

## INVESTIGATIONS INTO THE CAUSE OF ABORTIONS IN ANGORA GOATS IN SOUTH AFRICA \*

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*Dedicated to my Father*

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## CAUSE OF ABORTIONS IN ANGORA GOATS IN SOUTH AFRICA

### I. THE PROBLEM OF ABORTION IN ANGORA GOATS

#### A. Introduction

The object of this publication is to record investigations into the problem of abortion among Angora goats in South Africa, which has assumed such proportions as to constitute a serious economic menace to the mohair industry.

Before proceeding to the main subject, it will be of interest to record briefly the history and growth of the mohair industry in South Africa.

#### *Origin of the Angora goat*

According to Samin (1933) the Angora goat belongs to the *Capra prisca* type and arose through a mutation.

Batu (1941) states that a survey of the historical and archaeological literature leads to the conclusion that the Angora goat must be regarded as a very old breed, as it appears to have existed amongst the Sumerians (4,000 to 3,000 B.C.). Its association with Ankara is fairly recent, apparently dating from the time of the Turkish infiltration in the thirteenth century. The origin of the Angora is therefore to be sought in Asia, which is still the predominant country of distribution of goats of the prisca type resembling the Angora.

#### *History of the Angora goat in South Africa*

The first importation of Angora goats from Turkey was made by Col. Henderson in 1838 when he imported twelve rams and one ewe. The rams were sterilized before leaving Turkey, but fortunately the ewe was pregnant and gave birth to a ram kid. This ram was mated to indigenous goats, and the progeny and descendants of this mating spread rapidly through the Cape Province.

Successive importations occurred at intervals up to 1896, and in all some 3,000 goats were brought into South Africa. Many were poor specimens, but it is clear that a sufficient number of excellent goats were imported. The number of purebred and better crossbred goats increased rapidly, so that by 1911 the number of Angora goats in the country was 4½ million.

From 1912 a decline in the industry took place due to (a) a decline in the demand for mohair, (b) recurring droughts and unfavourable climatic conditions, (c) bad farming practices and (d) a lack of confidence in the future of the industry. The number of Angoras dwindled until by 1950 less than 500,000 remained.

From 1946 onwards a steady increase in the price of mohair occurred. This, coupled with a better organisation of the industry, resulted in a return of confidence in the Angora goat. The numbers started increasing again in 1951 and by 1960 there were approximately one million Angora goats in South Africa.

#### *Economic importance of the Mohair Industry*

Fluctuations in the number of Angora goats are greatly influenced by the market price of mohair as illustrated by Figures No. 1 and 2.



FIG. 1.—Number of Angora goats owned by European farmers. Source: Bureau of Census and Statistics.

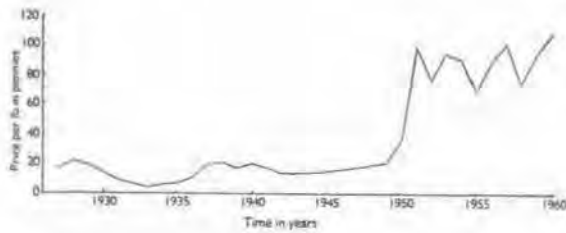


FIG. 2.—Price per pound of mohair of mature goats. Source: Division Economics and Markets.

The salient feature arising out of a comparison of these two graphs is that the increase in the number of goats from 1951 onwards was not as rapid as the price of mohair warranted. This may be attributed very largely to the increasing occurrence of abortion.

Since 1949 there was a spectacular rise in the price of mohair. From an average price of 20·3d per lb it rose to 108·3d per lb for the period July, 1959, to June, 1960. During the 1960 summer sales the world record price of 320d per lb was reached for super summer kids hair.

Every effort was made by breeders to produce a more robust type of goat carrying more hair of a higher quality, and at present it is claimed that the average weight of hair shorn per goat in South Africa is 7·8 lb per year as against 6·6 lb per goat in Texas (Kritzinger, personal communication, 1960). Mohair production is shown in Fig. 3.

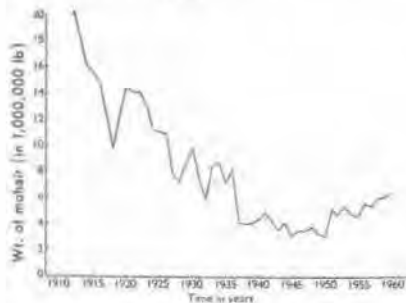


FIG. 3.—Mohair production in the Republic. Source: Division Economics and Markets.

A comparison between Fig. 1 and 3 shows that the breeders have succeeded in increasing the weight of mohair shorn per goat.

As Angora goats are selling at a premium and as it is impossible for the supply to satisfy the demand, the seriousness of the high percentage of abortions may be readily understood.

#### *Distribution of Angoras in South Africa*

The home of the Angora has always been the southern-central districts of the Cape Province and in particular the districts of Jansenville, Steytleville, Willowmore, Uitenhage, Somerset East, Pearston, Graaff-Reinet, Cradock and Bedford.

During the lean periods for the Angora industry, after 1911, and especially during and after the depression of 1930 to 1934, some stud breeders in these areas kept up their high standard of breeding at considerable expense.

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Goats in smaller numbers were found in the surrounding districts and with their increased economic value parcels of Angora goats are now found in all four provinces of the Republic.

The present study deals only with the eastern Cape and with experimental goats kept at Onderstepoort.

### *Systems of farming and breeding in the eastern Cape*

The general system of farming throughout the area depends mainly on the fact that the Angora ram shows a definite rutting season usually from the end of February to the end of May and the main kidding season is from July to September. A small percentage of kids is born in June. Some farmers have succeeded in having kids born from December to February, but trouble is usually experienced in raising these kids and they do not fit in well with the bi-annual shearing.

The goat is shorn twice a year, usually in January or February and again in June or July.

Since the introduction of Angora farming, most goats have been kraalled at night to protect them against predatory animals and to protect them from cold to which they are particularly susceptible.

During recent times, with farms well fenced and vermin to a large extent eradicated, kraaling is not done on such an extensive scale except during the kidding season. The Angora ewe is very prone to be separated from her kid, especially during the first week. The kids are therefore left in the kraals during the day while the ewes go out to feed. In the afternoon the ewes return to the kraal and a fair proportion of ewes have to be held or tethered to ensure that the kids get enough to drink.

It has thus become an established custom to handle Angora ewes with extreme care and protect them against severe cold spells and very windy conditions. At kidding, every ewe must receive special attention to prevent the kids from dying of hunger. These precautions have been intensified with the enhanced value of the animals, with the result that the law of the survival of the fittest has not operated and a possible increase in sensitivity has resulted.

Another aspect of great importance to the present problem is the breeding policy which has been followed for many years. In the first place no importations of any significance have been made during the present century, so that all the pure-bred Angoras in this country must be closely related. Secondly, selection has been almost exclusively on quality and quantity of hair with little or no regard to reproductive capacity. Thirdly, until recently very few farmers identified their goats or kept breeding records. A ewe which did not breed or had aborted the previous year, would tend to stand out well amongst those which had reared kids. There may therefore have been a long-standing, unconscious tendency to select aborting lines for breeding. The significance of this fact will be emphasised later.

### *B. Incidence of Abortion in South Africa*

#### *Seriousness of the problem*

Although subsequent investigation proved that a fairly high incidence of abortion had been noted among Angoras for at least sixty years, the matter was not brought to the notice of the veterinary authorities until the early 1950's, when the increasing value of mohair brought the matter to the fore. At that time some farmers reported losing up to 80 per cent of their potential kid crop and the general consensus of opinion was that abortions had been on the increase since 1933.

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A questionnaire was circularised after the 1956 kidding season. Replies were received from 32 farmers in respect of 10,500 breeding ewes from the districts of Bedford (7), Jansenville (1), Pearston (5), Somerset East (4), Steytlerville (6), Uitenhage (6), Willowmore (2) and Uniondale (1). The aborting rates reported were as follows:—

Percentage abortion	Number of farms
Nil	3 = 9%
1-10%	8 = 25%
11-20%	5 = 15%
21-30%	4 = 12%
31-40%	6 = 19%
41-50%	2 = 6%
Over 50%	4 = 12%

Details of the four farms with an abortion rate of over 50 per cent were:—

- (1) Somerset East district. 135 ewes = 51.8% abortions
- (2) Steytlerville district. . . . 160 ewes = 56.6% abortions
- (3) Bedford district. . . . . 334 ewes = 60.0% abortions
- (4) Bedford district. . . . . 200 ewes = 90.0% abortions

A second questionnaire was circularised at the end of 1958. Replies were received from 168 farmers from 13 districts and owning 113,972 ewes. The number of replies from each district and the incidence of abortion in these districts are shown in Table 1.

TABLE 1.—Number of replies from each district and incidence of abortion in these districts

Districts	No. of replies received	No. of farmers reporting abortion rate of—				
		Under 5%	5%-10%	11%-25%	26%-50%	Over 50%
Aberdeen. . . . .	8	8	0	0	0	0
Adelaide. . . . .	9	6	2	0	0	1
Bedford. . . . .	8	7	1	0	0	0
Cradock. . . . .	16	10	2	3	1	0
Graaff-Reinet. . . . .	18	12	1	4	0	1
Grahamstown. . . . .	3	3	0	0	0	0
Jansenville. . . . .	39	19	4	13	2	1
Pearston. . . . .	10	5	3	1	1	0
Rietbron. . . . .	3	1	1	1	0	0
Somerset East. . . . .	16	5	3	5	2	1
Steytlerville. . . . .	6	1	2	1	2	0
Uitenhage. . . . .	17	3	4	3	4	3
Willowmore. . . . .	15	8	5	0	2	0
TOTAL. . . . .	168	88 51%	28 16%	31 18%	14 8%	7 4%

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Details from the seven farms with an abortion rate of over 50 per cent were:—

Adelaide district.....	77 ewes = 66%	abortions
Graaff-Reinet district...	340 ewes = 60%	abortions
Jansenville district.....	300 ewes = 51%	abortions
Somerset East district...	370 ewes = 60%	abortions
Uitenhage district.....	150 ewes = 65%	abortions
Uitenhage district.....	300 ewes = 75%	abortions
Uitenhage district.....	150 ewes = 80%	abortions

A significant feature was that 51 per cent of farmers did not consider abortion below 5 per cent of economic significance. Numerous farms were also visited where the farmers did not complete the questionnaires and where the abortion rate was over 50 per cent.

### *Abortions confined to Angoras*

One of the most striking facts that came to light during these investigations was that abortion, as an acute economic problem, is confined to the Angora goat. Many of the heavily affected farms run Merino, Persian and Dorper sheep and Boer goats, but only isolated cases of abortion could be found amongst these breeds.

### *No similar problem in other countries*

Black (1900) writes of goats in the United States of America as follows: "Goats are rarely troubled with abortion unless they have eaten something that disagrees with them during the period of gestation. A sudden change of weather, overfeeding, pasturing on frosty herbage, sudden alarm, or being chased by a dog, or wild animal, may produce abortion.

A goat is very fond of acorns, and when these are abundant will often gorge themselves with them which frequently causes them to abort.

A doe, if regularly fed and watered, and kept well protected from stormy weather, will seldom miscarry".

An exhaustive search through world literature failed to reveal references to a similar problem in other countries where Angoras are bred in large numbers, i.e. Turkey, Madagascar, India, Albania and parts of Russia.

As far as the United States of America (especially Texas) is concerned, no further reference to abortion as a problem could be found in the literature and correspondence with the Texan authorities confirmed that abortion was no problem in that State.

The problem, therefore, appears to be peculiar to South Africa and its investigation had of necessity to include the systematic elimination of all possible aetiological factors including infections, nutritional deficiencies, toxic agents such as possible poisonous plants, climatic and other environmental conditions and the genetic make-up of the Angora goat itself.

### *Effects of cross-breeding*

Investigation showed that the tendency to abortion in Angora ewes was not affected by mating them with Boer-goat rams, indicating that abortion was not due to a lethal gene transmitted by the Angora ram. This conclusion is strengthened by the fact that, when Angora rams are mated to Boer-goat ewes, abortions are extremely rare. These facts indicate that the cause lies in an innate weakness in the Angora ewe.



*Better bred goats more prone to abort*

It has been mentioned earlier that the last importation of Angora goats was made towards the end of the nineteenth century and that their numbers dwindled to under half-a-million between 1948 and 1952. The few stud breeders who persevered had to resort to a very marked degree of inbreeding and had to rely on the progeny of their own breeding in order to improve their goats. These goats form the basis of our expanding industry, and with an inadvertent tendency to retain aborters, it could be expected that the better bred ewes would be more prone to abortion if the cause was hereditary. This theory was fully investigated during the 1959 breeding season and the results, which will be given in a later chapter, proved it to be the case.

*Geographical distribution*

An analysis of the geographical distribution of high and low abortion rate farms covered by the questionnaires and by visits to numerous farms, failed to reveal any significant concentrations of either type. In many instances high and low abortion rate farms were found to border on one another. It was, therefore, impossible to postulate that abortion was correlated to any particular vegetation or soil types.

*Aborters transferred to other farms tend to kid*

One anomaly that cannot be explained at this stage, is the apparent tendency of ewes that have aborted repeatedly on one farm, to kid when moved to another. Instances can be cited where this did not happen, but on the other hand there are many examples where the ewes only show a strong tendency to abort again after the second or third pregnancy on the new farm.

This condition is found where aborting ewes have been transferred to farms where Angora farming has been practised for many years as well as to farms where this type of farming has just been started. The type of veld, deficiencies or climatic factors cannot therefore be incriminated.

*Fertility of Angora goats*

Some farmers considered that the low kid crops were due more to infertility than to abortion. A thorough investigation showed that the vast majority of ewes which the owners considered had failed to conceive, had in fact aborted at an early stage.

The percentage rams used for mating usually varies between 2 to 3.5. With flock mating the rams are allowed to run with the ewes for six to nine weeks.

During 1958, which was an extremely dry year, one farmer carried out individual mating with a ram for 16 nights only and 68 per cent of the ewes conceived. On eight farms during 1958 out of 3,572 ewes, 2,855 (80 per cent) conceived.

During 1959 the veld conditions were very much more favourable, and on the same eight farms, out of 3,836 ewes, 3,478 (91 per cent) ewes conceived. On one farm five rams were put to 168 ewes for 21 nights only. Four ewes failed to conceive, i.e. 97.5 per cent pregnancy.

Fertility amongst Angoras would, therefore, appear to be exceptionally high.

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### *Gestation period*

As no recent work could be found on the gestation period of the Angora ewe, careful records were kept of the service, abortion and kidding dates of 135 ewes. Of these ewes 103 kidded normally.

The average gestation period was found to be 151 days with a range of from 139 to 160 days as illustrated in Fig. 4. These figures coincide with those given by Dukcs (1959) viz. average 151 (range 140 to 160).

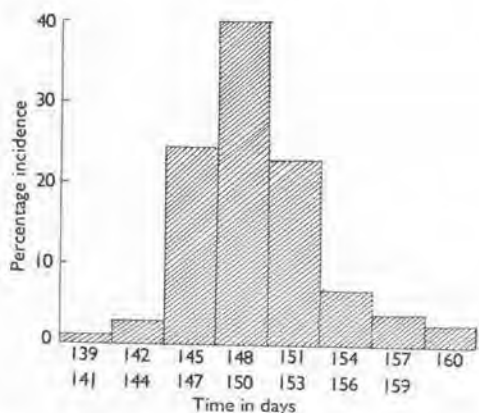


FIG. 4.—Gestation periods

### *Mortality amongst newborn kids*

As many farmers described abortions as occurring near full term, it was decided to investigate what percentage of these losses was due to mortality amongst newborn kids. This question was put specifically in the first questionnaire circularised and of the 32 replies received, only three reported losses of 8, 7 and 6 to 7 per cent. The rest of the farmers described losses amongst newborn kids as "low" or "negligible".

Personal observations and discussions with farmers confirmed that post-natal death amongst kids was not a significant factor. Where it did occur, the main cause was failure of the ewe to suckle.

### *Tendency for ewes to show oestrus immediately after abortion*

This observation was originally made by a few farmers who kept a very close watch on their ewes. It was subsequently confirmed by 20 per cent of farmers in a second questionnaire.

The author's observations, which support the above, will be dealt with later.

### *Stage of pregnancy at which abortion occurs*

A special effort was made to determine at what stage of pregnancy most abortions took place. The conclusion arrived at was that abortions occurred from two weeks after conception to full term, with peaks following windy weather conditions and after shearing or dipping shortly before the actual kidding season. As soon as kidding commenced, abortions tended to decrease rapidly.



On three farms it was possible to record accurate dates of service and dates of abortion:—

Of 39 abortions.... 3 (8 per cent) took place between the 70th and 99th day;  
 26 (67 per cent) took place between the 100th and 119th day;  
 10 (25 per cent) took place after the 120th day.

Most farmers state that the majority of abortions occur at 3 to 4½ months pregnancy. Such cases are easily noted and usually occur at the time that the ewes are kept near the homestead for shearing, dipping and prior to kidding. Earlier abortions are not so easily noticed. Proof of their being more frequent than realised, was found in ewes slaughtered at the mobile laboratory at Somerset East and in ewes kept under close observation at Onderstepoort. Most farmers who have kept a close watch on their ewes during mating, have noticed a bloody, dirty discharge from the vagina usually near the end of the mating period or just thereafter. Some farmers have observed ewes to abort up to three times during one season.

