crown-rump measurement has relatively long fibres present. On the earlier areas - A B and C there is quite a marked curl effect - the region about the shoulder point being the most tightly curled. Precurly-tip fibres were easily recognizable from A B and C areas and also some curly-tip ones were distinguishable. As well as these are some fine straight short fibres not able to be distinguished as yet as belonging to definite fibre types. On the E and F areas the fibres are uncurled and are not able to be sorted into definite fibre types.

On the earlier regions however it is possible to find representation of all fibre types, except histerotrichs, on a 127 day foetus.

No dated foetuses were secured older than this but some lambs that died at birth were secured. These were from 50 to 54 cms. crown-rump measurement. The wool was found to be curled on all regions the halo-hairs standing up rather stiffly. The fibres had grown considerably longer in the time intervening between the 127 day foetus and birth. Samples taken from various regions on these when sorted gave halo-hairs, super-sickle,

sickle and curly-tip fibres and a few short fibres which might have been histerotrichs but in all probability are late curly-tip ones.

Undated Foetuses:

From the dated material in my possession no definite information could be gathered as to whether the fibres on the E or F areas pierced the skin first. From the relative times when the two areas began to grow it was surmised that E areas pierced slightly in advance of the F ones. Undated material confirmed this. An undated foetus 33 cms. crown-rump measurement has the E areas just piercing the skin and the F areas not. Another two foetuses 33 - 36 cms. crown-rump measurement have their E areas through and their F ones with just a few scattered fibres piercing the skin with in addition a number of white papilla-like spots which are follicles with the fibres just ready to pierce the skin.

Another foetus 32 cms. crown-rump measurement showed the mid-dorsal line of the E area in advance of the side regions of the same area. This is also found on the foetuses - the 33 - 36 cms. ones - which have only a few fibres piercing the skin the number of fibres through on the mid-dorsal line being greater than elsewhere on the F area.

One whole skin of an undated foetus 21 cms. crown-rump measurement was stained with borax carmine and cleared in cedar oil. On this foetus the trio arrangement could still be detected on the D area while on the B and C ones the new follicles coming in were beginning to mask the arrangement . On the E areas the trio grouping was obvious but new x'y' follicles were appearing. The F area was still at the trio stage.

Study of the skin of the dated series suggests that the approximate age of this foetus is 83 days. Study of the arrange- of the follicles revealed a linear arrangement similar to that figured for the masham foetus in Wildman's paper (14) p. 267.

Examination of the undated foetus illustrates the fact

fibres burst through the skin in the order that they are laid down - that is in accordance with the directional currents, - halo-hairs appearing first followed by sickle-fibres, curly-tips and last of all, histerotrichs.

In the account of the development of the coat it will be noted that after the nine stage - there is no further mention of development in threes. Odd follicles are mentioned as appearing beside the nine stage which may suggest that a further stage - a twenty seven stage - is possible. From post-natal observations, however, this is unlikely. The pre-curly tip fibres are never more than thirty three out of one hundred fibres but on the poll region they usually approximate this number. We thus find that pre-curly-tips constitute about a third of the coat. The remaining two-thirds are curly-tips and a few histerotrichs. From this we may assume that the pre-curly tips are from the trio stage follicles and the curly-tips from the additional x' follicles constituting the nine stage. The histerotrichs may be from the few extra follicles appearing after the nine stage. If a twenty seven stage appeared one would expect that the histerotrichs would be twice as numerous as the pre-curly-tips and curly-tips together.

Further if any stage later than a nine stage occurred the post-natal density of the Romney - not a very dense woolled sheep - would necessarily be very high, or the sheep very much larger than it is.

It is conceivable, however, that on a dense woolled sheep such as the merino there may be a complete twenty-seven stage of development; in the Romney, however, it is unlikely.

Another point of interest is the time taken between the laying down of the follicle and the fibre piercing the skin. On the poll region the first follicles are laid down at about seven weeks while the first fibres are not through the skin till after thirteen weeks. Thus the time taken between the initiation of the follicles and the fibre bursting through the skin is between six and seven weeks. The time from the

initiation of the follicle till it has attained its full length is between two and a half weeks and three weeks. The remaining period - two and a half weeks to three weeks - is taken up with the formation of the fibre.
Rudall (in a personal communication) mentions that it takes over two weeks for the regeneration of a fibre.

When the lapse of time between follicle initiation and the fibre piercing the skin is considered, it is not inconceivable that there is a delay between the causal event determining the prenatal check and the resultant expression.

Dry (2) in the Mouse finds that the length of a Zigzag fibre can be prophesied within narrow limits by examining the length of the distal segments of some fibres. This indicates that total length is determined at an early stage of development. In the sheep he finds expression that suggest they are the delayed result of a causal event. Such expressions are the percentage of chalky sickles shed and the nature of the Halo-hair successors. - Dry (unpublished paper).

The nature of the succession of the first lot of secondary kemp is evidence of a very much delayed result of a past causal event. Dry - (Unpublished paper).

See Table 2. Summarizing the follicle development.

TABLE 2, SHOWING THE STAGE OF DEVELOPMENT OF DIFFERENT AREAS AT DIFFERENT AGES.

Table 2

AGE OF FOETUS	AREA A	AREA B	AREA C	AREA D	AREA E	AREA F
42 days	-	-	-	-	-	-
49 days	X follicles	-	-	-	-	-
56 days	X and Y follicles	X follicles	X follicles	X follicles	X follicles	X follicles
64 days	xXx and Y follicles	X and Y follicles	X and Y follicles	X and Y follicles	X follicles	X follicles
68 days	Trio stage xXx and yYy follicles	X and Y follicles	X and Y follicles	X and Y follicles	X and Y follicles	X follicles
72 days	Late trio stage xXx and yYy follicles	Trio stage xXx and yYy follicles	xXx and Y and yYy follicles	xXx and Y follicles	X and Y follicles	X and Y follicles
76 days	xXx'x and y'yYy'y follicles	Late Trio stage xXx and yYy follicles	Trio stage xXx and yYy follicles	Trio stage xXx and yYy follicles and odd Y follicles	xXx and Y follicles	X and Y follicles
83 days	Trio gone x'xx'Xx'x'xx' and y'yy'Yy'yy'	Trio gone x'xXx'xx' and yy'Yy'yy' follicles	Trio gone xx'Xx'x and y'yYy'yy' follicles	Trio disappearing xXx'x and yy'Yyy' follicles	Late trio stage xXx'x and yYy follicles	Late trio stage xXx and yYy follicles.
90 days	Nine stage x'xx'x' X x'x'xx' and y'yy'y'Yy'y'yy'	x'xx'x'Xx'x'x and y'yy'y'Yy'y'yy' follicles	x'xx'Xx'x'x and y'yy'Yy'y'yy' follicles	Trio gone x'xx'Xx'x and y'yy'Yy'yy' follicles	Trio still detectable xx'Xx'x and yYy'y follicles	Trio disappearing xXx'x and yYy'y follicles.
97 days	Fibres through the skin	Fibres piercing the skin	Nine stage x'xx'x'Xx'x'xx' and y'yy'y'Yy'y'yy'	xx'Xx'x'xx' and yy'y'Yy'y'yy' follicles	Trio gone xx'Xx'xx' and yy'Yy'y'yy'	Trio gone xXx'x yYy'y'y follicles

AGE OF FOETUS	AREA A	AREA B	AREA C	AREA D	AREA E	AREA F
111 days	Fibres begun to curl	Fibres begun to curl	Fibres through the skin	Fibres piercing the skin	Nine stage x'xx'x'Xx'x'xx' and y'yy'y'Yy'y'yy'	x'xx'x'Xx'xx' and y'yy'y'Yy'y'yy' follicles
122 days	Halo-hairs and sickle fibres recognisable		Fibres begun to curl Sickles present	Fibres begun to curl. Sickles present.	Straight fibres	Straight fibres.
124 days	All Pre-Curly tip and some curly-tip fibres recognisable		Pre-curly-tip and a few curly-tip fibres recognisable			Straight fibres.

DISCUSSION:

Before summarising the account of the follicular development, it is necessary to discuss the trio and nine groupings which have figured somewhat prominently in the above account. The present work emphasises the fundamental importance of the number three, the importance of which in hair arrangement was first recognised by de Meijere (9).

The trio stage of development is referred to by Wildman (14) p. 272 as occurring on the Down and Scottish Blackface breeds on certain specialised regions. In his account he has not, however, attached the same importance to it that I have done in this account of the New Zealand Romney. On the Romney this trio stage is a definite stage in the prenatal development of the follicles of the coat. It occurs on all areas, and is a means of determining how far developed the area concerned is. It is considered that it may be a method of determining the approximate ages of undated foetus. Examination of undated material, of dated twins, and of two dated foetuses of the same age, suggests that although length and width may vary the stages of development are comparatively constant for the same age - for example the trio stage appears on the withers at about 76 days along with non-trioing on the F areas and the commencement of trio stages on the E ones. The A areas are now well on towards the nine stage - see Fig. 13 and 17. The nine grouping succeeds the trio stage of development - through the development of trio follicles about each follicle of the trio. This stage may be useful for dating older foetuses. It is not quite so marked as the trio stage and when completed may possibly be mistaken for an advanced trio stage, the nine follicles of the group being inclined to separate themselves into three groups of three follicles, each follicle being approximately the same size. The trio grouping was found on

no part of the body after 80 days though indications that such a grouping had been present can be found on the F area as late as 97 days.

From this account of the development of trio and nine stages it follows that all the first follicles - the X and Y follicles - are forerunners of eight additional follicles, giving the following groupings :- xXx and yYy at the trio stage and x'xx' x'Xx' x'xx' and y'yy' y'Yy' y'yy' at the nine stage.

At the completed nine stage we see additional small follicles appearing which as far as can be ascertained at present do not develop in any regular way - appearing haphazardly beside any of the follicles of the nine group. From both pre - and post-natal observations I do not think that these follicles are very numerous and never result in a 27 stage of development. It is suspected that these follicles are the follicles of the histerotrich fibres. The number of histerotrichs in post natal material apparently varies considerably, but is not usually high. We find therefore that the bulk of the coat is made up of fibres which grow from the follicles of the nine stage.

If the depression be due to density it follows that the original number of X and Y follicles, that is original density, will be one of the important factors determining both a fibre's career and the subsequent fibre type array.

The depression is caused by the action of two variables (5) - the prenatal check and the reducing of inherent coarseness. This depression - which prenatal observations suggest may be due to density at the trio and at the nine stages has been considered to be a local phenomenon (5). The observations made on the different Areas further support this view - different Areas attaining to the same stage of development at different times.

From present observations it is suspected that density at the various stages of development may be correlated with fibre type array. Further it is thought that the original density together with varying skin expansion is of

paramount importance in determining the fibre type arrays; it is also thought that these same two interacting factors influence the number of precurly-tip fibres.

With this in mind we turn to a more detailed study of the follicle development. We have the following marked stage -

(1) The completed first follicle - the X and Y follicle stage.

(2) The trio stage.

(3) The nine stage.

This arrangement of three successive stages emphasises the fact that the number of first X and Y follicles is perhaps the chief factor determining the density of the adult animal. Secondly it reveals that the greater the early density the greater the trio stage density and the greater the nine stage density. It is known that at seventeen weeks halo-hairs, sickle-fibres and curly-tip ones can be seen on the advanced areas. From post natal work it is known that the proportion of pre-curly-tip fibres per hundred fibres is higher on the advanced than on the later areas (see Section C), as many as thirty-three precurly-tip fibres per hundred fibres being found. From this we must assume that in such cases all trio stage follicles produce pre-curly-tip fibres. On the other hand on some of the later areas we can assume that only the X and Y follicles become precurly-tip fibres and not necessarily all of these.

From these we can make the general assumption that there is an original density which varies from position to position.

