# Studies of the skin follicle development in Border disease of sheep

Volume Two

Contents

# DIAGRAMS

EX BIBL. UNIV. EDINBURGEN.

Diagram 1: Longitudinal section through a primary follicle showing the zones of differentiation of the keratinised structures, and indicating the following:

a. epidermis

b. sebaceous gland

c. outer root sheath

d. Henle's layer } inner root sheath

e. Huxley's layer }

f. cuticle

g. fibre cortex

h. fibre cuticle

i. follicle bulb

j. follicle papilla

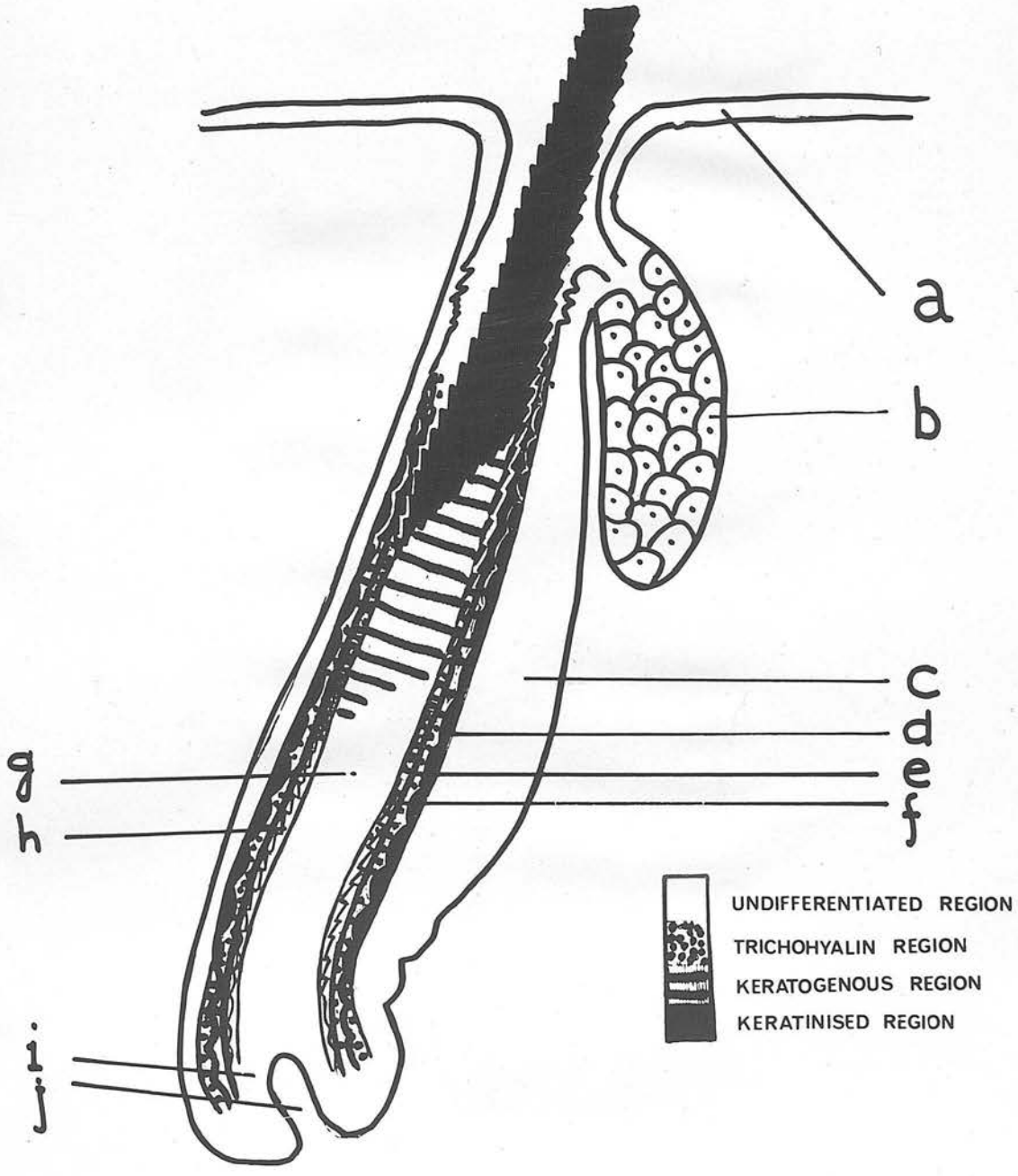

a
b
c
d
e
f
g
h
i
j
UNDIFFERENTIATED REGION
TRICHOHYALIN REGION
KERATOGENOUS REGION
KERATINISED REGION

Diagram 2: Diagrammatic representation of a follicle group from an adult sheep with three primary follicles, each associated with a sweat gland, sebaceous glands and an erector muscle along the ental margin of the group, and a number of secondary follicles behind the primary follicles.

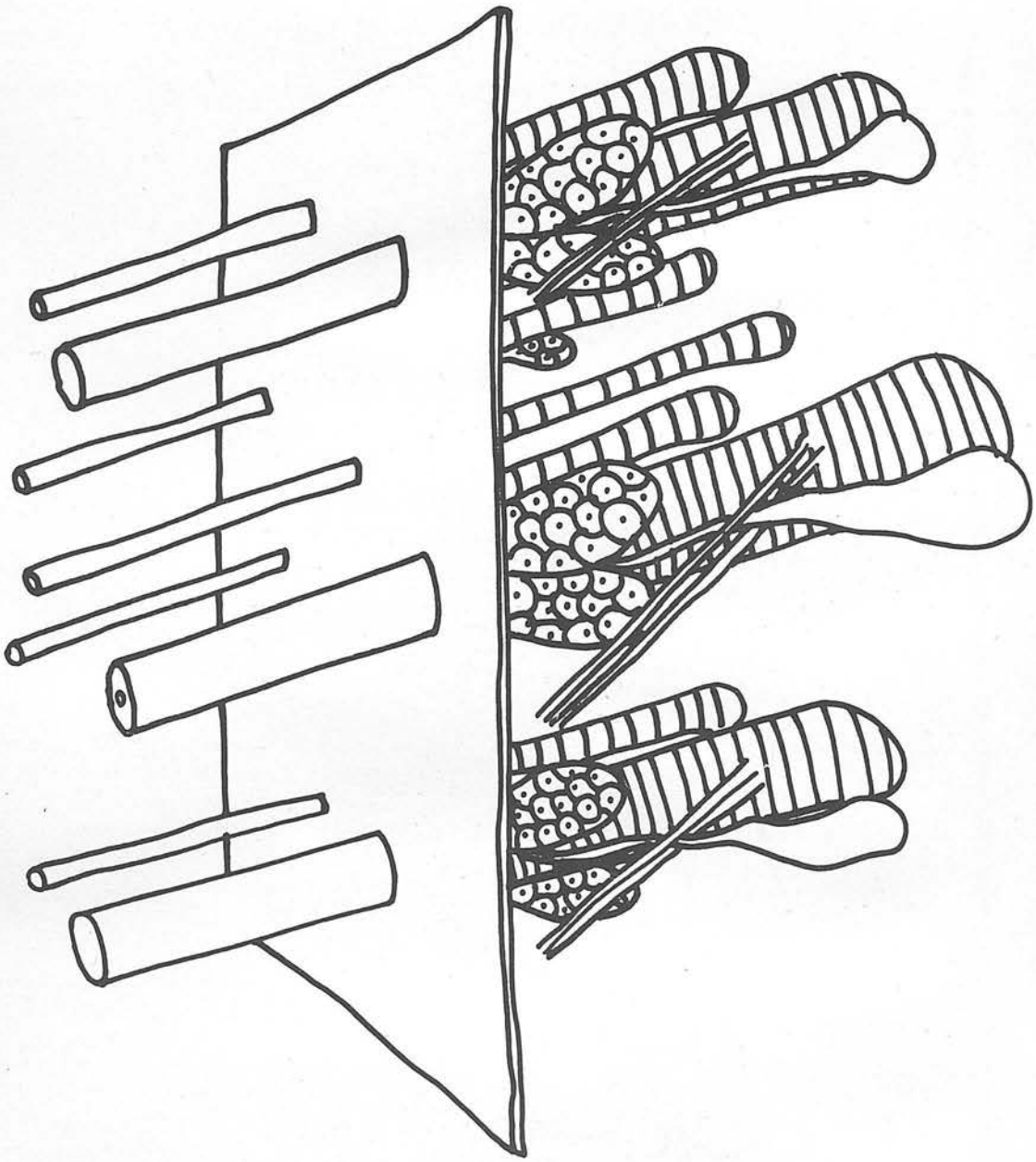


Diagram 3: The fibre types of the birthcoat.

The pre-curly tip fibres have a coarse tip beneath which is a finer region grown before birth, and a coarse post-natal region.

The later initiated curly tip fibres have a fine region grown before birth, and a coarse post-natal region.

The histerotrichs may have a short fine tip, produced pre-natally, but indistinguishable from the fine post-natal region.

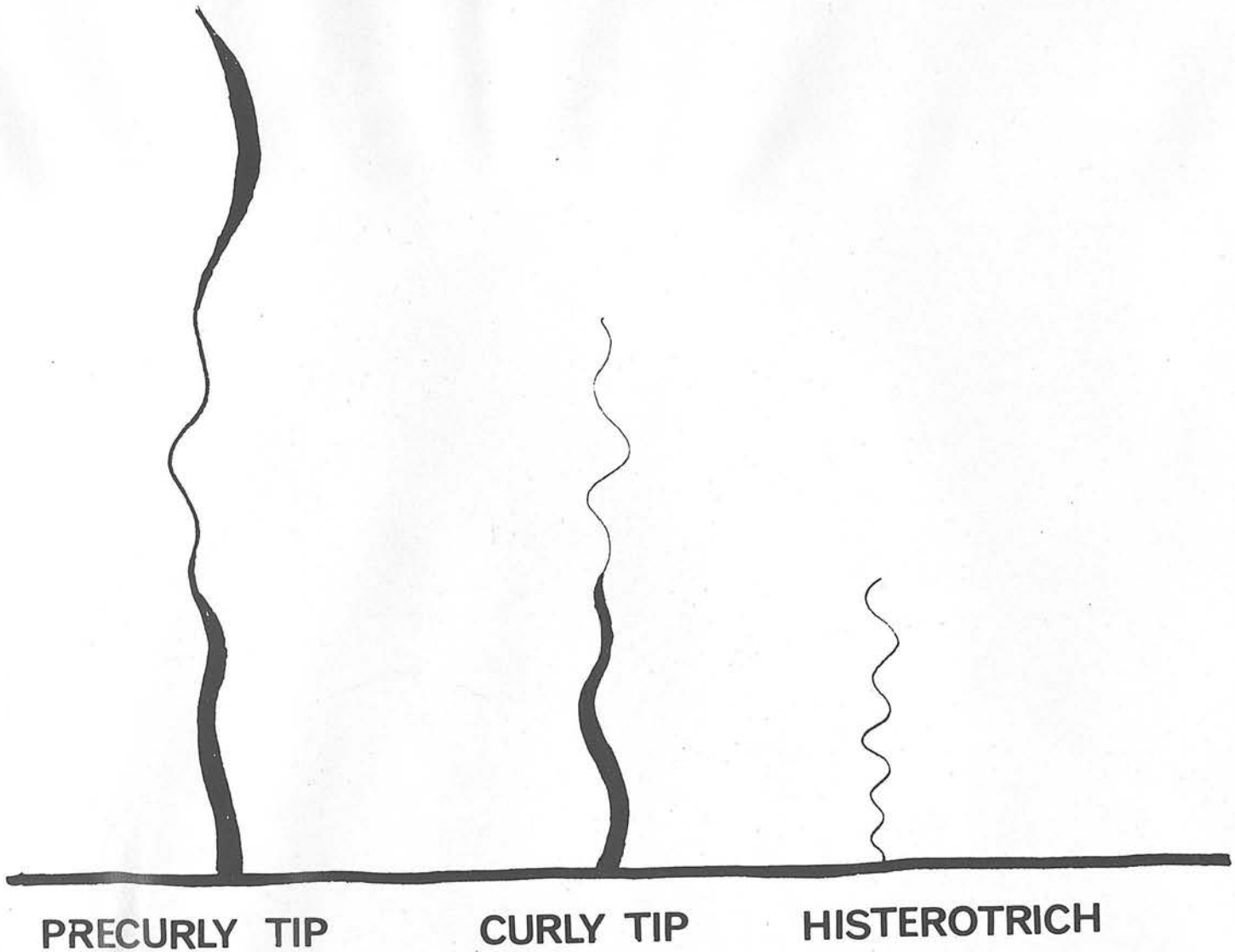

PRECURLY TIP
CURLY TIP
HISTEROTRICH

Diagram 4: The stages of development of a primary follicle (after Hardy and Lyne, 1956), fully described on pp. 37-38.

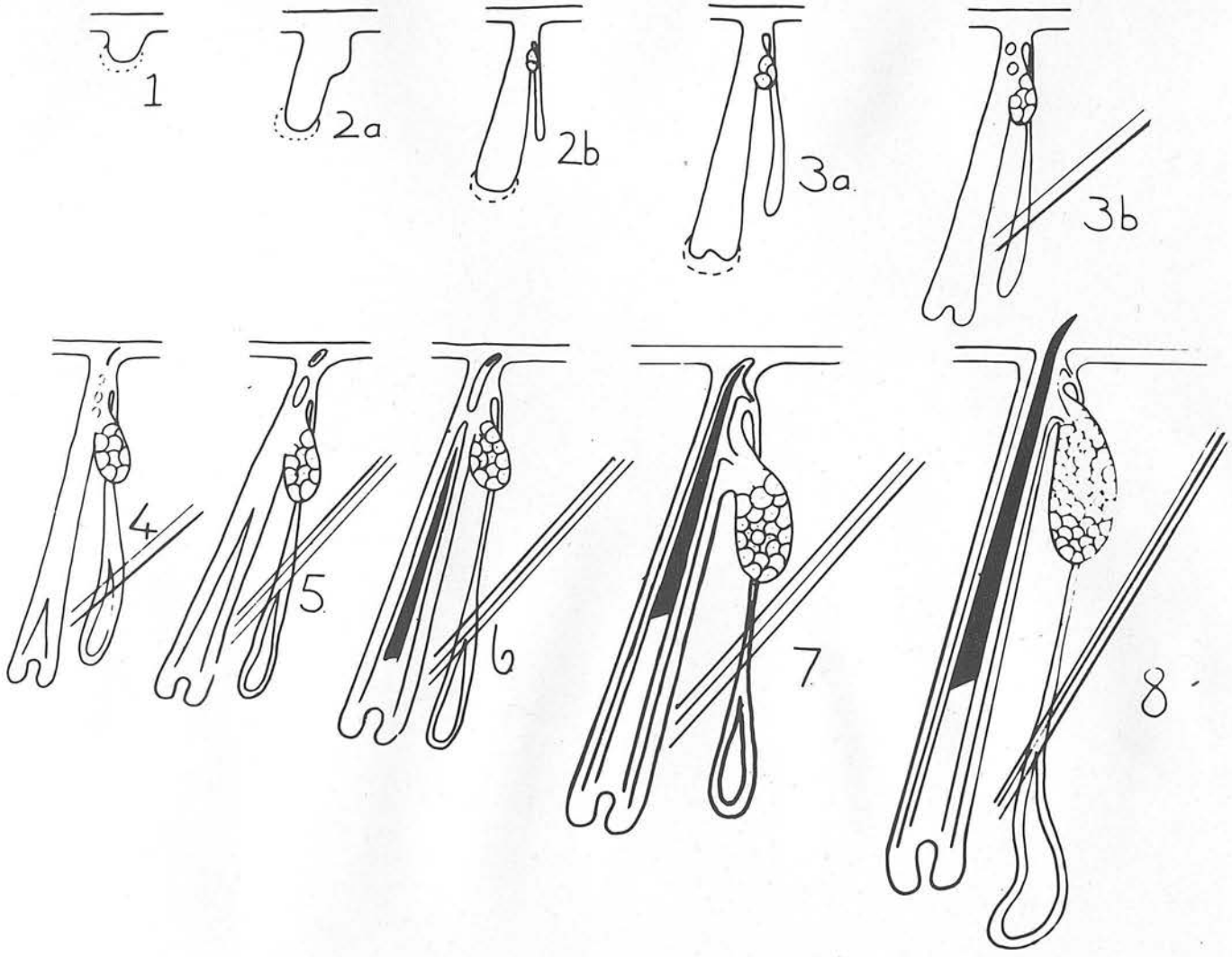

1
2a
2b
3a
3b
4
5
6
7
8

Diagram 5: Sampling sites.

A. Mid-way along the spine of the scapula.

B. Over the end of the second last rib.

C. Over the femur, at a point one-third of the distance from the hip to the stifle.

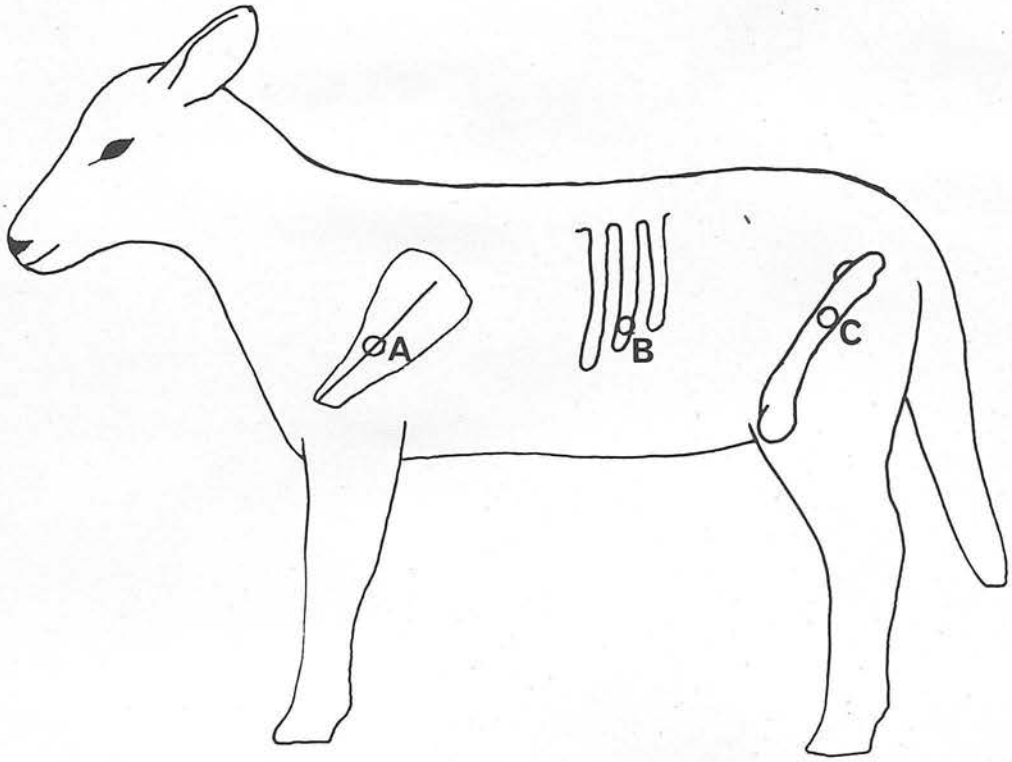
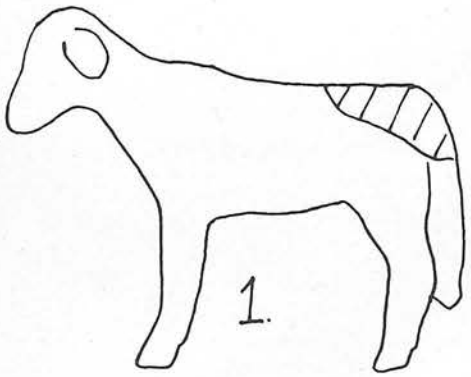

A
B
C

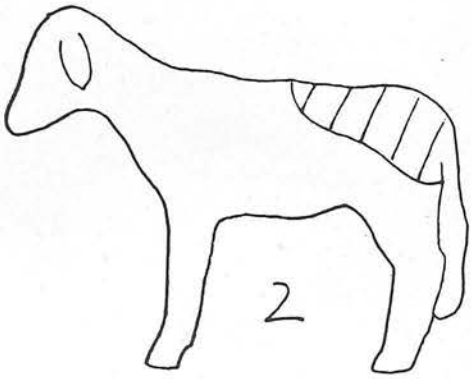
Diagram 6: The grades of coverage of birthcoat coarseness.

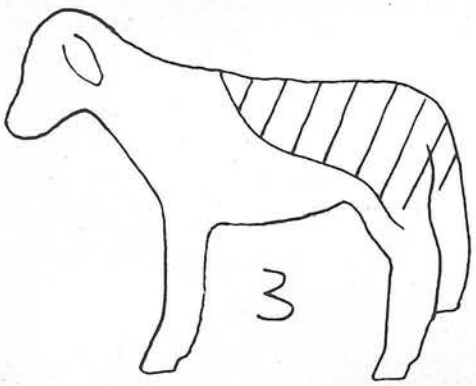
1 to 4 Birthcoat coarseness tends to appear over the rump, and to extend antero-ventrally towards the shoulders.

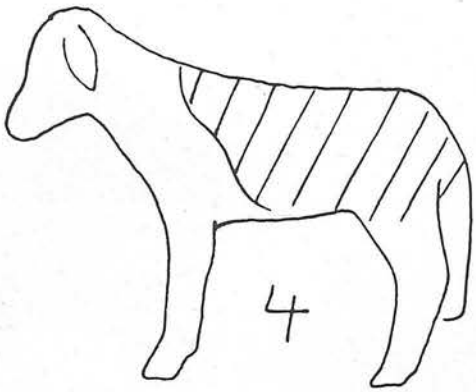
5. The coarseness covers the fleece-bearing surface of the body, except for areas on the neck and behind the shoulders.

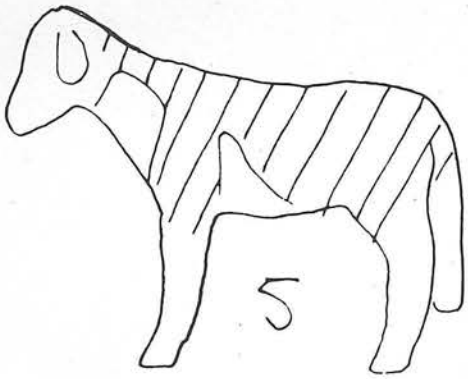
6. Birthcoat coarseness covers the fleece-bearing surface of the body.