The discharge due to abortion at an early stage of pregnancy must not be confused with the bloody discharge one sometimes finds with very young ewes during mating. When they have been served by vigorous mature rams, one very often finds an injury to the vagina, with a resultant bloody discharge.

#### *Time between death and expulsion of the foetus*

Examination of a large number of freshly aborted foetuses has left no doubt that a considerable interval often occurs between death and expulsion of the foetus. Freshly expelled foetuses usually show subcutaneous oedema, often anasarca, reddish fluid in the body cavities and unmistakable signs of autolysis, especially of the liver. Even in the limited number of pregnant ewes slaughtered for the collection of histological material, several were found with dead and autolysed foetuses.

The general observation that a storm of abortion frequently follows any stress to the ewes, such as inclement weather, shearing or dipping, may well be explained by the fact that such conditions promote the expulsion of already dead foetuses rather than that they act as primary causes of the abortions.

#### *Influence of age on abortion*

The ages of a total of 141 aborting ewes from eight different farms were recorded and found to be as follows:—

<i>Age group</i>	<i>Percentage of ewes</i>
2-4 tooth.....	5 per cent
6 tooth.....	13 per cent
Full mouth.....	35 per cent
Aged.....	47 per cent

It would, therefore, appear that the tendency to abort increases with age, although the full mouth and aged ewes might have had earlier abortions.

#### *Recurrence of abortion in individual ewes*

One of the main reasons why the aborting percentage is so high on some farms, is that the owners have failed to eliminate the aborters. In an experiment done on ten farms during the 1959 season, 45 per cent of the ewes that aborted the previous year, aborted again; while only 19 per cent of ewes on these farms aborted for the first time.

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### *Complications after abortion seldom encountered*

The abortions are seldom complicated by retention of the afterbirth, metritis or morbidity in the ewe. As stated before, ewes frequently come into oestrus immediately after aborting and very often conceive, indicating that there is no interference with conception or nidation as would be expected in an infection of the genital tract.

### *C. The influence of environmental factors*

#### *Climatic conditions*

Many farmers reported that storms of abortions frequently coincided with cold, windy weather conditions. As the majority of ewes are in the critical stage of pregnancy ( $3\frac{1}{2}$  to  $4\frac{1}{2}$  months) during July and August, when such weather conditions commonly occur, this observation might have been fortuitous. Investigation showed that although adverse weather conditions were frequently accompanied with large scale abortions, this occurred only on farms where abortion rates were high irrespective of the weather conditions. Furthermore, several farmers with high abortion rates amongst their flocks had taken particular precautions to protect their pregnant ewes from adverse weather conditions without any effect in reducing abortions. It was also frequently noticed that ewes that were mated immediately after aborting in June to August, aborted again in November to January, when the weather was mild and warm. It would, therefore, appear that the stress of adverse weather conditions precipitates abortion in susceptible ewes and also probably causes the expulsion of a large number of already dead foetuses, but it is not the primary cause of abortion.

#### *Handling and shearing*

Storms of abortion have frequently been reported after shearing, but these instances may well have been fortuitous.

The abortions easily noticed by farmers usually occur from  $3\frac{1}{2}$  months' pregnancy. At this stage of pregnancy most goats have just been shorn and are thus near the homestead and more easily observed. The high percentage of abortions observed shortly after shearing has led many farmers to believe that the handling and the sudden removal of hair, play an important part in the causation of abortion.

The following examples might well lead one to suspect that this could be the case:—

- (a) Out of eighteen ewes that aborted in 1959, eight aborted during the month before shearing while ten aborted during the week following shearing.
- (b) Mating commenced in March, 1959. Before shearing two out of 500 ewes aborted. Shearing ended 24th July, 1959. From 24th July, 1959 to 3rd August, 1959, 20 ewes aborted. Thirty ewes left unshorn, of these 25 kidded. After these had kidded, the last five ewes were shorn; of these one aborted two days later.

Superficially it would seem that shearing was responsible for the abortions that occurred. These were stud ewes from one of the most inbred studs in the country. The animals were looked after and handled with care, and shearing was definitely the worst experience of the ewe during her whole period of pregnancy.

A few instances where shearing obviously had no effect on the incidence of abortion, were the following:—

- (a) Mating commenced 16th March, 1959, and all of the 127 cases of abortion showed foetuses of between two and four months' development. Shearing started the end of June and most of the cases of abortion occurred before shearing.
- (b) Out of 343 ewes, 123 aborted before shearing and nine after shearing, all the foetuses showing a development of between three to four months.
- (c) In 1958 two groups of ewes were mated at an interval of three weeks. Later, both groups were shorn at the same time. There was an immediate storm of abortion among the ewes which had been mated first, followed by one in the second group three weeks later. In other words, the ewes aborted at about the same stage of pregnancy irrespective of shearing.

Many farmers have postponed their shearing until after kidding in an effort to overcome the incidence of abortion. Unfortunately, no accurate records were kept, but no spectacular decrease in abortion occurred, with the result that all of them reverted back to the old custom of shearing just before the commencement of kidding.

During 1959 many ewes were subjected to extra handling, as some of the experiments conducted in that year entailed regular ten to fourteen day dosing. The control groups were also brought into the kraals and were put through the dosing race, i.e. they received exactly the same treatment as the experimental groups. No difference in aborting percentage attributable to the extra handling was noted.

During these observations fifty pregnant ewes that had aborted the previous year, were examined per speculum at about three months pregnancy, and only two of these aborted within one week of the examination.

As stated previously, expulsion of the foetus may not follow immediately on its death, so that abortion after shearing or handling may only indicate that the handling causes expulsion of dead foetuses and not their actual death.

#### *Effects of drought and general nutritional level*

It was the general belief that abortions were more prevalent in drought years, an assumption that could be considered as probably correct from general principles. The years 1958 and 1959, however, gave an excellent opportunity of testing this impression. By this time many farmers were keeping accurate records in collaboration with the investigation and 1958 was an exceedingly bad year with severe drought and dry windy conditions, while 1959 was an excellent year. The average rainfall on the farms where the experiments were conducted was 6 inches in 1958 and 10 inches in 1959. The figures from eight farms were as follows:—

	1958	1959
No. of ewes.....	3,572	3,856
No. of ewes kidded.....	2,072 (58%)	2,783 (72%)
No. of ewes aborted.....	783 (22%)	715 (19%)
No. of ewes dry.....	717 (20%)	358 (9%)

(For detailed figures see Appendix I Table 1.)

As will be seen, the greater kidding percentage in 1959 was not so much due to a lower abortion rate, but to a higher conception rate.

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Many stud breeders with high abortion rates amongst their flocks had repeatedly attempted to reduce their losses by supplementary feeding of the pregnant ewes but without success.

Cases were also noted where well managed farms with good grazing and good goats showed a high percentage of abortion, while neighbours with poor grazing and often poor goats had a low percentage of abortion.

On many of these farms aborters were strictly eliminated in 1959. During 1960, which was again an adverse year, better kidding results were obtained.

### *Possible role of poisonous plants*

The fact that the prevalence of abortion could not be correlated to types of vegetation, was against any specific plant being the primary cause. On one farm fourteen ewes aborted after being severely ill from poisoning by *Cotyledon* species (*Nenta* sp.) but this was an isolated incident.

### *Topography*

Many farmers with high abortion rates amongst their flocks and farms in the flats believed that their trouble was due to lack of mountain veld. On the other hand as many owners in the mountains blamed their abortions on the terrain. An experiment was conducted in which a group of 55 ewes, all of which had aborted previously and had been served by the same ram, was divided into two groups. The one group (27 ewes) was put into very mountainous country and 26 aborted. The other 28 ewes were run on well sheltered, flat Karoo veld, and of these 24 aborted. The type of veld, therefore, had no effect on the abortion rate.

### *The role of overstocking*

One would have liked to have found a correlation between overstocking and the abortion percentage, but the available evidence suggests that, although malnutrition and overstocking may play an important role as contributory or predisposing factors, they cannot on their own be regarded as the main cause of abortion. Abortions occur under all conditions, e.g. on high and low rainfall farms; all types of veld, Karoo and grass veld, densely bushed as well as devoid of bush, on the flats and in the mountains, on overstocked as well as lightly stocked farms, and even when the pregnant ewes receive special attention and food or are allowed to run on pastures for the whole pregnancy period.

No environmental factor could, therefore, be incriminated as a primary cause of abortion, and a systematic investigation on the broadest possible front had to be initiated.

## II. THE ELIMINATION OF INFECTION AS THE CAUSE OF ABORTION

In planning a systematic investigation into the cause of the problem, the first essential was considered to be the identification or elimination of a specific infection as the cause of abortion, although much of the evidence already to hand was not consistent with a contagious disease.

A comprehensive survey of the literature on different infectious diseases, mainly of sheep, in which abortion is a symptom, indicated that the following diseases should be taken into consideration: viz. Brucellosis, Leptospirosis, Q fever, *Vibrio foetus*, *Listeria monocytogenes*, Salmonellosis, Enzootic abortion, Toxoplasmosis, *Corynebacterium* infections and Tick-borne fever. Only in the first three of these were goats specifically mentioned.

*A. Epizootology*

The epizootological considerations, all of which have been enumerated in Chapter I, may be summarised again as follows:

*No evidence of "spread" of abortion*

It is generally accepted in the area that the introduction of aborters into a flock with a low abortion rate does not result in an increase of abortions among the original ewes. A controlled observation in this regard can be cited as an example.

During 1959 an Angora breeder who suffered little from abortion among his flock, bought twenty-three old stud ewes, most of which had aborted previously. They ran with his other ewes and were served by the same rams. That year twelve of the introduced ewes aborted and eleven kidded, while the abortion rate of the original flock remained under 5 per cent.

*No evidence of development of immunity*

As explained in Chapter I, young ewes in a high aborting flock tend to kid normally for one or two years and then abort, often repeatedly. In most infectious forms of abortion the position is the reverse, newly infected animals tend to abort most often and the abortion rates decrease with age and the development of immunity.

During 1958 ten farmers were persuaded to mark all the ewes which aborted. The breeding histories of these ewes were again followed in 1959 to ascertain whether there is a tendency for immunity to develop after abortion.

For comparative purposes the breeding history of ewes that did not abort in 1958 on the same farms is also given:—

	<i>Aborted</i> 1958	<i>Did not abort</i> 1958
No. of ewes.....	549	3,256
No. of ewes kidded.....	263 (48%)	2,367 (73%)
No. of ewes aborted.....	212 (40%)	556 (17%)
No. of ewes dry.....	74 (11%)	333 (10%)
Percentage pregnant ewes aborted.....	45%	19%

(For detailed figures see Appendix I, Table 2.)

As will be seen the high incidence of repeat abortions indicates that there is no development of an immunity.

*Incidence of abortion amongst flocks*

In infectious forms of abortion the incidence shows a marked rise on the introduction of the disease, followed by a decline to a more or less steady level as a flock immunity develops. In abortion in Angora goats the incidence among a particular flock tends to remain more or less constant, with minor variations from season to season, and with a possible steady increase occurring throughout the years. Farmers are unable to supply accurate figures, but the general consensus of opinion amongst them is that the incidence of abortion has been showing a gradual increase over the last number of years.



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### *B. Post mortems and histopathological examinations*

Wherever obtainable, ewes were slaughtered and a post mortem carried out in addition to specimens being taken for histopathological and biological examination.

#### *Ewes slaughtered*

1957.—Five post mortems were carried out on different farms.

1958.—At Somerset East the following post mortems were carried out:—

(a) Pregnant ewes that had aborted in 1957, some showing liquefaction of the cervical plug.....	8
(b) Ewes slaughtered just after abortion.....	5
(c) Ewes in the process of aborting.....	4
(d) Apparently normal pregnant ewes that aborted in 1957, with foetuses found to be dead.....	2

1959.—Ten ewes that were aborting or had aborted recently were slaughtered on different farms, and ten ewes were slaughtered at Onderstepoort.

The investigations at Somerset East were conducted from the mobile laboratory which is placed at the disposal of the Division of Veterinary Services for field investigations by the Trustees of the Stock Diseases Research Fund. A description of this laboratory was given by Brown (1959).

#### *Specimens for histopathological examination*

The following specimens were collected: Ovaries, uterus and cotyledons, pituitary, adrenals, thyroid, lymph glands, liver, kidney, spleen, myocard, pancreas and costochondral junction.

At post mortem smears were made of maternal and foetal cotyledons, foetal stomach contents, foetal stomach wall and foetal peritoneal fluid.

#### *General post mortem symptoms*

Four of the ewes slaughtered in 1957 were in excellent condition and showed nothing abnormal on examination, except for slight degenerative changes of the liver. One ewe suffered from severe verminosis and emaciation (this probably precipitated the abortion).

The ewes from Somerset East and the twenty ewes slaughtered during 1959 were generally speaking in excellent condition. Most of them showed degenerative changes of the liver and degeneration or slight inflammation of the kidneys. Hyperplasia of the bone marrow was fairly common.

For comparison a number of Merino ewes were also slaughtered at Somerset East and they showed the same liver and kidney damage on post mortem. Similar lesions have been reported in a large proportion of Karoo sheep by Brown (1959, personal communication).

The degree of worm infestation was from light to medium-heavy with *Ostertagia*, *Haemonchus* and *Trichostrongylus* species predominating.



Ewes slaughtered just after abortion, or with a dead foetus in the uterus, all showed oedema of the broad ligaments and of the wall of the uterus. The cotyledons were pale, the foetal membranes loosely attached and stripped easily with no visible necrotic foci present. A pinkish exudate around the maternal cotyledons was sometimes apparent in those cases where advanced maceration of the foetal membranes had taken place. The whole genital tract had an anaemic appearance without any indication of an infection such as inflammation and purulent exudates.

The foetuses, whether freshly aborted or dead *in utero*, showed anasarca with red stained fluid in the body cavities and subcutaneous tissues. All had yellow soft friable livers. A few mummified foetuses were encountered. In all cases it was obvious that death of the foetus had taken place some days previously.

The ovaries of these ewes showed well developed follicles with markedly atretic corpora lutea. In some cases no corpora lutea could be found. This observation prompted the collection of hypophyses in conjunction with the ovaries for further microscopical examination. The ovarian and hypophyseal changes will be described in Chapter IV.

#### *Histopathological examinations*

The results of the histological examination of sections from twenty-eight pregnant ewes with either normal, dead *in utero* or aborted foetuses may be summarised as follows:—

*Liver.*—In nine cases nothing abnormal was found. The other livers showed a cloudy swelling, slight central degeneration or slight fatty degeneration. In three cases a slight focal hepatitis was found.

*Kidney.*—In a few instances slight nephrosis or congestion was found. Most sections, however, showed nothing abnormal.

*Spleen.*—Most sections examined showed nothing abnormal. In a few cases there was congestion.

*Uterus and cotyledons.*—No indication of any infection could be found in sections examined from ewes that had just aborted, or were on the verge of aborting. The changes were essentially degenerative with necrobiosis commencing in the maternal villi, and foetal villi showing necrosis only when the foetus was already dead.

*Other organs.*—A number of specimens of thyroid, lymph gland, myocard, pancreas and costo-chondral junction were also examined, but showed no pathological changes.

*Smear examinations.*—Smears from maternal and foetal cotyledons, foetal liver, cervix, uterine mucosa, foetal stomach contents, foetal stomach wall and foetal peritoneal fluid were stained with Giemsa, Gram and modified Ziehl-Neelsen. Those from foetal peritoneal fluid, foetal stomach contents and foetal stomach wall were stained in addition with Hansen and Carbol Thionine Blue. The modified Ziehl-Neelsen staining technique is described by van Rensburg, van Heerden, le Roux and Snyders (1958). No trace of any specific bacterial infection could be found.

*Semen smears.*—Semen was collected from 128 Angora rams from over thirty farms and stained with Giemsa, Gram and modified Ziehl-Neelsen. No trace of any specific bacterial infection that could be the cause of abortions could be found here either.

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### *C. Cultural Methods*

In the field, cultures were made from foetal stomach, liver and cotyledons and from maternal cotyledons. These materials were collected from the ewes slaughtered at Somerset East as described under the previous heading. Aerobic, anaerobic and cultures incubated in 15 per cent CO<sub>2</sub> were made on serum agar and tryptose agar culture media. After 48 hours incubation, smears were made from any visible colonies and stained with Hansen, Gram and Giemsa methods. The majority of cultures showed no growth whatsoever, and in those that did show colonies only non-specific contaminants were found. In this series twelve cases were examined.

A similar cultural examination was carried out on the semen of seven Angora rams from high aborting flocks, with negative results.

At Onderstepoort specimens were taken from ewes and foetuses from Angora ewes on the station, and the following specimens from the field were also submitted on ice:—

- (a) Serum of mother for bacteriological and virological examination;
- (b) Portion of brain of mother and foetus;
- (c) Portions of foetal liver, lung and kidneys;
- (d) Ligated stomach;
- (e) Stomach contents and liver in sealed pipettes;
- (f) Foetal and maternal cotyledons;
- (g) Allantoic and peritoneal fluid in sealed pipettes.