The original number of follicles is increased three times at the trio stage and nine times at the nine stage. This increase in the number of follicles is offset in part by expansion of the skin. It is assumed that the increase in the number of follicles is gradual for each stage- but it is possible that in some sheep it may be sudden. From this it is postulated that the prenatal check is due to the increase in the number of

follicles at the trio stage - the strength of the prenatal check being due to the number of follicles as opposed to the extent of the expansion of the skin. Further the second check - the reducing of inherent coarseness - may be due to the nine stage of development increasing the density which is again in part offset by the skin expansion.

If the formation of the nine stage takes place from a sufficiently dense trio stage it may oppose the effects of skin expansion and the fibre type array will show no increase in coarseness - will be a Plain Array. However, if the density is not sufficiently high the skin expansion may be too great to be combated by a gradual or even a sudden appearance of a number of nine stage follicles and we will find the fibre type arrays ranging according to the increase in the number of follicles in relationship to the skin expansion.

We therefore find that the fibre type arrays are due to the interaction of two variables - (1) the prenatal check and (2) the reducing of inherent coarseness. These two variables it is suggested are two expressions of the same kind of balance the increasing of the varying original (X and Y) densities as opposed to skin expansion at different times - viz. the trio and nine stages. These two variables however cannot be separated but according to the extent they interact do we get the varying fibre type arrays. It now seems as if we may regard the prenatal check as a trio depression and the reducing of inherent coarseness as a nine depression. On this theory the arrays may be described as follows :-

The Plateau : would be due to a slight trio depression succeeded by a late nine depression. Hence the original density was not sufficient to combat the skin expansion and only when all follicles were developed did the coarseness appreciably diminish. This would account for the common occurrence of precipices in Plateau arrays.

Saddle: In this case the trio depression is slight and the nine depression is not effective until at least

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some curly-tips have become coarse. Hence original density was again insufficient to outweigh skin expansion but was sufficient to cause a slight checking at the trio stage which is not repeated till well along the series.

Ravine: Here the original density is sufficient to cause a strong trio depression but the skin expansion is too great to allow it to persist long enough to overlap with the nine depression - hence the marked rise in coarseness prior to the nine depression causing the reducing of inherent coarseness.

Valley: The trio depression is of longer duration here but the nine depression though not usually late is not soon enough to overlap with the trio one. Very rarely the nine depression is late. Here the original density is sufficient to cause a marked check at the trio stage which extends into the beginning of the nine stage. Now, however, there is a greater expansion in skin than the density can cope with and there is a rise in coarseness prior to the check caused by the completion of the nine stage. The extent of the rise will depend upon the extent of the disparity between skin expansion and density.

Plain: The trio depression and the nine depression overlap - the original density is sufficiently great to counteract skin expansion so the trio and nine stage checks overlap and no rise occurs.

Escarpment:
Here the trio is early and the nine depression is potent and both overlap depressing all sickle-fibres to curly-tip ones. The original density is sufficient to give an early potent trio depression and the nine stage density overlaps it.

This array suggests that a "break" in follicle formation occurs at some period - pre-curly tips being one side the "break" and curly-tips the other.

From this we can say that the fibre type arrays can be explained as due to the varying interactions of skin expansion and the increasing of original density - taking place at different times - viz. at the trio and nine stages. The first stage - the trio depression - has been called the prenatal check, the second the nine depression - the reduction of inherent coarseness (5) (6). Further we may say that these two variables - the skin expansion and the original density have to be considered when the pre-curly-tip distribution is discussed. (See Section C). Here the varying skin expansion up to a definite period - the trio stage - is with the number of first follicles of all importance. The varying proportions of pre-curly-tip to curly-tip fibres may be due to a greater expansion of skin prior to the trio stage on those regions with high counts than on those with low counts. This will not affect the later density and will therefore not affect the later portion of the fibre type array. This early density followed by marked expansion may account for the prevalence of Ravine arrays on the superior ileum and thurl positions.

The follicles that appear after the nine stage have not been considered as affecting the fibre type array being only additional follicles which may or may not comprise all the histerotrich fibres.

It is hoped that future more detailed work on density variation and skin expansion will further test this view.

SUMMARY.

Summarising the above account it can be said that the first follicles formed are the first to pierce the skin and that certain areas are always in advance of other areas in the following order of developmental progress. A, B, C D, E then F areas.

The first fibres to come through are the sensory hairs Dry (2) de Meijere (9) Wildman (14). The next positions to pierce the skin are the horn region and posterior coronet regions. The areas now pierce in the order given above - A, B, C, D, E and then F.

What fibres these first follicles produce is dependent upon the prenatal check - in the New Zealand Romney on all except the B and C areas and portions of the D one - the withers - they are often halo-hairs - but on the finer woolled breeds they will usually be sickle-fibres.

The later fibres keep piercing the skin and what they become depends upon the time and extent of the reducing of inherent coarseness.

For the purposes of describing the development of the Romney lambs' coat it was found convenient to divide the skin into certain areas - A, B, C, D, E and F - each being formed by the grouping of all regions that develop at the same time and rate.

These areas are determined by the following methods :

(1) All regions where X and Y follicles begin growth at the same time belong to the same area.

(2) All regions attaining the trio stage of development at the same time belong to the same area.

(3) All regions reaching the nine stage of development at the same time belong to the same area.

(4) All regions on which follicles pierce the skin at the same time belong to the same area.

These are the four main stages in the development of the coat and may be termed

(1) The foundation of X and Y follicle stage.
(2) The trio stage.
(3) The nine stage.
(4) The skin piercing stage.

These four stages take place on different areas at different times but never more than three stages can be recognised on a foetus at one time. Further it is possible to detect marked differences in the extent to which a stage is developed - for example two areas may both be at the trio stage but one area may be at an advanced stage and the other just trioed. It is a study of these differences in the stage of development of the trio group that is most useful in defining the areas.

From this work we can state: (1) that different areas develop at different times; (2) there is orderly progression in development from A to F areas; (3) there are certain marked stages of development that enable one to judge the approximate age of the foetus by a study of the different stages of follicle development occurring over the foetus at the same time; (4) that each region is a local governor of its own development; - this last fact supporting the view that the depression is a local phenomenon.

In future work it is hoped to correlate this information with post natal growth and put to the test the theory that the fibre type array is due to the original density and its relationship to skin expansion - the prenatal check being due to density at the trio stage / a trio depression- / and the reducing along the array of the inherent coarseness to a similar depression at the nine stage / a nine depression.

SECTION C.

RELATIVE ABUNDANCE OF FIBRES OF THE HALO-SICKLE GROUP OF DIFFERENT BODY REGIONS.

DISTRIBUTION OF THE HALO-SICKLE (PRE-CURLY-TIP) GROUP.

We turn now to consider the proportion of halo-hairs sickle-fibres and their intermediate fibre types to curly-tip and post-curly-tip fibres - See Graphs 14, 15 and 16.

It was evident at a glance, when making a study of the fibre type arrays, that the shoulder point and withers specimens had more sickle-fibres than the back and side while the back and side samples had more than the superior ileum and thurl samples. Counts were made confirming these observations. It was then apparent that excluding the poll and britch, the higher the sickle-fibre count on any region of the body the earlier does the coat begin to grow on that region.

The poll had a low sickle count; the coat commences growth on the poll first; halo and sub-halo hairs and super-sickles were plentiful on the poll. As it is possible to obtain fibres that are intermediate between these fibre types and sickle-fibres it was considered that they may be grouped together as a pre-curly-tip group. Further support for this grouping is that in a few lambs of Dr. Dry's with a very high number of halo-hairs, these fibres are far more plentiful than the super-sickles. Then in all Dr. Dry's lambs in which super-sickles are plentiful the sickles are relatively scarce. Further Mr. Rudall points out that in one lamb shed sickles were followed by shed kemp. Another reason for grouping these fibres together is that the pre-curly-tip fibres are the fibres that constitute the Kemp. Curly-tip fibres are only very occasionally shed in the Romney. Further these pre-curly-tip fibres all shed the same way - even in the finer breeds - that is there is a thinning followed by a brush in a bulb like swelling (5). The subsequent counts justified this grouping of the pre-curly-tip fibres together; these counts were made from samples taken from

the same positions as the fibre type array samples - see Fig. 2. A preliminary examination of prenatal material was made and it was found that the order in which positions commenced growth was the same for the New Zealand Romney as for the British breed described by Wildman (14).

Lambs of the Southdown and Ryeland breeds were also sampled and counted.

The precurly-tip fibre count for the different positions naturally fell into groups. The groups on examination of foetal material were found to represent regions on which the follicles burst through the skin at approximately the same time. Further the groups arranged themselves in the order of diminishing counts and the groups with the highest counts burst through the skin earlier than those with lower counts.

The grouping in order of diminishing counts was - see Graphs 14, 15 and 16.

Poll	A area
Ventral neck	B area
Shoulder point	C area
Withers, fifth rib, and britch	D area
Back and side	E area
Superior ileum, thurl and superior flank	F area

The following table gives the counts for nine New Zealand Romney, two Southdown, and two Ryeland lambs.

The positions or groups of positions are allocated to the area they belong to as described in Section B of this paper. See Fig. 9 - Section B - Areas A, B, C, D, E or F., being the terms given respectively to the different regions which commence growth at the same time. Area A is the first area to burst through the skin - Area F the last. The number of regions belonging to an Area varies - see Fig. 9, Section B.

Table 3 showing the number of pre-curly-tip fibres per hundred fibres on Romney, Southdown and Ryeland lambs. For some animals the complete series of samples was not available.

---

osition	Area according to Section B.	Counts												
		Romney									South-down		Rye-land.	
Sheep No.		638	641	745	755	763	607	619	622	628	80	85	50	63
oll	A	32	30	20	24	25	-	-	-	-	19	32	31	31
entral eck	B	-	25	14	21	22	-	-	-	-	-	-	-	-
houlder oint	C	25	20	10	20	20	22	19	20	27	15	29	24	24
ithers)		22	18	7	14	13	17	13	17	21	12	27	19	20
ritch)	D	22	16	9	14	13	15	15	16	21	9	26	18	19
ifth Rib)		-	-	8	14	14	-	-	-	-	-	-	18	20
ide)														
ack)	E	20	14	7	11	8	14	11	12	19	5	23	11	13
		18	13	6	12	9	14	10	10	18	7	25	14	13
uperior ileum)														
hurl)F.		8	10	5	8	5	8	8	8	15	4	17	6	7
uperior flank)		7	8	5	-	6	10	9	9	17	-	-	-	-
		7	9	-	-	-	8	8	8	17	-	-	-	-

See Graphs 14, 15 and 16 illustrating the diminishing counts as one passes from early to later developing areas. These graphs emphasise the fact that there is no definite line of demarkation separating one area from the next making the actual definition of areas somewhat arbitrary.

This grouping suggests that areas showing the same stage of follicle development may be easily observed in prenatal material. See Section B.

From Graphs 14, 15 and 16 and the above table it can be seen that the number of precurly-tip fibres present may vary considerably on different animals but the relationship between the regions generally conforms to the following order :-

A areas having between 4 and 5 times as many pre-curly-tip fibres as the F areas; the B and C ones have between 2 and 4 times, the D between 2 and 3 and the E between 1 and 2 times as many as the F area.

We can describe the limits of variation thus :-

	Poll	Ventral Neck	Shoulder Point	Withers Britch and Fifth Rib	Side and Back	Superior ileum and Thurl and Superior Flank
Areas	A :	: B :	C :	D :	E :	F

The Graphs (14, 15 and 16) show a similar type of curve for Romney, Southdown and Ryeland lambs - each sheep showing a gradual diminishing of the count from early to late areas. We thus find that the Ryeland and Southdown breeds agree with the Romney in their distribution of pre-curly-tip fibres.

CONCLUSION.

From the facts reported it is concluded that the earlier a fibre begins to grow the greater its chances of being a halo-hair, the depression determining theparticular fibre type array, however, resulting in the diversification of the expression achieved from follicles with similar potentialities. With this in mind we may suggest that there may be an essential sameness in the follicles that produce halo-hairs, sickle and curly-tip fibres, each fibre-type being an expression of the effect of the depression upon the follicles at different stages of development.