1


2


3


4


5

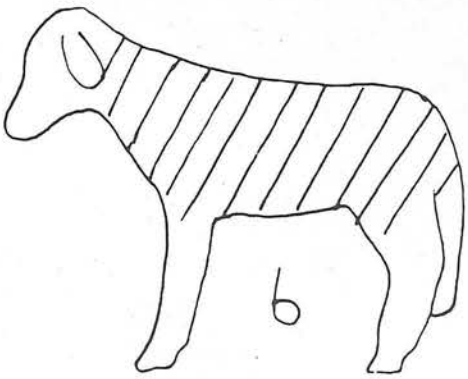

6

Diagram 7: Transverse section of a follicle group at sebaceous gland level from a newborn lamb, coloured to represent Sacpic staining.

a. erector muscle

b. sweat gland duct

c. sebaceous glands

d. sheath of follicle, with outer root sheath and red inner root sheath

e. small green medulla in primary fibre

f. non-medullated primary fibres

g. secondary follicle plug

h. greenish keratinising secondary follicle

i. secondary fibre

j. medullated secondary fibre

k. sebaceous gland of secondary follicle

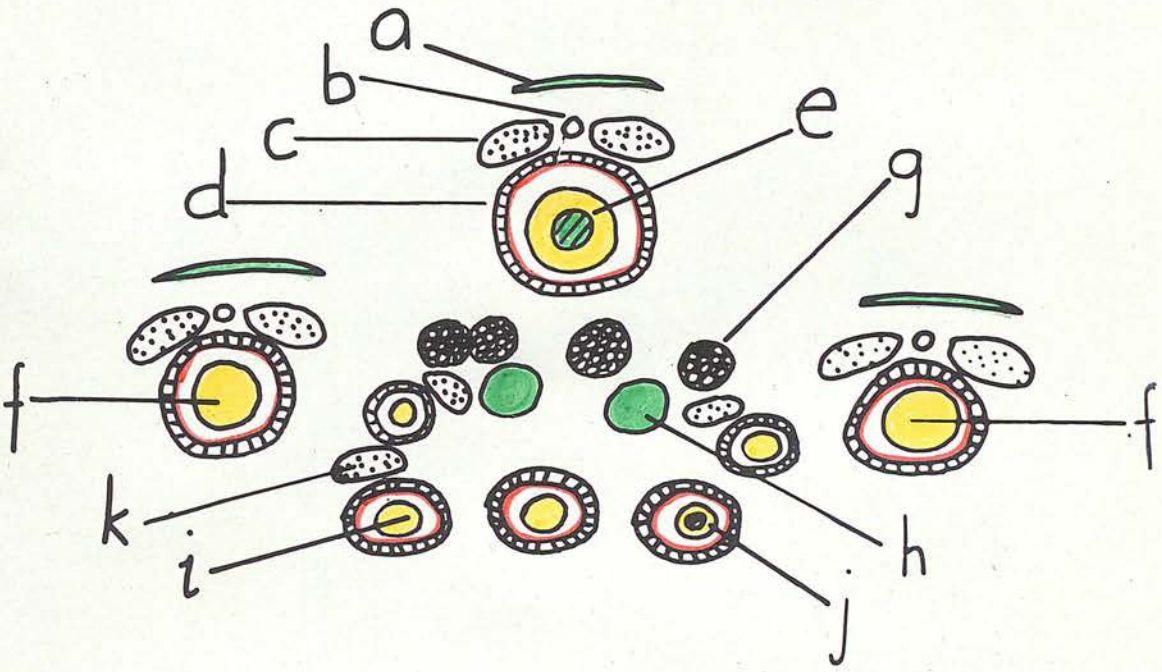

a
b
c
d
e
g
f
f
k
i
h
j

Diagram 8: An example of a data sheet from which the frequencies of fibre types and $\frac{S}{P}$ ratios were calculated.

B72/67F

115 days' gestation  Group I
Border disease affected

| | SHOULDER | | | | SIDE | | | | HIP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Density | Cent. 1° | Lat. 1° | 2° KKyb | Density | Cent. 1° | Lat. 1° | 2° KKyb | Density | Cent. 1° | Lat. 1° | 2° KKyb |
| 1 | | KM | IC K | -34 | | ICM | IC K | -14 | | KM | Km K | --4 |
| 2 | | ICM | K K | 2-4 | | ICM | K K | --4 | | KM | Km Km | --3 |
| 3 | | ICM | K K | 1-4 | | K | - - | -12 | | ICM | K - | --2 |
| 4 | | KM | K K | -33 | | ICM | IC K | -14 | | Km | - - | --1 |
| 5 | | Km | K K | --4 | | Km | - - | -12 | | Km | Km IC | -12 |
| 6 | | KM | K IC | 215 | | KM | K K | --4 | | KM | Km Km | --2 |
| 7 | | KM | Km Km | 2-7 | | KM | K IC | --6 | | ICM | Km Km | -12 |
| 8 | | Km | K - | --3 | | KM | K K | -26 | | ICM | Km - | -11 |
| 9 | | ICM | K K | -24 | | KM | K K | -25 | | Km | K K | -13 |
| 10 | | KM | Km Km | 2-6 | | KM | K K | -13 | | KM | Km K | --4 |
| 11 | | KM | K IC | 214 | | KM | Km K | -14 | | KM | IC K | --4 |
| 12 | | Km | K K | -13 | | KM | - - | 1-2 | | KM | K - | --2 |
| 13 | | KM | K K | -33 | | KM | Km K | -12 | | Km | Km IC | -12 |
| 14 | | Km | K - | --4 | | ICM | K IC | -14 | | Km | - - | --1 |
| 15 | | KM | K K | -14 | | ICM | K K | -16 | | Km | Km Km | --3 |
| 16 | | KM | K K | 113 | | KM | K K | -15 | | ICM | Km Km | -12 |
| 17 | | Km | K K | -14 | | Km | K K | --4 | | ICM | Km Km | --2 |
| 18 | | KM | K K | -14 | | ICM | Km IC | -24 | | ICM | Km - | -12 |
| 19 | | KM | K K | 114 | | K | IC K - | --2 | | KM | K IC | -12 |
| 20 | | KM | K K | -23 | | ICM | K K | -15 | | KM | Km K | --4 |
| 21 | | Km | - - | 1-3 | | KM | Km Km | 1-4 | | KM | Km K | -12 |
| 22 | | KM | K K | -33 | | KM | Km Km | 124 | | KM | Km K | -12 |
| 23 | | KM | K K | 113 | | Km | - - | -11 | | KM | K - | --2 |
| 24 | | ICM | K K | 215 | | KM | K K | -14 | | Km | Km K | -12 |
| 25 | | ICM | Km K | 127 | | KM | K K | -13 | | ICM | Km Km | --3 |
| 26 | | Km | K K | 114 | | KM | K K | --3 | | Km | Km K | -11 |
| 27 | | KM | K K | 114 | | Km | K K | 1-4 | | Km | - - | --1 |
| 28 | | Km | K K | 136 | | KM | Km K | 114 | | ICM | Km - | --1 |
| 29 | | KM | K K | 113 | | KM | Km K | -13 | | Km | K K | --3 |
| 30 | | Km | K K | -35 | | ICM | Km K | 2-4 | | Km | K K | --4 |
| 31 | | Km | K K | -14 | | Km | K K | -1 | | ICM | Km K | --4 |
| 32 | | KM | Km Km | 116 | | KM | K K | --2 | | ICM | Km Km | -12 |
| 33 | 2°2° | KM | K K | -36 | 2°2° | KM | K K | 114 | 2°2° | KM | Km K | --3 |
| 34 | p 147<br>Cg 44 | KM | K K | 1-4 | p 140<br>Cg 29 | KM | K K | 113 | p 90<br>Cg 15 | Km | - - | --1 |
| 35 | K 25 | ICM | Km - | 124 | K 10 | Km | K K | 1-4 | K - | KM | Km K | -12 |
| 36 | | | | | | Km | - - | --2 | | KM | K K | --4 |
| | | | | | | KM | Km K | -24 | | KM | Km K | --3 |
| | | | | | | | | | | ICM | K K | -12 |
| | | % KM | % Km | % K | | | | | | | | |
| | cent. 1° | 71 | 29 | 0 | | cent. 1° | KM 76 | Km K 19 5 | | | KM | Km K |
| | 1° 1° | 25 | 18 | 57 | | 1° | 28 | 18 54 | | cent. 1° 1° | 71 | 29 - |
| | | | | | | | | | | 1° | 27 | 44 29 |
| | Sp follicle ratio | | | 2·16 | | Sp foll. = | | 1·79 | | Sp foll. | | 1·05 |
| | Sp fibre ratio | | | 0·69 | | Sp fibre | | 0·39 | | Sp fibre | | 0·15 |

# PLATES

Plate 1: Control Cheviot x Dorset Horn lamb 10 days old, showing the normal fine, curled birthcoat.

Plate 2: Border disease affected Cheviot x Dorset Horn lamb 10 days old, showing the coarse, straight birthcoat characteristic of affected lambs.

Plate 3: Longitudinal section of spinal cord from a control foetus at 115 days' gestation.

OTAN x 600

Plate 4: Longitudinal section of spinal cord from a Border disease affected foetus at 115 days' gestation.

OTAN x 600

Note the relative scarcity of myelin in the cord of the Border disease affected foetus, and the presence of interfascicular lipid droplets.

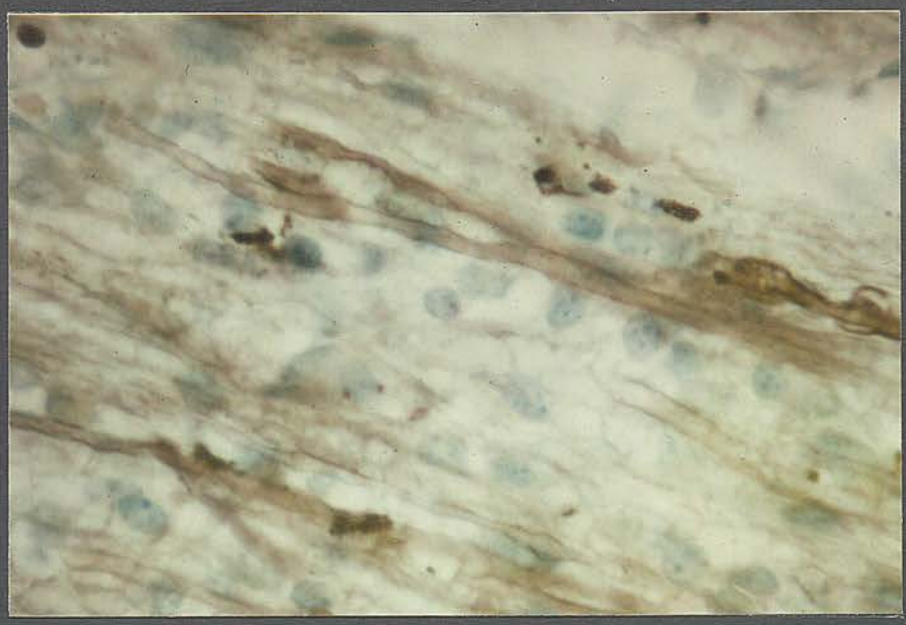


Plate 5: Vertical section of skin from a control foetus at 65 days' gestation. Sacpic stain x 400

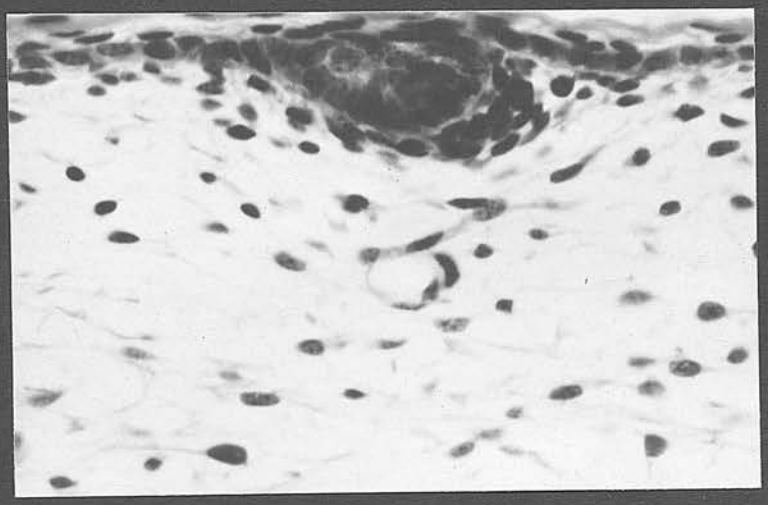
A central primary follicle plug is present.

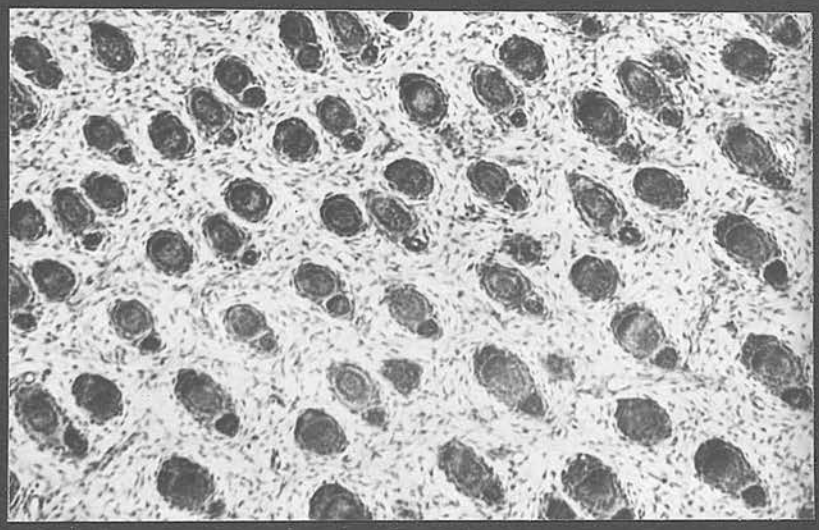
Plate 6: Horizontal section of skin, slightly oblique, from a Border disease affected foetus at 85 days' gestation. Sacpic stain x 75

Note the complete primary follicle trios, with an occasional couplet or single primary follicle at mid follicle level (top left). At deeper levels of sectioning (bottom right) only central primary follicles, by virtue of their greater length, are evident.

Plate 7: Vertical section of skin from a Border disease affected foetus at 85 days' gestation. Sacpic stain x 75

Note the central primary follicles and shorter lateral primary follicles of the groups.





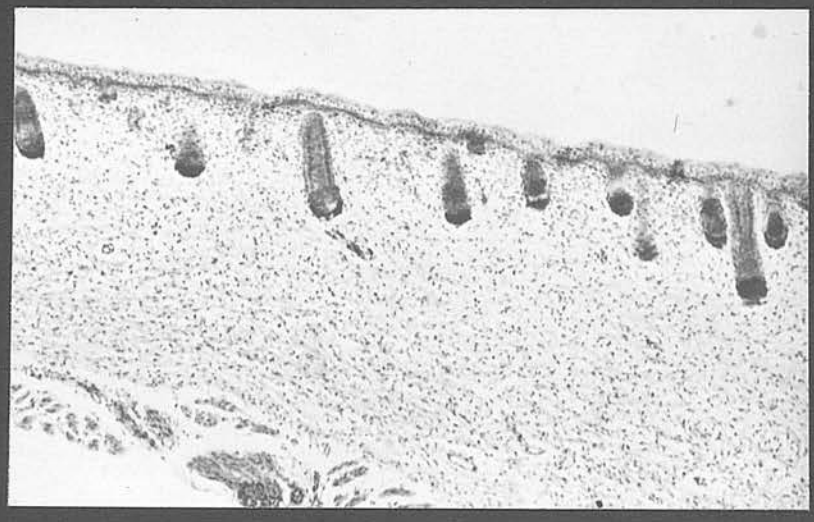


Plate 8: Vertical section of skin from a control foetus at 95 days' gestation. Sacpic stain x 150

Plate 9: Vertical section of skin from a Border disease affected foetus at 95 days' gestation. Sacpic stain x 150

Note the more advanced stage of development of the control skin, as evidenced by:

1) The thicker epidermis
2) The greater size of the primary follicle and the presence within it of a red-staining keratinising fibre.
3) The presence in the follicle papilla, and in the dermis, of blood vessels (containing yellow-staining red blood cells).
4) The presence of a secondary follicle plug, indicated by a red line.

Plate 10: Horizontal section of skin from a control foetus at 105 days' gestation. Sacpic stain x 75

Plate 11: Horizontal section of skin from a Border disease affected foetus from sebaceous gland level (top left) to mid follicle level where the inner root sheath stains red (lower right). Sacpic stain x 75

Note that there is no difference between the stages of development of the follicle populations at this age. In both cases, the primary follicles contain fibres and secondary follicle plugs are apparent.

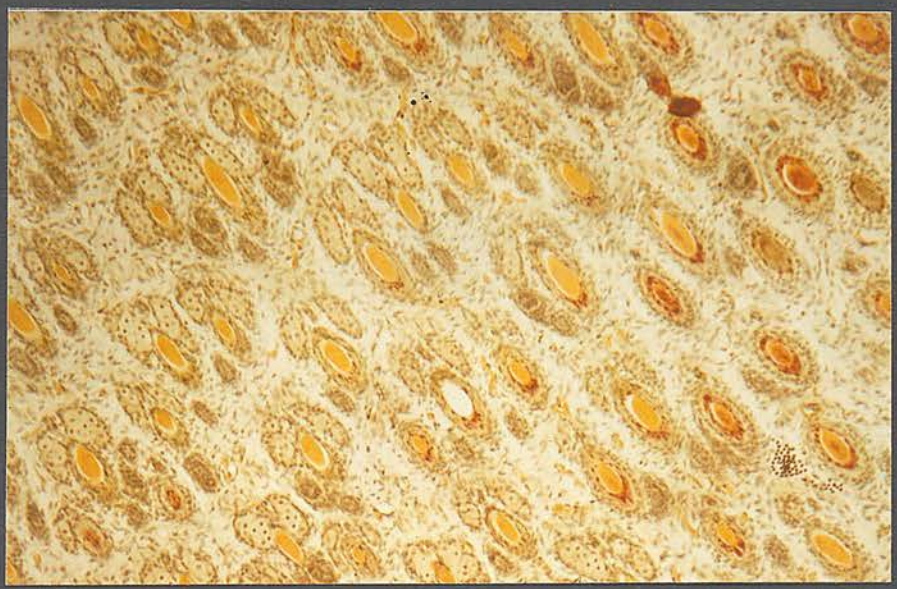


Plate 12: Vertical section of skin from a control foetus at 145 days' gestation. The red line indicates a group of secondary follicle plugs arising from an established secondary follicle.

Sacpic stain x 75

Plate 13: Vertical section of skin from a Border disease affected foetus at 145 days' gestation. The red lines indicate secondary follicle plugs arising from established secondary follicles.

Sacpic stain x 75

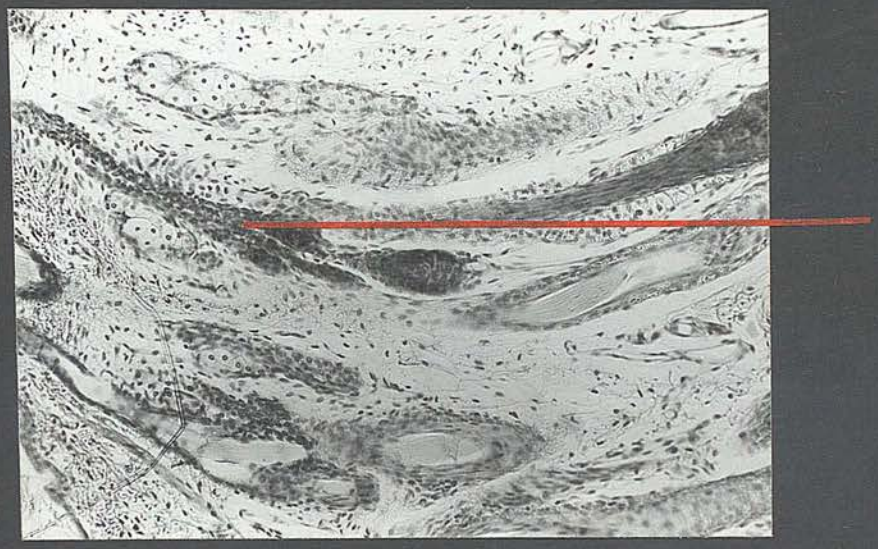


Plate 14: Horizontal section of skin from a control foetus at 115 days' gestation.

Sacpic stain x 150

Plate 15: Horizontal section of skin from a Border disease affected foetus at 115 days' gestation.

Sacpic stain x 150

In the control foetus, all primary follicles contain fibres, and a few of these have small medullae. In Border disease, the primary follicles and fibres are enlarged, and there is a high frequency of fibre medullation.

In both cases, fibres are appearing in secondary follicles (as indicated by the red line), but there are fewer secondary follicles in Border disease.

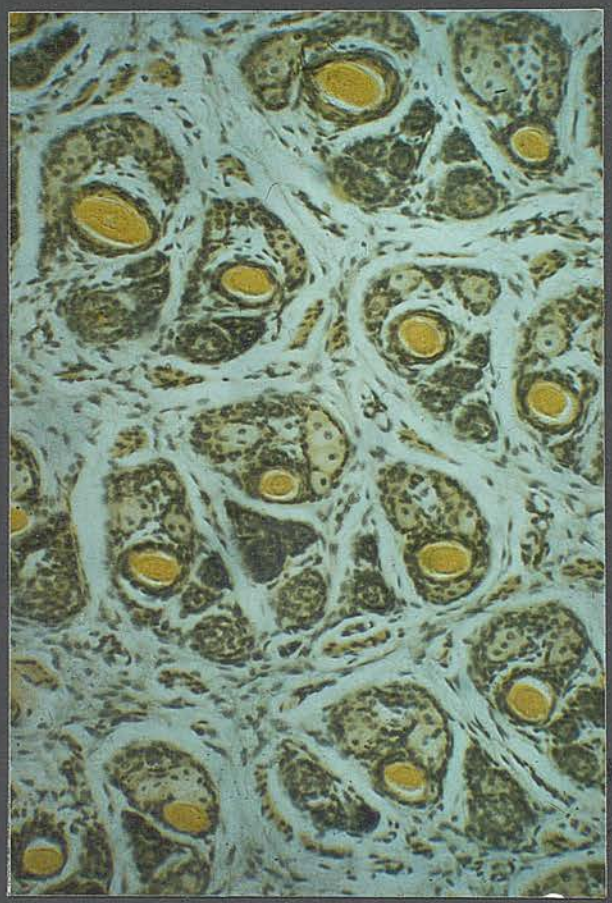
Plate 16: Vertical section of skin from a control foetus at 115 days' gestation.

Sacpic stain x 75

Plate 17: Vertical section of skin from a Border disease affected foetus at 115 days' gestation.

Sacpic stain x 75

In both cases, primary fibres have grown above the skin surface. In Border disease, the primary follicle hypertrophy is evident, and the primary fibres are heavily medullated.



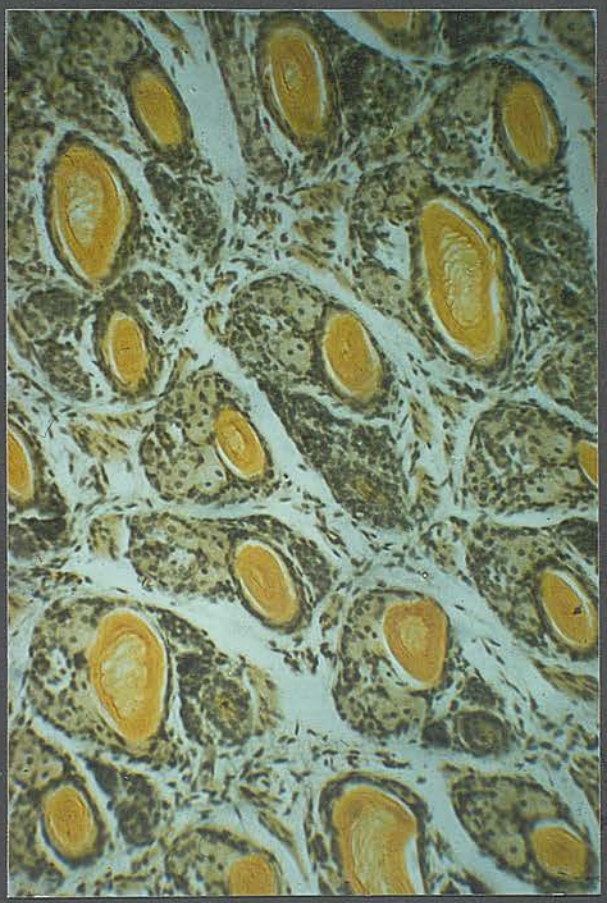


Plate 18: Horizontal section of skin from a control foetus at 145 days' gestation.