Cultures were prepared from these specimens on blood agar, serum agar, tryptose agar, and coagulated serum plates. After incubation for 48 hours smears were made of colonies whenever present and stained as above. Only non-specific contaminants were found on those plates that did show some growth.

The stomach contents of aborted foetuses was injected intraperitoneally into five to six weeks old pregnant guinea pigs. They were killed after five days and the stomach contents of the guinea pigs cultured on thiol medium (DIFCO), incubated under 15 per cent CO<sub>2</sub> for 48 hours and stained Hansen, Giemsa and Carbol Thionine Blue. These cultures were also bacteriologically negative.

### *D. Serological Tests*

The following tests were carried out at Onderstepoort on serum specimens submitted: Agglutination, 5 per cent Saline Agglutination, Coombs Antiglobulin Agglutination and Complement Fixation.

The following specimens were submitted:—

- (1) Serum and/or blood sent before June 1958..... 64 samples
- (2) Serum from mobile laboratory, June and July 1958... 50 samples
- (3) Serum from specific farms during 1959..... 213 samples

As far as items 1 and 2 are concerned, most of the results were negative, but a few suspicious and positive results for *Brucella* prompted the author to collect semen samples from specific farms where the breeding records of the ewes were known. These results are listed later.

*E. Virological Tests*

The following specimens were submitted for virological examination:—

- (a) Six specimens from freshly aborted foetuses taken to the laboratory on ice, from Somerset East;
- (b) Specimens taken from two ewes No. 6490 and 6491 used in transmission experiments ex Somerset East;
- (c) Three specimens taken from aborted foetuses at Onderstepoort.

These specimens were injected into mice and incubated eggs, according to latest virological techniques at Onderstepoort.

No virus was detected in any of the eleven specimens examined.

*F. Transmission Experiments*

During 1958 three pregnant Angora ewes were presented to the author by a farmer who claimed that no abortions occurred on his farm. They were dosed, and injected subcutaneously, with finely macerated material from three separate, freshly aborted foetuses, 10 cc being given by each route. One of the ewes was slaughtered a week later. The foetus, which was alive at post mortem, was packed in ice and submitted to Onderstepoort where routine investigation failed to demonstrate any infection. Macerated material from this foetus, together with that from another aborted foetus sent up, was dosed and inoculated subcutaneously into one pregnant Boer goat and one pregnant Angora ewe. Both kidded normally later. The remaining two Angora ewes were railed to Onderstepoort after being "infected". Both were slaughtered at about four months pregnancy and the foetuses appeared normal. Foetal material was submitted for cultural examination for PPLO biological test for Leptospirosis and virological tests, all with negative results.

The possibility of a mechanical transmission of infection by the ram through service, was eliminated by experiments on two farms during the 1958 season. Young rams were mated to ewes that had aborted the previous year. Dates of service were carefully noted. Abortions occurred at random and was highest amongst the first 50 per cent of ewes served and not *vice versa* as one would have expected if the ram was the carrier of a disease. (For details of experiment see Appendix I, Table No. 3.)

*G. Consideration of Specific Diseases*

*Brucellosis*

Henning (1956) in discussing brucellosis, states that in goats abortion plays a less important role than in cattle. In the caprine species miscarriages are serious only in the newly infected flocks. Recovery usually confers a lasting immunity on the animal which remains a passive carrier of the disease. He also states that man is susceptible to all species or types of brucella organisms. Edgar (1959) and van Drimmelen (1959) regard the microscopical examination of ram semen to be more satisfactory for the detection of *Brucella ovis* infection than serological tests. Renoux (1957) described the disease in goats and sheep and van Drimmelen (1953) described the clinical diagnosis of the disease. Van Rensburg, van Heerden, le Roux & Snyders (1958) wrote on the occurrence of *Brucella ovis* infection in sheep in South Africa.

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Medical practitioners throughout the Angora goat farming areas find that the incidence of brucellosis in man is negligible. Goats are handled very frequently and usually daily during the kidding season by farmers and labourers. If brucellosis were prevalent human cases could be expected.

Notwithstanding the fact that the symptomatology of caprine abortion does not correspond with brucella infection, and that the cultural and microscopical examinations of semen and foetal organs proved to be negative, extensive serological tests were done.

The results of the serological tests and microscopical examinations of ram semen done on 23 farms during 1959 are listed in Table 2.

TABLE 2.—Results of serological tests and microscopical examinations of ram semen done on 23 farms during 1959

Farm No.	Aborting Percentage, 1959.	Serological tests				Ram No.	Semen Neg.	Ex. Pos.
		Specimens	Pos.	Susp.	Neg.			
1	12	12	3	1	8	—	—	
2	15	6	2	2	2	2	—	
3	28	4	—	—	4	—	—	
4	22	9	—	2	7	4	—	
5	11	17	3	8	6	4	—	
6	31	8	—	—	8	—	—	
7	11	9	1	2	6	4	—	
8	20	—	—	—	—	4	—	
9	12	8	1	7	—	4	—	
10	22	4	1	3	—	—	—	
11	16	26	7	12	7	4	—	
12	30	4	—	1	3	4	—	
13	20	19	2	9	8	4	—	
14	20	10	1	—	9	—	—	
15	28	9	—	—	9	—	—	
16	16	8	—	—	8	4	—	
17	28	16	2	1	13	4	—	
18	10	2	—	—	2	—	—	
19	42	6	—	—	6	—	—	
20	15	16	10	5	1	4	—	
21	12	6	1	1	4	—	—	
22	15	10	3	4	3	—	—	
23	8	4	—	1	3	—	—	
		213	37 17%	59 28%	117 55%	46	46	—

It will be noted that the presence of positive or suspicious serological tests bears no correlation with the prevalence of abortion, e.g. the farm with the highest abortion rate (No. 19) showed no positives, whereas farm No. 20 with only a 15 per cent abortion rate showed a high proportion of positive sera.

The breeding history of some of the ewes bled is known and is given in Table 3.

TABLE 3.—Breeding history of some of the ewes

Ser. Test	No. Ewes	1956	1957	1958	1959
Positive.....	1	A	A	A	A
	1		A	K	A
	1		A	A	K
	2		A	A	A
	9			A	A
	4			A	K
	1			K	A
	2			K	K
	1			A	A
	2			A	A
Suspicious.....	1	A	A	A	A
	2		A	A	A
	1		A	A	K
	16			A	A
	5			A	K
	2			K	A
	14			K	K
	4		A	A	A
	1		A	A	K
	1		A	K	A
Negative.....	18			A	A
	16			A	K
	5			K	A
	30			K	K

(K = Kided, A = Aborted)

As will be seen, there is a strong tendency towards habitual abortion and no evidence of an immunity developing as is usual with brucellosis.

During 1957 to 1958 the semen of 82 Angora rams was stained with modified Ziehl-Neelsen and examined microscopically. The semen of seven Angora and two Boergoat rams was also examined by cultural methods. A total of 128 rams was therefore tested on different farms, all showing no indication of brucella infection.

Brucellosis as the main cause of abortion in Angora goats may therefore be eliminated due to:

- (a) No evidence of "spread" of the disease to other farms through the introduction of aborters;
- (b) No evidence of any immunity developing after abortion;
- (c) Absence of complications like retention of the afterbirth;
- (d) Negative findings on the microscopical examination of semen samples and foetal stomach wall scrapings stained with Ziehl-Neelsen and Hansen;
- (e) Cultures of foetal stomach contents incubated in an atmosphere of CO<sub>2</sub> for 72 hours, were invariably negative on examination for brucella.

These findings tend to prove that the serological test for brucellosis is not as effective for diagnostic purposes in Angora goats as in the case of cattle.

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### *Salmonellosis*

*Salmonella abortus ovis* infection in sheep and goats shows the following distinctive characteristics according to Manley (1932), Henning (1956) and Shearer (1957):—

- (a) The infection is spread through carrier sheep and by rams during coitus;
- (b) The infection spreads rapidly through a flock, but a strong immunity develops;
- (c) Abortions start suddenly, usually about six weeks before lambing or kidding and weak, premature lambs which die shortly after birth are common;
- (d) The ewes are not much affected, but occasionally retention of the afterbirth occurs with a subsequent septic metritis followed by death of the foetus.

In Angora goats no immunity develops and abortions occur right through pregnancy with the birth of premature live kids a rare occurrence.

Henning (1956) states that *S. abortus ovis* can usually be isolated from the stomach contents and the organs of the foetus, and from the afterbirth. The presence of infection in a flock can be detected by the presence of agglutinins in the sera of carrier ewes.

Cultures were made from specimens of foetal liver, stomach contents and cotyledons on serum agar plates and incubated for 48 hours, with negative results. Agglutination tests on sera of ewes that aborted were also negative.

### *Enzootic abortion*

This disease is caused by Rickettsia-like organisms of the pseudo-lymphogranuloma group as described by Stamp, McEwen, Watt & Nisbet (1950), Littlejohn (1950) and Henning (1956) who is quoted below.

“Some of the characteristics are that the incidence of abortion or premature births may be as high as 25 per cent in first and second lamb ewes, and in clean flocks. The disease usually appears after the introduction of brought-in ewes from elsewhere. Most of the cases of abortion or premature lambing occur late in the gestation period, from two to six weeks before full term. The main lesions in the aborted foetus are a blood-tinged oedema in the subcutaneous and intramuscular tissues, and blood-tinged transudates in the large serous cavities. The foetal cotyledons and the adjacent parts of the chorion exhibit various stages of necrosis. The colour of the cotyledons varies from dark-red to dull clay-like, instead of the purplish colour of normal tissue; there is an accumulation of a reddish to a dirty-pink discharge. Smears made from diseased cotyledons and chorion, and from the uterine exudate stained with Ziehl-Neelsen, reveal the presence of red-staining elementary bodies either in clusters or singly.”

The presence of this disease was eliminated by—

- (a) The tendency of abortion to recur and no immunity developing;
- (b) Abortion amongst Angoras being more prevalent amongst older ewes;
- (c) Failure to transmit the disease by introducing “infected” ewes to clean flocks and by dosing and inoculating material from aborted foetuses to pregnant Angora, Boergoat and Merino ewes;



- (d) The normal appearance of the cotyledons and foetal membranes with no complications such as retention of the afterbirth; the cotyledons and adjacent parts of the chorion showed no necrotic areas and the colour was pale in most instances; and
- (e) Smears made from the foetal membranes and uterine discharges stained with Gram and Ziehl-Neelsen which were negative and displayed no intracellular elementary bodies.

These examinations also eliminated the presence of other Rickettsias that might have been responsible for abortion such as the case of caprine abortion in the Belgian Congo described by Jadin & Giroud (1957).

#### *Toxoplasmosis*

Jacobs (1956) described the propagation, morphology and biology of toxoplasmosis and Simm (1956) the chemical and pathological aspects of the disease in the United States of America.

Hartley, Jebson & McFarlane (1954), Osborne (1959) and Smith (1961) described the occurrence of *Toxoplasma gondii* as a cause of abortion in sheep in New Zealand and Australia, and Hartley & Marshall (1958) succeeded in transmitting the infection from diseased cotyledons to mice and sheep. No references of the disease occurring amongst domestic animals in South Africa have been made up to the present.

According to the above authors toxoplasmosis is more prevalent in moist warm areas, and is characterised by abortion and perinatal mortality. Macroscopically, pale yellow necrotic foci were found constantly on firm, bright red cotyledons. A febrile reaction in sheep artificially infected is a constant symptom. Generally a high degree of immunity develops in animals that survive toxoplasmosis.

Verified cases of *Toxoplasma gondii* are reported from almost all parts of the world from wild and domestic animals. This acts as a source of infection to man.

Toxoplasmosis as the principal cause of abortion amongst Angora goats in South Africa, may be discarded for the following reasons:—

- (a) The general post mortem appearance of the foetal membranes was pale and anaemic and necrotic foci on reddish cotyledons were never found;
- (b) Histopathological examinations of sections of the foetal cotyledons stained with H/E failed to reveal the presence of intra- or extra-cellular *Toxoplasma*-like bodies;
- (c) Perinatal deaths are extremely rare, especially in comparison to the number of abortions occurring;
- (d) No febrile reaction with abortion in Angora goats have been noticed;
- (e) There is no evidence of any immunity developing. It has been noticed that an Angora ewe might abort up to three times during one season, and goats aborting four years in succession are not uncommon;
- (f) While abortion might be as high as 80 per cent on some affected farms, Boergoats and sheep are peculiarly free of this condition. It is inconceivable that *Toxoplasma gondii* should exhibit such a marked host specificity;
- (g) Angora goats are farmed with mainly in the arid regions of South Africa;
- (h) There is no evidence of widespread abortion amongst Angora goats in the United States of America or any other country where Angoras are farmed with and Toxoplasmosis is known to occur.

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### *Vibrio foetus*

Vibriosis as described by Buxton (1930), Marsh, Firehammer & Scrivner (1954), Marsh & Tunnicliff (1955), Henning (1956), Tucker & Roberts (1956) and van Rensburg (1957), was the only disease causing abortion where no characteristic post mortem symptoms were mentioned and one of the few where the disease did not affect the general health of the animal adversely.

The following characteristics, however, tended to eliminate the role of vibriosis as a major cause of abortion in goats:—

- (a) In affected flocks or herds infertility of the females is a more important symptom than abortion and repeated services are necessary to fertilise the animals. The exceptionally high fertility of Angora goats is a feature of the breed, pregnancy figures of over 90 per cent not being uncommon and usually one service is sufficient to ensure pregnancy;
- (b) Where vibronic abortion occurs, retention of the afterbirth is fairly common. In Angoras it is a rare occurrence;
- (c) Failure to transmit the infection by mating old "infected" rams to young virgin ewes;
- (d) A fairly strong immunity develops and ewes infected with *Vibrio foetus* seldom carry the infection to the next breeding season. This is in direct contrast to abortion in Angora ewes where there is a very strong tendency of recurrence;
- (e) No pale necrotic areas were seen on the livers of Angora foetuses as are usually seen when this disease is present.
- (f) Foetal stomach scrapings and foetal membranes stained with diluted Carbol Fuchsin, Hansen and Carbol Thionine Blue did not show the presence of *Vibrio foetus*;
- (g) Cultures of the foetal organs on blood agar plates incubated for 48 hours in an atmosphere of CO<sub>2</sub> showed no growth except for non-specific contaminants.

### *Leptospirosis*

A description of the disease with methods of diagnosis is given by Beamer, Hardenbrook & Morrill (1953), Howarth (1953), Henning (1956) and Freeman (1957). Van der Hoeden (1953) also describes the disease in goats.

Leptospirosis is characterised by—

- (a) Affected ewes are off their feed and listless;
- (b) Abortion is not a constant occurrence;
- (c) Most cases are complicated by retention of the afterbirth with a greenish white purulent discharge;
- (d) The main features on post mortem in the ewe are icterus, swollen kidneys, marked haematuria and fatty changes in the liver;
- (e) Diagnosis of leptospiral infection is made by isolating the organism from the stomach contents of the foetus, where it can be seen swimming about under dark field microscopical examination. Guinea pigs inoculated subcutaneously usually die within three days and kidney sections stained with Levaditi's method, Giemsa or May-Grunewald will reveal the organism. Serum-agglutination tests are specific.

Although abortion amongst Angoras bears no resemblance to the above disease, it was further eliminated by guinea pig inoculations as described above, serum agglutination tests and dark field microscopical examinations.

#### *Listeriosis*

*Listeria monocytogenes* or "circling disease" as described by Gray, Sing & Corpjus (1956), Eide (1956), Gray, Lassiter, Webster, Hoffman & Thorp (1956), Young (1956) and Diplock (1957), shows constant nervous symptoms in the affected animals, and in cases where the afterbirth was not expelled immediately after an abortion, the ewe died of listerial septicaemia. There are human cases on record that followed the handling of aborting animals.

Nervous symptoms was never a symptom of abortion in Angora goats and cultures from the brain sent to Onderstepoort, foetal organs, placenta and genital excretions of ewes were constantly negative.

#### *Corynebacterium species*

Dhanda & Singh (1955) describe corynebacterium lesions in goats and sheep and Belonje (1951) and Maddy (1953) gave excellent descriptions of the lesions and complications arising from these multiple abscesses in sheep. An occasional abortion might occur.

Angora goats are remarkably free of this condition despite the extreme prevalence among sheep in the area. No abscesses were found in the ewes slaughtered. Microscopical examination of 128 rams revealed only one case of corynebacterium organisms in the semen of a ram.

Smears from maternal and foetal organs stained by Gram's method were consistently negative for the pleomorphic organisms. Aerobic and anaerobic cultures from these organs showed no corynebacterium colonies.

#### *Tickborne fever*

Foggie (1951) and Littlejohn (1950) describe tickborne fever as a febrile disease with pleomorphic bodies in the cytoplasm of the neutrophils, eosinophils, basophils and monocytes which may cause abortion in pregnant ewes. A strong immunity develops with this disease.

Aborting Angora ewes show no febrile reaction and the tendency for abortion to recur is very strongly developed. These factors alone eliminate tickborne fever as a cause of abortion among Angoras, and it was not deemed necessary to make and stain a series of blood smears.

#### *Q-Fever*

Q-fever or *R. burnetti* infection as described by Henning (1953, 1956) is an important clinical disease of man characterised by its sudden onset, severe headaches and high fever. Abortion is apparently confined to the goat only.

