Onderstepoort J. Vet. Res (1966), 33 (1), 363–378
Printed in the Republic of S. Afr. by the Government Printer, Pretoria

THE HAEMATOLOGY OF THE ANGORA GOAT WITH SPECIAL REFERENCE TO THE HABITUAL ABORTER.

I. THE PREGNANT DOE

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Haematological changes occurring during gestation in the goat have become of material interest since Van Rensburg (1963, 1964) showed that some deviations were detectable between normal and aborting does. A mass of data on the blood of goats is available (Schalm, 1961; Dukes, 1955; Albritton, 1952; Hofferber & Dienemann, 1954; Hofferber & Scholz, 1953; Holman & Dew, 1963; Purushotham & Mahendar, 1963; Brown & De Wet, 1963), yet no systematic study in relation to gestation has been reported.

The occurrence of habitual abortion among Angora goats in South Africa has been investigated by Van Heerden (1961a, 1961b, 1963) who excluded infectious diseases as the cause. He described regressive changes in the acidophil cells of the pituitary at abortion, and concluded that gestational failure was due to failure of the mechanisms maintaining gestation. The work of Van Rensburg & Van Rensburg (1961) who established that the corpus luteum of the aborter ewe was in a more advanced stage of regression than at normal parturition, appears to support this view. Brown, Van Rensburg & Gray (1963) studied the urinary excretion of pregnanediol, and also suggested that abortion in the Angora was due to luteal failure. Subsequently Van Rensburg (1963, 1964) reported limited data on alterations of the blood leucocytes which could be a consequence of adrenal hyperfunction. Actual adrenal hyperplasia was demonstrated in aborter does, and this was associated with high quality mohair production.

In this work a detailed study of the haematological variations in normal and poor breeders throughout gestation was made with the object of investigating the feasibility and validity of using haematological parameters for identifying potential aborters. When does that usually abort are kept under favourable environmental and nutritional conditions, many complete normal gestation; such ewes were used in this study to obtain data on the full course of gestation from animals liable to abort.

Experimental Procedures

Twenty-nine mature Angora ewes were used. They were kept free of internal parasites by twice yearly drenching with Thiabenzole (Merck, Sharp and Dohme) and external parasites were controlled by dipping every six months.

Daily at 8 a.m. and 4 p.m. vasectomized rams were used for the detection of oestrus and hand service was practised with known fertile rams. Abortions were ascertained by twice daily inspection of the camp, and clinical examination of the ewes including vaginal inspection per speculum.

Every 14 days between 9 a.m. and 10 a.m. at the periods shown in Table 1, blood samples were collected from the external jugular veins of the experimental goats. Care was taken to limit handling and excitement as far as possible.

Haemoglobin was determined by the cyanmethaemoglobin method described by Crosby, Munn & Furth (1954). Blood films were prepared on microscope slides and stained with a 20 per cent buffered Giemsa solution for 25 minutes. Differential leucocyte counts were performed by counting 400 to 600 cells according to the method described by MacGregor, Richards & Loh (1940), and absolute eosinophile counts according to Pilot (1950).

The methods described by King & Wootten (1956) were used for plasma calcium and inorganic phosphorus, and blood sugar concentrations were determined by Lehman & Silk's (1952) modification of the Folin & Wu (1920) method. Clark's (1959) method was employed for plasma sodium and potassium concentrations. All colorimetric analyses were made with an E.E.L. photoelectric colorimeter.

Results

The differential distribution of leucocytes

No difference could be found between the total white blood cell counts of the pregnant aborter and the non-pregnant doe.

The mean differential and absolute eosinophil counts of normal, mature pregnant Angora ewes are compared with the corresponding data of known habitual aborters in Table 1.