We find that there is a regular distribution of pre-curly-tip fibres and for this reason alone we may group them together, We thus have all pre-curly-tip fibres expressions of follicles with similar potentialities. When we consider the counts in conjunction with pre-natal work we find that on no part of the body can any follicles but trio stage follicles become pre-curly tip fibres. From this one may assume that the follicles of the nine stage are so affected by the nine depression that they become fine tipped curly tips. On some areas all of the trio follicles may be pre-curly-tips while on later ones very few will be allowed to become pre-curly-tips. It is on the later areas however that we find coarse curly-tips which presumably comprise the remaining fibres from the trio follicles. This may be the clue to the relation between pre-curly-tip hairiness and curly-tip hairiness, suggesting that both are different expressions of a similar phenomenon. In support of such a view we may mention that in animals with marked pre-curly-tip hairiness - Plateau arrayed animals - the curly-tips are often

hairy. Also in the occasional high shedding of curly-tips Dry (unpublished paper) we have behaviour on the part of the follicles that is usually confined to those containing pre-curly-tips. Further, Dry finds that his no-halo-hair animals are never grossly hairy, gross curly-tip hairiness accompanying gross pre-curly-tip hairiness. It may also be put forward in support of this suggestion that the very fact that the two depressions coalesce in the Plain and Escarpment arrays indicates that both types of hairiness may be reduced by the same depression - suggesting similar potentialities in the follicles.

From this it can be gathered that no definite conclusion can be drawn as to why the high and low counts are distributed as they are. Prenatal investigation, however, suggests that only trio stage follicles form pre-curly-tip fibres and that the original density together with the skin expansion determines the future career of a fibre. Further it is suspected that the same two factors are all important in determining the fibre type array distribution. This suggests that pre-curly-tip fibre distribution and fibre type array distribution may be closely related. This is more fully discussed in the section headed "discussion" in Section B of this paper.

GENERAL SUMMARY.

1. A new fibre type array - the Escarpment - has been found, the interpretation of which leads one to suggest that the founding of follicles may proceed in "jerks" - "breaks" occurring between one fibre type and the next.

2. There is a general posterior - anterior (britch-poll) gradient in the depression causing the fibre type array together with subsidiary inferior-superior gradients for the dorsal and dorso-lateral portions of the coat of the Romney, Southdown and Ryeland breeds.

3. The ventral surface from more casual examination has a similar but less marked posterior-anterior gradient, in the depression causing the fibre type array.

4. This orderly variation is due to anterior positions always being more depressed than posterior ones. The britch position array therefore limits the arrays on the other positions of the body to being no less depressed than the britch position array.

5. Variation in fibre length is correlated with the fibre type arrays - the more depressed an array - that is an array severely affected by both the prenatal check and the reducing of inherent coarseness - the less the variation in its fibre length. Also the more depressed an array the finer the fibres comprising it and the lower the percentage of medullation.

6. Shedding of fine fibres is discussed and although the fine fibres of Southdown and Ryeland are of the same fibre types as those of the Romney in which shedding is regarded as an expression of vigour, it is thought that this shedding is due to some other unknown factor.

7. The body of a foetus can be divided into six areas - A, B, C, D, E and F, each area being made up of regions which develop at the same time. The areas develop in this order - A, B, C, D, E then F.

Neither the eyes, ears, nostrils nor lips which have sensory follicles, nor the posterior and anterior coronet regions are included.

in these areas.

8. The first follicles laid down on any region are the first follicles from which fibres burst through the skin on that region. The time from the foundation of the follicle to the bursting through the skin of the fibre is between six and seven weeks - a follicle taking between two and three weeks to attain its full size after which presumably the fibre commences growth.

9. Development proceeds on the A areas in a series of three - each first follicle (X or Y) being the forerunner of nine follicles x'xx' x'Xx' x'xx'.

10. There are four marked stages in the development of the coat, each area reaching the same stage of development at a different time.

(1) The foundation of follicles (X and Y) stage.
(2) The trio stage.
(3) The nine stage.
(4) The skin piercing stage.

11. It is suggested that the prenatal check is a trio depression and the reduction of inherent coarseness a nine depression.

12. It is suggested that the intensity of the trio and nine depressions is due to the number of first X and Y follicles (the forerunners of the three and nine groups) as opposed to the skin expansion up to the trio and nine stages.

13. The number of pre-curly-tip fibres per hundred fibres from the different areas decreases as one passes from early to late developing areas.

14. It is shown that the earlier a follicle commences growth the greater its chance of being a halo hair; halo-hairs pierce the skin first, then sickle fibres and then curly-tips and last of all histerotrichs.

15. The greatest number of pre-curly-tip fibres per hundred fibres was thirty-three; therefore only trio follicles ever form pre-curly-tip fibres.

16. On the regions where the pre-curly-tip count is low the hairy-tipped curly-tips are more abundant.

17. The suggestion is put forward that pre-curly-tip and curly-tip hairiness may both be expressions of an essential sameness.

18. It is concluded that every region is a local governor of its own development.

I wish to acknowledge my indebtedness to Dr. Dry and to Mr. K. M. Rudall for their helpful criticisms. My thanks are also due to the donors of the Farmers' Union Scholarship for the opportunity to carry out this investigation.

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DESCRIPTION OF PLATES.

PLATE 1 :
Fig. 1.

Escarpment array - note the direct transition from supersickles to curly tip fibres.

Fibres

From left to right.

Halo hair shed.

Super sickle shed.

Super-sickle persistent.

Curly-tip persistent.

PLATE 11:

Fig. 2:

Diagram of a lamb showing the positions sampled.

Fig. 3: Diagram of the fibre type array distribution on the Romney Lamb No. 755 - the example from the coarse woolled class of Romney lambs.

Fig. 4:

Diagram of the fibre-type array distribution on the Romney Lamb No. 618 - the example from the fine woolled class of Romney Lambs.

PLATE 111:

Fig. 5: Diagram of the fibre type array distribution on the Romney Lamb No. 763 - the example from the intermediate class of Romney Lamb.

Fig. 6:

Diagram of the fibre type array distribution on the Southdown lamb No. 80.

Fig. 7:

Diagram of the fibre type array distribution on the Ryeland Lamb No. 50.

PLATES 1V: Graphs 1, 2, 3

V: 4, 5, 6

V1: 7, 8, 9

V11: 10,11,12.

These are graphs of the fibre type array distributions on

various Romney, Southdown and Ryeland lambs. The graphs are drawn to show the increasing intensity of the depression causing the fibre type arrays as one passes from posterior to anterior positions and from inferior to superior positions - the inferior - superior gradient being subsidiary to the general posterior-anterior one.

Graph 1:

Graph for Romney lamb no. 755.

See Fig. 3.

Graph 2

Graph for Romney lamb No. 618.

See Fig. 4.

Graph 3

Graph for Romney Lamb No. 628.
Note: the side less depressed than the back position.

Graph 4

Graph for Romney Lamb No. 745.
Note the 5th rib less depressed than the withers position.

Graph 5

Graph for Romney Lamb No. 641.

Graph 6

Graph for Romney Lamb No. 763.

See Fig. 5.

Graph 7

Graph for Romney Lamb No. 638.

Graph 8

Graph for Southdown Lamb No. 85.

Graph 9

Graph for Southdown Lamb No. 80.

See Fig. 6.

Graph 10

Graph for Ryeland Lamb No. 63.

Graph 11

Graph for Ryeland Lamb No. 50.

See Fig. 7.

Graph 12

This graph is drawn from Table 1 giving the commonest

fibre type arrays on the various positions. This graph gives the fibre type array gradient typical for the New Zealand Romney lambs studied.

PLATE V111:

Graph 13

Graph showing the minor variations in fibre type array gradient due to variation in the extent to which the same fibre type array is depressed.
The graphs are for Romney Lambs Nos. 755 and 641.
Compare with Graphs 1 and 5 for the same sheep.

PLATE 1X:

Fig. 8

Diagram of a lamb to indicate the positions from which skin snippets were taken on prenatal material.

Fig. 9

Diagram of the dorsal and ventral portions of a pelt of a lamb to show the Areas A, B, C, D, E, F and the different regions comprising an Area. The sensory follicles round the eyes, lips and nose and those of the anterior and posterior coronet regions do not belong to any Area.

Ant. Coronet	Anterior coronet region.
Ext. Genitals	External genitals
Post. Coronet	Posterior coronet region.

PLATE 10:

Fig. 10

Diagram to show the first follicles just appearing.

Fig. 11

Diagram to show the appearance of two types of first follicle - the X and Y follicles.

Fig. 12

Diagram showing the commencement of the trio stage, some of the X follicles being trioed but none of the Y ones. Note the linear arrangements.

Fig. 13

Diagram of the trio stage - all X and Y follicles are trioed. xXx and yYy stage.

(to be opposite Plate 10).

PLATE 11:

Fig. 14

Diagram of the completed trio stage with odd new x' follicles appearing - X and x and Y and y follicles are all the same size.

Fig. 15

Diagram showing the trio appearance disappearing due to the addition of new x' follicles.

Fig. 16

Diagram to show the disappearance of the trio stage and the groupings of six, seven and eight follicles.

Fig. 17:

Diagram of the nine stage - showing the tendency for each of group of nine to form three groups of three.

PLATE 12 Graphs 14, 15 and 16.

These graphs are drawn to show the decrease in the number of Pre-curly-tip fibres per hundred fibres as one passes from early to late Areas. The areas are those described from pre-natal observations.

Graph 14:

Showing the decrease in the number of Pre-curly tip fibres as one passes from early to late Areas on the Romney lambs - Nos. 638, 641, 763, 755 and 745.

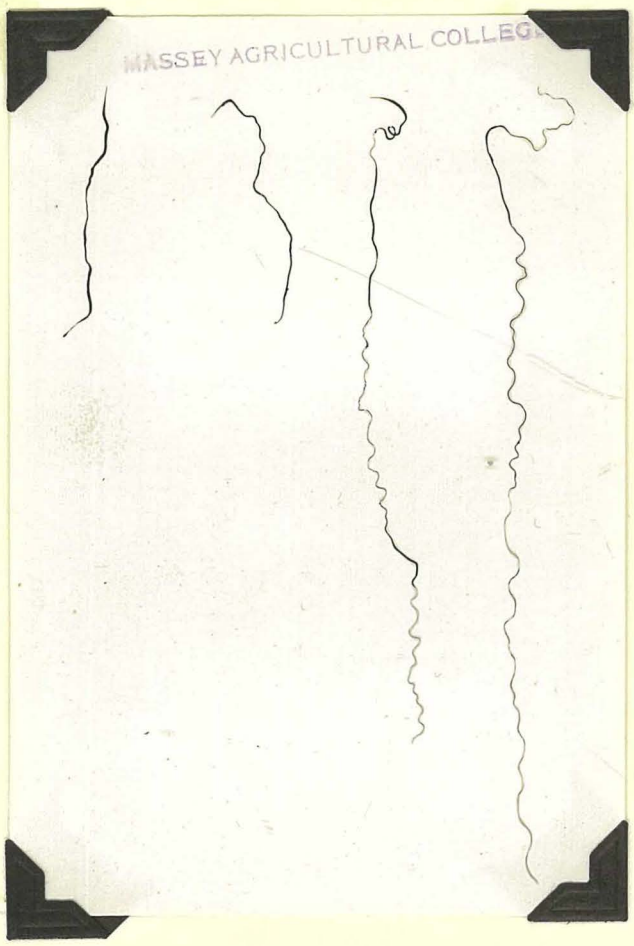
Graph 15:

Shows the decrease in the number of Pre-curly-tip fibres as one passes from early to late Areas on the Southdown Lambs Nos. 85 and 80.

Graph 16 :

Shows the decrease in the number of the Pre-curly-tip fibres as one passes from early to late Areas on the Ryeland lambs Nos. 63 and 50.