In animals the infection is inapparent, but goats may abort or develop a pneumonia. Several species of ticks were found to be naturally infected, but the most important source of infection is most probably the infected placental tissues, or the mammary gland where the organism is most commonly located.

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Diagnosis is by means of (a) the agglutination test, (b) the complement fixation test or (c) the pleomorphic organisms showing up well by staining the infected foetal membranes with modified Ziehl-Neelsen, Hansen, Gram or Giemsa.

Q-fever as a cause of abortion in Angora goats was eliminated by means of (a) microscopical examination of the foetal membranes, stained as mentioned above and showing no pleomorphic organisms; (b) the system of farming where goats are handled daily during the kidding season and man shows no symptoms.

### H. Conclusion

When the epizootology of the condition and the negative findings of all the tests enumerated above, are taken into consideration, the possibility of infection as the main cause of abortion amongst Angora goats is eliminated.

## III. FIELD EXPERIMENTS

### A. Introduction

The elimination of infection as the cause of the problem made it necessary to investigate the role played by a large number of possible contributing factors. In many instances it was found necessary to investigate and disprove locally held beliefs of extremely doubtful validity in order to gain the confidence of the farmers and to prevent large scale expenditure on commercial "remedies".

### B. Verminosis

It was deemed necessary to determine the exact role, if any, played by internal parasite infestations in the causation of abortion as verminosis is a major problem in the Angora farming areas of South Africa. It was felt by many farmers that a heavy internal parasite infestation might play a major role in the causation of abortion as the Angora is our most sensitive farming animal.

#### *Evidence of verminosis in Angoras*

The following few examples will illustrate that internal parasite infestations are a problem in some flocks at least.

A number of farmers described swellings under the lower jaw, on the ventral aspects of the body and of the extremities. On investigation these proved to be due to heavy internal parasite infestations. Recovery followed suitable therapy.

Before the actual investigation started, a farmer complaining of approximately 60 per cent abortions, brought some ewes for examination. They were suffering from a very severe internal parasite infestation.

At the start of the investigations the first foetal specimens were taken from a ewe which had just aborted and was in extremely poor condition and suffering heavily from verminosis.

#### *Types present*

The parasite most commonly found amongst Angoras and proving the most difficult to control is without doubt *Ostertagia ostertagi*. The female appears to have a tendency to lie under the mucous layer near the pyloric sphincter for at least part of its cycle. This may be one of the causes why *Ostertagia* is so difficult to eradicate.

Of the other parasites present, *Trichostrongylus* species and *Haemonchus contortus* were found to be the most common, with *Trichostrongylus* causing severe losses on some farms.

*Analysis of abortion on farms*

An analysis of the replies to the questionnaires revealed that less than half of the farmers carry out systematic treatment of their goats for verminosis. The extent to which abortion occurred in the flocks that were treated, as compared to those that did not receive any treatment, was as follows:—

<i>Incidence of Abortion</i>	<i>No. of Farmers who treated</i>	<i>Infrequent or no Treatment</i>
Under 5 per cent.....	33 (44%)	41 (46%)
5–20 per cent.....	28 (37%)	31 (35%)
21–50 per cent.....	12 (16%)	14 (16%)
Over 50 per cent.....	2 (3%)	3 (3%)
TOTAL 164 replies: .....	75	89

From the above data it would appear that abortion was as high in flocks that were treated for internal parasites as in those that were not treated.

*Worm egg counts*

Twenty-five farms showing a wide range of incidence of abortion were selected and mixed faeces samples were collected at regular intervals. On twelve of these farms regular dosing with various proprietary vermicides was carried out, while on the remaining thirteen farms dosing was very sporadic or entirely neglected.

Worm egg counts were made by the author, using the MacMaster technique as described by Gordon & Whitlock (1939). Duplicate samples were forwarded in 2½ per cent potassium bichromate for culturing. The results corresponded very well.

The incidence of verminosis in the flocks and the aborting percentage on the various farms are given in Table 4.

TABLE 4.—*Incidence of verminosis and aborting percentages on various farms.*

Item	Worm egg counts (e.p.g.)		
	Below 200	200 to 400	Over 400
Abortion percentages.....	7% 15% 16% 20% 22% 28% 30% 31% 40% 61%	9% 10% 11% 11% 12% 19% 20% 28% 28% 28% 40%	6% 12% 13% 22%
No. of farms.....	10	11	4
Range of percentage abortions.....	7 to 61%	9 to 40%	6 to 22%
Average percentage abortion.....	27%	20%	13%
Average percentage abortion on 25 farms.....	21%		

As will be seen, there was no correlation between the severity of verminosis as judged by the egg count and the incidence of abortion.

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### *C. Coccidiosis*

Coccidiosis is frequently encountered among rams which are kept confined in small paddocks. The incidence of this infection among flock ewes on open range was investigated by examination of the faeces specimens taken on the twenty-five farms selected for the verminosis survey.

A generalised light infestation with *Eimeria arloingi* was found but the severity bore no correlation to the incidence of abortion.

### *D. Dosing with Vitamin A*

Before proprietary Vitamin A preparations came onto the market, some farmers endeavoured to postpone kidding until after the first spring rains had fallen. No improvement in the aborting percentage resulted and all reverted back to the usual kidding season. Others put their pregnant ewes on green lands for varying periods, also without beneficial results.

In the questionnaire, 42 farmers replied that they dosed Vitamin A regularly, while 112 had never used it.

<i>Incidence of Abortion</i>	<i>Number of Flocks that were</i>	
	<i>Dosed Vitamin A</i>	<i>Not dosed Vit. A</i>
Under 5 per cent.....	14 (33%)	61 (55%)
5-20 per cent.....	13 (31%)	36 (32%)
Over 21 per cent.....	15 (36%)	15 (13%)
TOTAL, 154 replies.....	42	112

The following examples, taken from individual farms, will illustrate how the farmers tried to combat abortion by means of supplementary feeding and dosing of vitamins, with no apparent success:—

*Farm (a).*—During 1956 all the ewes were regularly dosed with a Vitamin A preparation and given yellow maize from eight weeks before kidding. Notwithstanding this, 45 per cent of the ewes aborted or were dry. During 1957, on windy days, lucerne was given to ewes in well sheltered camps and from eight weeks before kidding the ewes were given lucerne and yellow maize and put on green lucerne for one hour a day. Of these ewes 54 per cent aborted or were dry.

*Farm (b).*—During 1958 stud ewes were handled very carefully and kraaled when abortions started. They were given the following rations: Lucerne *ad lib.*, yellow maize increasing to 6 ounces per day, concentrate cubes for a short while and a vitamin and trace element mixture dosed regularly from mating time. Of these ewes 36 per cent aborted and 25 per cent of the above abortions took place after one month's extra feeding.

*Farm (c).*—During 1957 all the ewes were dosed regularly with a Vitamin A preparation, and the usual high abortion percentage of 70 per cent occurred.



A certain firm supplied a preparation reputed to contain 8,000 i.u. Vitamin A and 800 i.u. Vitamin D per ounce, for experimental purposes. The recommendation was to dose one ounce every three months. On two farms one-half ounce was dosed every six weeks, with the following results:—

- (a) Of 60 ewes that had aborted the previous year, 30 were dosed and 30 left as controls, with the following results:—  
 30 ewes dosed—3 kidded, 1 dry, 26 aborted.  
 30 ewes controls—2 kidded, 3 dry, 25 aborted.
- (b) Of 66 ewes that had aborted the previous year, 33 were dosed and 33 left as controls, with the following results:—  
 33 ewes dosed—9 kidded and 24 aborted.  
 33 ewes controls—all the 33 ewes aborted.

The conclusion arrived at was that the supplementary dosing of Vitamin A preparations, kidding later to ensure a higher vitamin content of the grazing, or putting ewes on green lands did not have any influence on the abortion rate.

#### *E. Mineral deficiencies*

##### *Effect of dosing mineral licks*

Only 27 of the 165 owners who completed the questionnaire, reported using mineral licks. It would seem that here too most farmers who used mineral licks did so in an effort to combat abortion. The prevalence of abortion amongst flocks receiving licks and those not, was as follows:—

<i>Incidence of Abortion</i>	<i>Number of Flocks that were</i>	
	<i>Given Licks</i>	<i>Not given Licks</i>
Under 5 per cent.....	11 (41%)	64 (46%)
5-20 per cent.....	9 (33%)	42 (30%)
21-50 per cent.....	4 (15%)	31 (22%)
Over 50 per cent.....	3 (11%)	1 (1%)
TOTAL: 165 replies.....	27	138

The administration of licks did not appear to have any effect on the abortion rate. It will be seen that three of the four flocks with the highest abortion percentage received licks. There are, however, tremendous variations in the frequency of administration.

A trace element mixture containing Fe 0.2 per cent, Cu 0.06 per cent, Mn 0.15 per cent, Co 0.015 per cent and P 13.5 per cent was dosed on a large number of farms. A few farmers kept accurate records, but unfortunately no controls were kept. On the one farm 150 ewes that had aborted the previous year, were dosed during pregnancy and of these 114 (76 per cent) aborted again. On the second farm 400 pregnant ewes were dosed with this trace element mixture, and put on lucerne lands with a thorn and brak camp included; of these 250 (62 per cent) aborted.

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On one farm 97 ewes that had aborted the previous year were divided into three groups and dosed as follows:—

Group 1: 1 gram magnesium sulphate per ewe per week.

Group 2: 1 gram magnesium sulphate, 200 mgm copper sulphate, 1.8 mgm cobalt sulphate, 1 gram iron sulphate per ewe per week.

Group 3: Control ewes.

Result: All the ewes in all three groups aborted.

On another farm 120 ewes selected at random were given a salt and bonemeal mixture *ad lib.* and were divided into three groups of 40 ewes each and dosed as follows:—

Group 1: Trace element mixture..... No abortions.

Group 2: Vitamin A.D. compound..... 4 abortions.

Group 3: Controls..... No abortions.

No conclusions could be drawn from this experiment.

While investigating the cause of alopecia in lambs and kids in the Willowmore district, Steyn (1931) gave three groups of pregnant Angora ewes different daily doses of potassium iodide. Of these ewes, 37 per cent aborted as against 2.3 per cent in the controls.

The indications from the above are that the dosing of trace element mixtures has little or no effect on the incidence of abortion.

### *Controlled experiments*

In view of the above findings and the widespread use of different trace element mixtures, it was decided to conduct the following experiments during the 1959 season.

*Experiment 1.*—The following mixture was dosed on eleven farms to ewes from the time of mating to the commencement of kidding: ferri sulph. excic. 64.5 per cent, copper sulph. 3.2 per cent, manganese sulph. 3.2 per cent, cobalt sulph. 0.5 per cent, dextrose 28.6 per cent. This mixture came in packets of 200 grams and had to be dissolved in 50 fluid ounces of water. The ewes received half-an-ounce each every fourteen days. Control ewes were kept on all these farms.

The results were:—

	<i>Min. Mixture</i>	<i>Controls</i>
No. of ewes.....	1,432	562
No. of ewes kidded.....	1,052 (73%)	397 (71%)
No. of ewes aborted.....	200 (14%)	80 (14%)
No. of ewes dry.....	180 (12%)	85 (15%)
Percentage pregnant ewes that aborted.....	16%	16.7%

(For detailed analysis see Appendix I, Table 4.)

*Experiment 2.*—To test the effect of iron only, 2 cc of an iron solution containing 50 mg elemental iron per cc was injected into 132 ewes at about two months' pregnancy and again a month later. These ewes were injected on five farms and the results were as follows:—

	<i>Iron injection</i>	<i>Controls</i>
No. of ewes.....	133	414
No. of ewes kidded.....	89 (67%)	262 (63%)
No. of ewes aborted.....	31 (23%)	97 (23%)
No. of ewes dry.....	13 (10%)	55 (13%)
Percentage pregnant ewes aborted.....	25.8%	27%

(For detailed analysis see Appendix I, Table 5.)

It is apparent from the foregoing that the treatments had no effect on the incidence of abortion.

#### *Blood analyses*

Brown (1958, personal communication) collected blood and tissue samples from goats and sheep while the mobile laboratory was stationed at Somerset East and made a study of the chemical pathology of the disease. The conclusion arrived at was that (a) among Karoo sheep and goats there is evidence of widespread liver and kidney damage and anaemia not always associated with verminosis, and (b) among Angora goats low levels of inorganic phosphorus and plasma iron were frequently encountered. None of the above factors could, however, be correlated to abortion in Angoras as they were found in aborting and non-aborting animals,

The author analysed over 400 blood specimens taken from as wide a range of Angora ewes as possible during the 1959 season, and including those in the different experimental groups and controls. Some ewes were bled up to three times. Note was taken of the ewes which subsequently aborted, kidded or were dry. A few ewes were bled after having aborted or kidded.

The results from the following animals are given as being representative of the general findings in this investigation:—

- (1) Forty-three experimental ewes in Experiment 1 two months after dosing had commenced;
- (2) Twenty experimental ewes in Experiment 2 about one month after the second injection;
- (3) One hundred and fifteen control ewes which kidded subsequently;
- (4) Twenty-four control ewes which aborted subsequently.

The results are given in Table 5.

TABLE 5.—*Blood analysis of animals in experimental and control groups*

Item	Group			
	(1)	(2)	(3)	(4)
Serum iron (m.c.g.%).....	182	216	176	168
Haemoglobin (gm%).....	7.43	7.62	7.65	7.89
Serum copper (mg%).....	0.16		0.19	0.17
Serum magnesium (mg%).....			2.30	2.33
Total plasma calcium (mg%).....			9.47	9.32
Serum inorg. phos. (mg%).....			6.0	5.9
Ca/P ratio.....			1.58/1	1.58/1

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The results are the averages of all readings.

The figures obtained are all within the accepted normal ranges, with the exception of those for haemoglobin which are low. This is a general and as yet unexplained feature in sheep and goats throughout large areas of the Karoo as observed by Brown (1960, personal communication). Furthermore there was no significant differences between the findings from ewes which aborted and those which kidded, indicating that abortion cannot be correlated to the serum levels of any of the minerals mentioned.

The feeding of mineral mixtures also did not affect the serum mineral levels, indicating that there is no real deficiency of these minerals. Although the injection of iron tended to raise the serum iron for about one month after the second injection, it had no influence on the haemoglobin levels.

The colorimetric methods used in the above analyses were described by:—

Ferro & Ham (1957): Total plasma calcium;

King & Wootton (1956): Serum inorganic phosphates; serum iron and haemoglobin;

Neill & Neely (1956): Serum magnesium;

Cartwright, Jones & Wintrobe (1945): Serum copper.

### *F. The effect of enterotoxaemia vaccine*

Many farmers believed that vaccination against enterotoxaemia helped in reducing abortion. This did not appear rational as abortion is not a usual symptom of enterotoxaemia and the disease in its typical form was not prevalent among the Angoras. Nevertheless controlled experiments were conducted on eight farms and the results were as follows:—

	<i>Vaccinated</i>	<i>Controls</i>
No. of ewes.....	1,996	337
Kidded.....	1,413 (70%)	199 (59%)
Aborted.....	424 (21%)	109 (32%)
Dry.....	159 (8%)	29 (9%)
Percentage pregnant ewes aborted.....	23%	35%

Statistical analysis of these results showed a significant difference in the aborting rate between the two groups.

Serum samples were then taken from forty ewes which had aborted the previous season and which had not been inoculated against enterotoxaemia. These were tested for anti-bodies at Onderstepoort. Of the forty samples, thirty-one were negative and nine showed low titre antibodies. This proved that some 75 per cent of the aborters selected at random had never suffered from enterotoxaemia which eliminated this infection as a primary cause of abortion.

The apparent beneficial effects of immunisation can only be explained by postulating that mild attacks of enterotoxaemia may act as an additional stress which may precipitate abortion in ewes with a tendency to abort. That the effect of the vaccine was not due to a non-specific protein reaction was proved by a similar experiment in which black-quarter toxoid was used as a placebo. In this experiment there was no difference between the abortion rates of the injected and control groups (total 520 ewes).

### *G. Conclusion*

The above experiments indicated that abortion could not be correlated with verminosis or coccidiosis or with Vitamin A or mineral deficiencies.

## IV. PREMATURE REGRESSION OF THE CORPUS LUTEUM

The elimination of a specific infection as the cause of large scale abortions focussed the attention on the reproductive physiology of the Angora in South Africa.

Much of the preliminary evidence given in Chapter I indicated that the Angora ewe was particularly susceptible to abortion. These and other aspects will now be reviewed critically in order to show that the large scale abortions amongst Angoras in the eastern Cape Province are due to an innate weakness in the reproductive mechanism of the ewe.

*A. Breeding*

Such an inherent weakness in a breed would only be expected where long standing inbreeding without selection for reproductive efficiency had taken place. As shown in Chapter I these conditions apply to the Angoras of the eastern Cape. No significant importations have been made since 1896. During the slump in the industry starting from 1912, when a peak in the number of Angora goats had been reached, the number of Angora goats in the area decreased to the lowest level of under 500,000 in 1949 to 1951. From these the 1960 total of over 1,000,000 have been built up. It is generally acceded that selection has been made mainly on quality and quantity of hair with little or no regard to tendency to abortion. In fact, ewes which had not raised a kid the previous year might well be selected on hair production in preference to those that had, especially as few or no farmers kept breeding records, and did not connect abortion with an inherent weakness in the ewe. There may therefore have been a long standing inadvertent selection towards aborting strains.