TABLE 1.—*Differential leucocyte and total eosinophile counts of Angora does*

Gestation (weeks)	Differential Leucocyte Concentration %					
	Lymphocytes		Neutrophiles		Eosinophiles	
	Normal	Aborter	Normal	Aborter	Normal	Aborter
	%	%	%	%	%	%
−3	54±1	48±3*	39±2	46±2	4·2±·50	4·1±·94
3	52±2	40±2**	41±2	52±2*	5·5±·68	3·9±·82
5	47±2	42±3	44±2	50±2*	5·7±·69	3·5±·65
7	45±2	41±3	47±2	52±2*	4·1±·62	3·3±·62
9	46±2	40±2*	47±2	53±2*	4·07±·49	3·1±·66
11	45±2	41±2	47±2	52±1	3·9±·61	2·6±·27*
13	40±2	37±1	53±2	57±1	3·8±·60	3·0±·35
15	44±2	36±2**	49±2	58±2**	3·4±·52	2·0±·23*
17	47±2	36±2**	47±3	58±1**	3·08±·47	2·3±·35**
19	44±2	31±+2	47±2	63±+2	4·03±·55	2·0±·29**
21	36±1	33±2**	57±1	61±2*	2·78±·32	1·7±·23
3+	45±2	41±2**	45±2	50±2*	5·76±·60	5·0±·31

It is clear that the percentage neutrophils of the aborter group was consistently higher during pregnancy than in the normal controls. Similarly the lymphocytes proved to be lower, and these differences were more pronounced from the 13th to the 21st week of pregnancy.

Three weeks before conception the neutrophils of the control group comprised 39 per cent of the differential count. This value gradually increased during early gestation until it reached a first peak of 53 per cent at 13 weeks (Fig. 1). It then decreased to 46 at 17 weeks before it increased to the second peak of 57 at 21 weeks. By the 3rd week after parturition the neutrophil percentage had returned to 44.

The percentage of neutrophils of the aborters, on the other hand, increased linearly from 46 at three weeks before service to a single maximum of 63 at 19 weeks gestation. Although in the aborter the same rapid increase in the percentage of neutrophils occurred between 11 and 13 weeks, it did not return to a lower level, but continued increasing to a single peak of 63 at 19 weeks. In the post-parturient phase it decreased to 50 per cent at three weeks after partus.

The percentage lymphocytes varied inversely with the neutrophils during gestation (Fig. 1), and values for aborters were always lower than in the normal group.

The percentage eosinophils recorded during the test period approximated the curve of the absolute eosinophile count as graphically illustrated in Fig. 2. In the very early stages of gestation the percentage of eosinophils was at its maximum at about 5·5, which was similar to post partum levels. Between five to seven weeks it decreased rather rapidly, and thereafter more gradually to 3·08 per cent at 17 weeks. Two weeks prior to parturition an appreciable rise was recorded, which was followed by a decrease immediately prior to parturition. The total eosinophil count followed the same trend by decreasing from 190/mm^3 at five weeks, to 122/mm^3 at 21 weeks pregnancy with a slight increase to 132/mm^3 at 19 weeks.

TABLE 1.—*Differential leucocyte and total eosinophile counts of Angora does* (cont.)

Gestation (weeks)	Differential Leucocyte Concentration %					
	Monocytes		Basophiles		Eosinophile Count (per mm^3)	
	Normal	Aborter	Normal	Aborter	Normal	Aborter
	%	%	%	%		
–3	2·98±·30	2·1±·25	·09±·03	·19±·09	179±25	138±27*
3	3·11±·25	3·5±·34	·09±·03	·09±·04	174±24	94±28*
5	3·65±·25	4·2±·31	·10±·04	·10±·09	190±46	92±20*
7	3·58±·30	3·7±·34	·10±·03	·20±·05	138±35	60±17
9	3·18±·30	4·1±·29	·04±·02	·11±·09	174±45	75±$^{+}$13
11	3·49±·43	3·9±·26	·15±·06	·11±·06	124±19	73±11
13	3·30±·25	3·4±·20	·13±·65	·15±·09	139±32	60±16
15	3·91±·16	3·7±·32	·16±·06	·18±·04	135±28	53±17*
17	5·07±·37	3·6±·19	·15±·04	·17±·08	132±25	61±19*
19	3·84±·05	4·3±·27	·16±·06	·17±·06	132±25	63±9**
21	3·72±·07	4·9±·38	·04±·04	·07±·07	122±30	66±13*
3^{+}	3·64±·19	3·7±·23	·06±·04	·02±·02	198±31	124±21**