Sacpic stain x 75

Plate 19: Horizontal section of skin from a Border disease affected foetus at 145 days' gestation.

Sacpic stain x 75

In Border disease, there is a greater frequency of primary fibre medullation. Some heavily medullated fibres appear ribbon-shaped or flattened. There are fewer secondary follicles than in the control follicle groups, but in both Border disease affected and control animals, most secondary follicles contain fibres.

Plate 20: Vertical section of skin from a control foetus at 145 days' gestation.

Sacpic stain x 75

Plate 21: Vertical section of skin from a Border disease affected foetus at 145 days' gestation.

Sacpic stain x 75

The primary follicles in Border disease are much larger than in control foetuses.

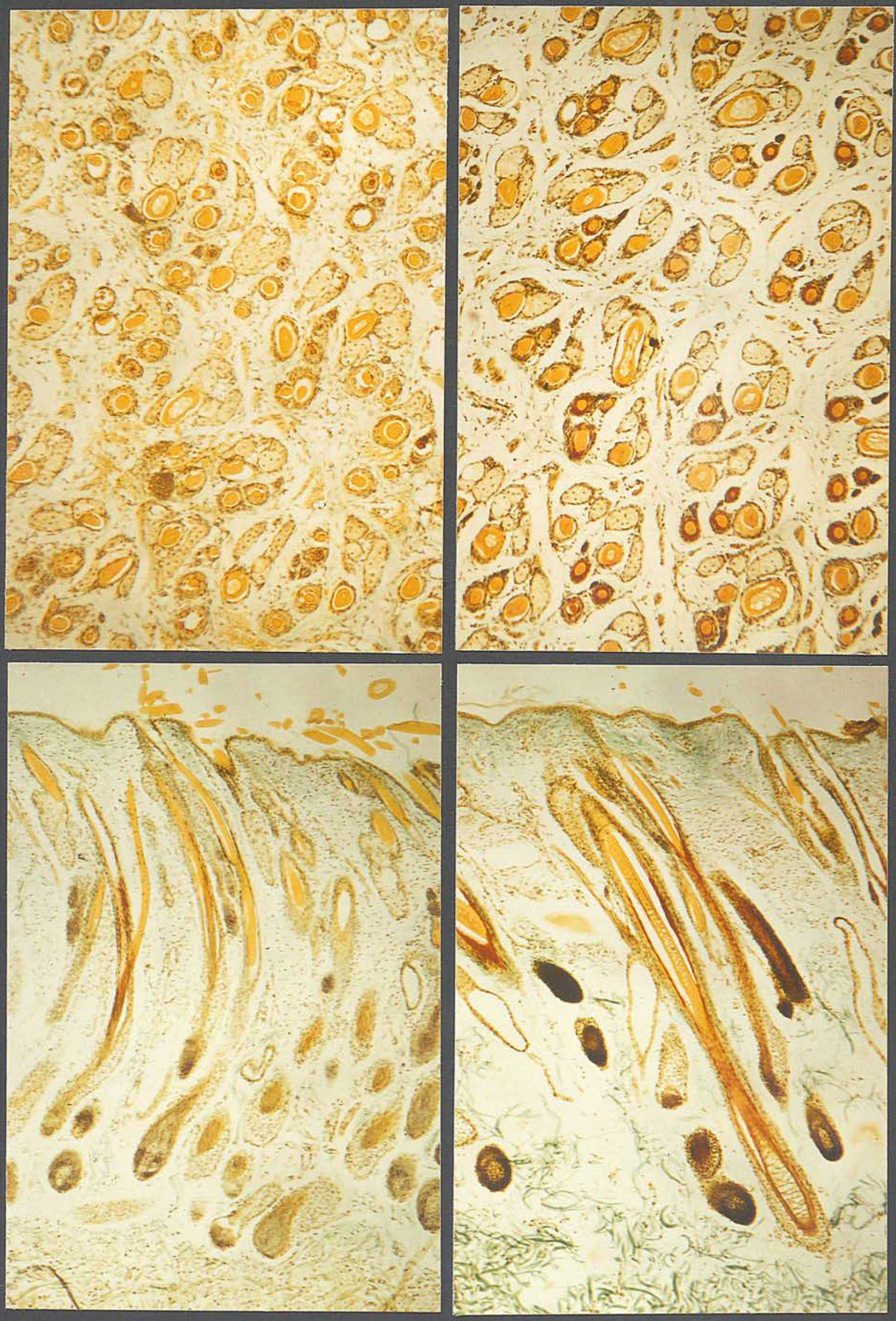


Plate 22: Vertical section of skin from a Border disease affected foetus at 95 days' gestation.

PAS x 150

Plate 23: Vertical section of skin from a Border disease affected foetus at 95 days' gestation.

PAS with diastase pre-treatment x 150

Note the presence of glycogen in the epidermis and cytoplasm of the cells of the outer root sheath. The glycogen has been removed by treatment with diastase prior to staining.

Plate 24: Vertical section of skin from a Border disease affected foetus at 115 days' gestation.

PAS x 150

Plate 25: Vertical section of skin from a Border disease affected foetus at 115 days' gestation.

PAS with diastase pre-treatment x 150

Note the absence of glycogen from the epidermis at this age, and the presence of glycogen in the cytoplasm of the cells of the outer root sheath.



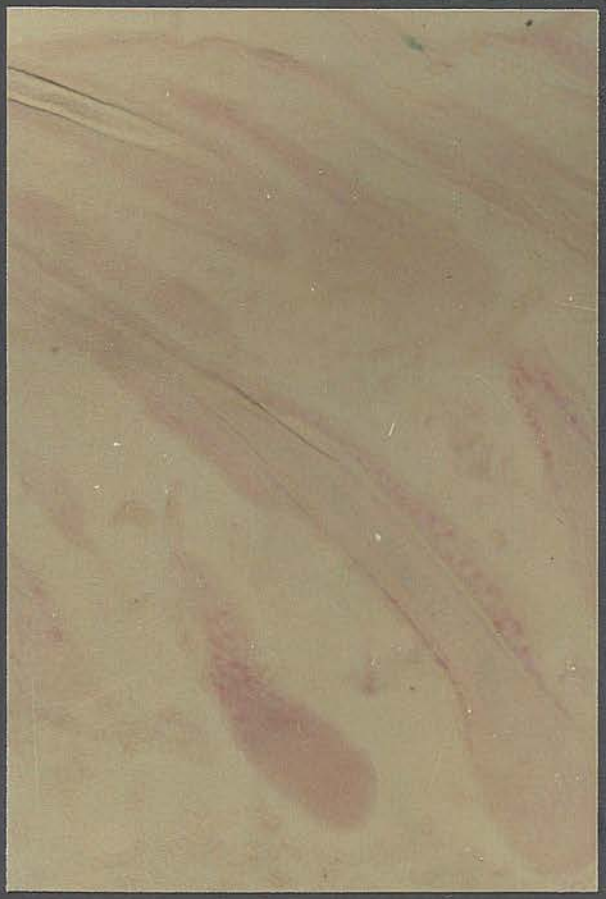



Plate 26: Vertical section of skin from a Border disease affected foetus at 95 days' gestation.

Gordon and Sweet x 150

Note the distribution of fine reticulin fibres in the papillary layer of the dermis (p), and the coarser nature of the reticulin fibres in the deeper reticular layer (r). The epidermis is labelled e.

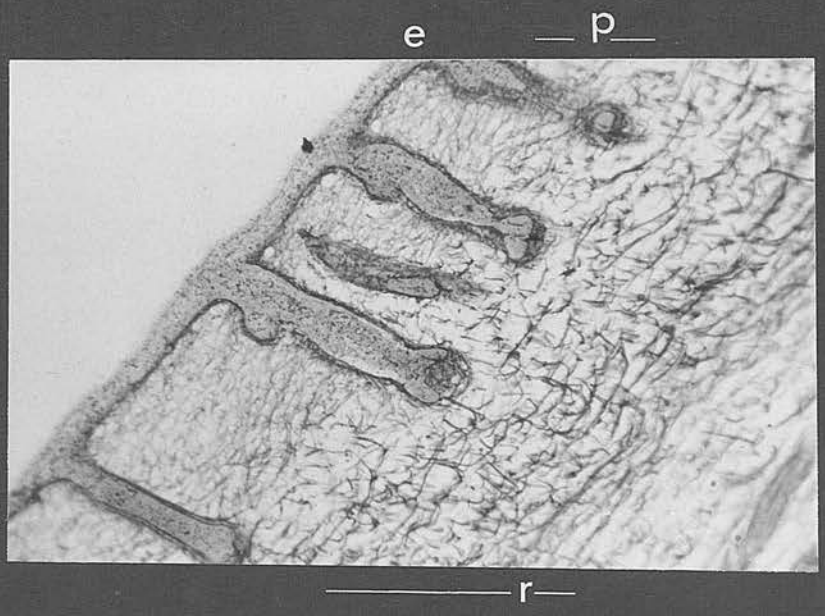

e
p
r

Plate 27: Vertical section of skin from a control foetus at 115 days' gestation. Mercury Orange X 40

Plate 28: Vertical section of skin from a Border disease affected foetus at 115 days' gestation. Mercury Orange X 40

Note the positive reaction of the keratogenous zone of the fibre in each case. In Border disease, there appears to be a "distal shift" of the zone, although its length relative to follicle length is not different from that of the control.

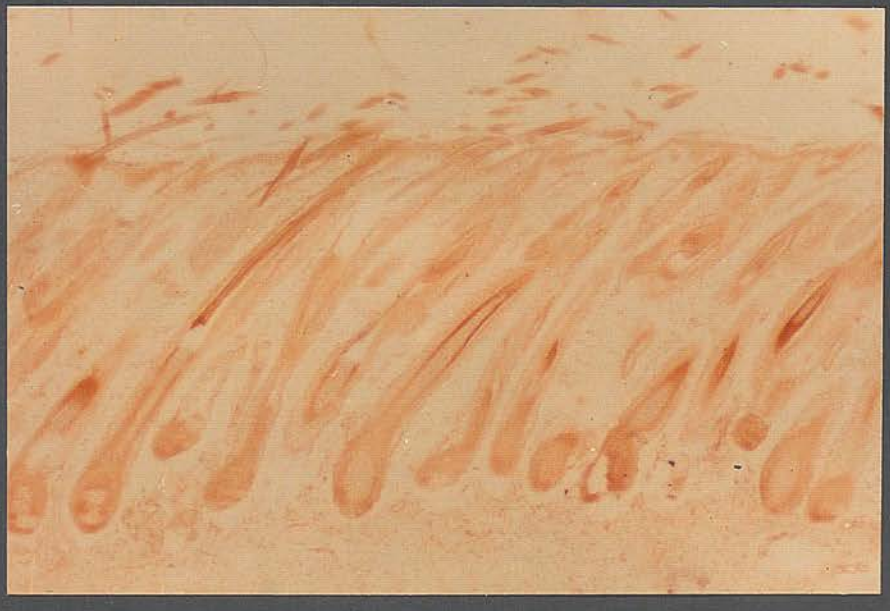


Plate 29: Horizontal section of a primary follicle trio at sebaceous gland level from a Border disease affected foetus at 95 days' gestation.

Sudan IV x 400

The sebaceous gland sebum stains strongly positive.

Plate 30: Horizontal section of a primary follicle trio at mid-follicle level from a Border disease affected foetus at 95 days' gestation.

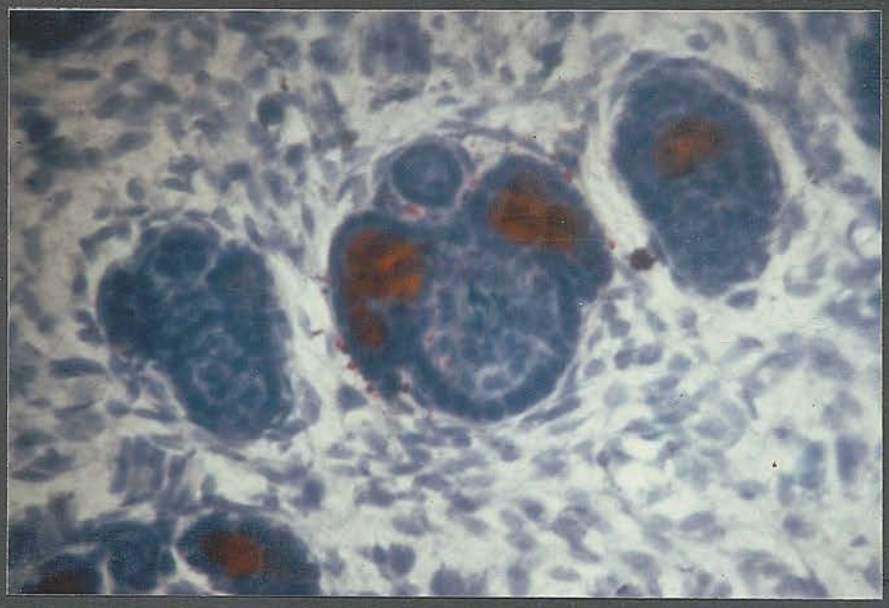
Sudan IV x 400

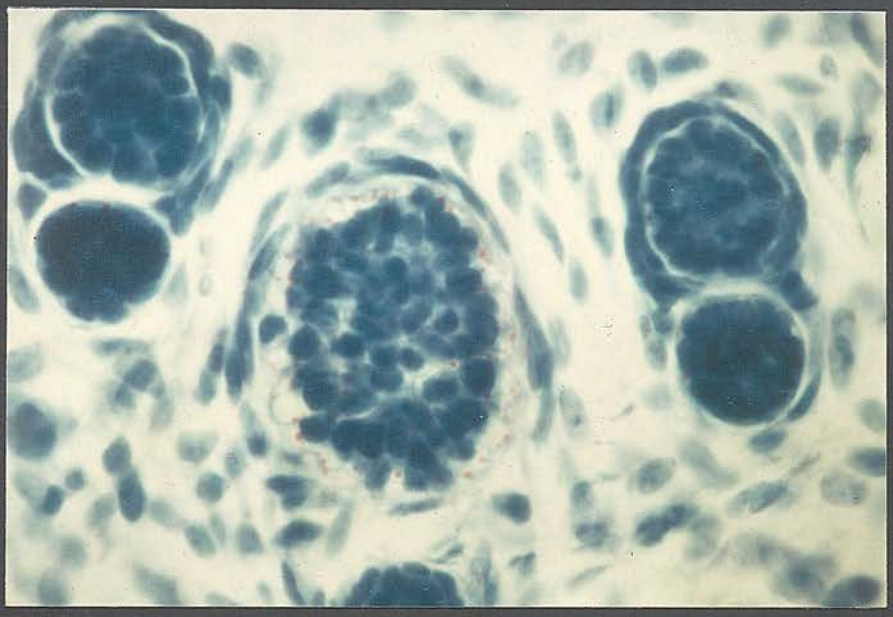
There are small lipid droplets in the cytoplasm of the outer root sheath of the central primary follicle.

Plate 31: Horizontal section of a central primary follicle at mid-follicle level, from a control foetus at 95 days' gestation.

OTAN x 400

Note the presence of a keratinising fibre, and to the right, the sweat gland duct, which stain brownish. There are small black-brown droplets of lipid in the cytoplasm of the cells of the outer root sheath.





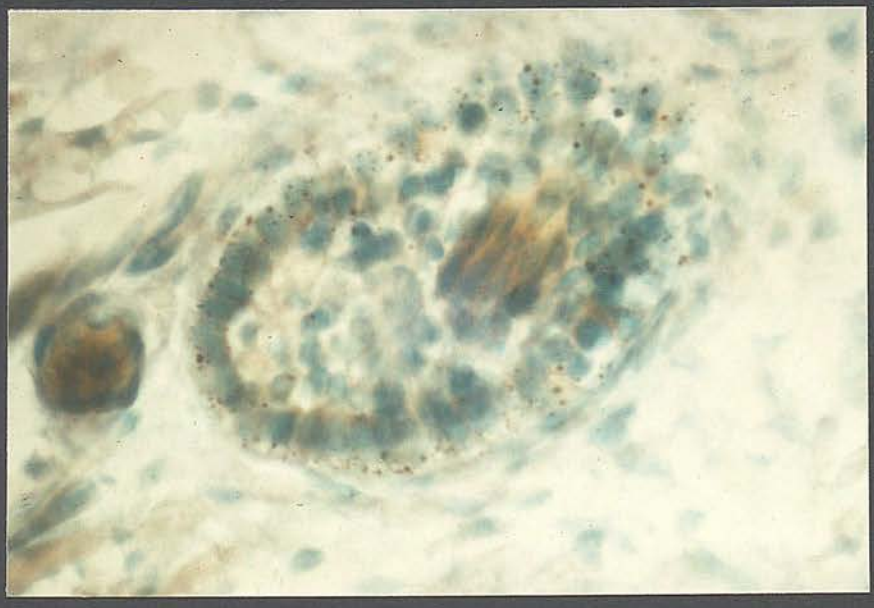


Plate 32: Electron micrograph of the follicle bulb and papilla of a control foetus at 95 days' gestation.

Lead citrate x 7500

Note (a) the presence of desmosomes between the cells of the follicle bulb, (b) the numerous small dense granules in the cytoplasm of the bulb cells, (c) the basal membrane, (d) the cells of the papilla with their paler cytoplasm.

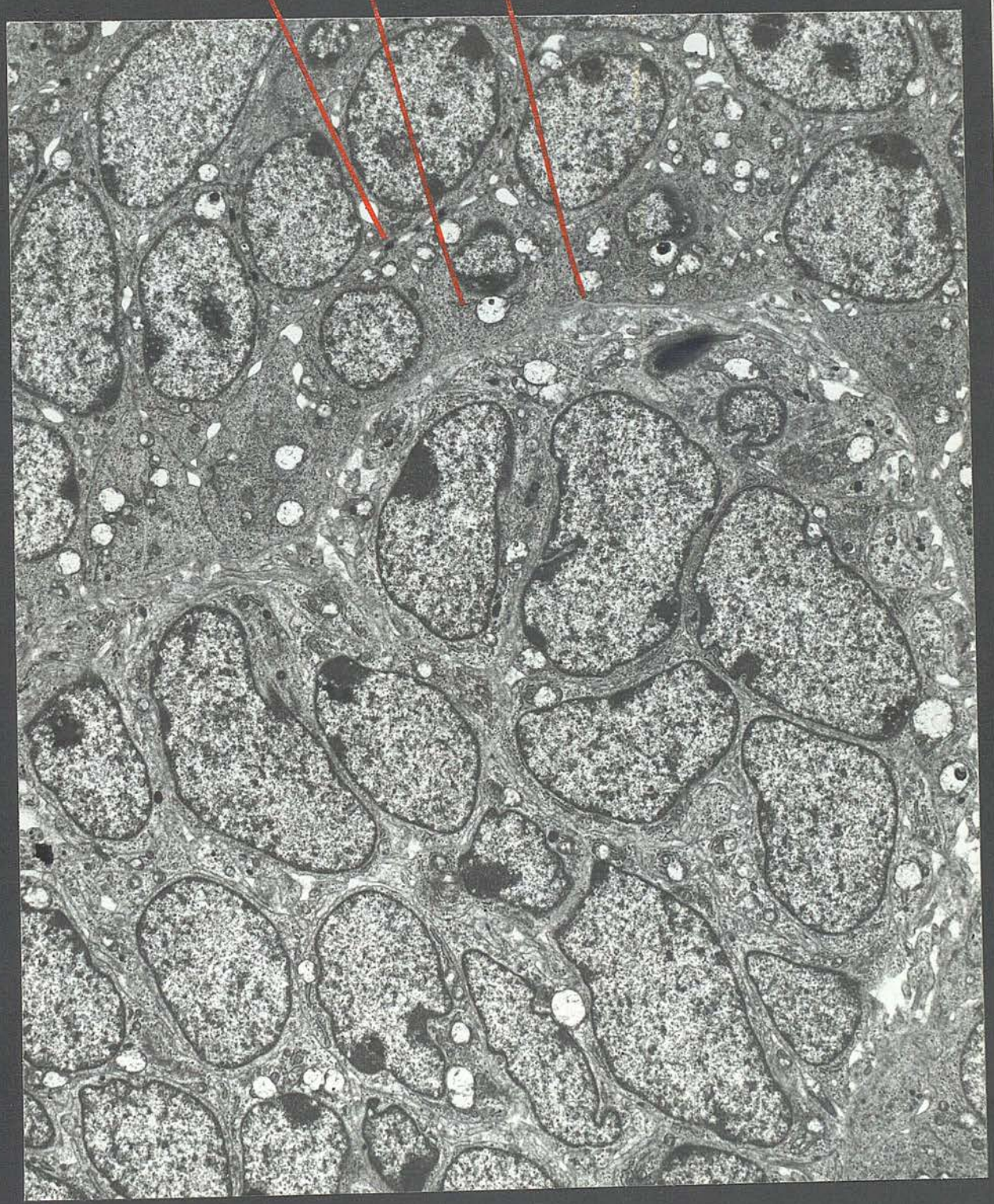

a
b
c
d

Plate 33: Electron micrograph of a primary follicle transected at mid-follicle level, from a Border disease affected foetus at 95 days' gestation.

Lead citrate x 3750

The nuclei of the cells of the outer root sheath are displaced towards the axis of the follicle.
The cytoplasm of thses cells is packed with glycogen, and exhibits a few lipid-like droplets, one of which is indicated by the red line.

Plate 34: Electron micrograph showing a portion of the outer root sheath of a follicle comparable with that illustrated in Plate 33, at a higher magnification.

Lead citrate x 7500

The cytoplasm of the cells of the outer root sheath is packed with granules of glycogen.

Plate 35: Electron micrograph of a portion of the bulb and papilla of a Border disease affected foetus at 115 days' gestation.

Lead citrate x 7500

The cells of the bulb (on the left) have a cytoplasm packed with small granules, and are oriented at right angles to the basement membrane, to which they are attached. The cells of the papilla (on the right) are more varied in their morphology than those of the foetuses at 95 days' gestation.