*B. Abortion highest in stud ewes*

If a tendency to abortion were transmitted on a hereditary basis, it might be expected that, on account of greater inbreeding, the stud ewes would show this characteristic to a higher degree than similarly situated flock ewes. A survey made in 1959 revealed the data contained in Tabel 6.

TABLE 6.—Comparison of abortion rates amongst stud and flock Angora ewes

Farm No.	No. ewes	Kidded	Aborted	Dry	% pr. ewes ab.
1	S. 147	96 (65%)	23 (15%)	28 (19%)	21
	F. 291	252 (86%)	16 (5%)	23 (8%)	6
2	S. 106	59 (56%)	35 (33%)	12 (11%)	37
	F. 430	291 (68%)	82 (19%)	57 (13%)	22
3	S. 73	58 (80%)	13 (17%)	2 (3%)	18
	F. 25	22 (88%)	2 (8%)	1 (4%)	8
4	S. 90	73 (81%)	15 (17%)	2 (2%)	17
	F. 347	298 (86%)	31 (9%)	18 (5%)	10
5	S. 39	25 (64%)	14 (36%)	—	36
	F. 267	207 (75%)	51 (19%)	9 (6%)	20
6	S. 176	89 (50%)	68 (38%)	19 (11%)	43
	F. 371	186 (50%)	49 (13%)	136 (36%)	21
TOTAL...	S. 631	400 (63%)	168 (26%)	63 (10%)	30
	F. 1,731	1,256 (73%)	231 (13%)	244 (14%)	15

(S.—Stud ewes. F.—Flock ewes.)

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As will be seen the stud ewes showed an average percentage abortion rate of twice that of the flock ewes despite preferential feeding and treatment.

### *C. Abortion low in crossbred ewes*

It is the general experience that crossbred (Angora × Boergoat) ewes show very much lower abortion rates than purebred Angoras.

This is well illustrated on one farm where an original flock of the progeny of 500 Boergoat ewes have been bred to Angora rams for six consecutive years. The corresponding abortion percentages have been as follows: 1955, 2 per cent; 1956, 2 per cent; 1957, 4 per cent; 1958, 6 per cent; 1959, 9 per cent and 1960, 10 per cent. In other words, the abortion rate has risen progressively with the proportion of Angora blood in the flock.

The position in Basutoland also indicates that cross breeding reduces the tendency to abortion. In that territory, with nearly 600,000 Angora goats, abortion is no problem (Wacher, 1960, personal communication; Wiggel, 1961). All the Angora rams have been imported from the Republic of South Africa but the main stock was built up from indigenous goat ewes and cross-breeding is still practised extensively in order to produce an animal better suited to the rigorous conditions. That the goats in Basutoland are less pure than those in the Eastern Cape, is shown by the following mohair prices realised:—

Year	Overall Weighted Mohair Prices Sold at South African Ports (pennies/pound)	
	ex Basutoland	ex Republic of S.A.
1957.....	72·12	101·1
1958.....	53·89	74·4
1959.....	82·43	94·7

The above figures were obtained from the Basutoland Department of Agriculture and the Division of Economics and Markets of the Department of Agricultural Economics and Marketing of the Republic respectively.

The low incidence of abortion in Basutoland can therefore probably be ascribed to the relatively high proportion of Boergoat blood in the breeding ewes.

### *D. Tendency to abortion not influenced by sire*

The possibility that abortion was due to a lethal factor in the genetic make-up of the foetus was considered. If this were the case, the sire and dam would be expected to contribute equally. The study of numerous breeding records failed to reveal any correlation between the incidence of abortion and the ram used. On the other hand there was clear evidence that the ewe was the deciding factor, and a ewe with a tendency to abort evidenced this tendency irrespective of the ram to which she was mated.

As stated in Chapter I, abortion was no problem among Boergoats in the area. An experiment in crossing Angora ewes with Boergoat rams was planned in order to test the part played by the ram. On three farms 28 Angora ewes were selected as having aborted at least twice previously. These were mated to Boergoat rams, and the results were as follows:—

	Boergoat Ram
Number of ewes.....	28
Number of ewes known pregnant.....	27 (96%)
Abortions.....	15
Percentage pregnant ewes aborted.....	55·5%



Ewes that have aborted once previously, show a strong tendency to abort again, as shown under the next heading. The slightly higher tendency to abortion amongst ewes that have aborted at least twice previously is to be expected, and the above experiment strengthens the statement that the tendency to abortion is not influenced by the sire.

In Chapter I it was shown that the tendency to abortion increases with the age of the ewe. As the figures were mainly taken from random flock matings, this observation would also indicate that the ram plays no role in determining the viability of the foetus.

#### *E. Recurrence of abortion in individual ewes*

During 1958 all the aborting ewes were tagged on ten farms. The performance of these flocks was recorded during 1959 and the results are summarised below:—

	<i>Tagged</i>	<i>Untagged</i>
Number of ewes.....	549	3,256
Known pregnant ewes.....	475 (88%)	2,923 (90%)
Number aborted.....	212	556
Percentage pregnant ewes that aborted..	45%	19%

(For details see Appendix I, Table 2.)

It will be seen that 45 per cent of the ewes that aborted the previous year again aborted in 1959, whereas the overall abortion rate was 23 per cent. The untagged ewes included young ewes in their first breeding season.

No ewes could be found that had aborted regularly and had never raised a kid. A few ewes were found, however, that after having kidded normally once or twice, aborted regularly every year for up to four seasons.

The tendency for abortions to recur, is well shown by the following figures from individual farms:—

*Farm 1.*—Of 35 ewes that aborted in 1959, 5 (14%) aborted for the first year, 13 (37%) for the second year and 17 (49%) for the third consecutive year.

*Farm 2.*—Of 99 ewes that had aborted the previous year, 58 (58%) aborted again as compared to 23 (12%) out of 193 ewes that had not aborted previously.

*Farm 3.*—Only seven live kids were born from a flock of 160 ewes with histories of previous abortions. Almost all the other ewes aborted and very few were found to be dry.

*Farm 4.*—Of 101 ewes that aborted, 50 had aborted for three consecutive years, 37 for two consecutive years and 14 aborted for the first time.

*Farm 5.*—A virile ram was selected and mated to 44 stud ewes. Of these 31 had a history of no abortions, while 13 had aborted twice previously. The kidding results were as follows:—

	<i>Non-aborters</i>	<i>Aborted twice</i>
Number of ewes.....	31	13
Known pregnant ewes.....	26 (84%)	10 (77%)
Number aborted.....	0 (0%)	7 (54%)
Percentage pregnant ewes that aborted	0%	70%

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### *F. Examination of the genital tract*

During the autopsies listed in Chapter II, it was noted that ewes which had recently aborted or were carrying dead foetuses at the time of slaughter did not show the presence of the typical corpus luteum of pregnancy which is soft, vascular and has a bright yellow colour. In some cases the corpus luteum was small, pale and fibrous, in others it had completely regressed to fibrous tissue or no trace of it could be found. At the same time the ovaries were invariably found to contain developing follicles which would account for the previously described phenomena of oestrus coinciding with abortion. Two apparently normal pregnant ewes which were slaughtered were found to be carrying dead foetuses and the ovaries showed atretic corpora lutea and follicles. Similar findings were made in ewes with mummified foetuses. In most other species mummification of the foetus is accompanied by atresia of the corpus luteum but not by follicle formation (Bell, Davidson & Scarborough, 1959). These observations of regression of the corpus luteum and follicle formation in aborting Angora ewes was also confirmed by van Rensburg & van Rensburg (1961). Details of the relevant post mortem findings during the present investigations are given in Appendix II.

These findings immediately raised the question as to whether abortion in the Angora was due to premature regression of the corpus luteum of pregnancy. The essentiality of the corpus luteum, through its secretion of progesterone, for the maintenance of pregnancy during the early stages of gestation in all species of mammals is generally accepted. There are, however, considerable species differences in its essentiality during the latter half of the gestation period when the function of progesterone formation is partly or wholly taken over by the placenta in many species. This is especially seen in the equidae where the corpus luteum regresses some six months before parturition (Dukes, 1959).

Enucleation of the corpus luteum after a certain stage of pregnancy has been reached in the bovine, sheep, horse, dog, cat, Rhesus monkey and the human being, is not followed by abortion as proved by Hartman (1941), McDonald, Nicholls & McNutt (1952, 1953 a, b), Short (1956, 1959), Rowson (1959) and Dawson (1959). That the function of the corpus luteum is taken over mainly by the placenta has been proved in the cow, sheep and mare by Edgar (1953), Neher & Zarrow (1954), Edgar & Ronaldson (1958), Short (1958 and 1959), Melanpy, Hearn & Rakes (1959), Short & Moore (1959), Moore & Rowson (1959) and Gorski & Erb (1959).

The essentiality of the corpus luteum during the full duration of pregnancy in the goat has been proved by Drummond-Robinson & Asdell (1926), Asdell (1946), Meites, *et al.* (1951) and Short (1959), who found that its enucleation during any stage of pregnancy invariably produced abortion. Raeside & Turner (1955) could not detect any progesterone in the venous drainage of the pregnant and non-gravid uterine horns in the goat, indicating that progesterone secretion from the foetal membranes, if any, is very slight and not sufficient to maintain pregnancy in the absence of a corpus luteum.

These findings are supported by van Rensburg & van Rensburg (1961) who consider the corpus luteum of pregnancy in the Angora goat to be far more active than that of sheep during the latter stages of pregnancy as judged by macroscopical examination. They also found that regression of the corpus luteum after kidding

occurred relatively slowly and in one ewe with twins the sizes of the two corpora lutea on laparotomy thirteen days *post partum* were still 6 and 7 mm as compared to 10 and 11 mm 58 days previously, i.e. 45 days before kidding. Premature regression of the corpus luteum associated with abortion was also confirmed by these authors who reported complete atresia as early as two months after conception.

It is now generally accepted that the maintenance and activity of the corpus luteum of pregnancy is dependent on the secretion of luteotrophic hormone, also known as prolactin or lactogenic hormone, by the anterior hypophysis (Evans *et al.*, 1938, 1941a, 1941b; Moore & Nalbandov, 1955; Roberts, 1956; van Rensburg, 1957).

According to Pearce (1952), Purves & Griesbach (1954, 1955, 1957), Cupps, Laben & Mead (1956), Greep (1957) and Cole & Cupps (1959) luteotrophic hormone is secreted by the acidophilic cells of the anterior hypophysis, while the follicle stimulating and luteinizing hormones are produced by the basophilic cells.

A detailed histological examination of the corpora lutea and hypophyses of aborting and normal pregnant goats was therefore initiated.

#### *G. Histological examinations*

A histological study was made of the ovaries alone of one nearly full term pregnant ewe, and of the ovaries of four ewes that had aborted. The period between post mortem and abortion varied from immediately after aborting to the presence of a macerated foetus. For detailed descriptions see Appendix II (Cases No. 1 to 5). On histological examination the corpus luteum of the pregnant ewe proved to be in a very active state of secretion, while the corpora lutea of all the aborters showed varying stages of regression.

A histological study was also made of the corpora lutea and hypophyses of four normal pregnant Angora ewes and of nine aborters (Appendix II, Cases No. 6 to 18). Sections of the corpora lutea were stained with haemalum-eosin, and the hypophyses by the Mallory-Azan method described by Bensley & Bensley (1938).

Two completely different pictures were presented by the two groups as is evident from the findings summarised in Table 7.

The following two cases further illustrate the findings:—

A ewe with a four week twin pregnancy (Appendix II, Case No. 19) had one active and one regressing corpus luteum. The acidophilic cells showed a tendency to become quiescent and the basophilic cells were markedly active. The assumption of impending abortion was supported by the history of three successive previous abortions.

A second ewe with a history of previous abortion (Appendix II, Case No. 20) was slaughtered four days after aborting. There was no sign of a corpus luteum of pregnancy, but a newly formed young active corpus luteum was present. Both the alpha and beta cells were active, with the basophilic cells showing a slightly higher activity.

The accompanying microphotographs (Plates I to VII) will help to illustrate the changes noticed in the corpora lutea and hypophyses.

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TABLE 7.—*Histological findings of corpora lutea and hypophyses of four normal pregnant Angora ewes and nine aborters*

Item		Normal ewes	Aborters
Corpus luteum.	Connective tissue. Lutein cells.....	Stroma not prominent.... Large and well packed. Nuclei mainly vesicular. Cytoplasm clear, slightly vacuolated and/or homo- geneous. Few pycnotic nuclei associated with intenser eosinophilic cyto- plasm	Stroma prominent Most lutein cells show pyc- notic nuclei, and some karyorrhexis. Cytoplasm mainly homogeneous with strong eosinophilic colora- tion
	Indications.....	Active corpus luteum.....	Regression to complete atre- sia of corpus luteum
Hypophysis....	Acidophilic cells..	Densely packed. Cyto- plasm well filled with brickred staining granules with mostly vesicular nuclei. Some more orange in colour with depleted granules and nuclei showing condensa- tion of chromatin. Both types of cytoplasm might be present in one cell. Brick-red and partly red cells at periphery of acini. Orange degranulated alpha cells with nuclei showing condensation of chromatin, found mainly around periphery of hypophyses especially ventrally	Mostly small and not densely packed. Cytoplasm mostly homogeneous and orange coloured with nuclei showing condensa- tion of chromatin and shrinking of the mem- brane, especially around periphery of pars distalis. Some orange cells, especi- ally near the centre with nuclei becoming vesicular. Brick-red cells with vesi- cular nuclei very scarce
	Indications.....	Acidophilic cells actively secreting	Marked depletion of acido- philic activity
	Basophilic cells...	Relatively few. More numerous in upper cen- tral area. Mostly darker staining, compact cyto- plasm and nuclei showing condensation of chroma- tin, situated around peri- phery of acinus. Some large beta cells with vesi- cular nuclei and vacuo- lated cytoplasm found mainly in centre of an acinus	More numerous especially centrally and ventrally with large cells. Nucleus showing condensation of chromatin while the cell is still large and cytoplasm vacuolated, and as the cytoplasm becomes smal- ler and more compact, the chromatin of the nucleus also shows a greater degree of condensation. Some large vacuolated cells with vesicular nuclei present
	Indications.....	Basophilic cells show nor- mal activity	Basophilic cells show marked activity

*H. General discussion and conclusions*

The phenomena of spontaneous and often habitual abortion among Angora ewes can be explained in the light of the above findings. The pathogenesis can briefly be summarised as follows.

An as yet unexplained but probably hereditary weakness of the acidophilic cells of the anterior hypophysis leads to the premature failure to secrete luteotrophic hormone to maintain the corpus luteum of pregnancy. The consequent regression of the corpus luteum results in an inadequate secretion of progesterone. The corpus luteum is the only significant source of progesterone throughout pregnancy in the goat. The corpus luteum is not maintained in the gestational phase and regresses, the foetus then dies of inanition and is subsequently expelled. With the declining level of progesterone in the blood of the mother, the basophilic cells of the anterior hypophysis are released from inhibition and commence to secrete follicle stimulating hormone with consequent development of follicles and oestrogen output. The release of luteinising hormone from the basophilic cells follows, and oestrus is often noticed even before the foetus has been expelled. Such an oestrus, shortly after an abortion, is usually fertile, and if rams are present, most of these ewes will conceive. In this manner up to three abortions have been noticed in one season. On the other hand a second abortion does not necessarily follow and the ewe might kid late in the season.\*

That abortion in the Angora is associated with an inadequate progesterone level is also supported by the frequent observations that aborting ewes show very little mammary development even when abortion takes place late in pregnancy. The synergism between oestrogen and progesterone in mammary development in the goat has been shown by Mixner & Turner (1943) and Cowie (1959). Citing these authors Smith (1959) states: "The mammary glands of goats developed by the administration of an oestrogen to progesterone ratio of 1:140 or 1:200 are comparable to those observed at parturition". These figures clearly indicate the relatively high level of progesterone needed.

Normal mammary development and milk secretion occur in ewes that kid. The accumulation in acidophilic cells described in case No. 21, Appendix II, might be an indication of luteotrophic hormone activity as a preparation for the pending milk secretion. Acidophilic cells were always markedly depleted in ewes that aborted, even near full term.

The crucial factor is therefore the failure of the acidophilic cells of the anterior hypophysis to maintain an adequate output of luteotrophic hormone. Unfortunately little is known about the mechanism by which such activity is maintained in normal pregnancy in those species in which the corpus luteum is essential throughout gestation. It is usually accepted to be mediated in some unknown manner by the endocrine activity of the foetal placenta. If this is so, its failure could either be due to failure of the placenta to excrete adequate stimulating substances or failure of the anterior hypophysis to respond to such stimulation. The former would amount

\* The essentiality of the hypophysis in the maintenance of pregnancy in the goat was shown by Cowie & Tindall (1960). These workers hypophysectomized nine pregnant goats, seven of which aborted three to nine days post-operatively. The other two kidded but subsequent examination raised doubt as to the completeness of hypophysectomy in these two cases. Unfortunately this publication came to the notice of the author after completion of the thesis. (Cowie, A. T. & Tindall, J. S., 1960. *Acta Endocrinol.* Vol. 35, Suppl. 51, pp. 679-680. Copenhagen).