Means and S.D. of 18 normal and 11 aborter does
*Significantly (P<0·05) different from corresponding value of non-aborters
**Significantly (P<0·005) different from corresponding value of non-aborters
$^{+}$Significantly (P<0·002) different from corresponding value of non-aborters

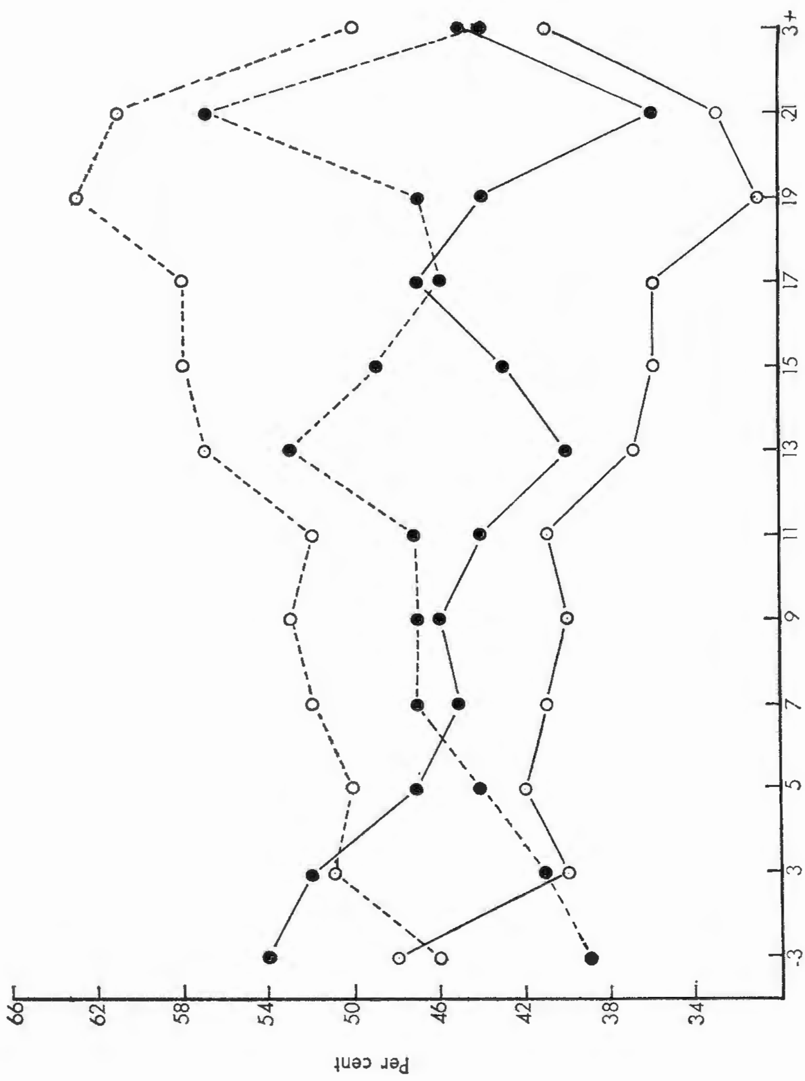

Fig. 1.—Changes in the differential distribution of lymphocytes: •——• normal does, 0——0 aborters, and neutrophils: •- - - -• normal does, o- - - -o aborters, during gestation