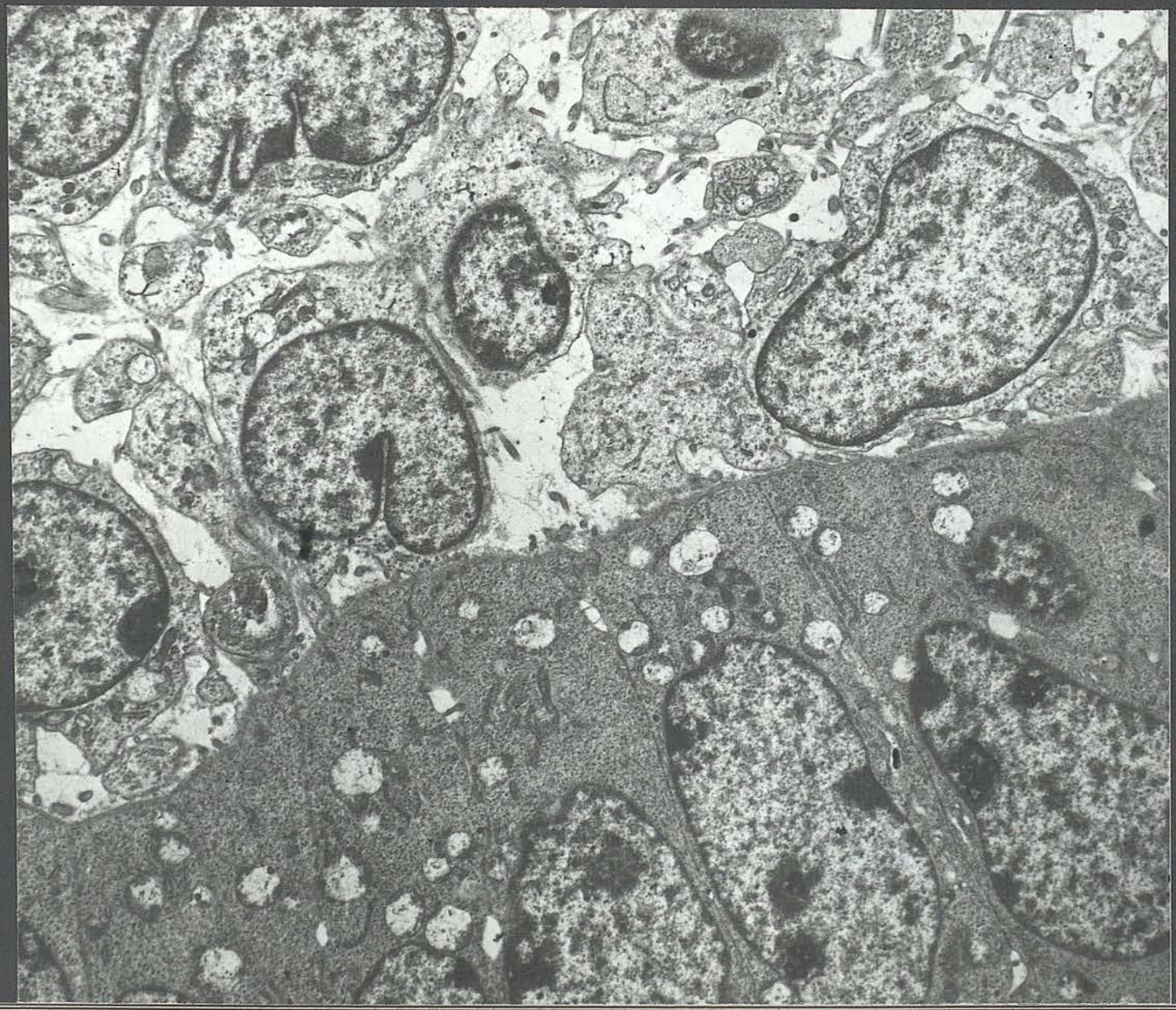


Plate 36: Electron micrograph of a portion of the follicle bulb and papilla of a Border disease affected foetus at 115 days' gestation.

Lead citrate x 7500

The papilla contains a cell in the cytoplasm of which are many large electron dense granules, the nucleus of the cell is lobulated or indented, and its cytoplasm granular.

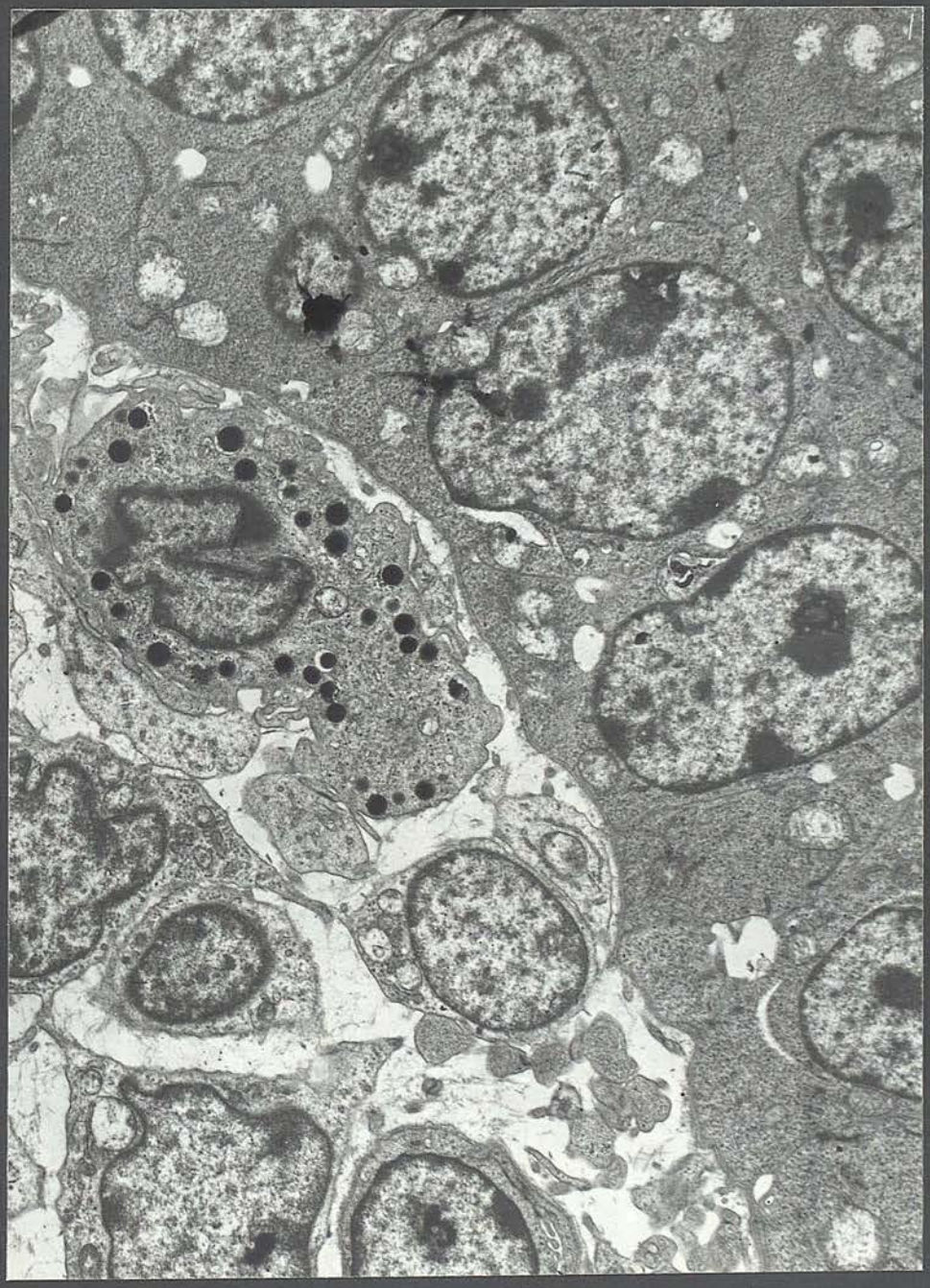


Plate 37: The fine, crimpy fleece of a control Cheviot x Dorset Horn cross lamb at six months of age.

Plate 38: The coarser, straighter fleece of a Border disease affected Cheviot x Dorset Horn cross lamb at six months of age.

Plate 39: Horizontal section of skin from a control Cheviot X Dorset Horn cross lamb at three weeks of age

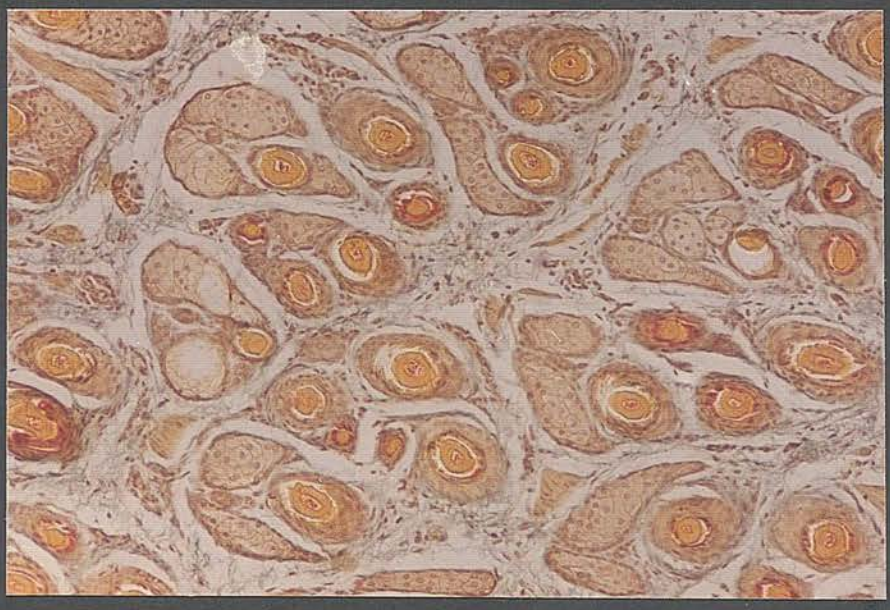
Sacpic stain x100

Note the presence of small medullae in some secondary fibres.

Plate 40: Horizontal section of skin from a Border disease affected Cheviot x Dorset Horn cross lamb at three weeks of age.

Sacpic stain x 100

The primary follicles and fibres are much larger than in the control, and there is a much greater frequency and degree of medullation.



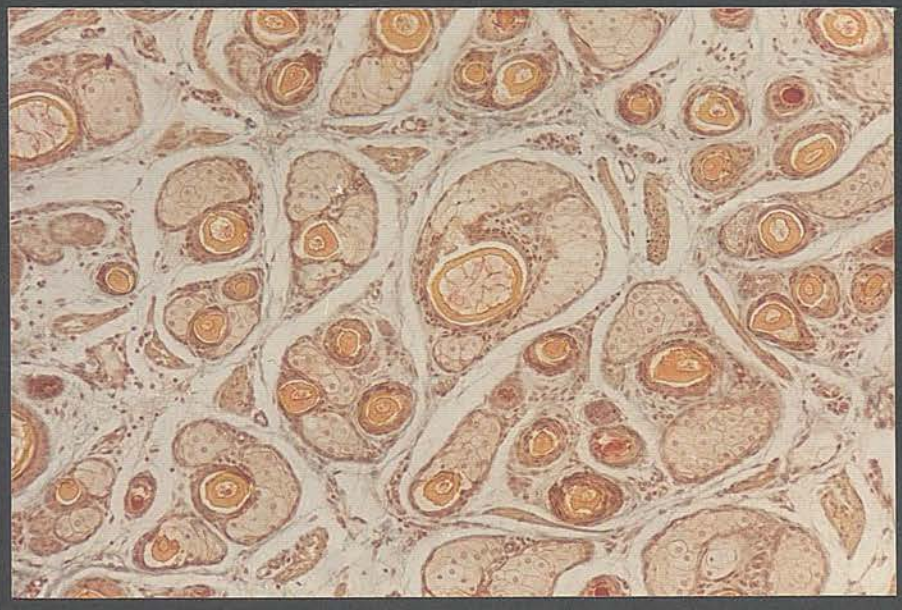


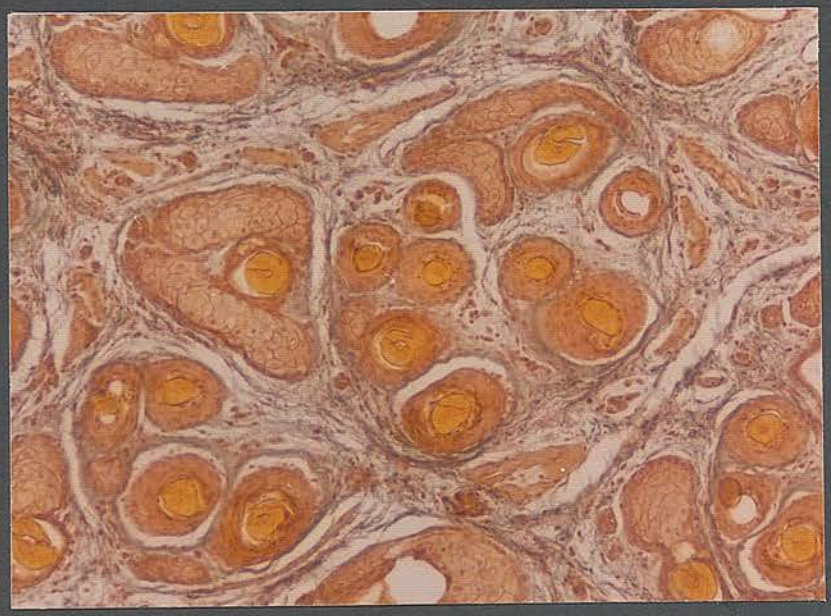
Plate 41: Horizontal section of skin from a control Cheviot x Dorset Horn cross lamb at six months of age.

Sacpic stain x 150

Plate 42: Horizontal section of skin from a Border disease affected Cheviot x Dorset Horn cross lamb at six months of age.

Sacpic stain x 150

Primary follicle and fibre size are still markedly greater in Border disease affected than in control lambs at this age.



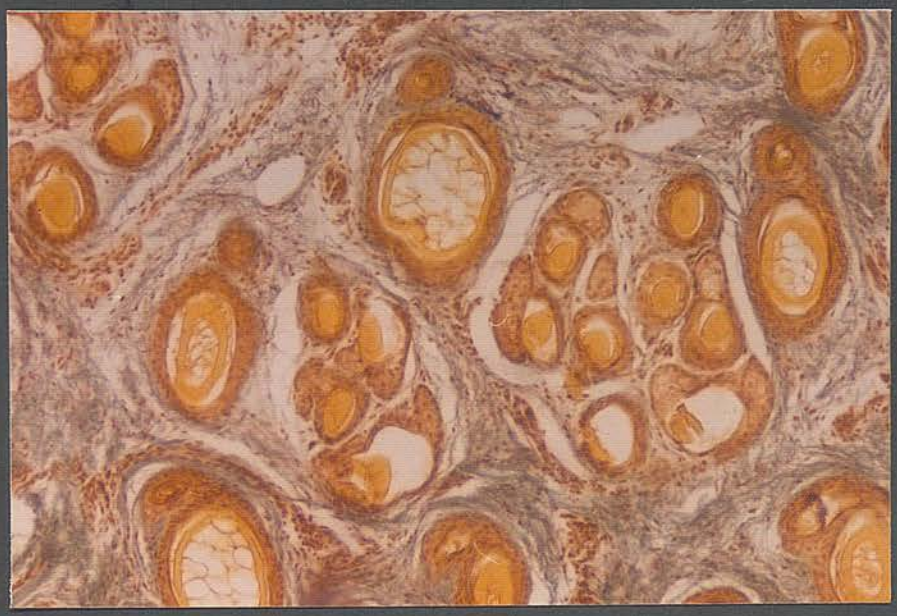
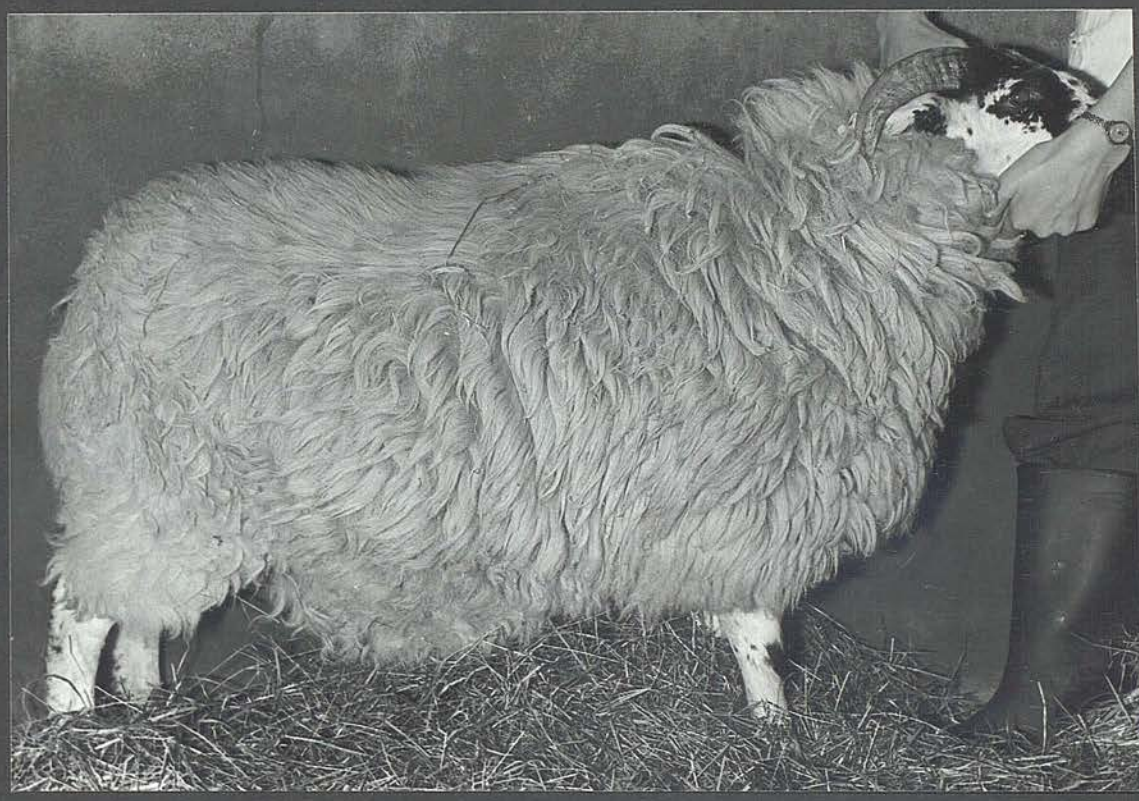


Plate 43: Control Blackface ewe lamb at 6 months of age, showing the normal straight, coarse fleece.

Plate 44: Border disease affected Blackface ewe lamb at 6 months of age, showing the curly-tipped staples on posteroventral parts of the body.
Note the small size and narrow horns of the lamb.



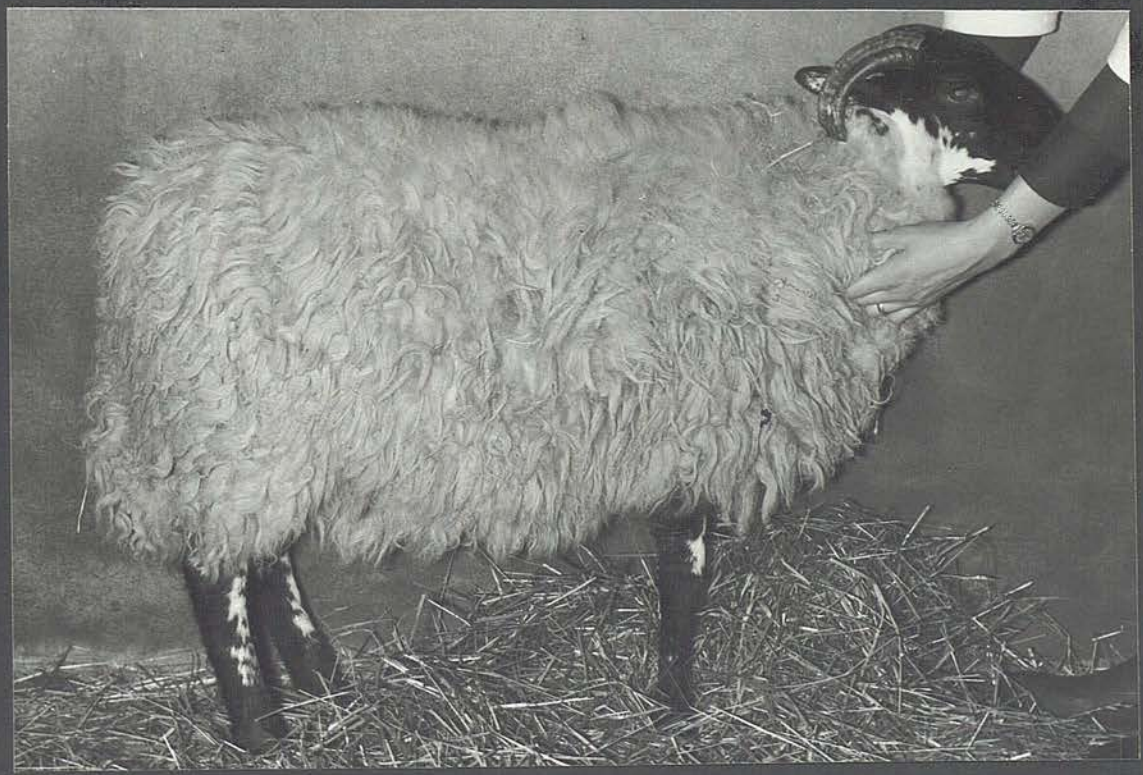


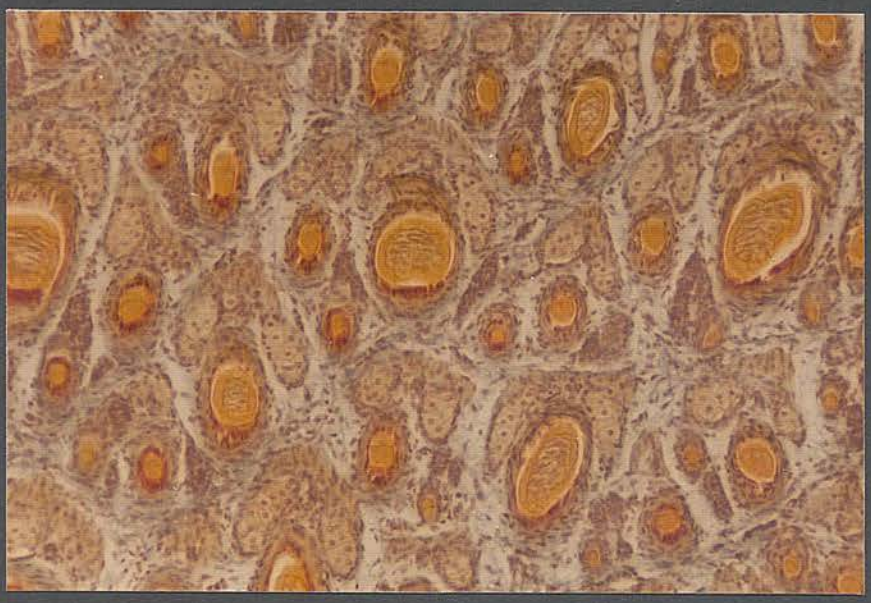
Plate 45: Horizontal section of skin from a control Blackface foetus at 115 days' gestation.

Sacpic stain x 100

Plate 46: Horizontal section of skin from a Border disease affected Blackface foetus at 115 days' gestation.

Sacpic stain x 100

There is no difference between the primary follicle populations of control and Border disease affected foetuses, but the secondary follicles of the affected foetus are less well developed, being still at the plug stage. Those of the control are producing fibres.