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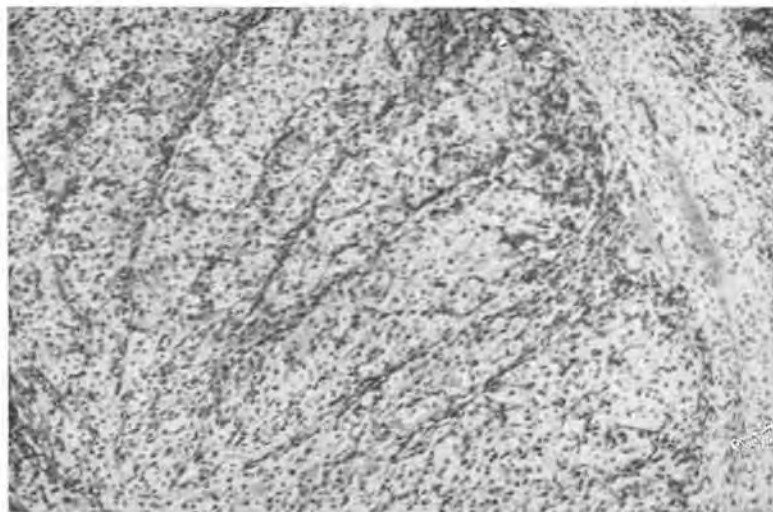


PLATE I.—Newly formed corpus luteum,  $\times 75$

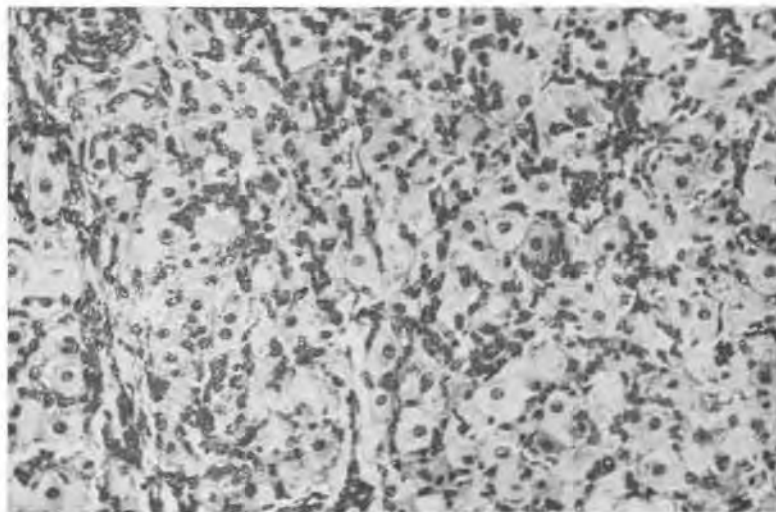


PLATE II.—Active corpus luteum,  $\times 200$



*Appendix II, Case No. 20*

*History.*—Mature ewe in excellent condition that aborted four days before post mortem.

*Macroscopical description of ovaries.*—Ovary (a) One medium/big and numerous small follicles. Ovary (b) Three medium and a number of small follicles. One corpus rubicans.

*Histological description of corpus rubicans.*—Connective tissue strands of corpus rubicans radially arranged. Luteal cells closely packed, clearly outlined with a minimum amount of connective tissue in between. Cytoplasm mainly finely vacuolated with vesicular nuclei. Capillary vessels engorged. Smaller theca lutein cells show up well in comparison to larger granulosa cells.

*Appendix II, Case No. 9*

*History.*—Aged ewe in excellent condition with no history of previous abortion, and 3½ months pregnant.

*Macroscopical description of ovaries.*—Ovary (a) Three small follicles and one large imbedded corpus luteum. Ovary (b) Lost.

*Histological description of corpus luteum.*—Stroma of corpus luteum medium. Lutein cells well packed. Vesicular nuclei predominating over pycnotic nuclei. Cytoplasm mainly large and often vacuolated.

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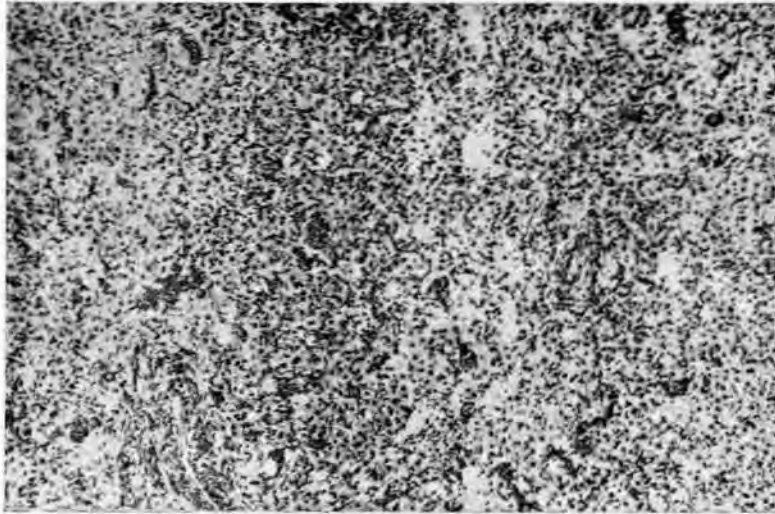


PLATE III.—Regressing corpus luteum,  $\times 75$

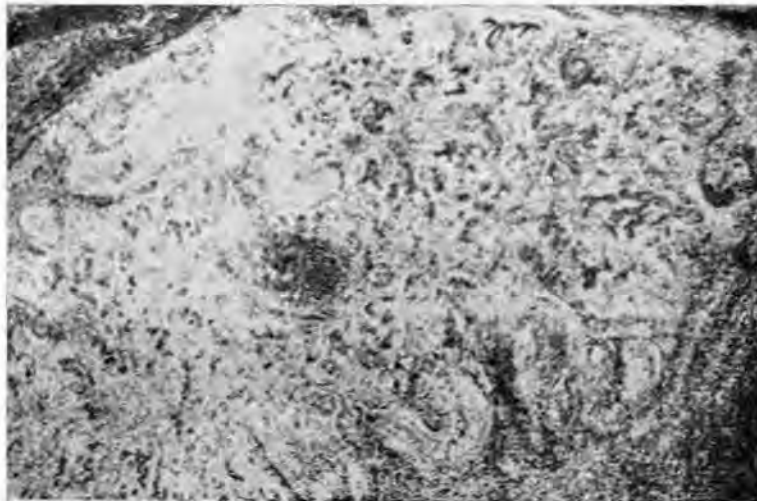


PLATE IV.—Corpus albicans,  $\times 30$

*Appendix II, Case No. 16*

*History.*—Regular aborter slaughtered three days after aborting a 4½ months old foetus in advanced state of autolysis.

*Macroscopical description of ovaries.*—Ovary (a) A number of medium sized follicles present. Ovary (b) A few medium follicles and one small corpus luteum.

*Histological description of corpus luteum.*—Connective tissue and arterioles prominent. Strongly eosinophilic cytoplasm with pycnotic nuclei showing tendency towards karyorrhexis. Vesicular nuclei also prominent, but most of their cells small with a strongly eosinophilic cytoplasm, i.e. non-active cells. Very few active lutein cells remaining.

*Appendix II, Case No. 17*

*History.*—Previous aborter slaughtered 15 days after aborting 3½ months old twins.

*Macroscopical description of ovaries.*—Ovary (a) Full of medium/small follicles. Ovary (b) One large and many small follicles. No sign of functioning corpus luteum.

*Histological description of corpus luteum.*—Two areas showing completely regressed corpora lutea. Arterioles very prominent, only thecal stroma present and no secreting lutein cells could be found.

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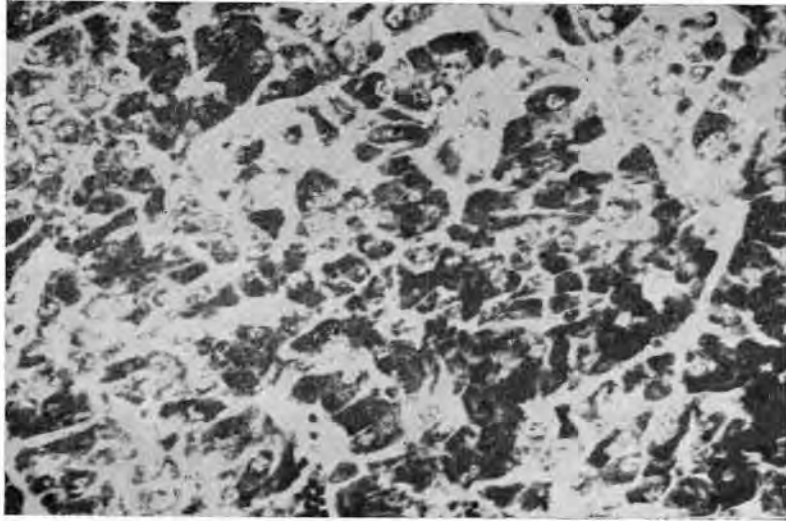


PLATE V.—Active acidophilic cells,  $\times 480$

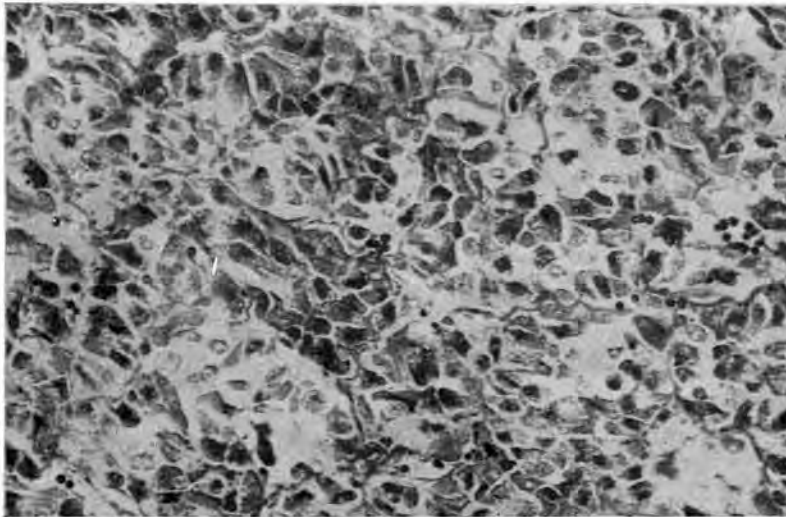


PLATE VI.—Depleted acidophilic cells,  $\times 480$

*Appendix II, Case No. 21*

*History.*—Ewe with no previous abortion history and four months pregnant.

*Macroscopical description of ovaries.*—Ovary (a) Six small follicles. Ovary (b) Three small follicles and one large corpus luteum.

*Histological description of acidophilic cells.*—Prominent and filling an acinus. Cytoplasm distinctly granulated and mainly brick-red in appearance. Nuclei mainly vesicular. Few nuclei showing condensation of chromatin with lighter coloured cytoplasm.

*Appendix II, Case No. 17.*

*History.*—Ewe that had aborted previously, slaughtered 15 days after aborting 3½ months old twins.

*Macroscopical description of ovaries.*—Ovary (a) Full of medium/small follicles. Ovary (b) One large and many small follicles. No sign of functioning corpus luteum.

*Histological description of acidophilic cells.*—Cells small, homogeneous and orange coloured. Nuclei showing condensation of chromatin and shrinking of the membrane.

CAUSE OF ABORTIONS IN ANGORA GOATS IN SOUTH AFRICA

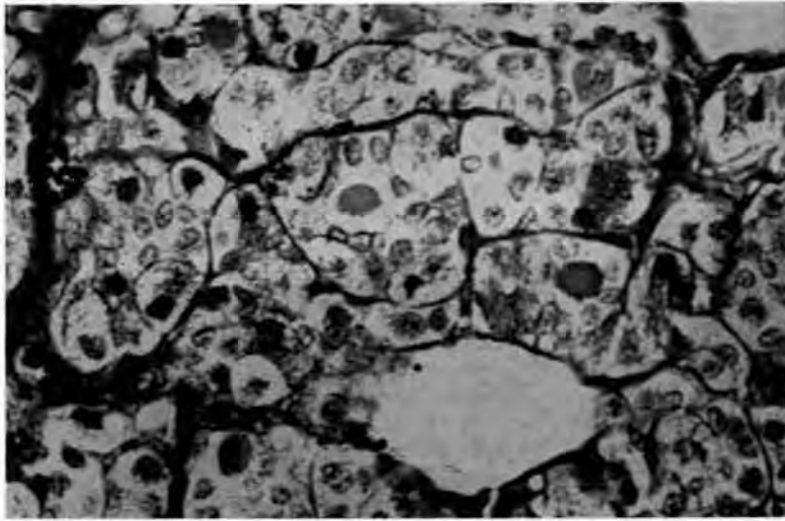


PLATE VII.—Active basophilic cells,  $\times 480$

*Appendix II, Case No. 16.*

*History.*—Regular aborter slaughtered three days after aborting a 4½ months old foetus in advanced state of autolysis.

*Macroscopical description of ovaries.*—Ovary (a) A number of medium sized follicles present. Ovary (b) A few medium follicles and one smallish corpus luteum.

*Histological description of basophilic cells.*—Nuclei showing condensation of chromatin while the cell is still large and cytoplasm vacuolated. A greater degree of condensation occurs as the cytoplasm becomes smaller and more compact. Some large vacuolated cells with vesicular nuclei present.



to a lethal genetic make-up of the foetus and this has been eliminated in the present investigation by the fact that abortion occurs irrespective of the sire. It can, therefore, only be concluded that the failure of the acidophilic cells of the Angora goat is due to an inherent defect in the cells themselves.

This weakness among Angora goats in South Africa can only be ascribed to a genetic factor. As already explained such a factor may well have been propagated by long inbreeding and failure to eliminate aborters from breeding flocks. Surviving progeny of parents carrying this factor will tend to propagate it.

Pituitary insufficiency due to inbreeding, may also occur amongst Merinos as shown by Doney (1959) where treatment of inbred lambs with a crude pituitary extract produced a highly significant increase in growth rate over the first ten weeks when compared with untreated inbred lambs. Similar treatment produced no detectable response in non-inbred lambs.

The observed contributory effect of environmental factors on the occurrence of abortion may be due to either their direct effects on a weakened system or through an indirect effect on the hypophysis via the nervous system. The close connection between the hypothalamus and the hypophysis is well known but not always fully appreciated. Although little is known of the effects of stress on the hypothalamic-hypophysial-gonadal axis in the lower animals, it is reasonable to assume that stress of any nature may influence it, especially where there is an innate weakness present. In this regard the Angora is well known to be a highly nervous animal and especially susceptible to external conditions such as cold. In this connection Hignett (1950) states:—

“Adverse hereditary influences often open the way to the full expression of nutritional disturbances.

In females hereditary and/or nutritional factors may result in ovulation failure with the possible development of ovarian cysts, the production of defective ova or the development of a poor corpus luteum which regresses early in pregnancy leading to death of the foetus”. (Author's italics.)

Conversely nervous influences may also tend to reduce abortion temporarily. As shown in Chapter I habitual aborters often kid normally for one or two years when moved to other farms. It is possible that the new surroundings promote stimulation of the hypophysis and so contribute to the maintenance of its function.

The only practical solution to the problem would appear to be the wide scale adoption of a breeding policy designed to eliminate the defect. This will entail not only the elimination from breeding flocks of all aborters, but also of all surviving progeny of aborters. As most aborters only reveal themselves after giving birth to one or more live kids, identification of all potential breeding animals and the keeping of full records will be essential. At the same time over-protection of pregnant ewes against contributing environmental factors should be avoided in order to allow of the defect making itself apparent as soon as possible.

The elimination of habitual aborters on many farms has already resulted in a spectacular drop in aborting percentages, e.g. on one farm with a regular aborting percentage of over 30 per cent, the incidence dropped to 7 per cent in 1960, after the elimination of all aborters in 1958 and again in 1959. Although this policy alone will not eliminate the genetic defect, it will in time contribute to reducing its prevalence.

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Intensive investigation into the genetics of the condition is essential but does not fall within the scope of the present work. The question as to whether foreign blood should not be imported from countries where abortions do not occur, should be carefully considered.

### V. SUMMARY

1. Investigations into the cause of large scale abortions among Angora goats in the eastern Cape Province of South Africa are reported. These abortions have been prevalent for many years and have reached such proportions as to constitute a menace to the mohair industry.

2. The condition was shown to be peculiar to the Angora goat and not to affect Boergoats or sheep even when run with affected Angoras. Habitual abortion is commonly encountered. It was further found that the incidence of abortion was in direct proportion to the amount to Angora blood present. The incidence of abortion among Angora ewes was not influenced by mating them to Boergoat rams.

3. The condition was shown not to be due to any infective agent by means of microscopical, cultural and transmission techniques. All the known possible diseases were eliminated by suitable specific tests. The epizootology is shown not to correspond with that of an infectious disease.

4. Mineral and Vitamin A deficiencies were eliminated as the primary cause by controlled supplementation experiments and blood analyses.