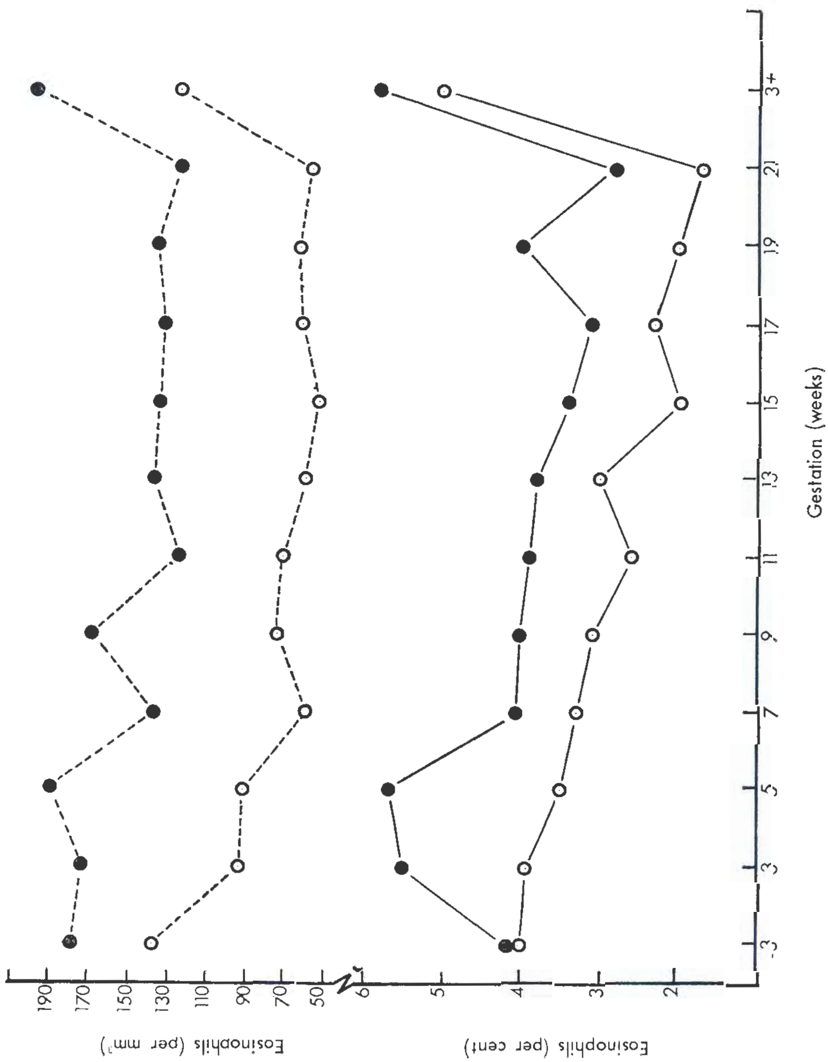

FIG. 2.—Changes in the differential distribution of eosinophils: • —— • normal does, o —— o aborters, and the total number of eosinophils per cubic millimeter: • - - - - • normal does, o - - - - o aborters, during gestation

Both the percentage of eosinophils and their absolute count per mm^3 were less in the aborters than in the controls. The percentage of eosinophils decreased from 3·9, and the total count from 94/mm^3, at three weeks pregnancy, to 1·7 and 66/mm^3 at 21 weeks respectively. There was also a slight increase in percentage and total count from the 15th to the 17th week, corresponding with the increase seen in the normal ewes. Many of these differences are statistically significant (Table 1).

There was a substantial variation in the percentage of monocytes within each group, but no significant differences were found between the groups during gestation. The percentage of monocytes remained fairly constant from conception to the 17th week with inconstant fluctuations between 3·2 and 4·2 for the two groups. From the 17th week the monocytes increased sharply to a maximum of 3·84 per cent at 19 weeks and 4·9 per cent at 21 weeks for normal ewes and aborters respectively. Three weeks after parturition these peaks returned to 3·7 per cent.

The basophils of both experimental groups remained low throughout gestation, varying from 0·04 to 0·20 per cent with no difference between the two groups.

Heart rate

The heart rate of control ewes and aborters is presented graphically in Fig. 3. It increased progressively from 105 and 102 per minute before pregnancy, to a maximum of 130 and 134 per minute at 21 weeks for non-aborters and aborters respectively. No significant differences were observed.