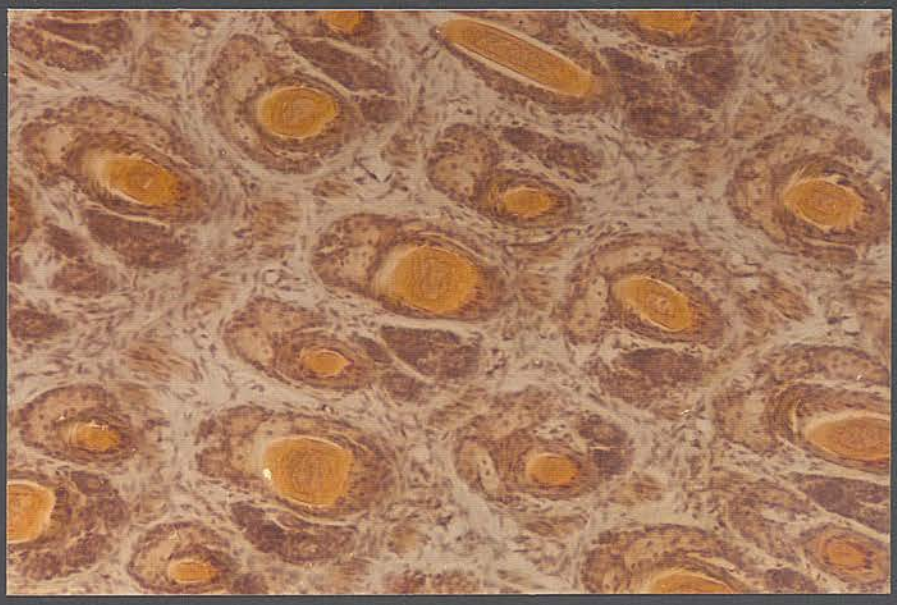


Plate 47: Vertical section of skin from a control Blackface foetus at 115 days' gestation.

Mercury Orange x 40

Plate 48: Vertical section of skin from a Border disease affected foetus at 115 days' gestation.

Mercury Orange x 40

There is no difference in the length or position of the keratogenous zone of the primary follicles, which extends from about one-third of the follicle's length from the bulb for about one-fifth of the follicle's length.

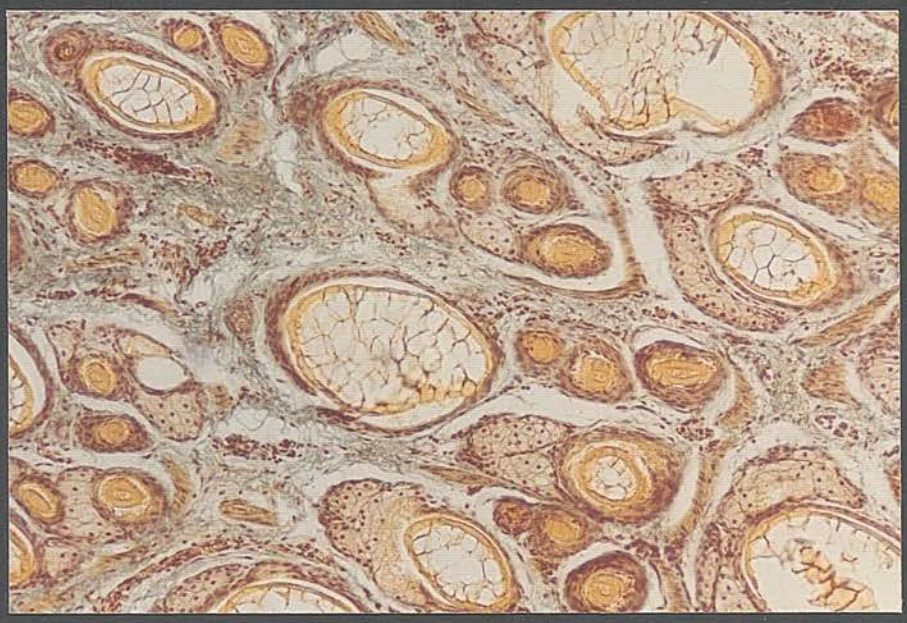
Plate 49: Horizontal section of skin from a control Blackface lamb at 3 weeks of age.

Sacpic stain x 100

Plate 50: Horizontal section of skin from a Border disease affected Blackface lamb at 3 weeks of age.

Sacpic stain x 100

There is no primary follicle hypertrophy in the Border disease affected Blackface, and in some cases, as illustrated here, the primary follicles and fibres are smaller than in control animals.



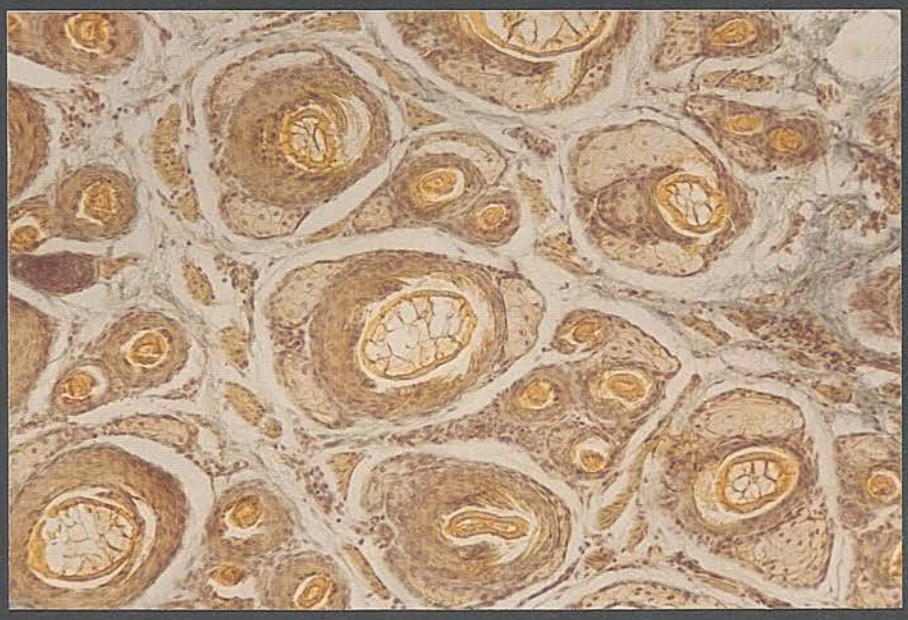


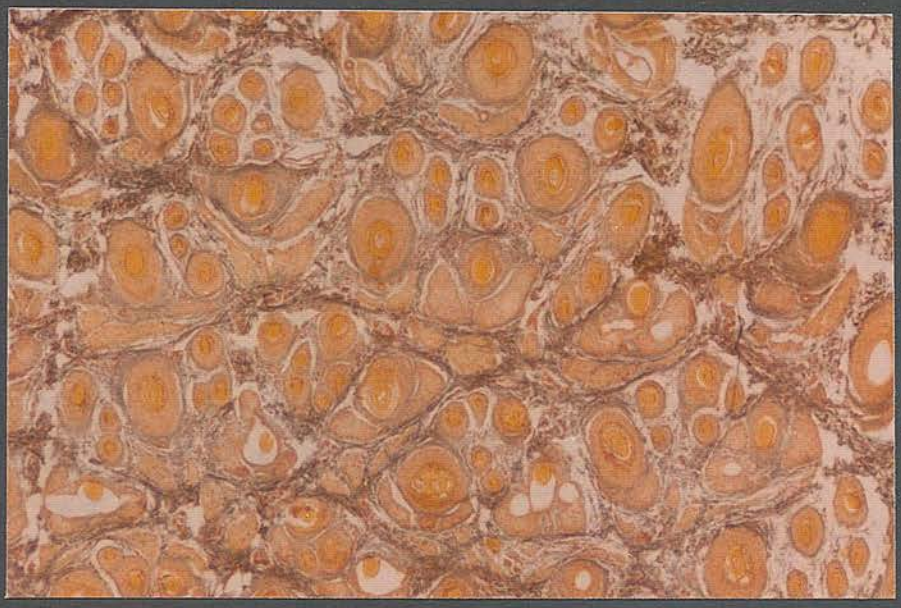
Plate 51: Horizontal section of skin from a control Blackface lamb at 24 weeks of age. x 40

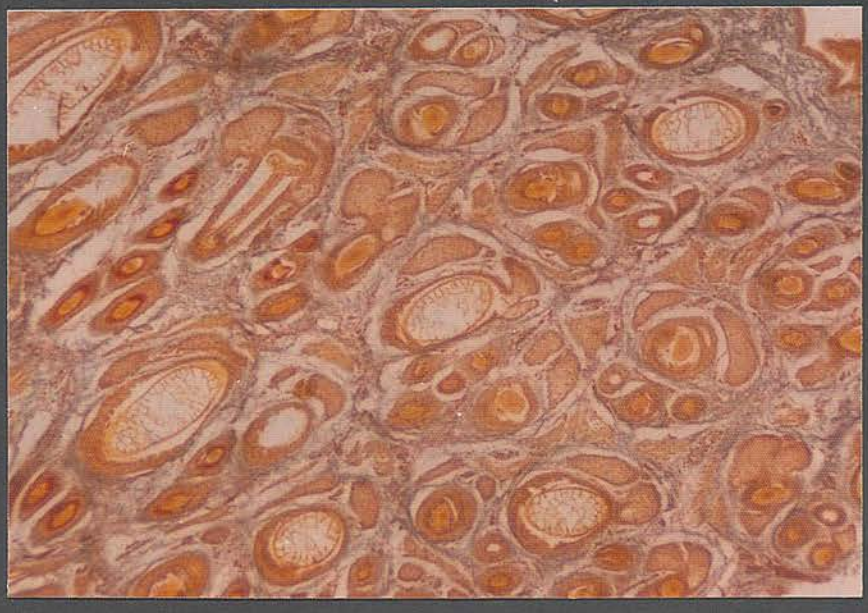
Sacpic stain

Plate 52: Horizontal section of skin from a Border disease affected Blackface lamb at 24 weeks of age.

Sacpic stain x 40

The primary follicles of the control lamb are small, and contain a high proportion of "brush end" follicles, which at sebaceous gland level, appear as non-medullated fibres. In Border disease, the primary follicles are more active, particularly the centrals, which are very large and are producing heavily medullated fibres.





# FIGURES

Figure 1: Graphs showing the range of stages of development of central primary follicles.  , lateral primary follicles  and secondary follicles  in control (a and c) and Border disease affected foetuses (b and d) as values for the three sites combined (a and b) and as side site values only (c and d)

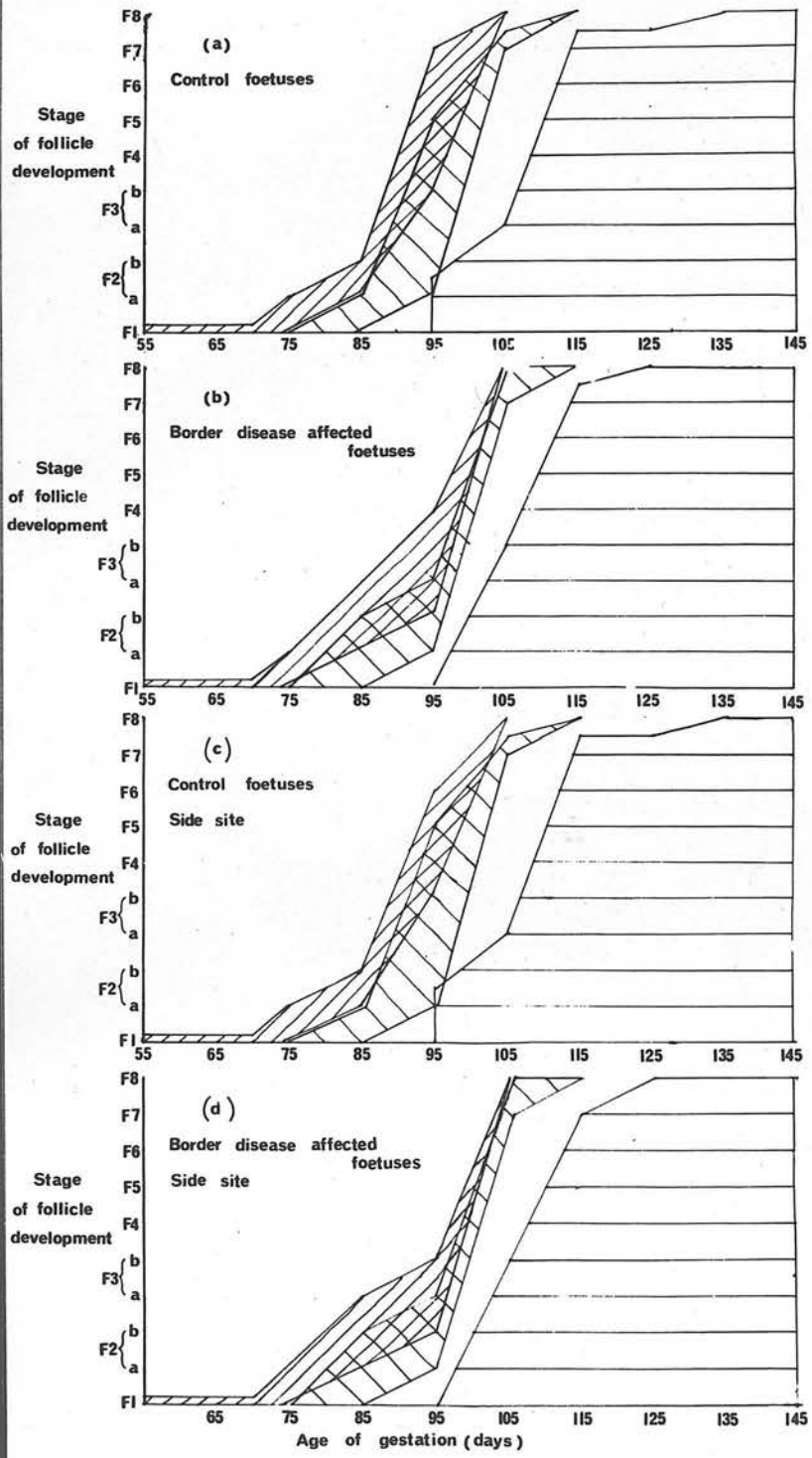

(a)
Control foetuses
(b)
Border disease affected foetuses
(c)
Control foetuses
Side site
(d)
Border disease affected foetuses
Side site
Stage of follicle development
F8
F7
F6
F5
F4
F3 b a
F2 b a
F1
55 65 75 85 95 105 115 125 135 145
Age of gestation (days)

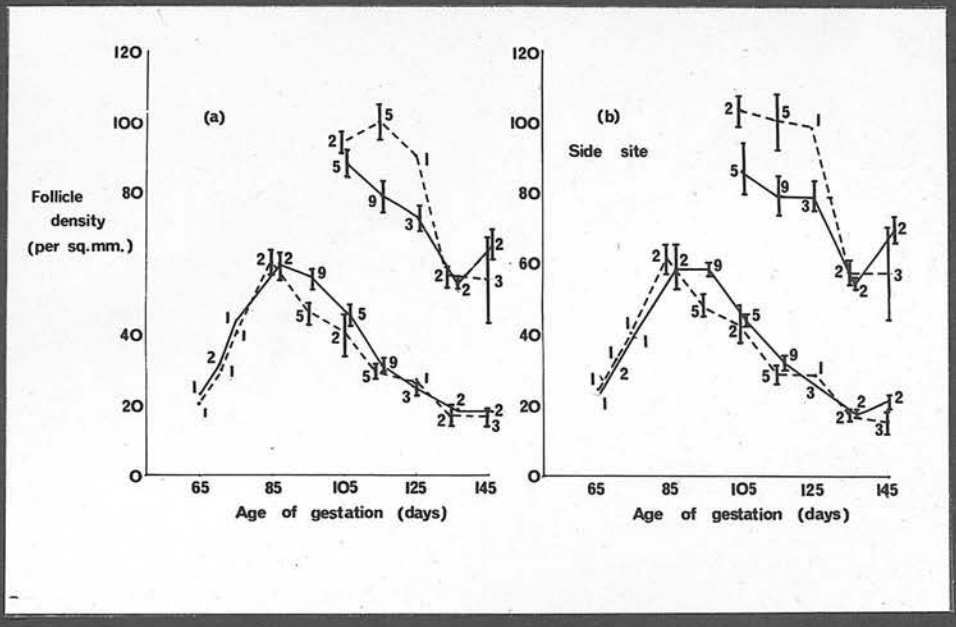
Figure 2: Graphs showing the relationship between primary and total follicle density ( $\pm$ Standard Deviation (S.D.)) and foetal age, recorded as a) the average values for the three sites and b) the side site values.

The higher values at 105 to 145 days' gestation show total follicle density; the values from 65 to 95 days', continuing as the lower values from 105 to 145 days' gestation, represent primary follicle density.

Figure 3: Graph showing the relationship between the estimated foetal surface area ( $\pm$ S.D.) and foetal age.

The numbers of animals sampled in each group are shown.

- - - - - control _____ Border disease affected.


(a)
(b)
Side site
Follicle density (per sq.mm.)
120
100
80
60
40
20
0
65
85
105
125
145
Age of gestation (days)

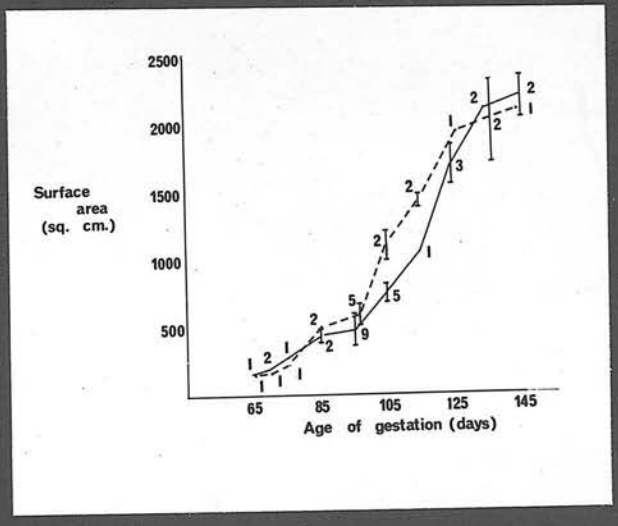

Surface area (sq. cm.)
2500
2000
1500
1000
500
65
85
105
125
145
Age of gestation (days)

Figure 4: Graphs showing the relationship between fibre medullation (± S.D.) and foetal age for primary fibres (a and b) and central primary fibres (c and d), recorded as average value for the three sites (a and c) and as side site values (b and d).

For each of the two groups (control and Border disease affected) there are two values shown. At each age, the higher value indicates the percentage of medullated fibres, the lower value indicates the percentage of medullated fibres with large medullae (KM).

The number of animals sampled in each group are shown.

- - - - - - - control _____ Border disease affected

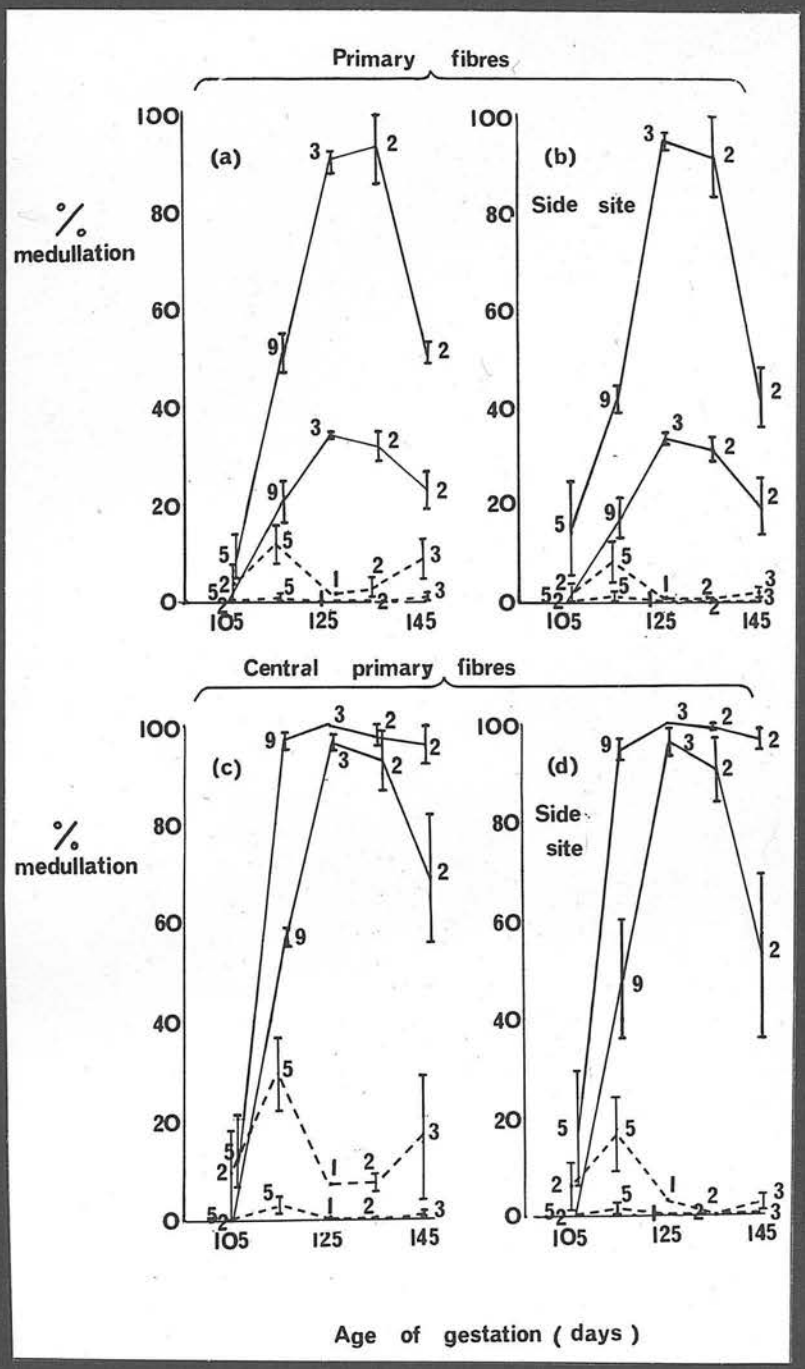

Primary fibres
(a)
(b)
Side site
% medullation
Central primary fibres
(c)
(d)
Side site
% medullation
100
80
60
40
20
0
105
125
145
Age of gestation ( days )

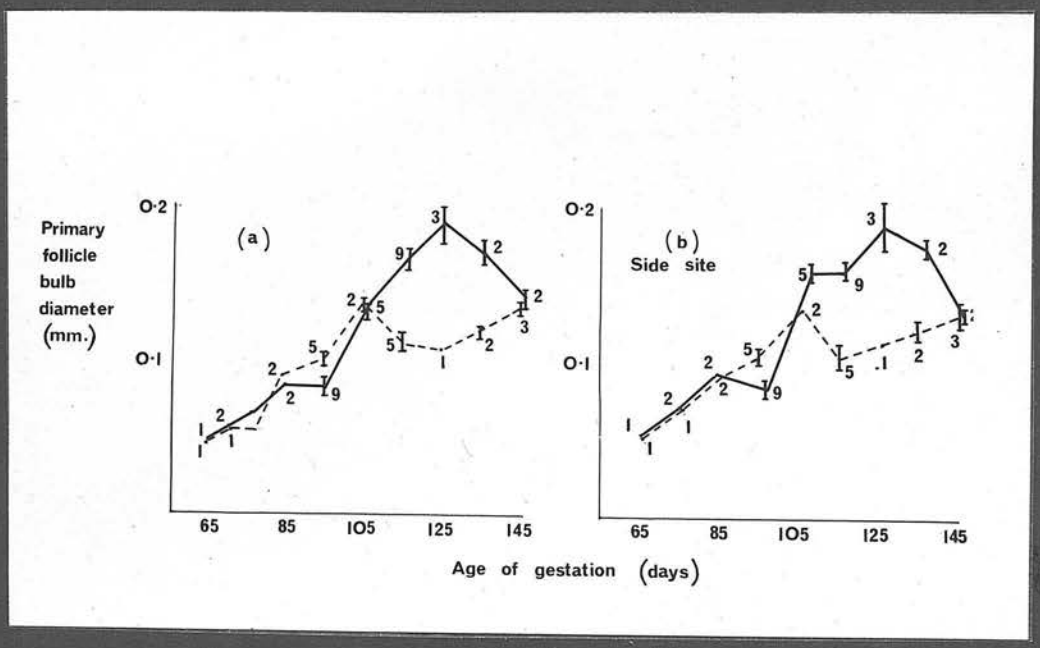
Figure 5: Graphs showing the relationship between primary follicle bulb diameter ( $\pm$ S.D.) and foetal age, recorded as (a) average values for the three sites and (b) side site values.