Plate I



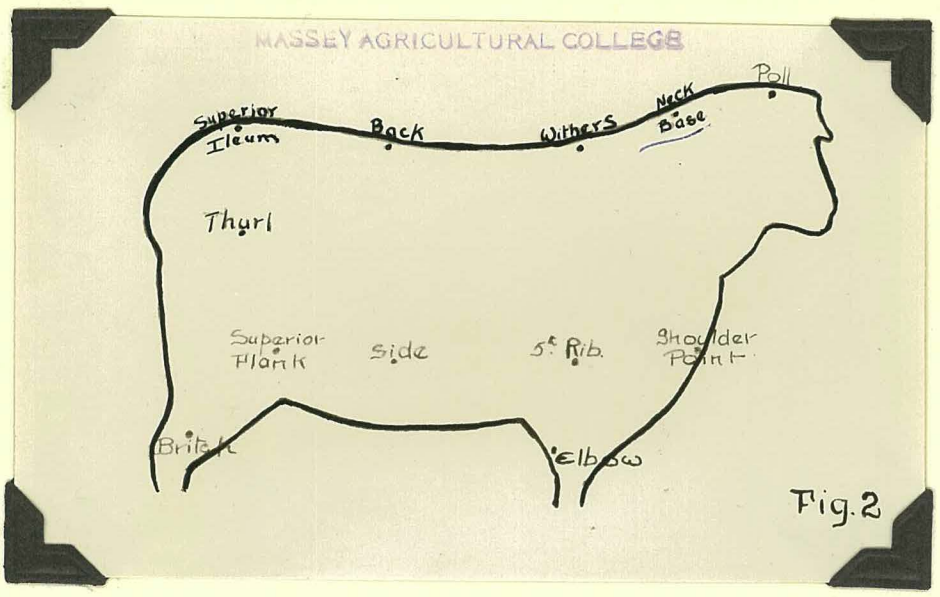


Fig. 2

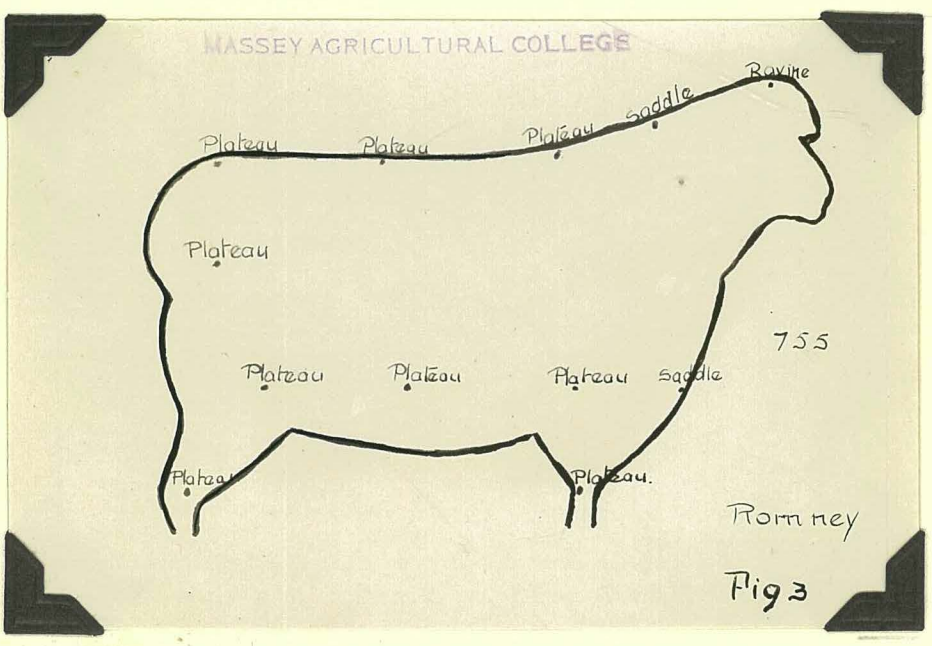


Fig 3

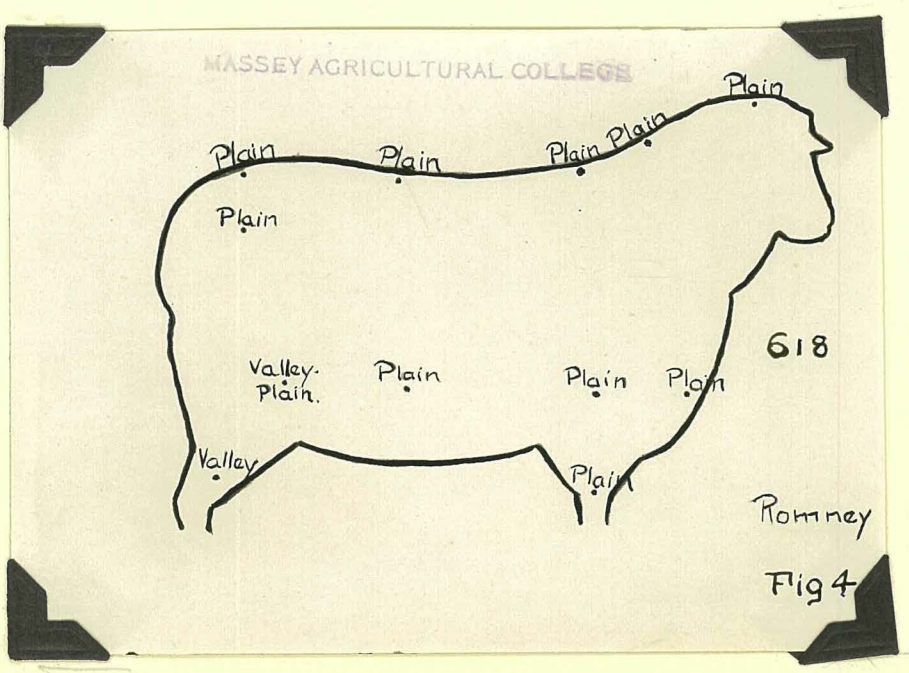


Fig 4

Plate III

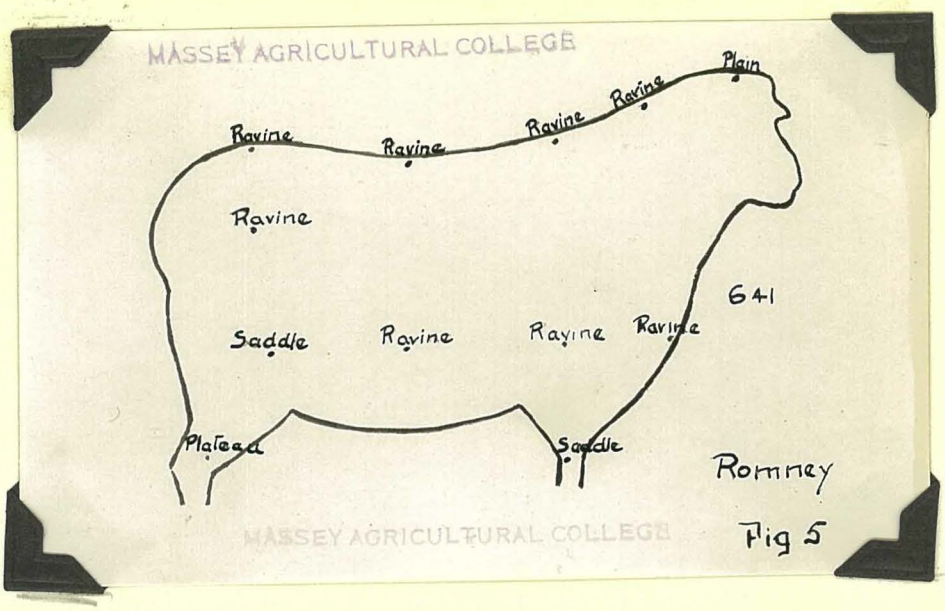


Fig 5

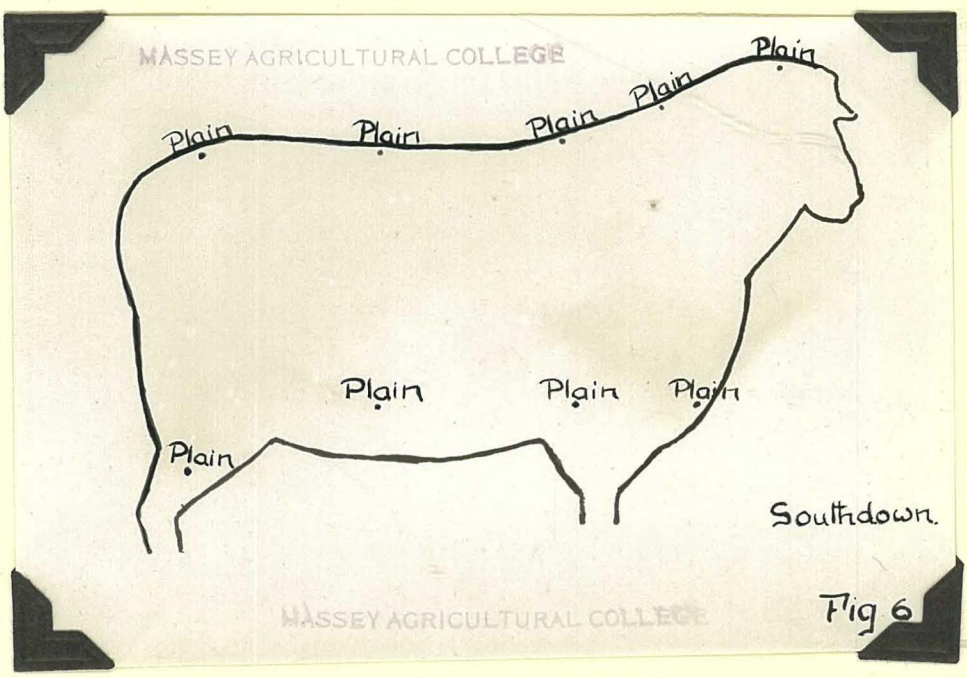


Fig 6

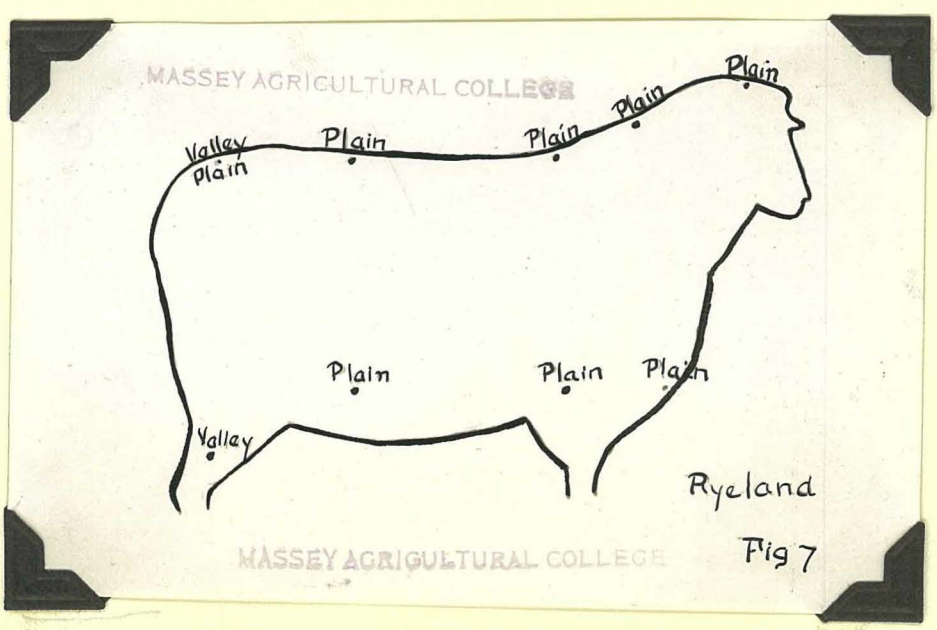
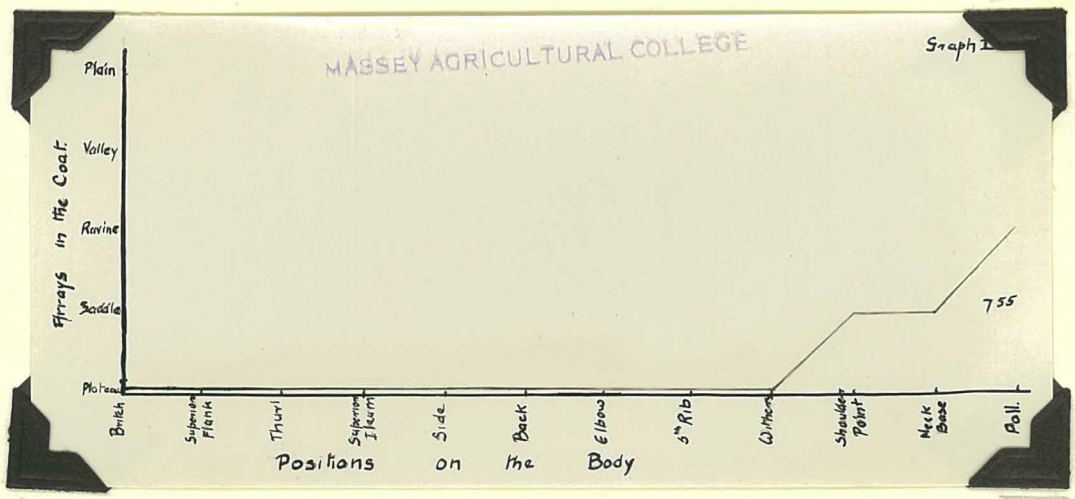
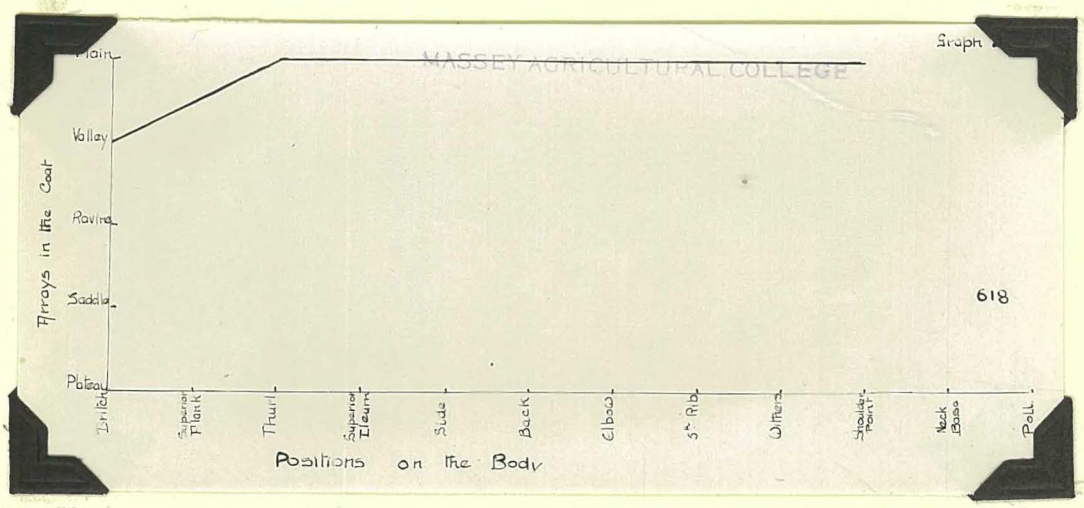


Fig 7

Plate IV


MASSEY AGRICULTURAL COLLEGE
Graph 1
Arrays in the Coat
Plain
Valley
Ravine
Saddle
Plateau
755
Britch
Superior Flank
Thurl
Superior Ileum
Side
Back
Elbow
5th Rib
Withers
Shoulder Point