Leucocytic ranges and averages during pregnancy

The ranges for the differential leucocyte distribution in the normal, non-aborting and aborting Angora does for the period three weeks before service, during pregnancy and three weeks post-partum were (mean in parenthesis):

	Normal	*Aborter*
Neutrophils........................	39—53 (43)	46—63 (54)
Lymphocytes.......................	36—54 (47)	31—48 (39)
Monocytes..........................	2·98—5·1 (3·64)	2·1—4·9 (3·75)
Eosinophils.........................	2·78—5·76 (4·19)	1·7—5·0 (3·04)
Basophils...........................	0·04—0·16 (0·11)	0·02—0·20 (0·13)

Blood sugar

The blood levels of glucose in the aborters were higher than the sugar values for the normal animals at all stages of pregnancy and significantly so at 5, 7, 11, 15, 19 and 21 weeks. The blood glucose of the aborter group increased from 47 mg/100 ml at the third week of pregnancy to 56 mg/100 ml at the fifth week and remained elevated with moderate fluctuations up to the termination of pregnancy (Fig. 3). The blood sugar values of the control ewes followed a similar pattern albeit at a lower level, and reached a maximum concentration of 53 mg/100 ml at 21 weeks of gestation. The level of blood sugar in the normal ewes decreased from the 13th to the 17th week before rising as the animals approached parturition. This decrease coincided with a decrease in neutrophils, an increase in lymphocytes, an increase in plasma potassium and to a lesser extent, an increase in both the eosinophil percentage and total eosinophil count during the same stage of pregnancy.

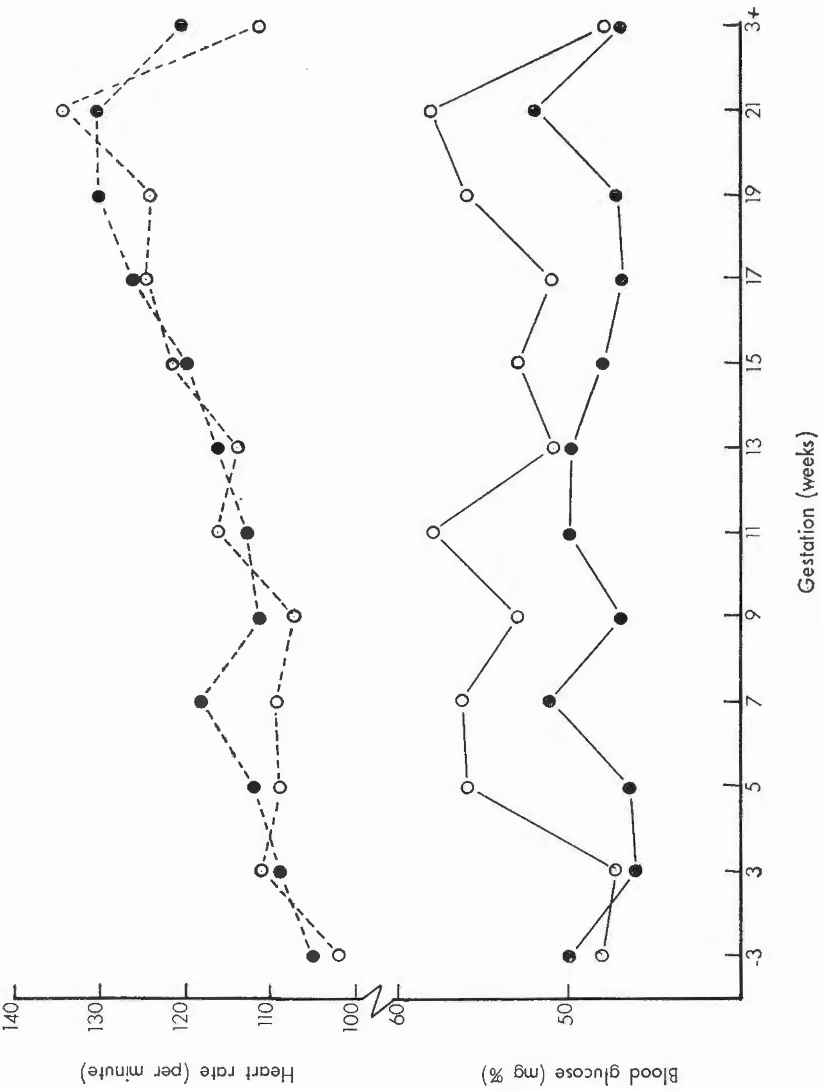

FIG. 3.—Changes in heart rate: · – – – · normal does, o – – – o aborters, and blood glucose concentrations: · ——— · normal does, o ——— o aborters, during gestation