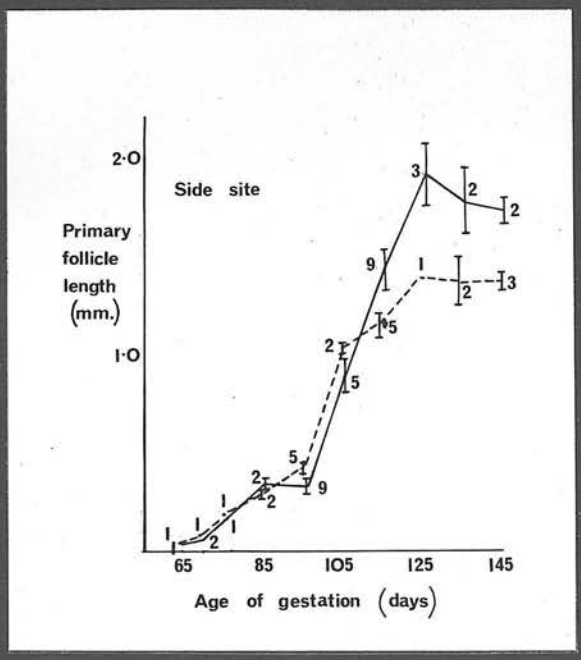
Figure 6: Graph showing the relationship between primary follicle length at the side site ( $\pm$ S.D.) and foetal age

Figure 7: Graph showing the relationship between primary fibre diameter at sebaceous gland level ( $\pm$ S.D.) and foetal age.

The numbers of animals sampled in each group are shown.

- - - - - control ———— Border disease affected


Primary follicle bulb diameter (mm.)
0·2
0·1
(a)
(b)
Side site
65
85
105
125
145
Age of gestation (days)


2·0
1·0
Side site
Primary follicle length (mm.)
65
85
105
125
145
Age of gestation (days)

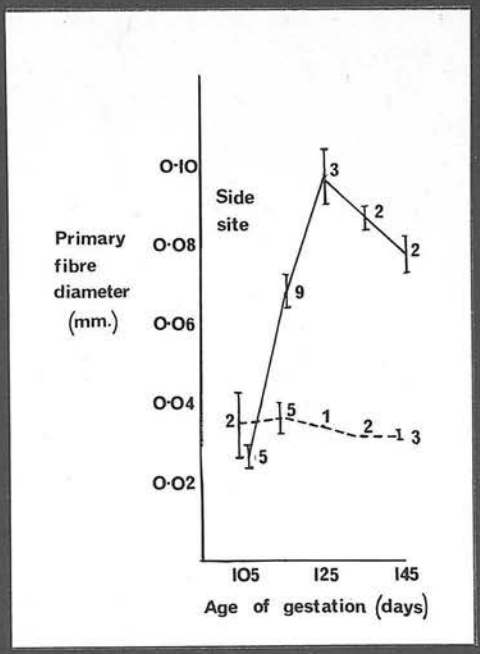

0·10
0·08
0·06
0·04
0·02
Side site
Primary fibre diameter (mm.)
105
125
145
Age of gestation (days)

Figure 8: Graphs showing the relationship between a) $\frac{S}{P}$ follicle ratio ($\pm$ S.D.) and b) $\frac{S}{P}$ fibre ratio ($\pm$ S.D.) and foetal age, recorded as average values for the three sites (a and c) and as side site values (b and d).

The numbers of animals sampled in each group are shown.

- - - - - - control ———————— Border disease affected.

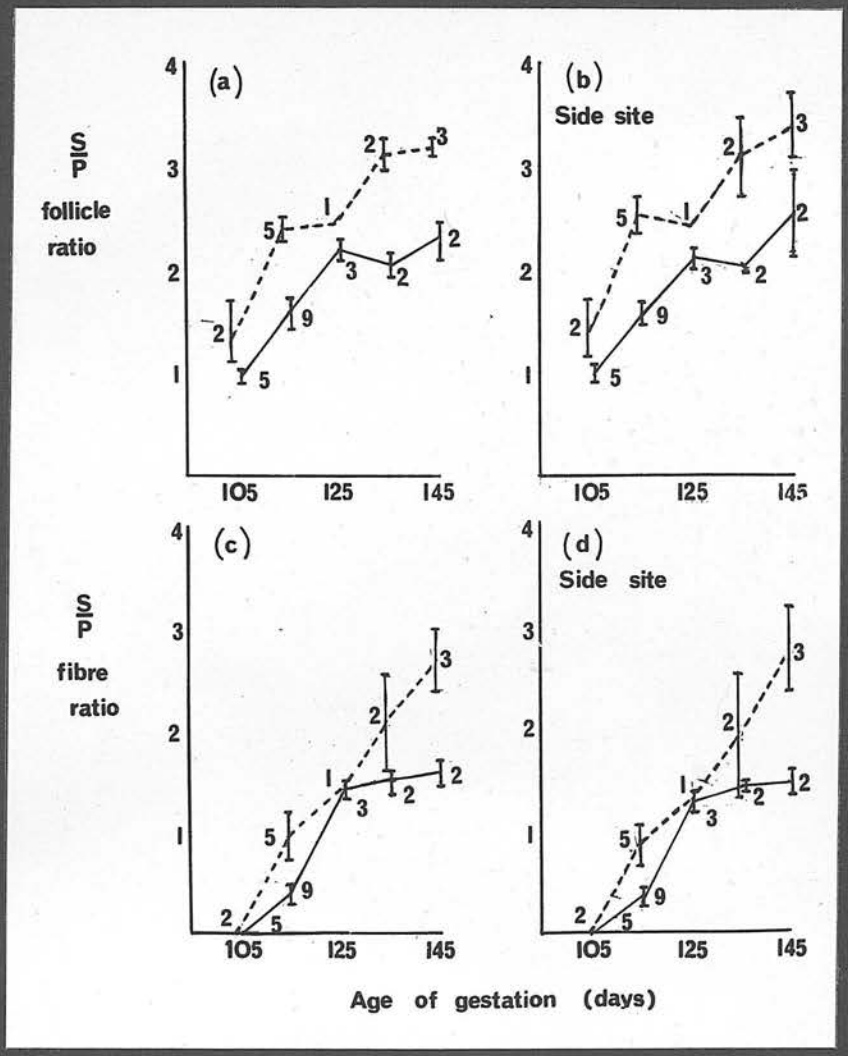

S/P follicle ratio
(a)
(b)
Side site
S/P fibre ratio
(c)
(d)
Side site
4
3
2
1
105
125
145
Age of gestation (days)

Figure 9: Graphs showing the relationship between the average estimated numbers of

lymphocytes ( ——L ——)

mast cells ( - - M - - )

and neutrophils (---- P ----)

in the dermis and foetal age, recorded for (a) control and (b) Border disease affected foetuses

\+ few, ++ some, +++ many cells

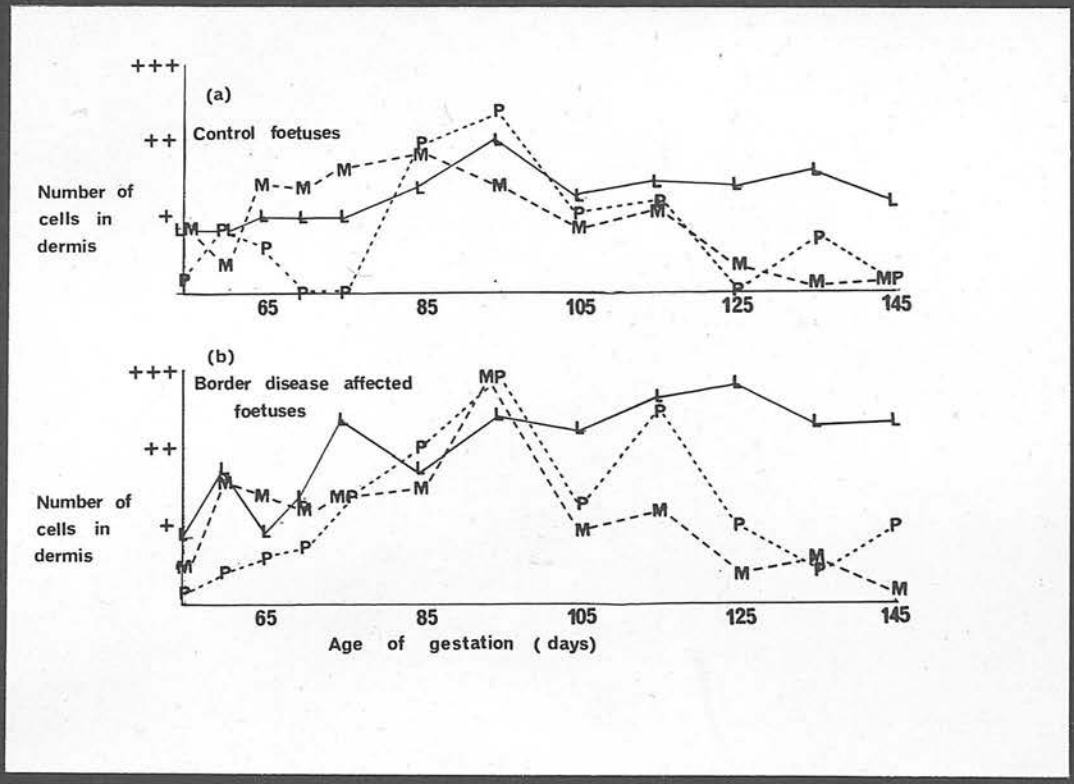
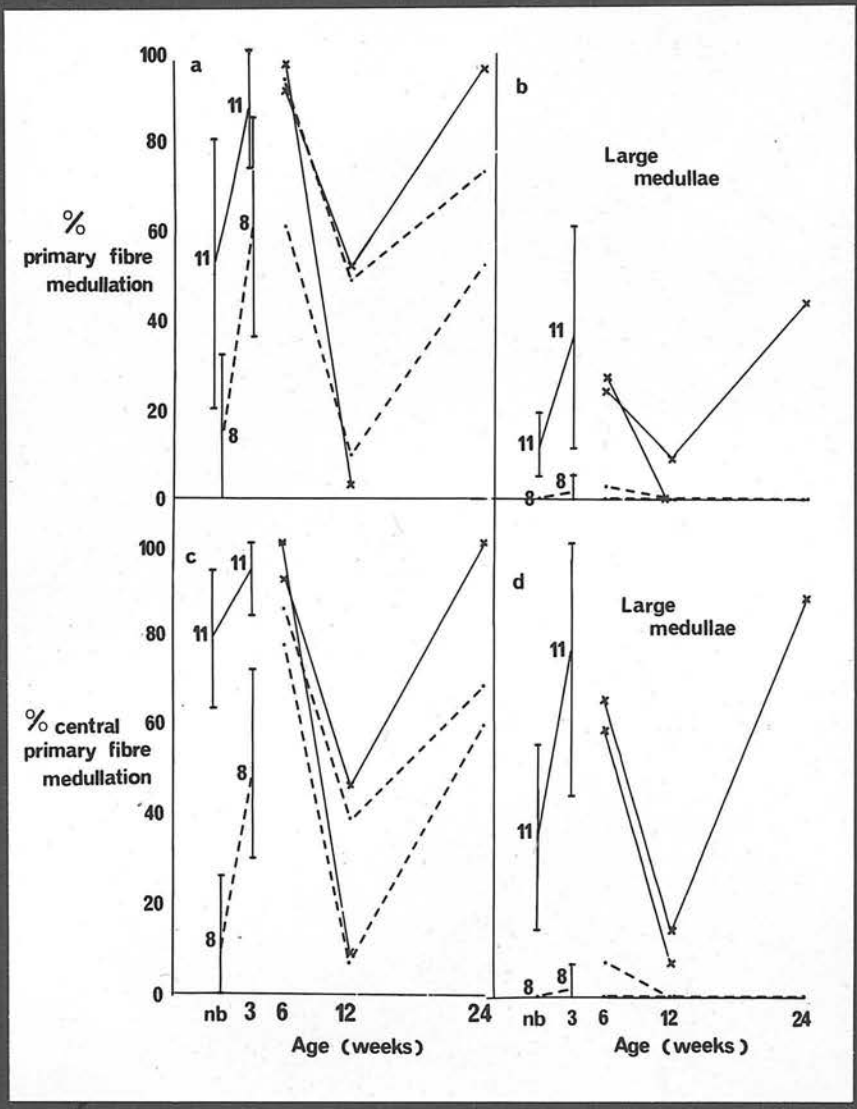

(a)
Control foetuses
Number of cells in dermis
+++
++
+
65
85
105
125
145
(b)
Border disease affected foetuses
Number of cells in dermis
Age of gestation (days)

Figure 10: The relationship between the frequencies of medullated fibres (a and c) and of heavily medullated fibres (b and d) in primary follicles (a and b) and central primary follicles (c and d) and age.

Figure 11: The relationship between the frequency of medullated secondary fibres and age.

For newborn (nb) and three week old lambs, the mean values $\pm$ SD and the numbers sampled are shown. At six weeks and over, the values for individual animals are plotted.

- - - - - - - control ———— Border disease affected


a
b
Large medullae
c
d
Large medullae
% primary fibre medullation
% central primary fibre medullation
100
80
60
40
20
0
11
8
nb
3
6
12
24
Age (weeks)

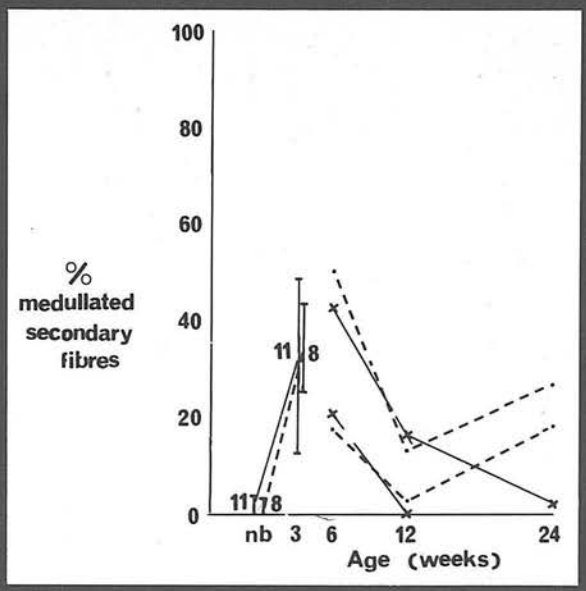

% medullated secondary fibres
100
80
60
40
20
0
11
8
nb
3
6
12
24
Age (weeks)

Figure 12: The relationship between the diameter of the largest follicle bulb and age

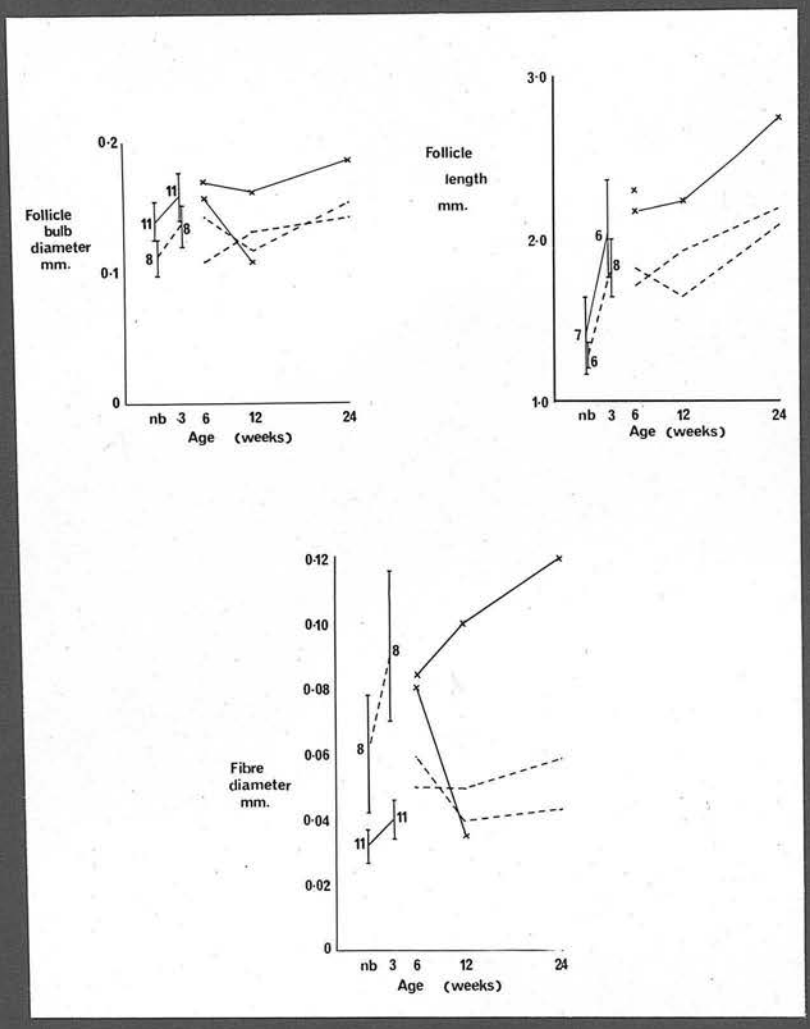
Figure 13: The relationship between the length of the longest follicle and age. Not all samples at birth and three weeks of age were suitable for examination.

Figure 14: The relationship between central primary fibre diameter and age.

Figure 15: The relationship between $\frac{S}{P}$ follicle ratio (a) and $\frac{S}{P}$ fibre ratio (b) and age.

For newborn and three weeks old lambs, the mean values $\pm$ SD and the numbers sampled are shown. At six weeks and over, the values for individual animals are plotted.

- - - - - - control ———— Border disease affected.


Follicle bulb diameter mm.
0·2
0·1
0
11
11
8
8
nb 3 6 12 24
Age (weeks)
Follicle length mm.
3·0
2·0
1·0
6
8
7
6
nb 3 6 12 24
Age (weeks)
Fibre diameter mm.
0·12
0·10
0·08
0·06
0·04
0·02
0
8
8
11
11
nb 3 6 12 24
Age (weeks)

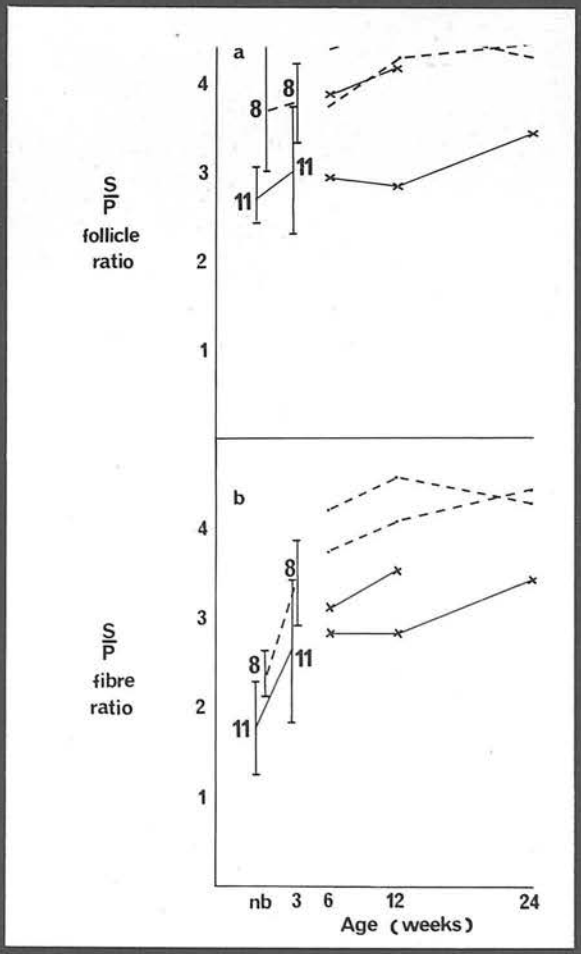
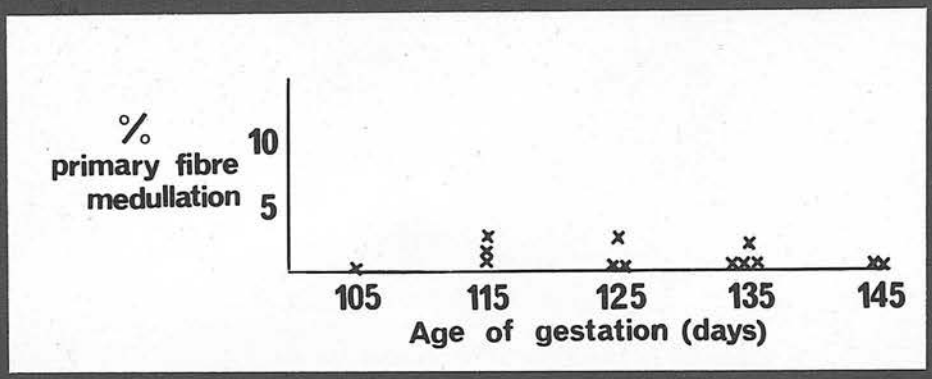

a
S/P follicle ratio
4
3
2
1
8
8
11
11
b
S/P fibre ratio
4
3
2
1
8
8
11
11
nb 3 6 12 24
Age (weeks)

Figure 16: Graph showing the relationship between primary fibre medullation and age of foetuses whose dams were inoculated 15 days before slaughter and sampling.

Figure 17: Graphs showing the relationship between the $\frac{S}{P}$ follicle ratio (a) and the $\frac{S}{P}$ fibre ratio (b) and age of foetuses whose dams were inoculated 15 days before slaughter and sampling.