5. Aborting Angora goats show marked regression of the corpus luteum of pregnancy and exhaustion of the acidophilic cells of the anterior hypophysis which, according to the literature, are responsible for the secretion of luteotrophic hormone. At the same time there was activity of the basophilic cells of the anterior hypophysis believed to be responsible for follicle stimulating and luteinising hormone production. This was associated with follicle development and oestrus at the time of abortion.

6. It is concluded that these abortions are due to a hereditary defect of the anterior hypophysis as regards the maintenance of the corpus luteum of pregnancy through luteotrophic hormone secretion. The peculiar history of the Angora goat in South Africa with marked inbreeding over some 60 years and the failure to eliminate aborters from breeding flocks are consistent with such a conclusion. Environmental factors play only a contributory role in producing abortion.

7. The only practical solution visualised is the adoption of a breeding program designed to eliminate the defect.

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APPENDIX I.

TABLE I.—Total kidding results, 1958-1959

Farm	No. ewes	Kidded	Aborted	Dry	% Pr. ewes aborted
1 a	480	366 (76%)	57 (12%)	57 (12%)	13
1 b	437	348 (79%)	39 (9%)	50 (11%)	10
2 a	360	124 (34%)	226 (63%)	10 (3%)	64
2 b	430	291 (68%)	39 (9%)	57 (13%)	22
3 a	200	125 (62%)	26 (13%)	49 (24%)	17
3 b	294	240 (82%)	31 (10%)	23 (8%)	11
4 a	220	110 (50%)	14 (6%)	96 (44%)	11
4 b	170	110 (65%)	20 (12%)	40 (23%)	15
5 a	343	162 (47%)	134 (39%)	47 (14%)	45
5 b	257	194 (75%)	46 (18%)	17 (6%)	19
6 a	274	200 (73%)	47 (17%)	27 (10%)	19
6 b	336	223 (66%)	89 (26%)	24 (7%)	28
7 a	697	471 (67%)	129 (19%)	97 (14%)	21
7 b	811	642 (79%)	127 (15%)	42 (5%)	16
8 a	998	514 (51%)	150 (15%)	334 (33%)	23
8 b	1,101	715 (65%)	281 (25%)	105 (9%)	28
TOTAL a	3,572	2,072 (58%)	783 (22%)	717 (20%)	27
TOTAL b	3,836	2,763 (72%)	715 (19%)	358 (9%)	20.5

a = 1958      b = 1959



TABLE 2.—*Tendency to recurrence of abortion, 1959*

Farm	No. ewes	Kidded	Aborted	Dry	% Pr. ewes aborted
1 a	52	25 (48%)	9 (17%)	18 (34%)	26
1 b	385	323 (84%)	30 (8%)	32 (8%)	9
2 a	56	24 (43%)	31 (55%)	1 (2%)	56
2 b	374	267 (71%)	51 (14%)	56 (15%)	16
3 a	17	10 (60%)	6 (35%)	1 (5%)	37
3 b	97	81 (83%)	9 (9%)	7 (7%)	10
4 a	63	34 (54%)	19 (30%)	10 (16%)	36
4 b	354	199 (56%)	90 (25%)	65 (18%)	31
5 a	109	41 (37%)	58 (53%)	10 (9%)	58
5 b	204	170 (83%)	23 (11%)	11 (5%)	12
6 a	12	8 (67%)	2 (17%)	2 (17%)	20
6 b	98	80 (81%)	15 (15%)	3 (3%)	16
7 a	63	34 (54%)	18 (28%)	11 (17%)	34
7 b	517	394 (76%)	73 (14%)	50 (10%)	16
8 a	28	15 (54%)	13 (46%)	—	46
8 b	229	179 (78%)	33 (14%)	17 (8%)	15
9 a	134	67 (50%)	49 (36%)	18 (13%)	42
9 b	967	648 (66%)	232 (24%)	87 (9%)	26
10 a	15	5 (33%)	7 (47%)	3 (20%)	58
10 b	31	26 (84%)	—	5 (16%)	—
TOTAL a	549	263 (48%)	212 (40%)	74 (11%)	44·6
TOTAL b	3,256	2,367 (73%)	556 (17%)	333 (10%)	19

a = Tagged i.e. aborted 1958

b = Untagged i.e. kidded 1958 and 1st service ewes

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TABLE 3.—*Transmission experiments, 1958*

Farm a			Farm b		
Ewe No.	Service Date	Result	Ewe No.	Service Date	Result
381	21/2/58	Abort	360	24/3/58	Abort
377	22/2/58	Kid	338	24/3/58	Kid
375	23/2/58	Abort	346	26/3/58	Abort
382	23/2/58	Kid	358	27/3/58	Kid
366	24/2/58	Abort	341	27/3/58	Abort
392	26/2/58	Abort	331	27/3/58	Kid
395	26/2/58	Abort	343	27/3/58	Kid
373	28/2/58	Kid	353	27/3/58	Kid
85	1/3/58	Kid	344	28/3/58	Abort
368	1/3/58	Abort	352	28/3/58	Kid
387	1/3/58	Abort	356	29/3/58	Kid
92	2/3/58	Kid	332	30/3/58	Abort
364	2/3/58	Abort	334	30/3/58	Kid
400	3/3/58	Abort	359	30/3/58	Kid
89	5/3/58	Abort	357	30/3/58	Kid
87	7/3/58	Abort	355	31/3/58	Kid
94	7/3/58	Kid	342	1/4/58	Kid
374	8/3/58	Kid	348	1/4/58	Kid
362	9/3/58	Kid	339	1/4/58	Kid
361	10/3/58	Abort	350	1/4/58	Kid
363	10/3/58	Kid	351	2/4/58	Kid
394	10/3/58	Kid	347	2/4/58	Abort
83	12/3/58	Abort	349	3/4/58	Kid
372	13/3/58	Kid	354	3/4/58	Abort
376	13/3/58	Kid	345	3/4/58	Kid
383	15/3/58	Kid	333	3/4/58	Kid
386	15/3/58	Kid	340	3/4/58	Kid
384	17/3/58	Abort	335	4/4/58	Abort
385	17/3/58	Abort	336	4/4/58	Abort
365	21/3/58	Abort	337	4/4/58	Abort
389	21/3/58	Abort			
84	23/3/58	Kid			
399	24/3/58	Abort			
398	25/3/58	Kid			
95	28/3/58	Abort			
397	29/3/58	Kid			

Farm a = Young ram used for first time to 36 ewes that had aborted in 1957  
 Farm b = Young ram used for first time to 30 ewes that had aborted in 1957

TABLE 4.—*Effect of dosing mineral mixture, 1959*

Farm	No. ewes	Kidded	Aborted	Dry	% Pr. ewes ab.
1 a	110	63 (57%)	31 (28%)	16 (14%)	33
1 b	25	16 (64%)	6 (24%)	3 (12%)	27
2 a	324	230 (71%)	44 (13%)	50 (16%)	16
2 b	50	37 (74%)	7 (14%)	6 (12%)	16
3 a	192	153 (80%)	15 (7%)	24 (12%)	9
3 b	151	129 (85%)	3 (2%)	19 (12%)	2
4 a	237	206 (87%)	15 (6%)	16 (6%)	7
4 b	29	21 (72%)	4 (14%)	4 (14%)	16
5 a	21	13 (62%)	5 (24%)	3 (14%)	28
5 b	20	9 (45%)	8 (40%)	3 (15%)	47
6 a	100	45 (45%)	6 (6%)	49 (49%)	12
6 b	100	57 (57%)	5 (5%)	38 (38%)	8
7 a	184	152 (82%)	21 (11%)	11 (6%)	12
7 b	20	18 (90%)	2 (10%)	—	10
8 a	110	88 (80%)	17 (15%)	5 (4%)	16
8 b	42	32 (76%)	8 (19%)	2 (5%)	20
9 a	30	28 (93%)	2 (7%)	—	7
9 b	30	23 (77%)	7 (23%)	—	23
10 a	15	5 (33%)	10 (67%)	—	67
10 b	15	5 (33%)	9 (60%)	1 (7%)	64
11 a	109	69 (63%)	34 (31%)	6 (5%)	33
11 b	80	50 (62%)	21 (26%)	9 (11%)	30
TOTAL a	1,432	1,052 (73%)	200 (14%)	180 (12%)	16%
TOTAL b	562	397 (71%)	80 (14%)	85 (15%)	16.7%

a = Dosed 10-14 day intervals      b = Control

TABLE 5.—*Effect of iron injections, 1959*

Farm	No. ewes	Kidded	Aborted	Dry	% Pr. ewes ab.
1 a	15	10 (67%)	3 (20%)	2 (13%)	23
1 b	25	16 (64%)	6 (24%)	3 (12%)	27
2 a	14	10 (71%)	2 (14%)	2 (14%)	17
2 b	11	9 (81%)	—	2 (18%)	—
3 a	22	12 (54%)	6 (27%)	4 (18%)	33
3 b	20	9 (45%)	8 (40%)	3 (15%)	47
4 a	56	48 (86%)	5 (9%)	3 (5%)	10
4 b	260	197 (76%)	35 (13%)	28 (10%)	15.5
5 a	26	9 (34%)	15 (58%)	2 (8%)	62
5 b	98	31 (31%)	48 (49%)	19 (20%)	61
TOTAL a	133	89 (67%)	31 (23%)	13 (10%)	25.8
TOTAL b	414	262 (63%)	97 (23%)	55 (13%)	27

a = Injected      b = Control

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### APPENDIX II

#### DETAILS OF HISTOLOGICAL FINDINGS

In order not to encumber the text matter with rather lengthy descriptions of each individual case, a detailed description of each case, with conclusions, is given below.

The early stages of cystic follicles and physiological atresia of the follicles as described by de Lange (1950), are histologically very similar. In the Angora ewe the many cases of atresia of the follicles could be diagnosed as such due to the history of the ewe with her exceptionally high fertility, and the observation that an oestrus following immediately on an abortion is usually fertile. In comparison, nymphomania, due to cystic follicles, has as a constant feature prolonged oestrous periods and infertility. The degenerative symptoms of some of the follicles were therefore regarded as physiologically normal and it was decided not to describe the individual follicles.

Colloid was commonly found in the anterior hypophysis of old ewes. Its presence seemed to be associated with age.

The criterion on whether a cell in the anterior hypophysis was secreting or not, was made on the appearance of the nucleus of the cell. When a cell started secreting, the vesicular nucleus showed condensation of chromatin and shrinking of the nuclear membrane with a resultant darker staining appearance. The granules which were usually firmly packed at this stage, gave an appearance of homogeneity.

Sections of the corpora lutea were made as near to the centre as possible and stained with haemalum-eosin. Sections of the hypophyses were cut longitudinally through the centre and stained by Mallory-Azan technique as described by Bensley & Bensley (1938).

#### GROUP A.—OVARIES ONLY

##### *Case No. 1 (Histological No. 596/58)*

*Description.*—Over four months pregnant ewe donated for post mortem.

*Macroscopical appearance.*—Ovary (*a*) One medium/small and few small follicles. Ovary (*b*) Few small follicles and one big corpus luteum.

*Histological examination of corpus luteum.*—Stroma medium, lutein cells well packed and clearly defined, nuclei mainly vesicular with very few pycnotic nuclei present; cytoplasm finely granular to vacuolated.

*Conclusion.*—Corpus luteum in very active state of secretion.

##### *Case No. 2 (Histological No. 589/58)*

*Description.*—Angora ewe busy aborting; cervix open, cervical plug fluid; uterus and broad ligaments oedematous; foetus appears to be normal and not autolysed as is usually the case.

*Macroscopical appearance.*—Ovary (*a*) One medium and numerous small follicles. Ovary (*b*) Few medium/small follicles and one corpus luteum.

*Histological examination of corpus luteum.*—Connective tissue very prominent, lutein cells not well packed, vesicular nuclei fairly prominent but cytoplasm strongly eosinophilic and homogeneous; some cells completely degranulated with pycnotic nuclei.

*Conclusion.*—Fairly advanced regression of corpus luteum.

##### *Case No. 3 (Histological No. 598/58)*

*Description.*—Aborted just before post mortem. Anasarca of approximately four months foetus.

*Macroscopical appearance.*—Ovary (*a*) Corpus luteum present, few small follicles. Ovary (*b*) Lost.

*Histological examination of corpus luteum.*—Prominent connective tissue; lutein cells mainly well outlined, not firmly packed and staining mostly deeply eosinophilic with pycnotic nuclei; some cell outlines not clearly defined.

*Conclusion.*—Regression of corpus luteum.

Case No. 4 (Histological No. 592/58)

*Description.*—Aborted some time before post mortem, and cervix starting to close.

*Macroscopical appearance.*—Ovary (a) Few medium/small and many small follicles. Ovary (b) One medium and few small follicles and one corpus luteum.

*Histological examination of corpus luteum.*—Prominent connective tissue; cytoplasm mainly eosinophilic also vacuolated; lutein cells not clearly defined, nuclei well stained to pycnotic, some showing commencing karyorrhexis.

*Conclusion.*—Regression of the corpus luteum.

Case No. 5 (Histological No. 601/58)

*Description.*—Cervix half-an-inch open, brown necrotic foetal membranes and about 2½ months old brownish "mummified" foetus in the uterus.

*Macroscopical appearance.*—Ovary (a) One medium/big, and a number of medium and small follicles. Ovary (b) Many medium/small and small follicles; one small imbedded corpus luteum.

*Histological examination of corpus luteum.*—Connective tissue stroma very prominent; lutein cells few and small, cytoplasm eosinophilic, few vacuolated; nuclei tending towards pycnosis.

*Conclusion.*—Advanced regression of corpus luteum.

GROUP B.—OVARIES AND HYPOPHYSIS

PREGNANT EWES

Case No. 6 (Path. No. 58853, Sp. Book No. 11)

*Description.*—Four tooth ewe *in extremis* with pneumonia and 3½ months pregnant.

*Ovaries*

*Macroscopical appearance.*—Ovary (a) Few very small follicles and one large corpus luteum. Ovary (b) Static; few very small follicles.

*Histological examination of corpus luteum.*—Stroma indistinct and lutein cells well packed; nuclei mainly vesicular with cytoplasm clear, vacuolated and/or homogeneous; occasional pycnotic nuclei associated with intenser eosinophilic cytoplasm.

*Hypophysis*

(a) *Acidophilic cells.*—Well packed and prominent; vesicular nuclei and nuclei showing a darkening of stain reaction due to condensation of chromatin, present in about equal proportions; cytoplasm of dark staining nuclei generally smaller and often degranulated with an orange-yellow colour indicating spent activity; cytoplasm of vesicular nuclei generally larger and filled with granules of a brick-red colour indicating accumulation just before secretion; various stages of activity between these two extremes present.

(b) *Basophilic cells.*—Scattered throughout and more numerous in upper central area; in an acinus the large basophilic cells with a vesicular nucleus and vacuolated cytoplasm, i.e. accumulating granules, are to be found mainly in the centre, while the mature, secreting basophilic cells with a nucleus becoming progressively darker staining, and smaller and darker staining compact cytoplasm, are to be found mostly around the periphery.

*Conclusion.*—Although this ewe is nearly four months pregnant, and *in extremis* with pneumonia she has a very active corpus luteum. The cells of the anterior hypophysis also indicate normal pregnancy, i.e. marked activity of the acidophilic cells and normal activity of the basophilic cells. The histological findings of this case support the statement that an innate weakness must be present in the individual ewe in order to abort.

Case No. 7 (Histological No. 607/58)

*Description.*—Aged ewe in excellent condition and a regular aborter. Two-and-a-half months pregnant (twins).

*Ovaries*

*Macroscopical appearance.*—Ovary (a) Few medium/small and small follicles, one corpus luteum. Ovary (b) Lost.

*Histological examination of corpus luteum.*—Section cut through edge of corpus luteum; stroma medium with vesicular nuclei predominating over pycnotic nuclei; cytoplasm varies from large, clear and often vacuolated, to smaller and more intense staining.

## CAUSE OF ABORTIONS IN ANGORA GOATS IN SOUTH AFRICA

### *Hypophysis*

(a) *Acidophilic cells*.—Well packed and prominent; cells with brick-red granulated cytoplasm and vesicular nuclei more numerous and found especially in centre of anterior hypophysis; cells with orange coloured degranulated cytoplasm and nuclei showing condensation of chromatin, found mainly around periphery; in many areas both colorations are present in one acinus.

(b) *Basophilic cells*.—Very scarce, evenly distributed, perhaps slightly more numerous in central area.

*Conclusion*.—Normal pregnant ewe with a very active corpus luteum, marked activity of the acidophilic cells and low to normal activity of the basophilic cells.

*Case No. 8* (Histological No. 610/58)

*Description*.—Aged ewe with no history of previous abortion and 2½ months pregnant.

### *Ovaries*

*Macroscopical appearance*.—Ovary (a) Large corpus luteum with no sign of follicles. Ovary (b) Lost.

*Histological examination of corpus luteum*.—Lutein cells well packed with medium stroma; nuclei mainly vesicular and cytoplasm varying from large, clear and often vacuolated to smaller and more intense staining.

### *Hypophysis*

(a) *Acidophilic cells*.—Most cells around periphery show spent activity, i.e. a darkstaining nucleus due to shrinking of nuclear membrane and condensation of chromatin, and small, homogeneous and orange coloured cytoplasm. In centre and to some extent around periphery cells show accumulation and active secretion, i.e. brick-red cells with vesicular nuclei tending to become darker staining. Some cells show both colorations in the same cytoplasm. They are usually situated around the edge of an acinus, with the red, granular, secretory portion distally near a capillary.