TABLE 2.—*Plasma electrolytes, blood glucose and haemoglobin concentrations of Angora does*

Gestation (weeks)	Blood Glucose (mg%)		Sodium (m eq/l)		Potassium (m eq/l)	
	Normal	Aborter	Normal	Aborter	Normal	Aborter
–3	50·1±2	48±2	141±5	147±3	4·7±·17	4·6±·72
3	45·5±2	47±2	143±5	151±3*	4·8±·76	4·3±·15
5	46·2±1	56±2**	159±3	152±4	4·5±·22	4·4±·20
7	50·2±2	56±2*	154±4	156±4	4·2±·05	4·0±·05
9	47·4±2	53*±2	143±4	161±3*	4·1±·15	4·2±·61
11	49·8±2	58±3*	149±4	158±4	4·4±·21	4·0±·06
13	50·8±2	51±2	153±5	158±2	4·1±·06	4·0±·10
15	48·0±2	53±*2	160±3	168±5**	4·2±·16	3·2±·17
17	47·0±2	51±2	154±3	164±4+	4·5±·18	3·8±·07**
19	47·0±2	56+±2	154±4	156±4	4·6±·19	3·9±·06*
21	53·0±2	58+±3	153±2	165±5**	4·3±·21	4·1±·17
3+	47·0±2	48±2	141±2	154±2	4·7±·18	4·3±·05

Means and S.D. of 18 normal and 11 aborter does
*Significantly (P<o ·05) different from corresponding value of non-aborters
**Significantly (P<o ·005) different from corresponding value of non-aborters
+Significantly (P<o ·002) different from corresponding value of non-aborters

TABLE 2.—*Plasma electrolytes, blood glucose and haemoglobin concentrations of Angora does* (cont.)

Gestation (weeks)	Calcium (m eq/l)		Phosphorus (mg %)		Haemoglobin (gm %)	
	Normal	Aborter	Normal	Aborter	Normal	Aborter
–3	10·0±·14	9·7±·12	5·5±·15	5·4±·15	9·6±·17	9·7±·24
3	9·9±·24	9·5±·17	5·6±·18	5·1±·17	10·1±·24	9·7±·18
5	9·4±·19	9·7±·28	5·4±·16	5·7±·18	9·6±·31	10·7±·21
7	9·8±·18	9·6±·26	5·4±·16	5·5±·14	9·9±·18	10·1±·19
9	9·6±·32	9·6±·30	5·5±·15	5·6±·17	9·9±·14	9·5±·15
11	9·9±·21	9·4±·18	5·5±·15	5·7±·21	10·0±·18	10·2±·23
13	9·8±·19	9·9±·17	5·6±·17	5·6±·08	9·9±·19	10·1±·16
15	9·8±·21	9·9±·19	5·6±·14	5·4±·23	10·0±·26	9·8±·24
17	9·7±·25	10·0±·27	5·7±·15	5·7±·19	10·2±·25	9·9±·17
19	9·6±·25	10·0±·21	5·4±·16	5·5±·21	10·3±·18	10·1±·17
21	9·7±·19	9·9±·19	5·6±·13	5·1±·14	10·3±·21	10·25±·19
3+	9·4±·19	9·8±·16	5·4±·19	5·3±·21	9·8±·18	9·9±·21

Means and S.D. of 18 normal and 11 aborter does
*Significantly (P<0·05) different from corresponding value of non-aborters
**Significantly (P<0·005) different from corresponding value of non-aborters
+Significantly (P<0·002) different from corresponding value of non-aborters

Plasma electrolyte levels

Sodium: The plasma sodium concentration increased during gestation in both groups, but the sodium values of the aborters were higher than that of the non-aborters, with the exception of the fifth week. In the aborters the sodium values increased steadily to a significantly higher value of 161 m eq/l at nine weeks, which was followed by maximal values in both groups at 15 weeks (Table 2, Fig. 4). The aborter group then showed an appreciable decrease before increasing again to 165 m eq/l at 21 weeks pregnancy.