% primary fibre medullation
10
5
105
115
125
135
145
Age of gestation (days)

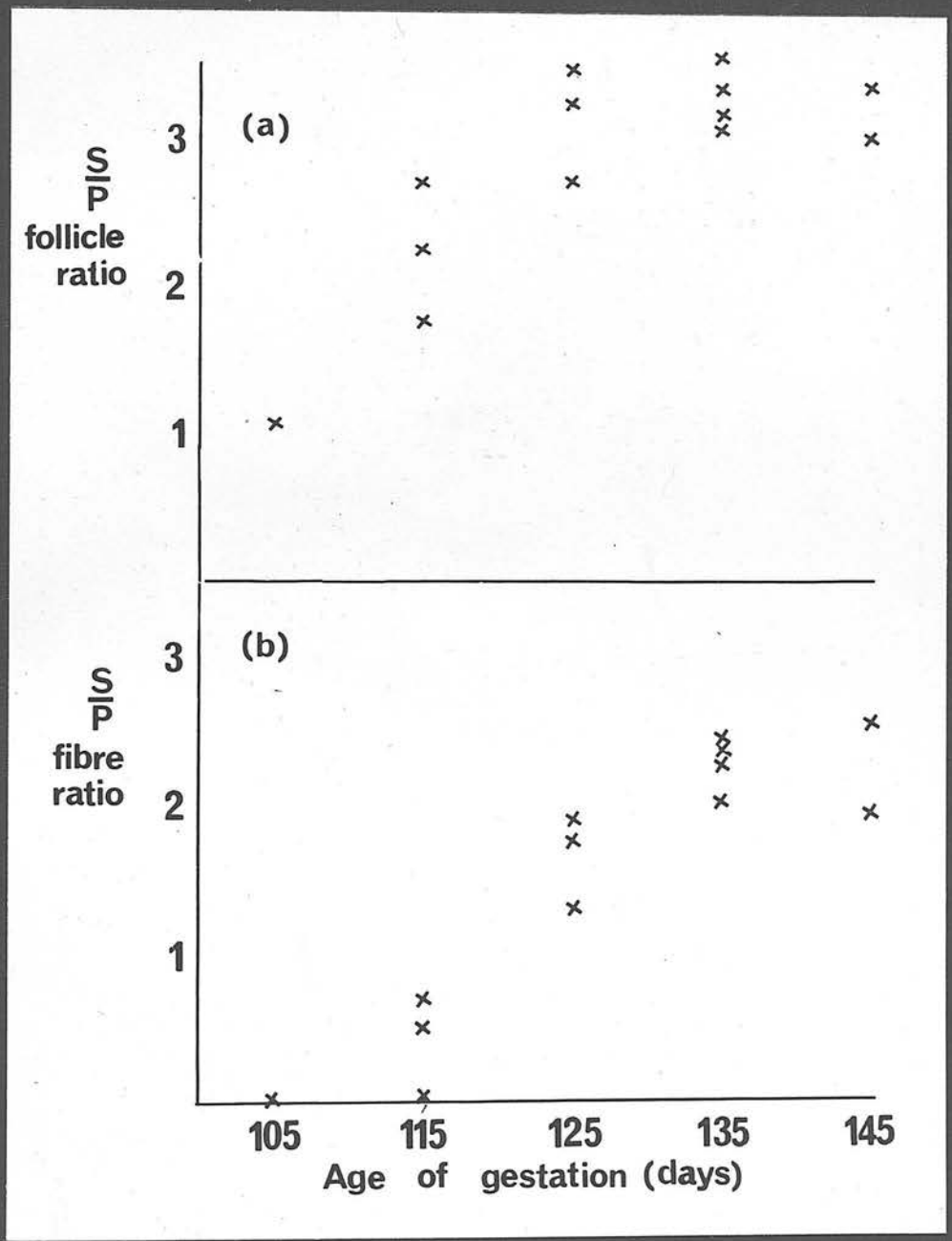

(a)
S/P follicle ratio
3
2
1
(b)
S/P fibre ratio
3
2
1
105
115
125
135
145
Age of gestation (days)

Figure 18: Graph showing the relationship between the largest follicle bulb diameter and age of foetuses whose dams were inoculated 15 days before slaughter and sampling.

Figure 19: Graph showing the relationship between the longest follicle's length and age of foetuses whose dams were inoculated 15 days before slaughter and sampling.

Figure 20: Graph showing the relationship between the largest central primary fibre diameter and age of foetuses whose dams were inoculated 15 days before slaughter and sampling.

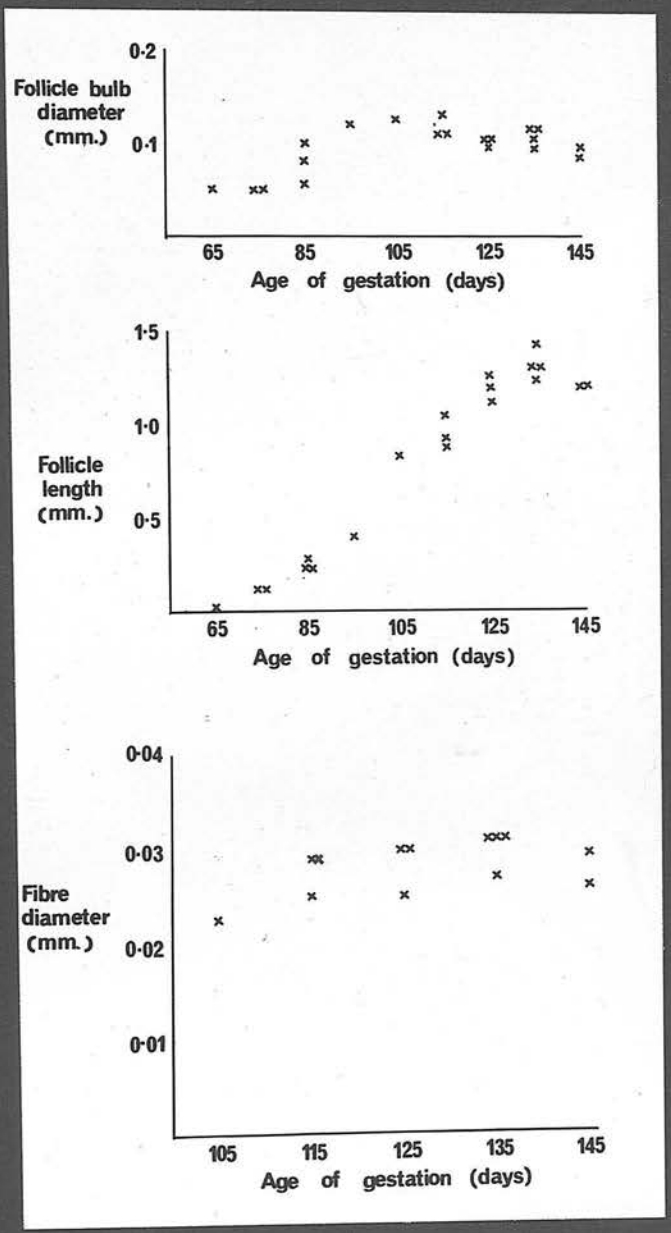

0·2
Follicle bulb diameter (mm.)
0·1
65
85
105
125
145
Age of gestation (days)
1·5
1·0
Follicle length (mm.)
0·5
65
85
105
125
145
Age of gestation (days)
0·04
0·03
Fibre diameter (mm.)
0·02
0·01
105
115
125
135
145
Age of gestation (days)

Figure 21: Graphs showing the relationship between the frequencies of primary fibre medullation (a) and primary fibres with large medullae (b) and foetal age at maternal inoculation, x at birth and + at three weeks of age.

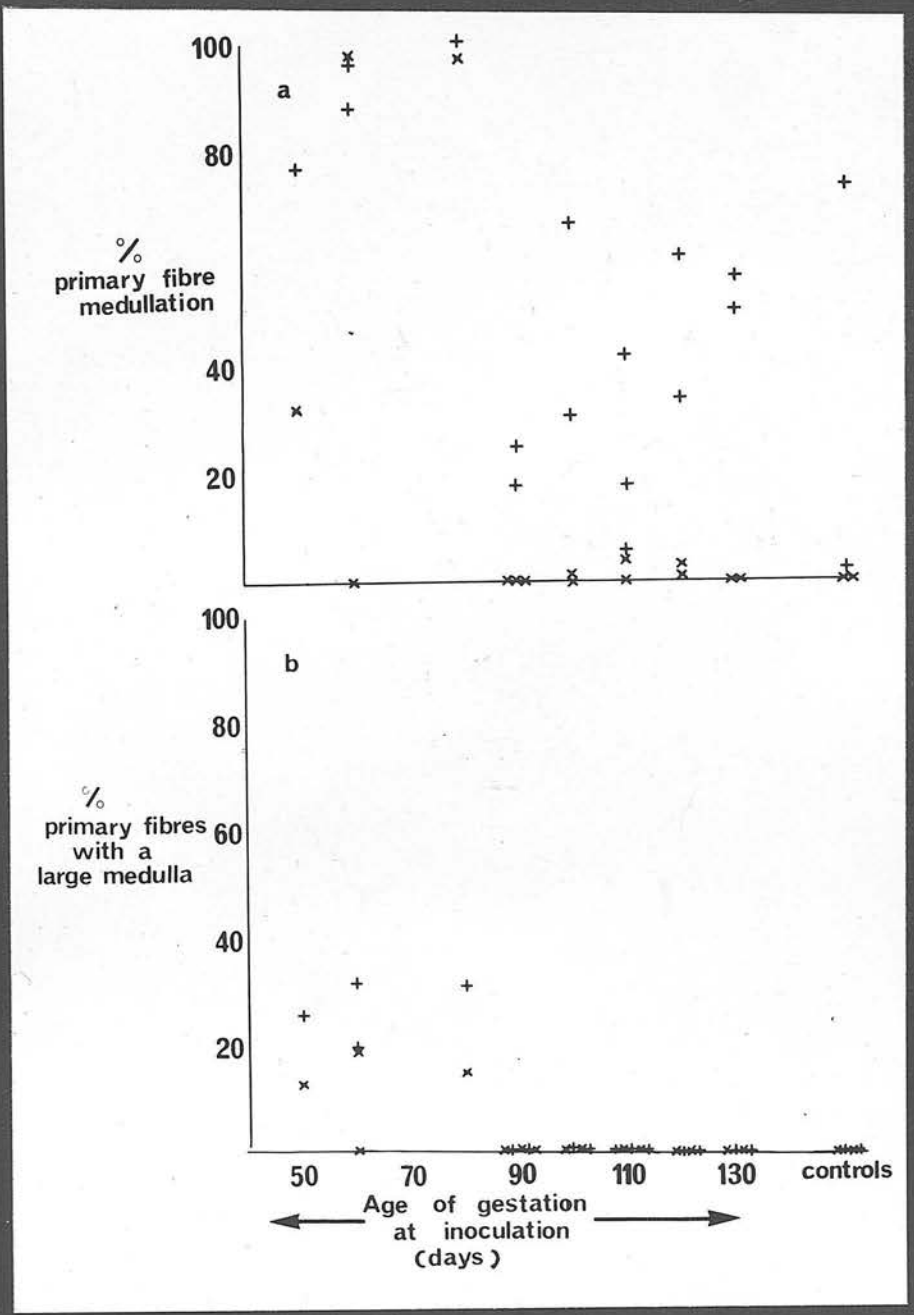

100
80
%
primary fibre
medullation
40
20
a
100
80
%
primary fibres
with a
large medulla
60
40
20
b
50
70
90
110
130
controls
Age of gestation
at inoculation
(days)

Figure 22: Graphs showing the relationship between a) $\frac{S}{P}$ follicle ratio and b) $\frac{S}{P}$ fibre ratio and foetal age at maternal inoculation

x at birth and + at three weeks of age.

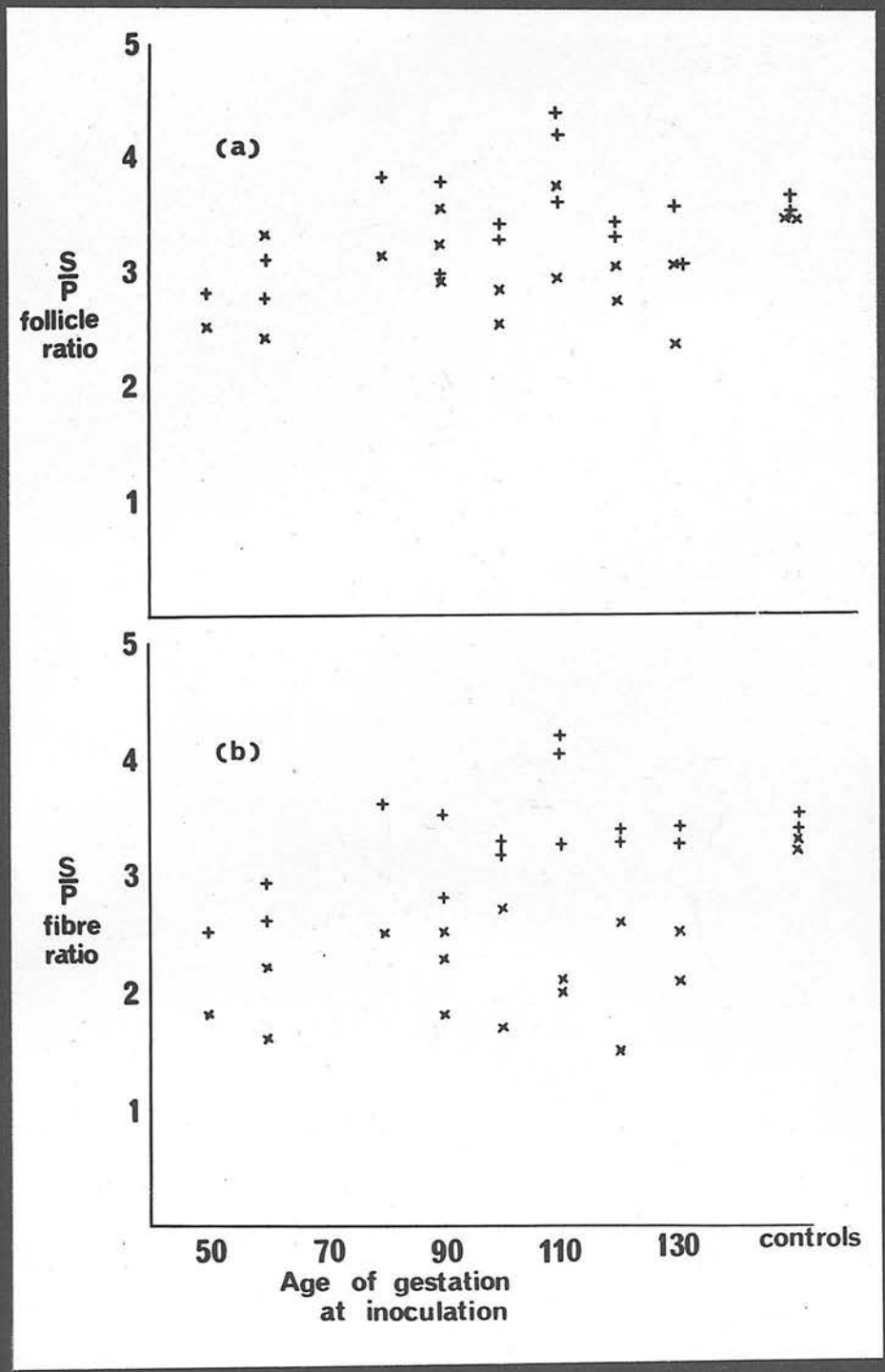

(a)
S/P follicle ratio
5
4
3
2
1
(b)
S/P fibre ratio
5
4
3
2
1
50
70
90
110
130
controls
Age of gestation at inoculation

Figure 23: Graph showing the relationship between the largest follicle bulb diameter and foetal age at maternal inoculation

x at birth and + at three weeks of age.

Figure 24: Graph showing the relationship between the longest follicle's length and foetal age at maternal inoculation

x at birth and + at three weeks of age.

Not all samples provided satisfactory sections for estimation of follicle length.

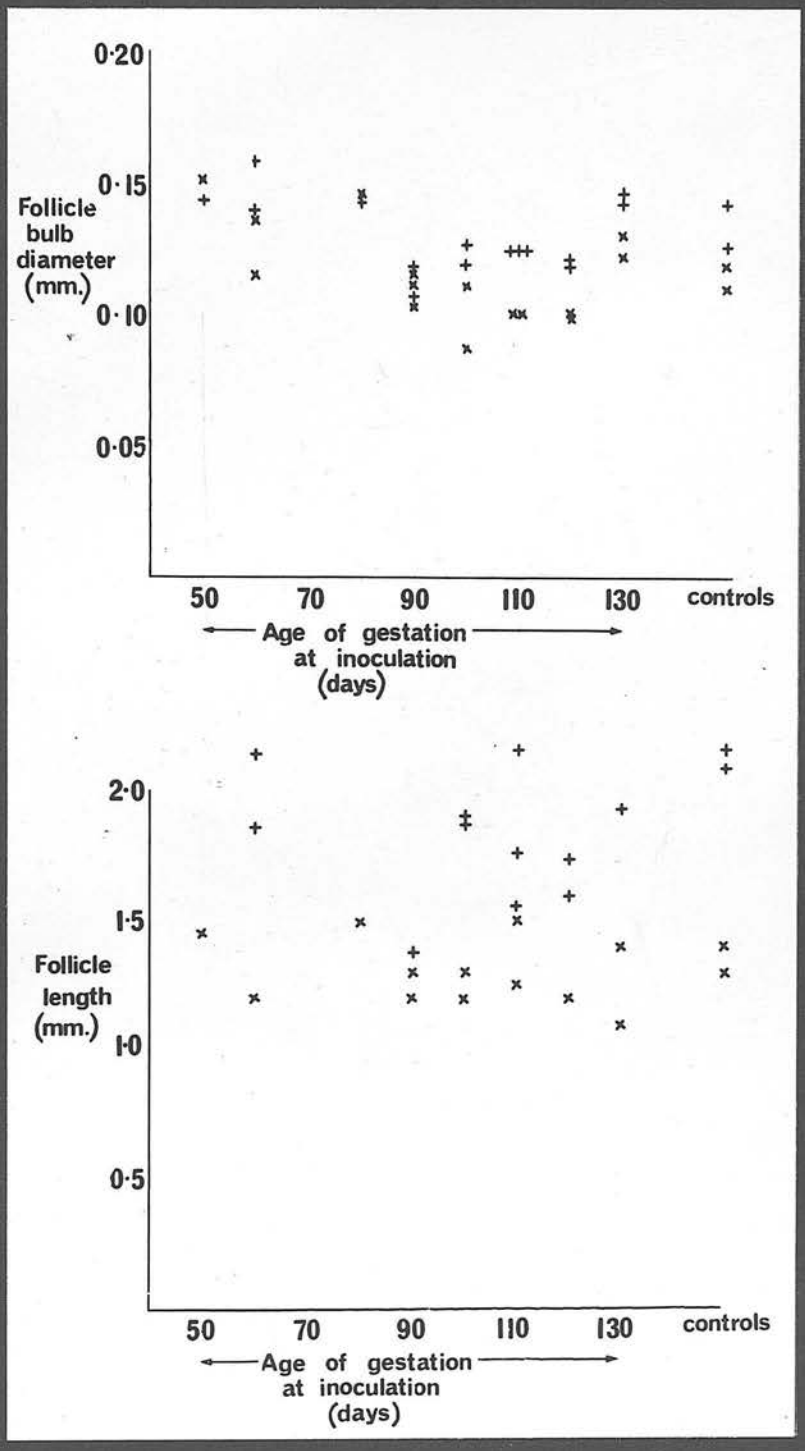

0·20
0·15
0·10
0·05
Follicle bulb diameter (mm.)
50
70
90
110
130
controls
Age of gestation at inoculation (days)
2·0
1·5
1·0
0·5
Follicle length (mm.)
50
70
90
110
130
controls
Age of gestation at inoculation (days)

Figure 25: Graph showing the relationship between the largest central primary fibre diameter and foetal age at maternal inoculation

x at birth and + at three weeks of age.