Neck Base
Poll.
Positions on the Body


MASSEY AGRICULTURAL COLLEGE
Graph 2
Arrays in the Coat
Plain
Valley
Ravine
Saddle
Plateau
618
Britch
Superior Flank
Thurl
Superior Ileum
Side
Back
Elbow
5th Rib
Withers
Shoulder Point
Neck Base
Poll.
Positions on the Body

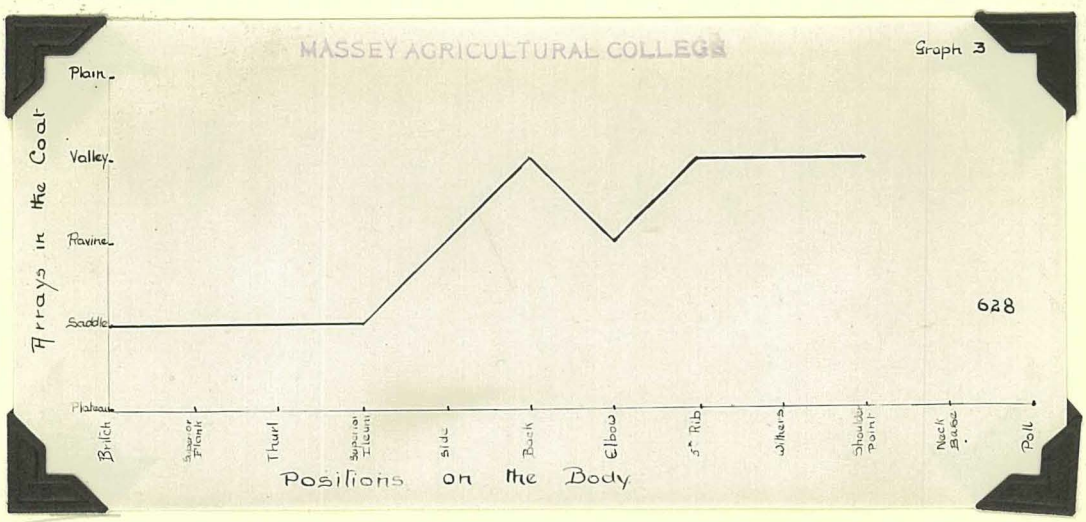
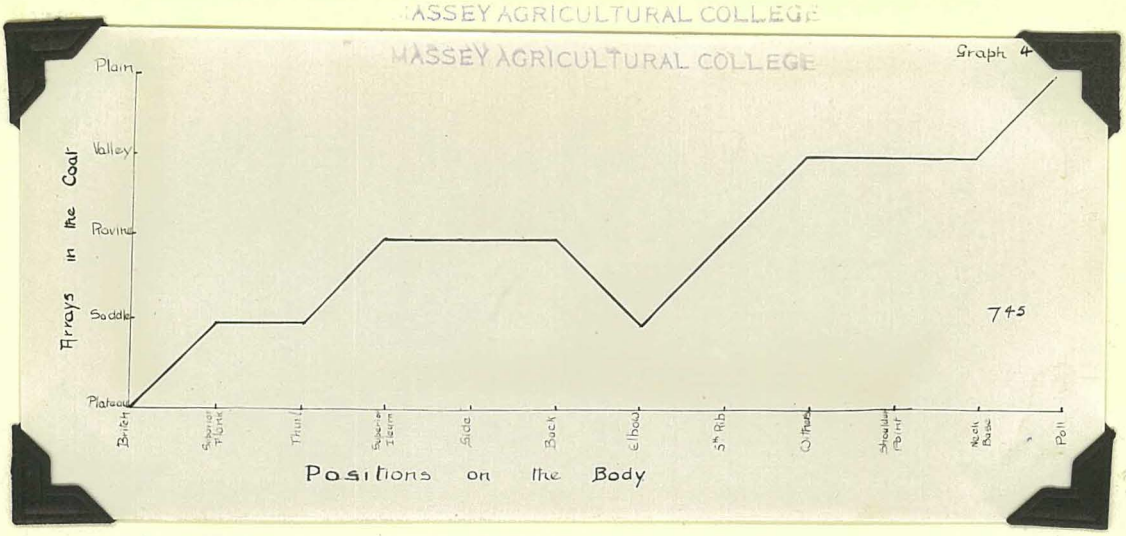
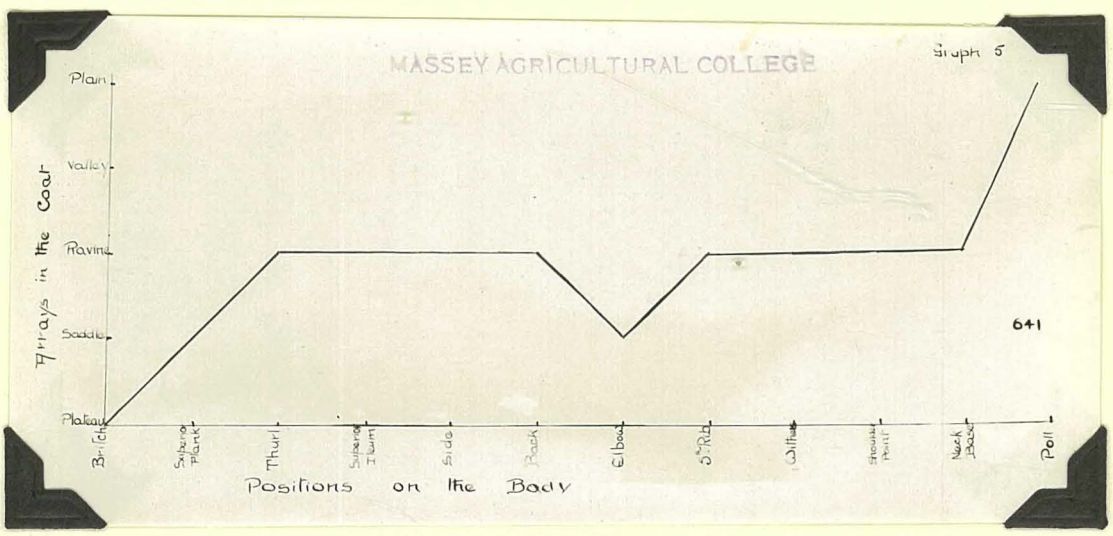

MASSEY AGRICULTURAL COLLEGE
Graph 3
Arrays in the Coat
Plain
Valley
Ravine
Saddle
Plateau
628
Britch
Superior Flank
Thurl
Superior Ileum
Side
Back
Elbow
5th Rib
Withers
Shoulder Point
Neck Base
Poll.
Positions on the Body