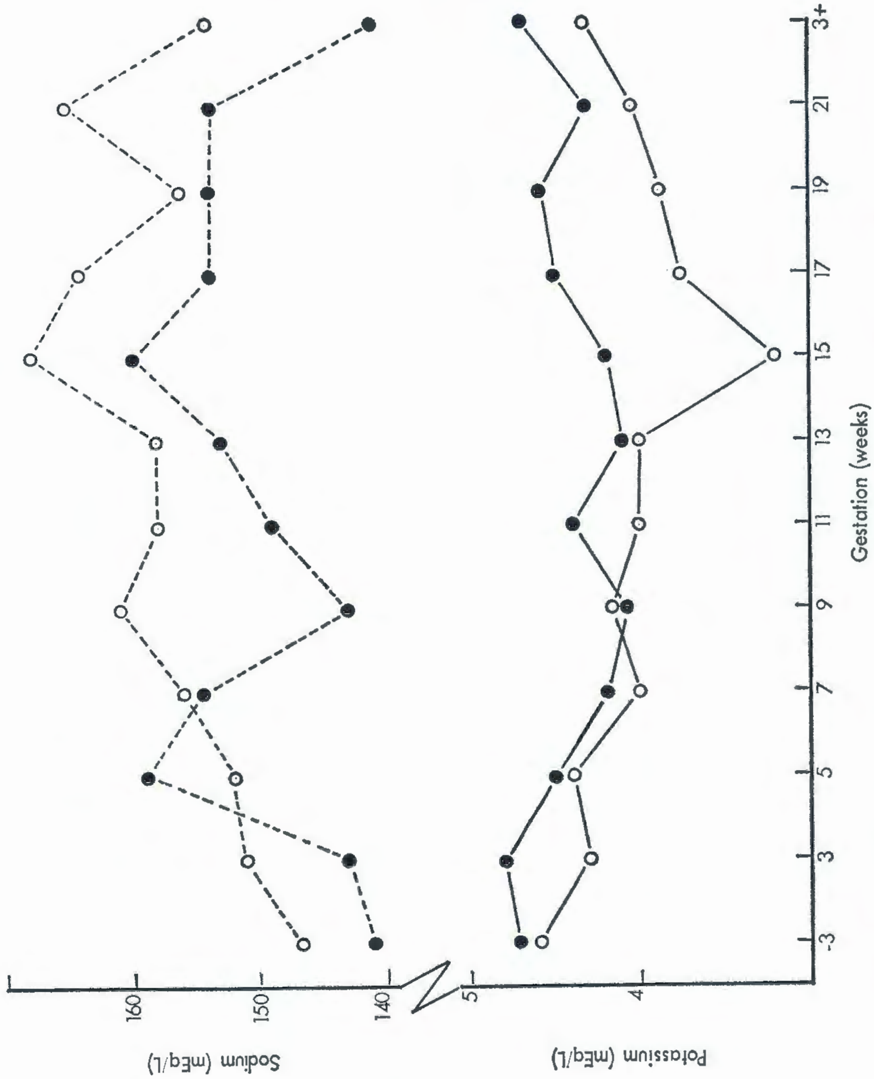

FIG. 4.—Concentration of sodium: · - - - - · normal does, o - - - - o aborters, and potassium: · ——— · normal does, o——o aborters, in the plasma during gestation

Potassium: The potassium levels of the normal ewes decreased during the first nine weeks of gestation, and rose again to a mean of 4·6 m eq/l at 19 weeks before falling to a somewhat lower value of 4·3 m eq/l at 21 weeks pregnancy.