(b) *Basophilic cells*.—Normal in number, evenly distributed and show normal activity.

*Conclusion*.—Normal pregnant ewe with an active corpus luteum, marked activity of the acidophilic cells and normal activity of the basophilic cells.

*Case No. 9* (Histological No. 604/58)

*Description*.—Aged ewe in excellent condition with no history of a previous abortion, and 3½ months pregnant.

### *Ovaries*

*Macroscopical appearance*.—Ovary (a) Few small follicles and one large imbedded corpus luteum. Ovary (b) Lost.

*Histological examination of corpus luteum*.—Stroma medium and lutein cells well packed; vesicular nuclei predominating over pycnotic nuclei; cytoplasm mainly large and often vacuolated.

### *Hypophysis*

(a) *Acidophilic cells*.—Only a very few cells have reached the quiescent stage, i.e. small dark staining nucleus with degranulated orange coloured cytoplasm. Acidophilic cells mostly brick-red in colour with granular cytoplasm and vesicular nuclei; some nuclei in these cells show a gradual darkening of the staining reaction.

(b) *Basophilic cells*.—Slightly increased in numbers especially centrally; the cytoplasm and nuclei of most of the cells are small, compact and dark staining; very few cells in the formation stage with vesicular nuclei and vacuolated cytoplasm.

*Conclusion*.—Normal pregnant ewe with a very active corpus luteum, marked activity of the acidophilic cells and basophilic cells showing a tendency towards quiescence.

## ABORTERS

*Case No. 10* (Path. No. 59319, PM. No. 36556, DOB. No. 5962)

*Description*.—Ewe that had aborted previously; full term kid born dead and post mortem one day after kidding.



*Ovaries*

*Macroscopical appearance.*—Ovary (a) Large number of medium/small follicles. Ovary (b) Fair sized corpus luteum.

*Histological examination of corpus luteum.*—Connective tissue prominent; pycnotic nuclei more numerous than vesicular; cytoplasm of lutein cells appears to be non-active with eosinophilic coloration.

*Hypophysis*

(a) *Acidophilic cells.*—Occasional cells showing brick-red coloured granular cytoplasm with nuclei varying in staining intensity found mainly around the edge of an acinus; most of the acidophilic cells, however, are depleted with orange coloured homogeneous cytoplasm and nuclei showing a shrinking of the nuclear membrane, condensation of chromatin and a resultant dark staining reaction. The significance of some orange coloured cells with vesicular nuclei, will be discussed under "conclusion".

(b) *Basophilic cells.*—More numerous centrally and ventrally. Nucleus tends to show a darker staining reaction while the cytoplasm is still large and vacuolated, and becomes smaller and darker as the cytoplasm also becomes smaller and more compact. Some large cells are present with vesicular nuclei; tendency for basophilic cells to reach active secretory phase in early stage of functional cycle.

*Conclusion.*—With the regression of the corpus luteum, depletion of the acidophilic cells and high activity of the basophilic cells, abortion or prenatal death was to be expected. The normal cycle of a nucleus from vesicular to dark staining due to condensation of chromatin and shrinking of nuclear membrane, to vesicular, is well demonstrated amongst the acidophilic cells of this section where some of the orange coloured cells have vesicular nuclei and very little cytoplasm. This is most probably acidophilic cells changing to chromophobes, or it might also be chromophobes developing into acidophilic cells, which is doubtful.

Case No. 11 (Path. No. 58680, Spec. Book No. 2)

*Description.*—Aged ewe in excellent condition with previous abortion history. Aborted three hours before post mortem, four month foetus.

*Ovaries*

*Macroscopical appearance.*—Ovary (a) Three medium and few small follicles. Ovary (b) A number of medium/small follicles and one big corpus luteum.

*Histological examination of corpus luteum.*—Connective tissue prominent; cytoplasm homogeneous tending to become acidophilic; complete absence of lipoid granules; vesicular nuclei well stained and tending to become pycnotic; pycnotic nuclei increased; cytoplasm of lutein cells appears to be non-active.

*Hypophysis*

(a) *Acidophilic cells.*—Mainly depleted acidophilic cells present with an orange coloured homogeneous cytoplasm and intense dark staining nuclei; occasional cells found with brick-red granulated cytoplasm.

(b) *Basophilic cells.*—Very prominent; nucleus tends to become dark staining due to condensation of chromatin while cell is still large and tends to become darker and smaller as cytoplasm becomes smaller and more compact; tendency for basophilic cells to reach active secretory phase in early stage of functional cycle.

*Conclusion.*—Regression of corpus luteum with depleted acidophilic cells and active basophilic cells.

Case No. 12 (Path. No. 58814, Spec. Book No. 6)

*Description.*—Previous history of ewe unknown. Post mortem done about 24 hours after aborting a three-and-a-half months old foetus.

*Ovaries*

*Macroscopical appearance.*—Ovary (a) One big thin walled, one medium/big and numerous small follicles. Ovary (b) Many medium follicles, one imbedded corpus luteum.

*Histological examination of corpus luteum.*—Connective tissue very prominent; arterioles prominent; pycnotic nuclei with strong eosinophilic coloration of the cytoplasm very much more numerous than vesicular nuclei. Some of the pycnotic nuclei show karyorrhexis.

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### *Hypophysis*

(a) *Acidophilic cells*.—Depleted acidophilic cells with an orange coloured homogeneous cytoplasm and dark staining nuclei most numerous; occasional acidophilic cells with vesicular nuclei and brick-red cytoplasm present.

(b) *Basophilic cells*.—Prominent and very active. Some large, vacuolated cells present with vesicular nuclei; tendency for basophilic cells to reach active secretory phase in early stage of functional cycle, i.e. nuclei showing a gradual darkening of staining reaction due to condensation of chromatin while the cytoplasm is still large and vacuolated, and tends to stain more intense as cytoplasm becomes smaller and more compact.

*Conclusion*.—Advanced regression of corpus luteum with depleted acidophilic cells and very active basophilic cells. Marked follicular activity in ovaries.

*Case No. 13* (Path. No. 58875, Post Mortem No. 35943, DOB. No. 5583)

*Description*.—Post mortem done about 48 hours after aborting a four week old foetus.

### *Ovaries*

*Macroscopical appearance*.—Ovary (a) Two medium and a few small follicles. Ovary (b) One medium and a few small follicles. One imbedded corpus luteum.

*Histological examination of corpus luteum*.—Connective tissue very prominent and active (fibroblasts large and vesicular); cell membranes indistinct with a strongly stained eosinophilic cytoplasm, completely degranulated and rounded off; pycnotic nuclei predominating, some showing karyorrhexis; very few functioning lutein cells remaining.

### *Hypophysis*

(a) *Acidophilic cells*.—Mainly depleted acidophilic cells with an orange coloured homogeneous cytoplasm and intense dark staining nuclei present; a few scattered brick-red acidophilic cells also present.

(b) *Basophilic cells*.—Normal in numbers and activity.

*Conclusion*.—Advanced regression of the corpus luteum with an appreciably higher activity in the basophilic cells as compared to the acidophilic cells. This is probably a case where insufficient luteotrophic hormone has been secreted from the start with the formation of a poor corpus luteum. The foetus therefore never had a chance to become properly attached.

*Case No. 14* (Path. No. 58776, Spec. Book No. 6)

*Description*.—Aged ewe aborted 48 hours before post mortem; age of foetus and further history unknown; average aborting percentage on this farm about 25.

### *Ovaries*

*Macroscopical appearance*.—Ovary (a) One medium/small and numerous small follicles. Ovary (b) Two medium and few small follicles; one corpus luteum.

*Histological examination of corpus luteum*.—Connective tissue very prominent; lutein cells poorly outlined with nuclei pycnotic or tending towards pycnosis; cytoplasm poorly staining or eosinophilic; most cells show various stages of regression; very few active secreting cells left.

### *Hypophysis*

(a) *Acidophilic cells*.—Depleted especially at periphery, i.e. mainly orange-coloured cytoplasm and dark staining nuclei present; Acidophilic cells losing activity and tending to become quiescent.

(b) *Basophilic cells*.—Numerous and very active; nucleus showing a gradual darkening of staining reaction due to condensation of chromatin while the cytoplasm is still large and vacuolated, and tends to stain more intense as cytoplasm becomes smaller and more compact.

*Conclusion*.—Advanced regression of corpus luteum with low activity of the acidophilic cells and very marked activity of the basophilic cells.

*Case No. 15* (Path. No. 58881, Spec. Book No. 12)

*Description*.—Eight tooth ewe in excellent condition which aborted 48 hours before post mortem; no further history known.

*Ovaries*

*Macroscopical appearance.*—Ovary (a) One large and numerous small follicles. Ovary (b) A number of medium follicles; one corpus luteum.

*Histological examination of corpus luteum.*—Connective tissue very prominent; very few lutein cells left all of which show various stages of regression.

*Hypophysis*

(a) *Acidophilic cells.*—Mainly depleted acidophilic cells present with orange-coloured homogeneous cytoplasm and nuclei showing condensation of chromatin; occasional acidophilic cells found with brick-red granulated cytoplasm and nuclei mainly vesicular.

(b) *Basophilic cells.*—More numerous centrally and ventrally; nucleus shows gradual darkening of staining reaction while cell is still large and vacuolated, which tends to become darker and smaller as cytoplasm becomes smaller and more compact; some large cells present with vesicular nuclei; tendency for basophilic cells to reach active secretory phase in early stage of functional cycle.

*Conclusion.*—Regression of corpus luteum with depleted acidophilic cells, marked activity of basophilic cells and follicle formation in ovaries.

Case No. 16 (Path. No. 59099, Post mortem No. 36221, DOB. No. 5970)

*Description.*—Regular aborter slaughtered three days after aborting a four-and-a-half months foetus in advanced state of autolysis.

*Ovaries*

*Macroscopical appearance.*—Ovary (a) A number of medium sized follicles present. Ovary (b) A few medium follicles and one smallish corpus luteum.

*Histological examination of corpus luteum.*—Connective tissue and arterioles prominent; strongly eosinophilic cytoplasm with pyknotic nuclei showing tendency towards karyorrhexis; vesicular nuclei also prominent, but most of their cells small with a strongly eosinophilic cytoplasm, i.e. nonactive cells; very few active lutein cells remaining.

*Hypophysis*

(a) *Acidophilic cells.*—Mainly depleted cells with an orange-coloured homogeneous cytoplasm and dark staining nuclei present.

(b) *Basophilic cells.*—Prominent with tendency to reach active secretory phase in early stage of functional cycle, i.e. cells with vacuolated cytoplasm and nuclei showing condensation of chromatin most numerous.

*Conclusion.*—Regression of corpus luteum with depleted acidophilic cells and marked activity of basophilic cells.

Case No. 17 (Path. No. 58901, Post mortem No. 36006, DOB. No. 5974)

*Description.*—Aged ewe; previous aborter slaughtered 15 days after aborting three-and-a-half month old twins.

*Ovaries*

*Macroscopical appearance.*—Ovary (a) Full of medium/small follicles. Ovary (b) One large and many small follicles; no sign of functioning corpus luteum.

*Histological examination of corpus luteum.*—Two areas showing completely regressed corpora lutea. Arterioles very prominent, only thecal stroma present and no secreting lutein cells could be found.

*Hypophysis*

(a) *Acidophilic cells.*—Complete depletion of acidophilic cells with only orange-coloured cells present.

(b) *Basophilic cells.*—Very prominent with tendency to reach active secretory phase during early stage of functional cycle.

*Conclusion.*—Complete regression of corpora lutea i.e. corpus albicans with marked depletion of acidophilic cells and high activity of basophilic cells; follicle formation in ovaries.

## CAUSE OF ABORTIONS IN ANGORA GOATS IN SOUTH AFRICA

*Case No. 18* (Path. No. 58876, Post mortem No. 35999, DOB. No. 5973)

*Description.*—Previous aborter slaughtered one day after aborting a two months old foetus.

### *Ovaries*

*Macroscopical appearance.*—Ovary (a) One medium and few small follicles. Ovary (b) One big, one small follicle and small pale corpus luteum.

*Histological examination of corpus luteum.*—Graafian follicle present; advanced regression of corpus luteum with connective tissue and arterioles prominent; very few functioning luteal cells remaining.

### *Hypophysis*

(a) *Acidophilic cells.*—Poorly stained and scattered; orange coloration probably washed out according to types of cells present; practically only intense dark staining nuclei present.

(b) *Basophilic cells.*—Prominent with tendency to reach active secretory phase in early stage of functional cycle.

*Conclusion.*—Advanced regression of corpus luteum with acidophilic cells tending towards quiescence and high activity of basophilic cells; pending ovulation.

## GROUP C.—CASES OF INTEREST

*Case No. 19* (Path. No. 58528, Spec. Book No. 1)

*Description.*—Old ewe that had aborted for three years in succession slaughtered due to a cancerous growth and in excellent condition; found to be four weeks pregnant with twins on post mortem.

### *Ovaries*

*Macroscopical appearance.*—Ovary (a) Few very small follicles and one big corpus luteum. Ovary (b) One medium and one small follicle and one big corpus luteum.

*Histological examination of corpus luteum.*—(a) Stroma indistinct and lutein cells well packed; nuclei mainly vesicular with cytoplasm clear, vacuolated and/or homogeneous; occasional pycnotic nuclei associated with intenser eosinophilic cytoplasm. (b) Stroma of corpus luteum more prominent; mitotic figures observed; more pycnotic nuclei associated with intenser eosinophilic cytoplasm present.

### *Hypophysis*

(a) *Acidophilic cells.*—Well packed around periphery, with mostly dark staining nuclei and small degranulated, orange-coloured cytoplasm; only a few acidophilic cells in central and small ventral area appear to be in the secretory phase, i.e. granules of a more red-staining nature and nuclei varying from vesicular to darker staining. The general impression is that the acidophilic cells were very active, but are now in a quiescent stage, especially peripherally.

(b) *Basophilic cells.*—More numerous centrally and ventrally; nucleus dark staining while cell is still large and tends to become darker staining and smaller as cytoplasm becomes smaller and more compact; some large cells present with vesicular nuclei; tendency for basophilic cells to reach active secretory phase in early stage of functional cycle.

*Conclusion.*—The early stage of regression of one corpus luteum, quiescence of acidophilic cells and activity of basophilic cells, and the history of the ewe, enhance the diagnosis of a pending abortion.

*Case No. 20* (Path. No. 58855, Spec. Book No. 9)

*Description.*—Eight tooth ewe in excellent condition, aborted four days before post mortem; no further history known.

### *Ovaries*

*Macroscopical appearance.*—Ovary (a) One medium/big and numerous small follicles. Ovary (b) Three medium and a number of small follicles; one red-coloured corpus luteum.

*Histological examination of corpus luteum.*—Connective tissue strands radially arranged; luteal cells closely packed, clearly outlined with a minimum amount of connective tissue in between; cytoplasm mainly finely vacuolated with vesicular nuclei; capillary vessels engorged; smaller theca lutein cells in comparison to larger granulosa lutein cells show up well.

*Hypophysis*

(a) *Acidophilic cells*.—Compact in appearance and relatively active.

(b) *Basophilic cells*.—Prominent and active.

*Conclusion*.—Newly formed young, active corpus luteum with basophilic cells having a slightly higher activity than acidophilic cells; this corresponds with the latest theories on the release of sex hormones from the anterior hypophysis. The basophilic cells, secreting follicle stimulating and luteinising hormones, cause follicular growth, ovulation and formation of the corpus luteum. Luteotrophic hormone, secreted by the acidophilic cells, is being secreted in increasing proportions to keep the corpus luteum in a functional state of activity during pregnancy.

*Case No. 21* (Hist. No. 582/58, Post mortem No. 34945, DOB. No. 6490)

*Description*.—Ewe with no previous abortion history used in transmission experiments; dosed and injected finely macerated foetal material on 4th July, 1958 and post-mortemed on 18th August, 1958 with a normally developed four months old foetus in the uterus.

*Ovaries*

*Macroscopical appearance*.—Ovary (a) Six small follicles. Ovary (b) Three small follicles and one large corpus luteum.

*Histological examination of corpus luteum*.—Stroma shows up prominently due to thick section; lutein cells closely packed with mainly vesicular nuclei; a few pycnotic nuclei also present; the cytoplasm shows the changes associated with the nuclei, i.e. mostly finely granulated and vacuolated.

*Hypophysis*

(a) *Acidophilic cells*.—Prominent and filling an acinus; cytoplasm distinctly granulated and mainly brick-red in appearance with vesicular nuclei; few nuclei showing condensation of chromatin and cytoplasm lighter coloured; other lighter coloured cells in early stage of cycle, i.e. cytoplasm small with only a few granules present and nuclei vesicular.

(b) *Basophilic cells*.—Relatively few in number and those present show normal activity.

*Conclusion*.—Pregnant ewe near kidding with an actively secreting corpus luteum; acidophilic cells show a higher activity than basophilic cells, although the main impression is that most of the alpha cells with vesicular nuclei are building up a reserve of luteotrophic hormone for milk secretion.