Plate V





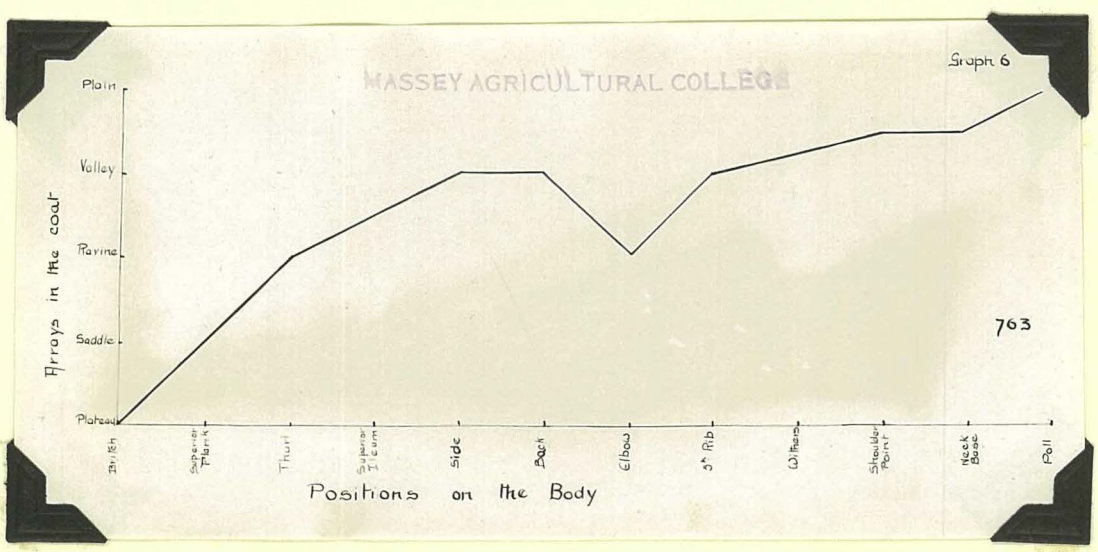
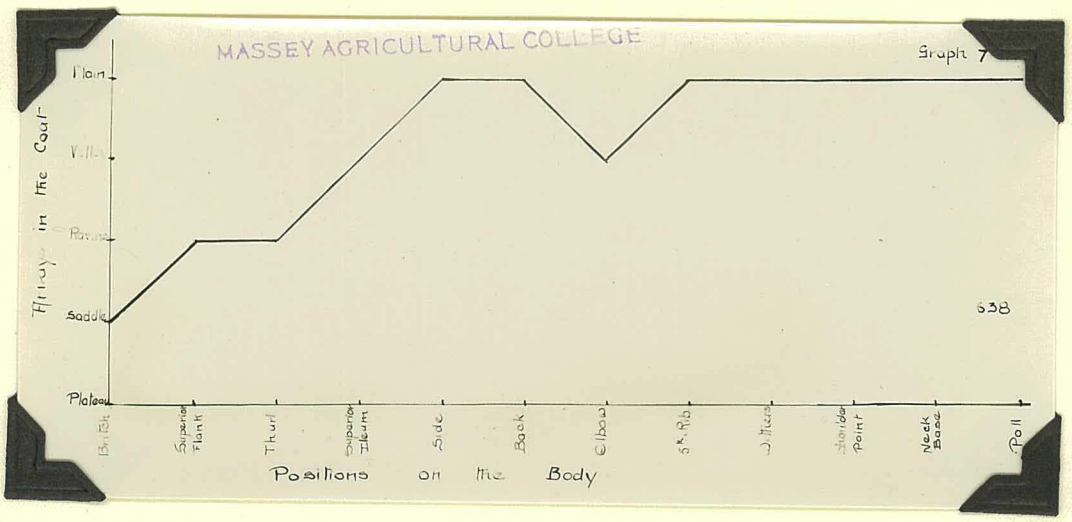
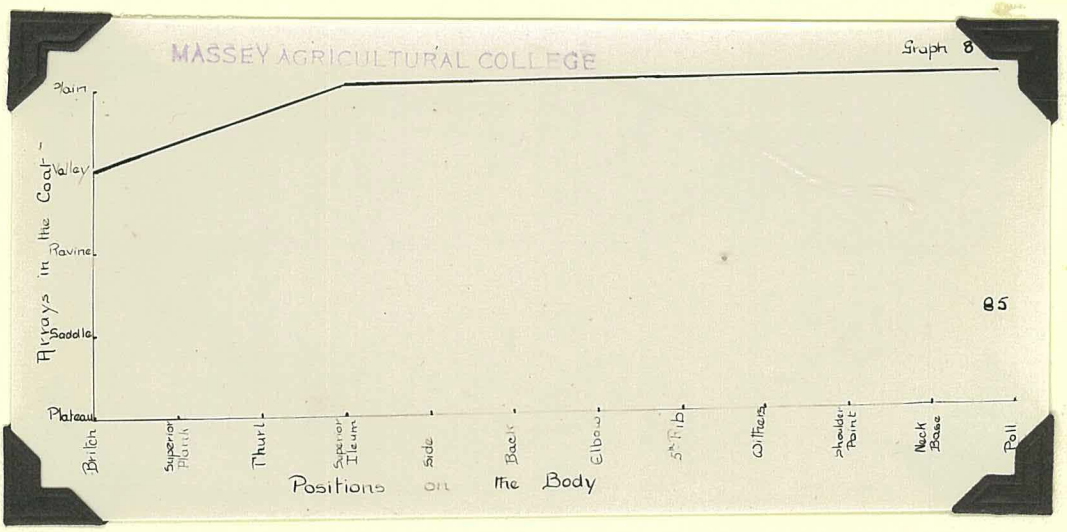


Plate VI


MASSEY AGRICULTURAL COLLEGE
Graph 7
Arrays in the Coat
Plain
Valley
Ravine
Saddle
Plateau
638
Brisket
Superior Flank
Thurl
Superior Ileum
Side
Back
Elbow
5th Rib
Withers
Shoulder Point
Neck Base
Poll
Positions on the Body


MASSEY AGRICULTURAL COLLEGE
Graph 8
Arrays in the Coat
Plain
Valley
Ravine
Saddle
Plateau
85
Brisket
Superior Flank
Thurl
Superior Ileum
Side
Back
Elbow
5th Rib
Withers
Shoulder Point
Neck Base
Poll
Positions on the Body

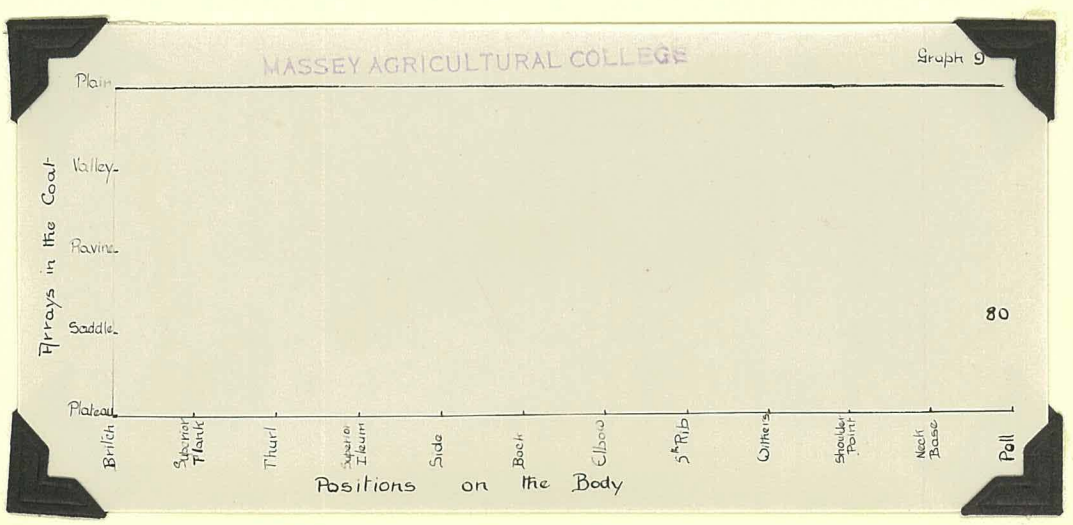
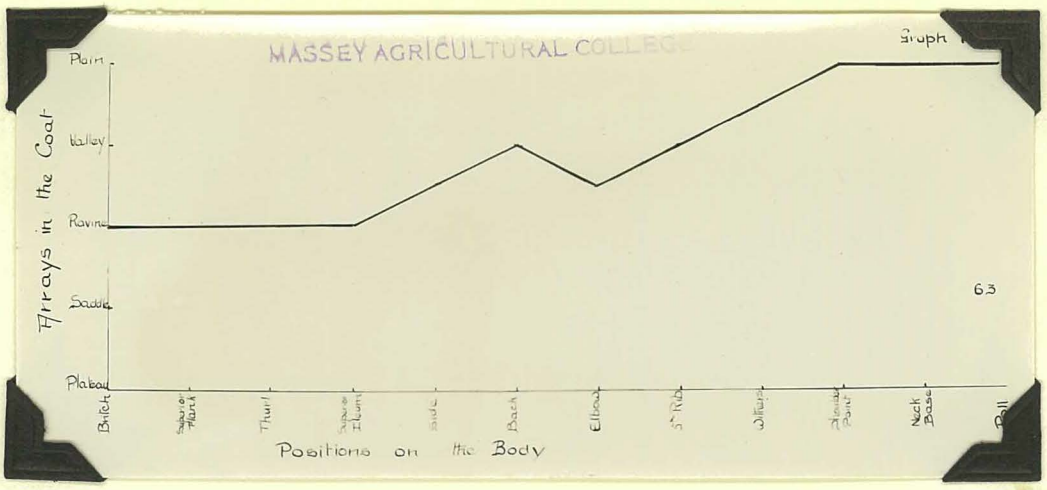
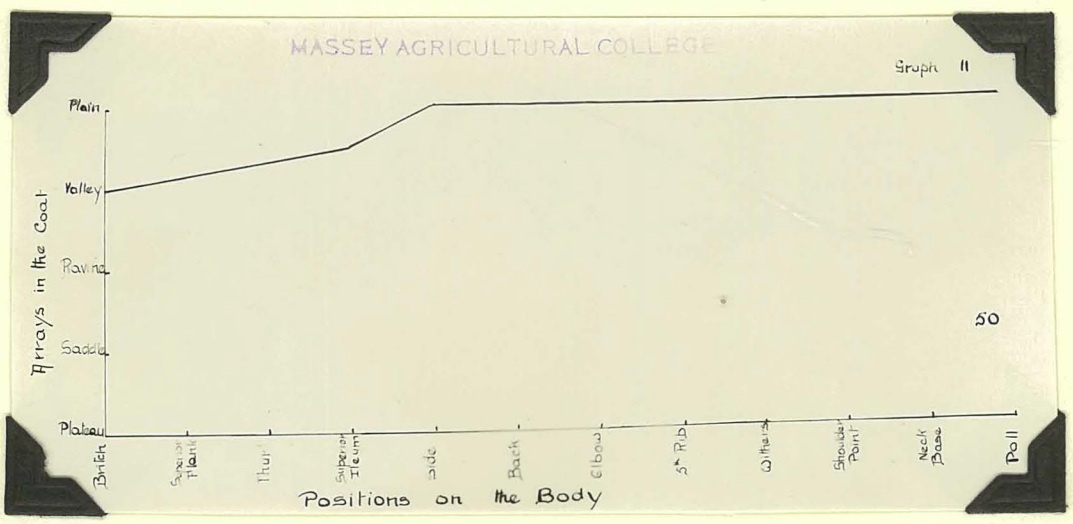
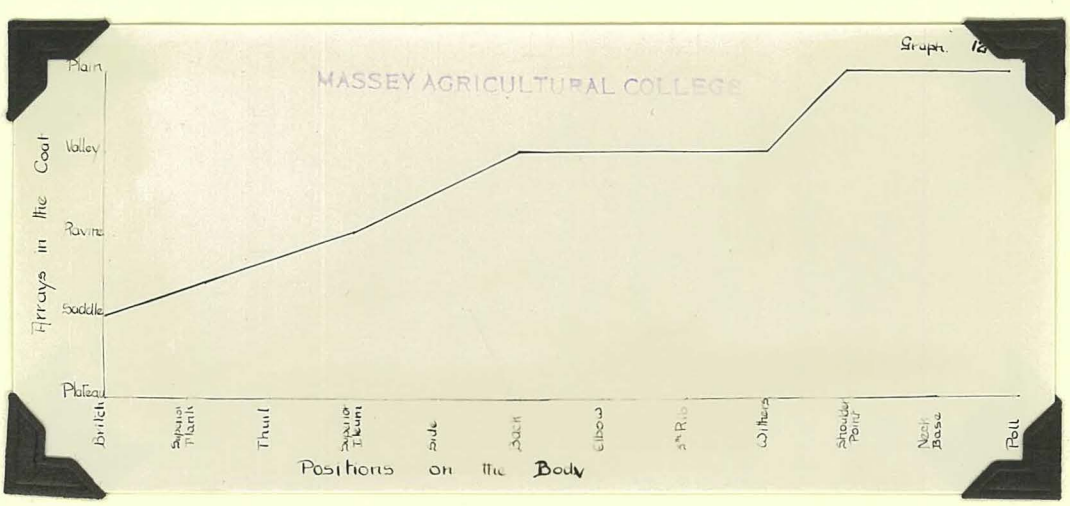

MASSEY AGRICULTURAL COLLEGE
Graph 9
Arrays in the Coat
Plain
Valley
Ravine
Saddle
Plateau
80
Brisket
Superior Flank
Thurl
Superior Ileum
Side
Back
Elbow
5th Rib
Withers
Shoulder Point
Neck Base
Poll
Positions on the Body