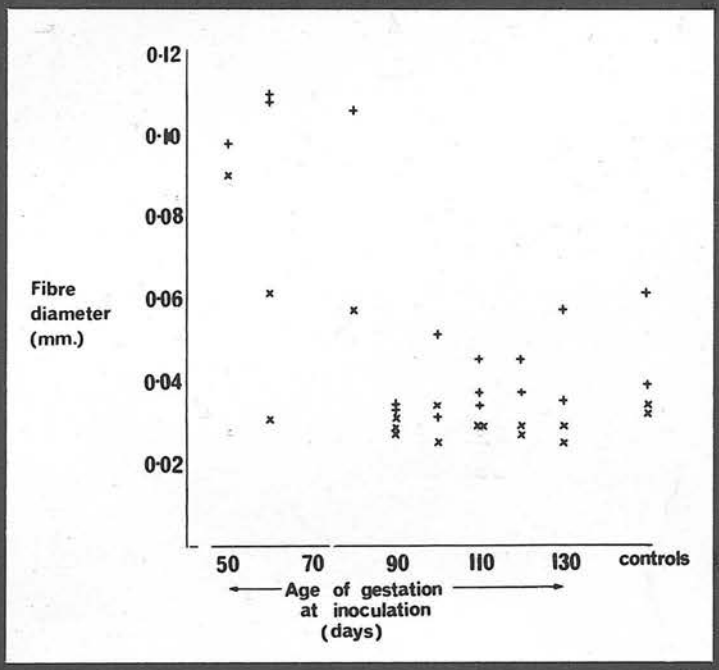

0·12
0·10
0·08
0·06
0·04
0·02
Fibre diameter (mm.)
50
70
90
110
130
controls
Age of gestation at inoculation (days)

Figure 26: Graphs showing the relationship between primary fibre medullation ($\pm$ S.D.) and age in the Scottish Blackface, expressed as medullae of any size (a and c) and large medullae (b and d), in primary fibres (a and b) and central primary fibres (c and d)

- - - - - control _____ Border disease affected

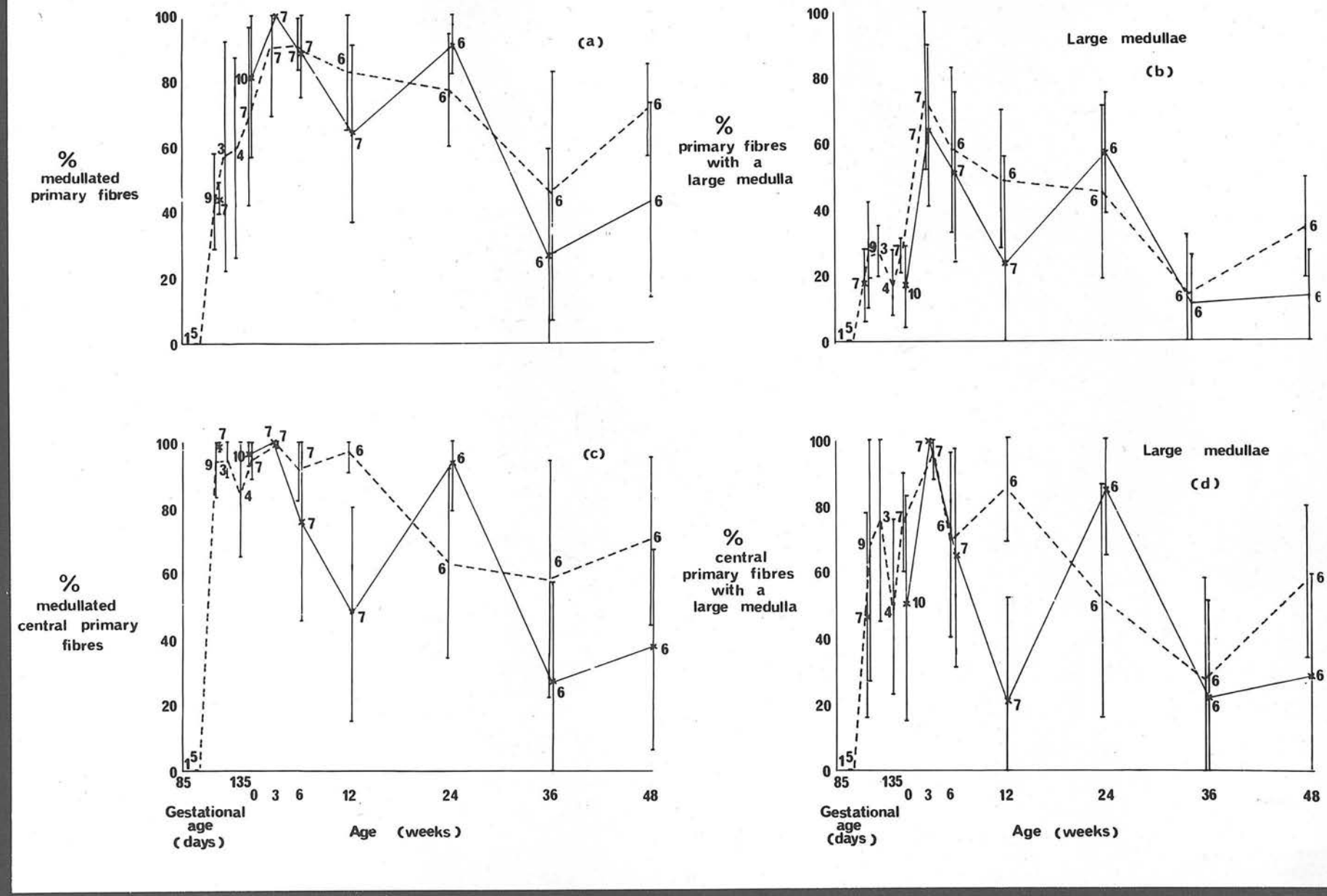
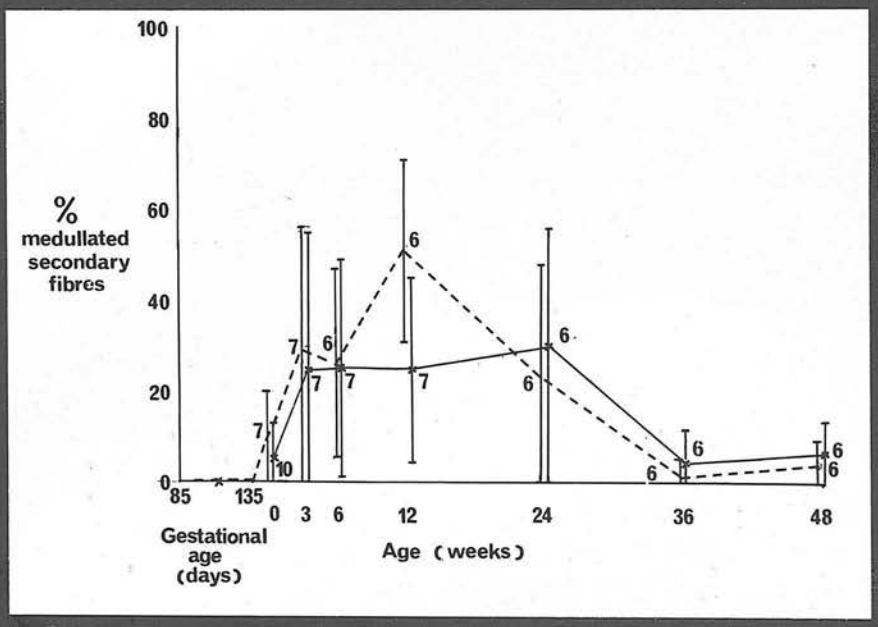

% medullated primary fibres
(a)
% primary fibres with a large medulla
Large medullae
(b)
% medullated central primary fibres
(c)
% central primary fibres with a large medulla
Large medullae
(d)
Gestational age (days)
Age (weeks)
85
135
0
3
6
12
24
36
48

Figure 27: Graph showing the relationship between secondary fibre medullation ($\pm$ S.D.) and age in the Scottish Blackface.

Figure 28: Graph showing the relationship between the largest follicle bulb diameter($\pm$S.D.) and age in the Scottish Blackface

- - - - - - - control ———— Border disease affected


100
80
60
40
20
0
%
medullated
secondary
fibres
85
135
0
3
6
12
24
36
48
Gestational
age
(days)
Age (weeks)

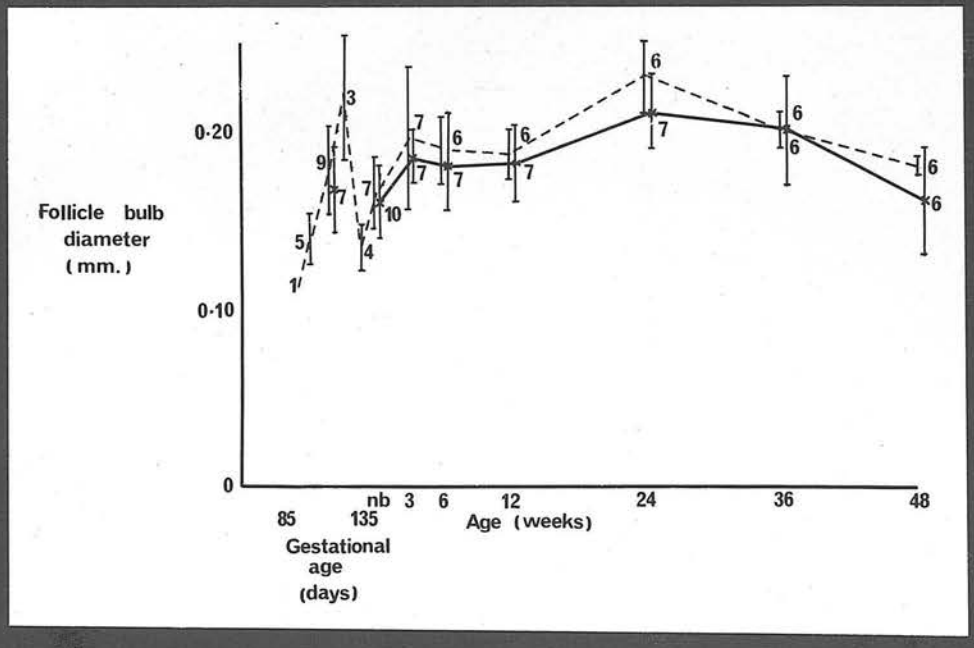
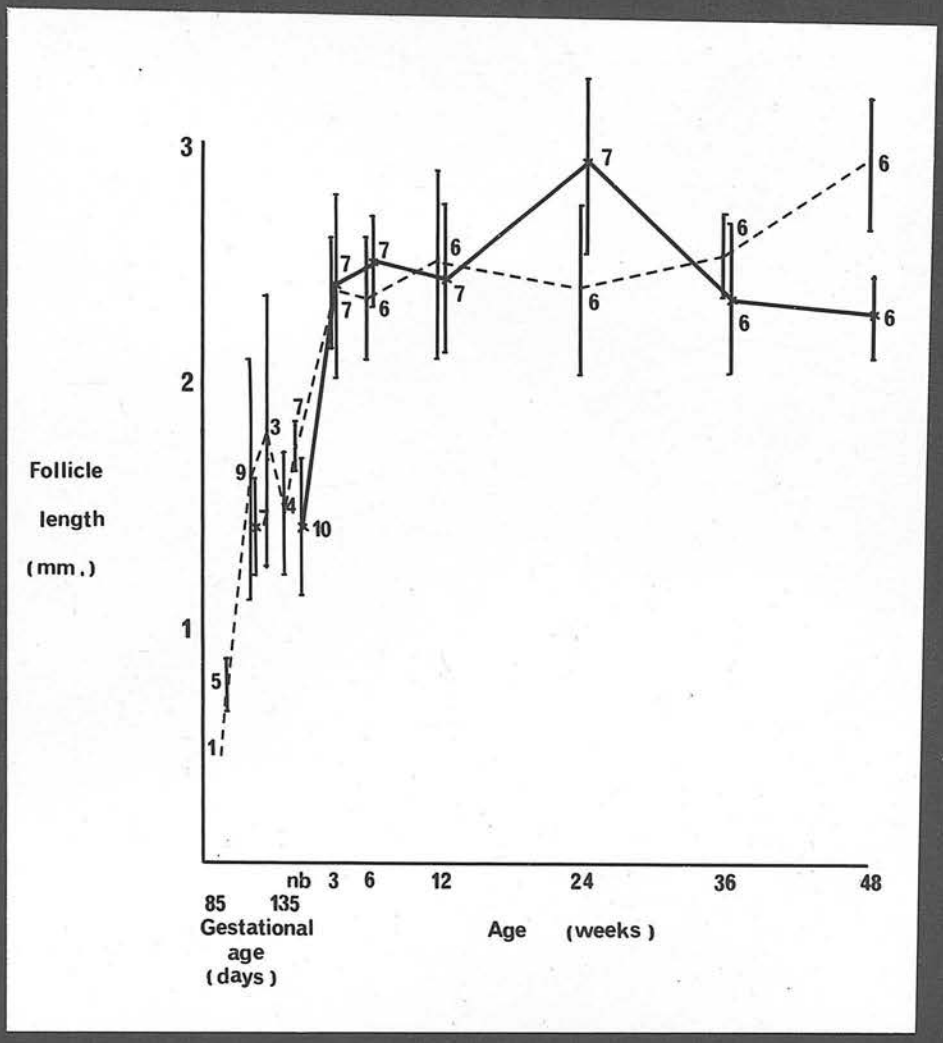

0·20
0·10
0
Follicle bulb
diameter
(mm.)
85
135
nb
3
6
12
24
36
48
Gestational
age
(days)
Age (weeks)

Figure 29: Graph showing the relationship between the longest follicle length ( ± S.D.) and age in the Scottish Blackface

Figure 30: Graph showing the relationship between the largest central primary fibre diameter ( ± S.D.) and age in the Scottish Blackface.

- - - - - control _____ Border disease affected.


Follicle
length
(mm.)
3
2
1
nb 3 6 12 24 36 48
85 135
Gestational
age
(days)
Age (weeks)

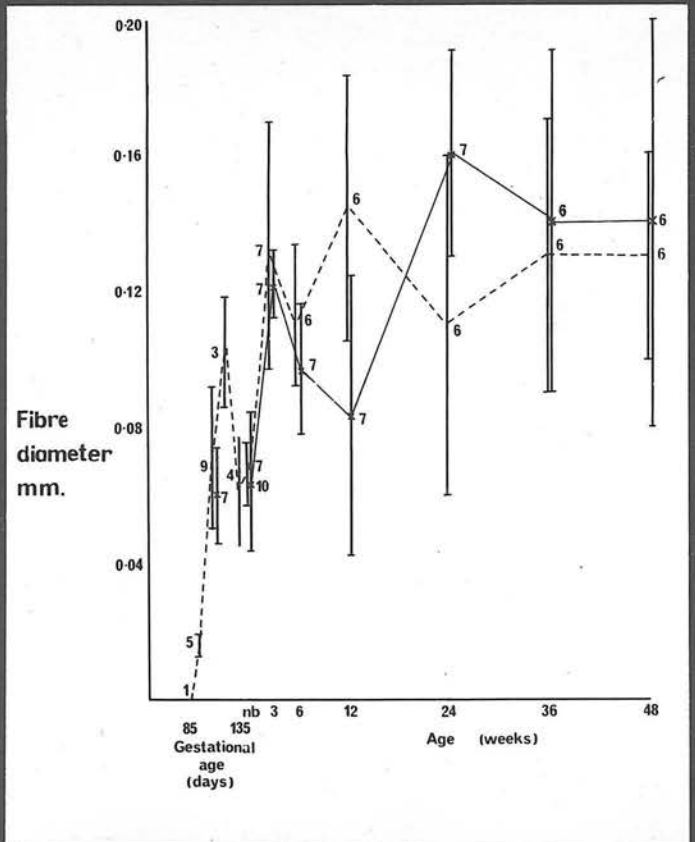
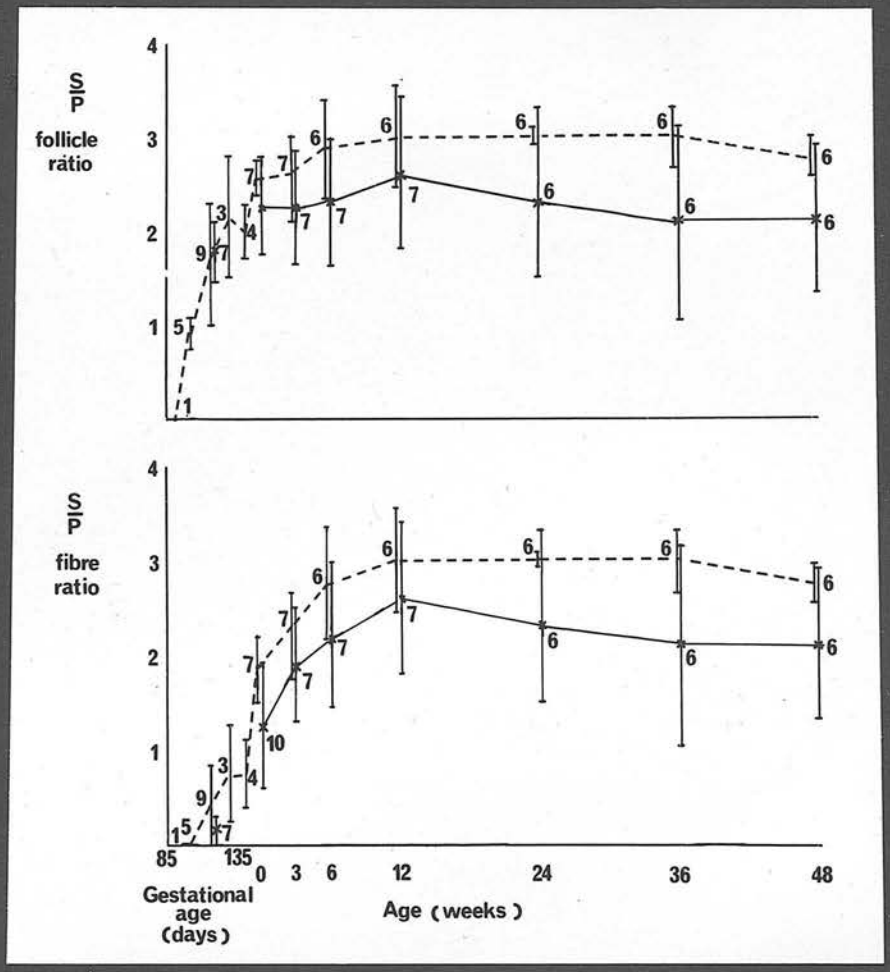
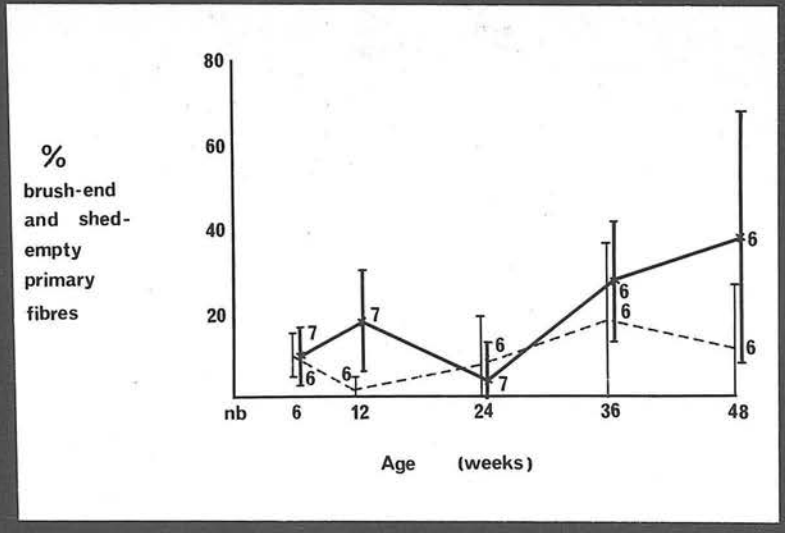

Fibre
diameter
mm.
0·20
0·16
0·12
0·08
0·04
nb 3 6 12 24 36 48
85 135
Gestational
age
(days)
Age (weeks)

Figure 31: Graph showing the relationships between a) $\frac{S}{P}$ follicle ratio and b) $\frac{S}{P}$ fibre ratio ($\pm$ S.D.) and age in the Scottish Blackface.

Figure 32: Graph showing the relationship between the percentage of brush-end and shed empty primary follicles ($\pm$ S.D.) and age in the Scottish Blackface.

- - - - - - control _____ Border disease affected.


S/P follicle ratio
S/P fibre ratio
4
3
2
1
85
135
0
3
6
12
24
36
48
Gestational age (days)
Age (weeks)


%
brush-end and shed-empty primary fibres
80
60
40
20
nb
6
12
24
36
48
Age (weeks)

# APPENDIX

# A P P E N D I X

**Formol phosphate:**

| | |
|---|---|
| $NaH_2PO_4.H_2O$ | 4 gm. |
| $Na_2HPO_4$ (anhydrous) | 6.5 gm. |
| 40% formaldehyde solution | 100 ml. |
| distilled water | 900 ml. |

Each new bottle of formalin should be neutralised with approximately 2 gm. sodium carbonate

**Carbolic xylol:**

| | |
|---|---|
| Carbolic acid | 25 gms. |
| Xylene | 75 mls. |

**Baker's formalin calcium:**

| | |
|---|---|
| 40% formaldehyde | 10 ml. |
| Calcium chloride (anhydrous) | 1 gm. |
| Distilled water to make | 100 ml. |

A piece of chalk is added to the mixture to maintain the pH at 4.7 - 4.9

**SOLUTIONS FOR SACPIC STAIN**

**Weigert's haematoxylin**

| | |
|---|---|
| Solution A: | 1 gm. haematoxylin |
| | 99 mls. absolute alcohol |
| Solution B: | 2.4 gm. ferric chloride |
| | 2 mls. concentrated hydrochloric acid |
| | 198 mls. distilled water |

Use equal quantities of solutions A and B. Mix immediately before use, and discard after 4 days.

**Acid alcohol:** 1% hydrochloric acid in 50% alcohol

**Basic fuchsin:**

1 gm. basic fuchsin
100 mls. 50% alcohol

Picro-indigo-carmine:

1 gm. indigo carmine

300 mls. saturated aqueous solution of picric acid

Araldite mixture:

A mixture of 19 parts araldite to 1 part hardener is made half an hour before use, and kept in a 60°C oven.

Hardener:

16 parts dibutyl phthalate

4 parts accelerator D7064

# Observations on the skin of striped piglets from Border disease injected sows

MARJORIE B. DERBYSHIRE, *ADRA, Moredun Institute, 408 Gilmerton Road, Edinburgh*

DURING work on Border disease of sheep, workers at Weybridge (J. T. Done personal communication) injected 20 per cent suspensions of affected lamb brain tissue into pregnant sows. Three Large White sows, in-pig to a Landrace boar, were injected when 34 days pregnant. Nineteen live and two dead piglets were delivered by hysterectomy. It was noted that most of the live piglets had an unusual light and dark horizontal striping along their bodies. The stripes were not pigmented and were "visible only from certain angles with the light in a particular direction."

A 1 cm diameter trephine was used to remove skin samples from the light and dark stripes from three piglets, and these together with comparable samples from three normal control piglets and other larger samples of striped skin, were fixed in calcium acetate formol for about 12 months before being given to the Moredun Research Institute for examination.

Following fixation, the stripes on the larger skin samples were no longer apparent. Using the trephine samples, horizontal 9$\mu$ Sacpic-stained (Auber 1952) paraffin sections were prepared, and from these, follicle densities and figures for the range of fibre diameters and the incidence of medullation were determined.

There was little variation in follicle density. The range of fibre diameters and the incidence of medullation were, however, consistently higher in the striped piglets than in controls, and furthermore in the former, the light stripes gave consistently higher values than the dark stripes (Fig 1).

It thus appears that the light stripes contained a population of larger medullated fibres than did the dark stripes, which in turn contained some larger medullated fibres than the control samples. It seems that the striped appearance of these piglets may be a consequence of the reflective/refractive properties of hair fibres of differing degrees of medullation. The disappearance of stripes on fixation could be accounted for by replacement of the air of the medullary cavities with fixative. This effect of Border disease on piglet hair follicles resembles the effect of the disease on the primary follicles of the lamb (Derbyshire unpublished observations; Carter and others 1972). The expression of this effect in the form of horizontal stripes has no obvious explanation, but since wild piglets can have a similar distribution of pigmented stripes, it may be that the disease causes a reversion to a more primitive pattern of hair fibre growth.

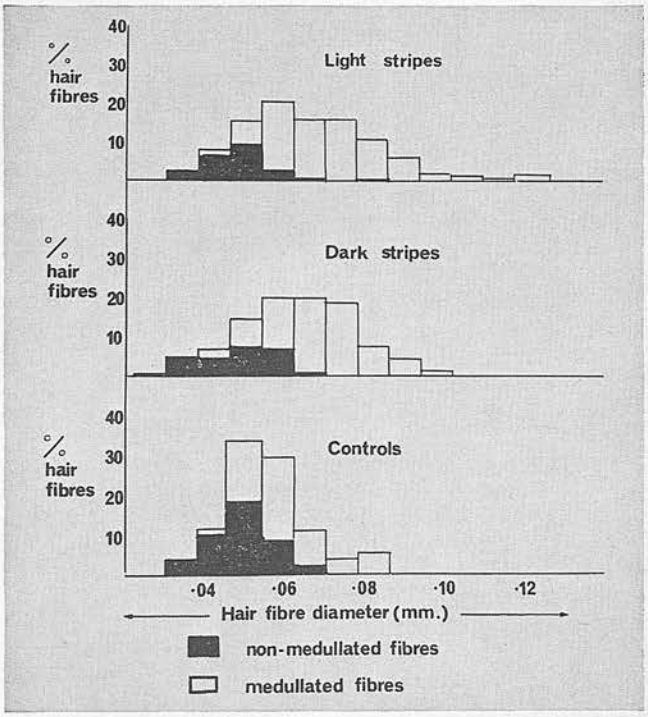



FIG 1: Histograms showing the average values for the incidence of fibres and fibre medullation at a range of fibre diameters in the light and dark stripes of the experimental piglets, and in the control piglets

I would like to thank the Meat and Livestock Commission for its financial support, Dr J. T. Done for supplying the material and Dr R. M. Barlow for his help and advice.

REFERENCES

AUBER, L. (1952). *Trans. Roy. Soc. Edin.* **52.** 191.
CARTER, H. B., TERLECKI, S., & SHAW, I. G. (1972). *B. vet. J.* **128.** 421.

Printed by H. R GRUBB LTD., 15 Imperial Way, Purley Way, Croydon, CR9 4PY.