Plate VII


MASSEY AGRICULTURAL COLLEGE
Graph I
Arrays in the Coat
Plain
Valley
Ravine
Saddle
Plateau
63
Brisket
Sternum Plank
Thurl
Sternum Ilium
Side
Back
Elbow
5th Rib
Withers
Shoulder Point
Neck Base
Poll
Positions on the Body


MASSEY AGRICULTURAL COLLEGE
Graph II
Arrays in the Coat
Plain
Valley
Ravine
Saddle
Plateau
50
Brisket
Sternum Plank
Thurl
Sternum Ilium
Side
Back
Elbow
5th Rib
Withers
Shoulder Point
Neck Base
Poll
Positions on the Body


MASSEY AGRICULTURAL COLLEGE
Graph 12
Arrays in the Coat
Plain
Valley
Ravine
Saddle
Plateau
Brisket
Sternum Plank
Thurl
Sternum Ilium
Side
Back
Elbow
5th Rib
Withers
Shoulder Point
Neck Base
Poll
Positions on the Body

Graph 13

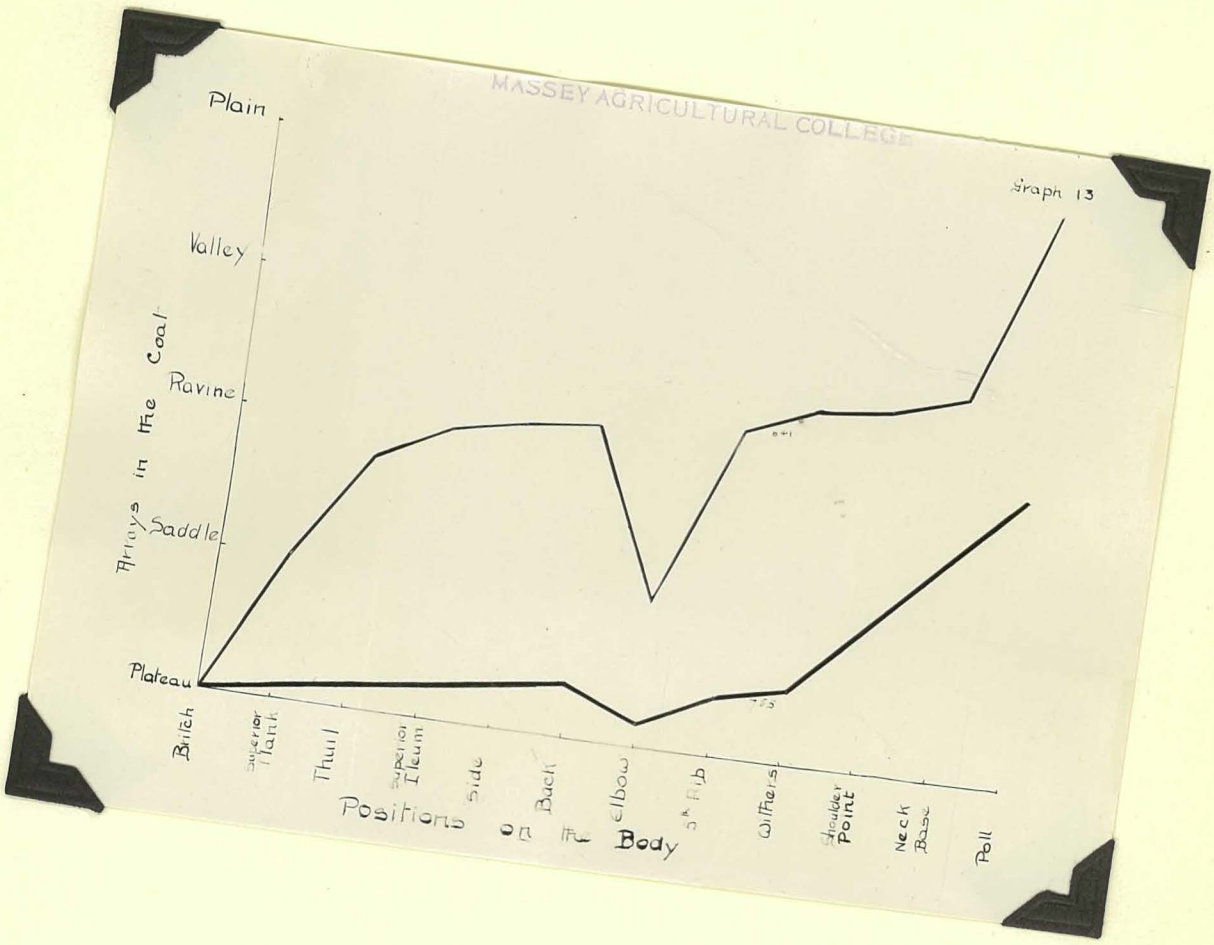
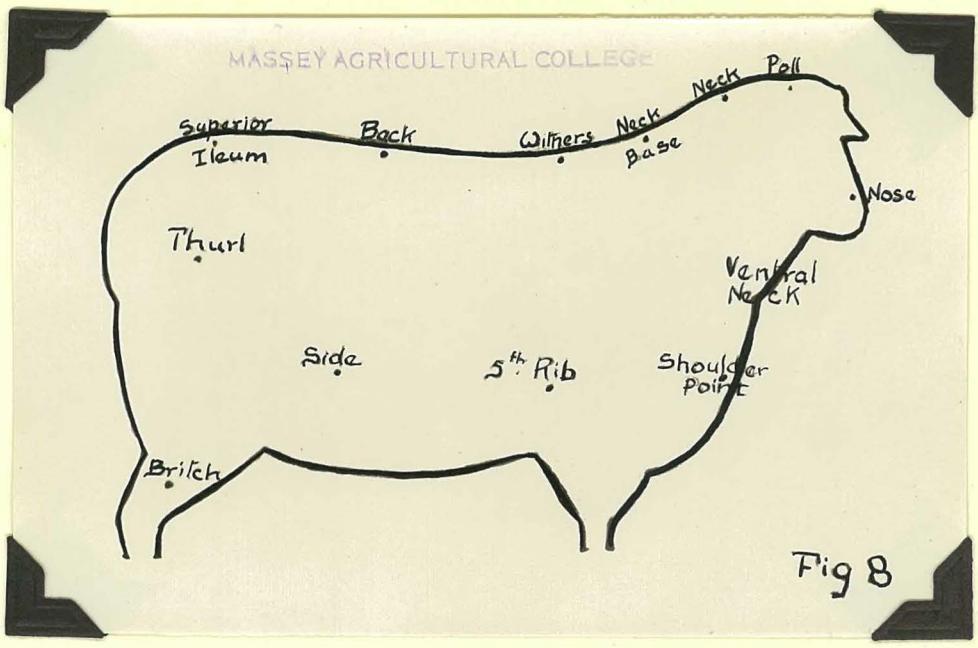


Plate IX


MASSEY AGRICULTURAL COLLEGE
Superior Ileum
Back
Withers
Neck Base
Neck
Poll
Nose
Thurl
Ventral Neck
Side
5th Rib
Shoulder Point
Britch
Fig 8

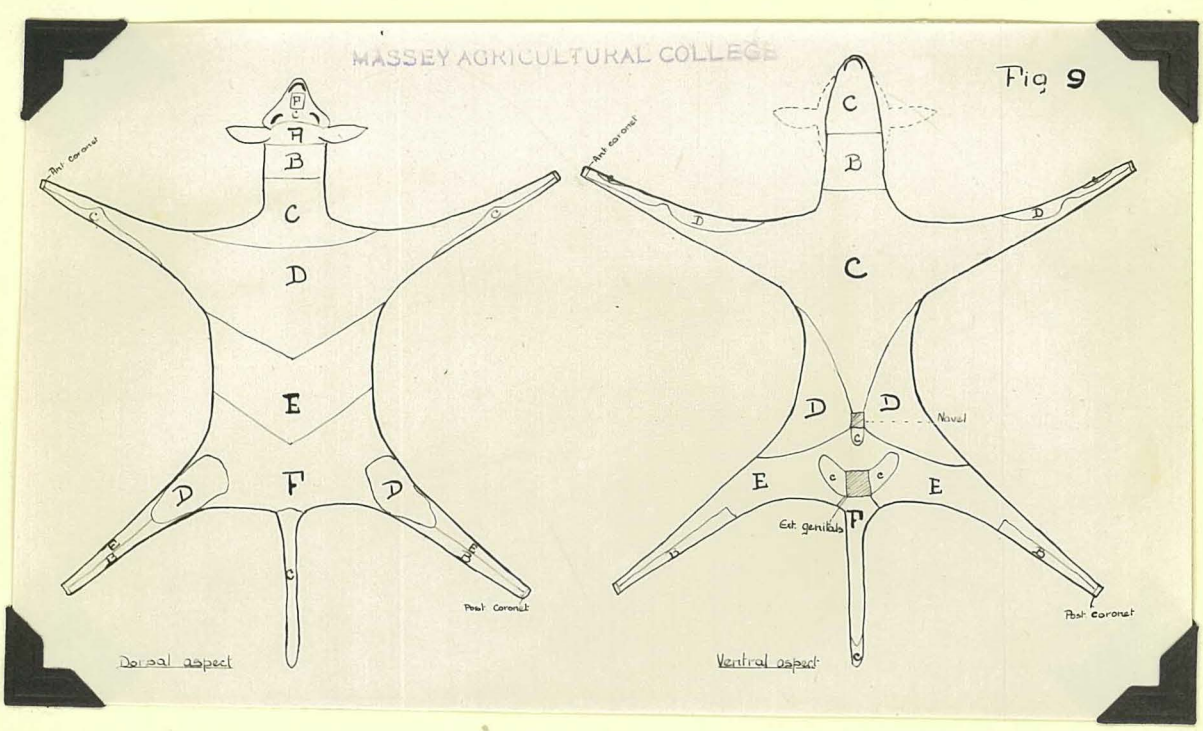

MASSEY AGRICULTURAL COLLEGE
Fig 9
Post. Coronet
A
B
C
D
E
F
Dorsal aspect
Navel
Ext. genitals
Ventral aspect

Plate X

First Stage

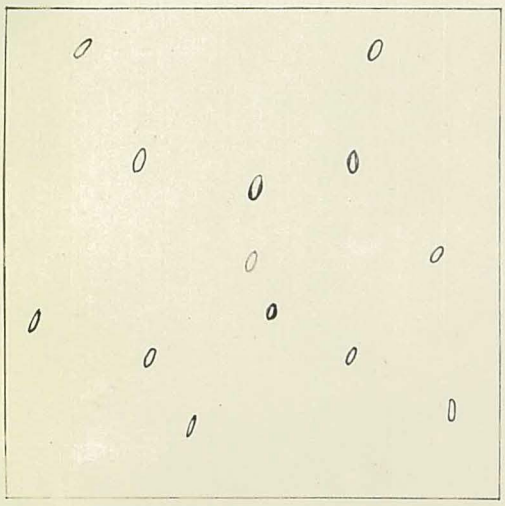


Fig 10

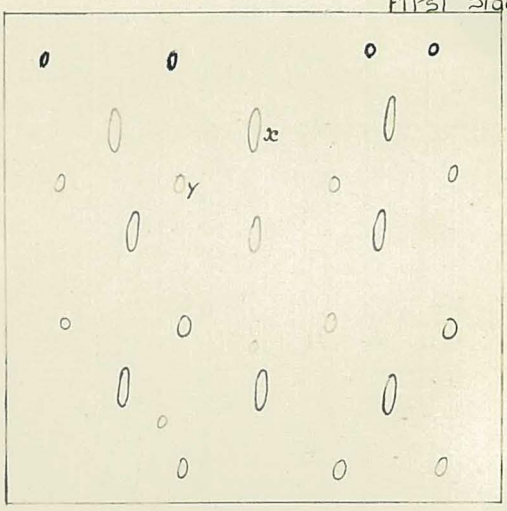


Fig 11

Trio Stage

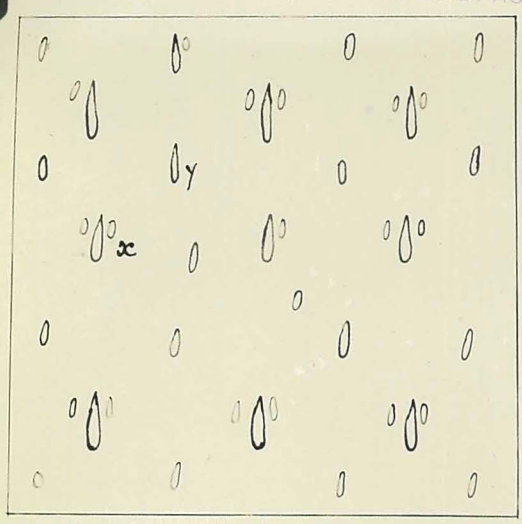


Fig 12

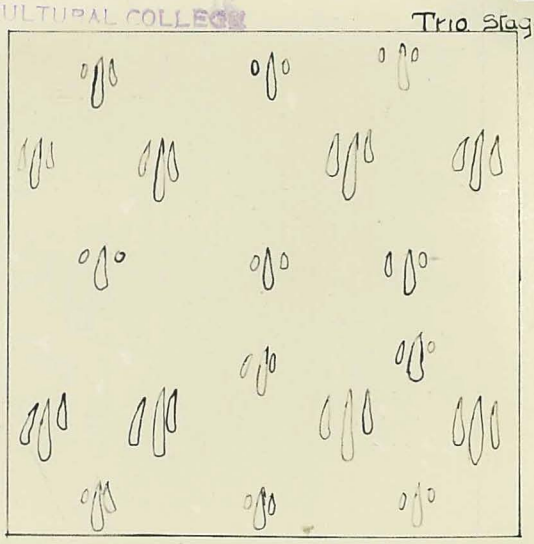


Fig 13

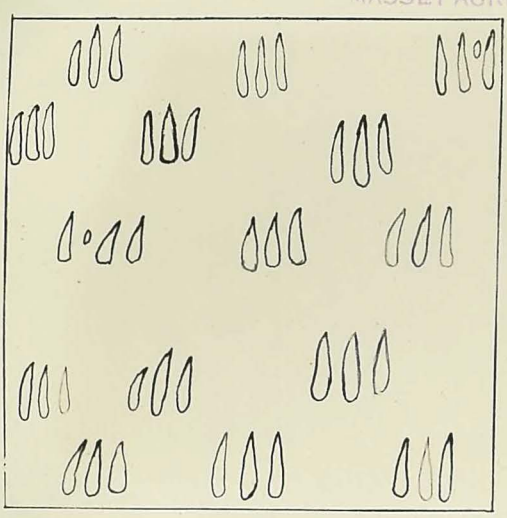


Fig 14

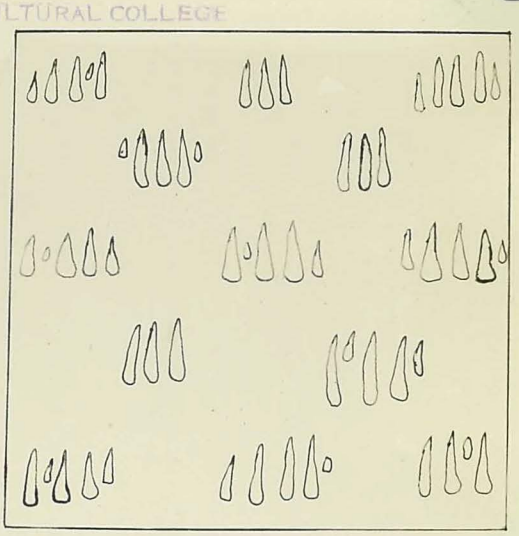


Fig 15

Nine Stage

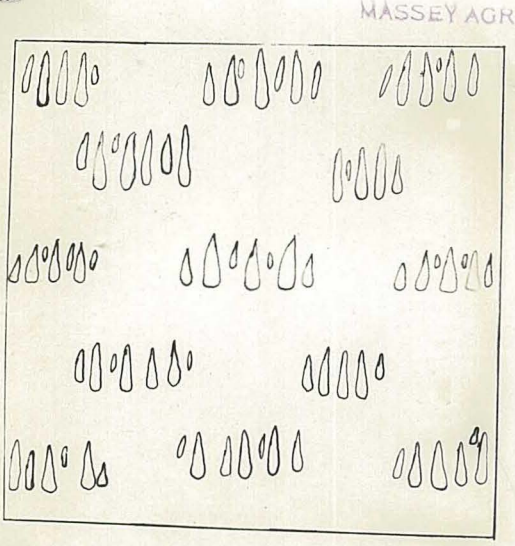


Fig 16

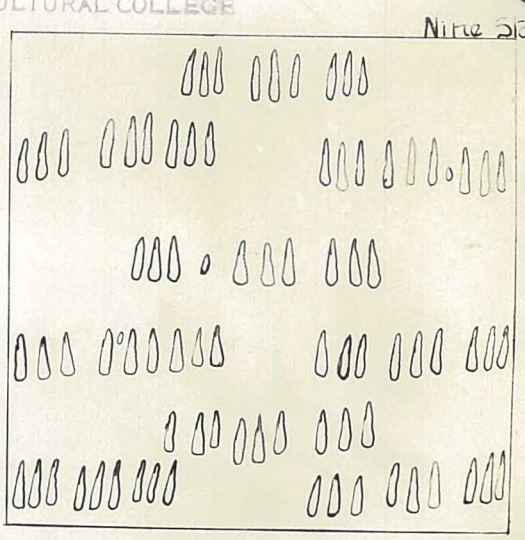
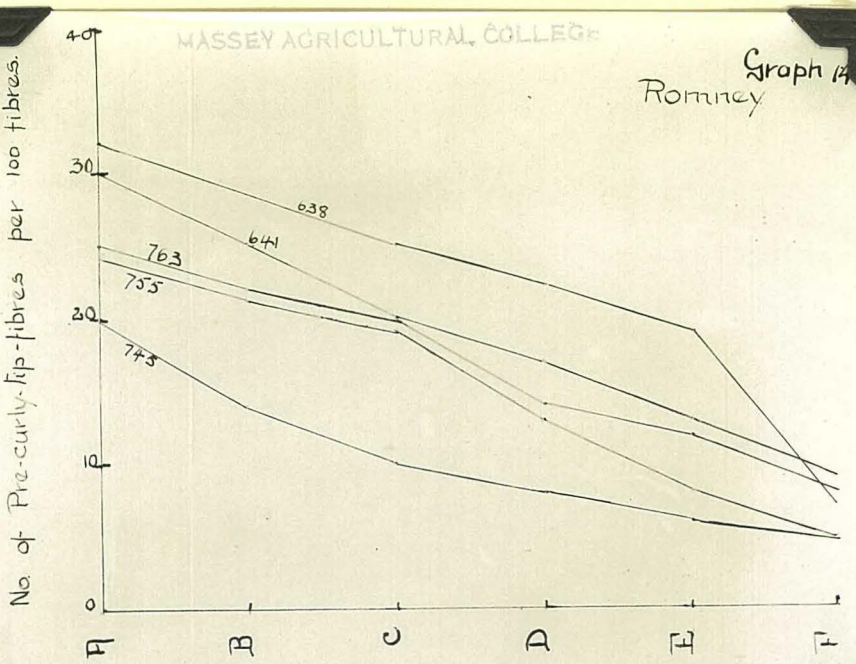


Fig 17

Plate XII

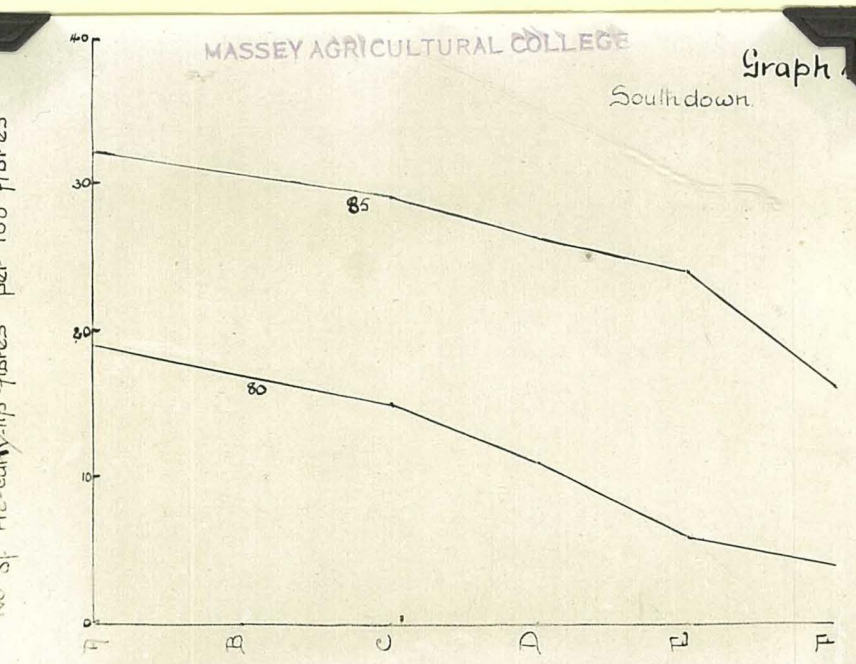
Graph 14

Romney



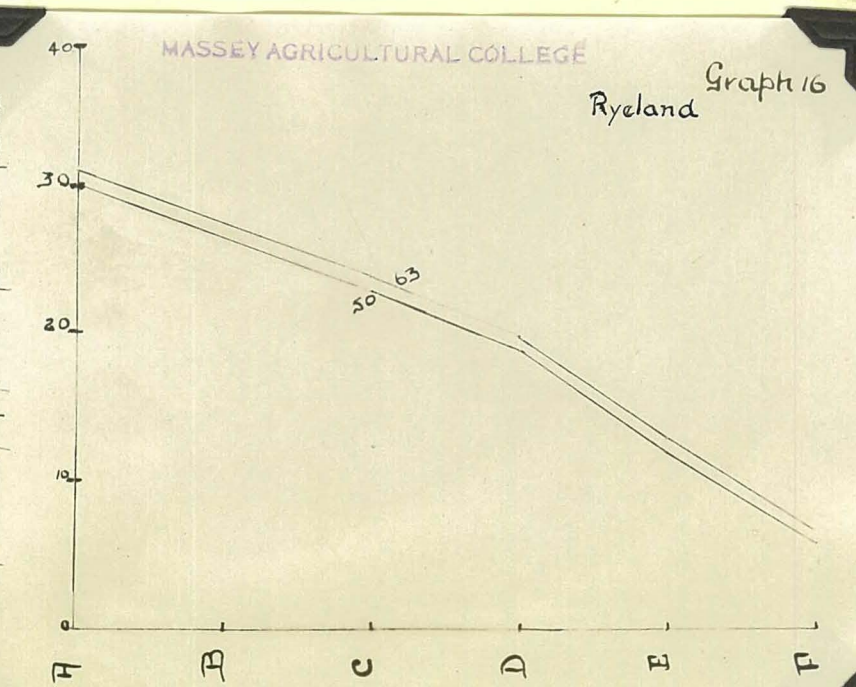
Graph

Southdown



Graph 16

Ryeland



REPORT ON DENSITY WORK.

A series of thirteen dated animals were secured, all of which had the same male parent - and treated as described in Section B.

Counts were made from the snippets taken from different regions.

Some of these regions were at the same stage of growth; others were not. See Section B. description of Areas.

It was found that when counts for the same region were plotted against time the graph showed two peaks when density was highest. These coincided with the trio and nine stages of development.

This Graph was found for every region studied, the counts, however, being made from different animals.

The regions studied however reached the same stage of development at different ages and still showed the same two peak graph, the peaks however becoming progressively later as the regions developed later.