The potassium values of the aborter ewes fluctuated appreciably more than the values for the controls. They were generally lower that the non-aborters' values. After 13 weeks gestation the potassium decreased from 4·0 m eq/l to a significantly lower concentration of 3·2 m eq/l at 15 weeks. After the rather sharp decline the potassium values continued to increase slowly in the same way as the controls, but never reached the same levels as the normal does.

Calcium: The concentrations of plasma calcium varied substantially in both groups, but in general the level of phosphorus and calcium never deviated to a large degree from those values obtained before and after gestation. The concentration of calcium was 10·0 and 9·7 mg per 100 ml plasma for controls and aborters respectively at three weeks gestation, and 9·4 and 9·8 mg per 100 ml for the same groups three weeks after parturition. There were no significant differences between the calcium levels of the two groups at any stage of gestation.

Inorganic phosphorus: The phosphorus levels were 5·5 and 5·4 mg per 100 ml for the controls and aborters respectively three weeks before conception, and 5·4 and 5·3 mg per 100 ml for the two groups three weeks after partus, with some variation without any set pattern during pregnancy, and no differences between the two groups.

Haemoglobin: The variation in haemoglobin values were appreciable during the first two weeks of pregnancy. The haemoglobin of the normal does increased from 9·6 gm per 100 ml blood at five weeks to 10·3 gm at 21 weeks gestation, and decreased to 9·8 gm three weeks after parturition. The haemoglobin of the aborters at first decreased from 10·2 gm per 100 ml blood at eleven weeks subsequently increasing to 10·2 gm at 21 weeks gestation. This concentration decreased to 9·9 gm at 21 weeks after parturition. Although the haemoglobin values of the aborters tended to be lower than that of the normal ewes for the last six weeks of pregnancy, it was found not to be significant.

Discussion

All the ranges of the leucocyte differential counts during pregnancy for both groups fall within the wide range of percentages reported for the two-year-old female goat by Holman & Dew (1963).

The overall mean lymphocyte percentage of the normal doe during pregnancy is in accordance with the data of Fish (1926), as quoted by Schalm (1961), but the percentage of lymphocytes and eosinophils found in this study are lower and the neutrophils higher than the results of Kobanawa, Wintrobe & Wirth (cited by Schalm, 1961). According to our observations the percentages of eosinophils, monocytes and neutrophils are less, and the lymphocytes lower than the figures submitted by Hofferber & Scholz (1953) for adult female goats.

The mean differential leucocyte count of the aborter does during pregnancy is only comparable to the blood picture of the parturient female (Moberg, 1955), but confirms the observations of Van Rensburg (1964) on similar goats.

The total eosinophil counts for both normal and aborter animals are lower than previously described for the goat (Schalm, 1961; Brown & De Wet, 1963).

The overall mean of the haemoglobin concentration in the blood of the pregnant Angora does was 10·00 gm per 100 ml blood, with a range of 9·6 to 10·3. This value is compared to the haemoglobin concentrations of normal goat ewes by various authors in Table 3.

TABLE 3.—*Haemoglobin values reported for the goat*

Author	No. of Animals	Haemoglobin (gm/100 cc blood)
Marhoff (1919)*	1	8·5
Schwartz (1923)*	9	9·8
Welsch (1923)*	10	10·86
Ranitovic (1925)*	70	9·7
Will (1933)*	8	11·5
Mann (1935)*	17	10·0
Abderhalden (1942)*	1	11·3
Murty & Kehar (1951)	30	6·7
Bettin (1952)*	120	10·7
Schalm (1961)	—	11·0
Brown & De Wet (1963)	6	9·03
Holman & Dew (1963)	62	11·09

*Cited by Hofferber & Dienemann (1953)

The tendency of the haemoglobin values to increase in the latter part of gestation agrees with results obtained with sheep (Ullrey, Miller, Long & Vincent, 1965a.)

The mean value for blood glucose of the normal goat during the period prior to gestation, during gestation and immediately afterwards is 48·5 mg per 100 ml, whilst the concentration for the aborter doe over the same period was 53 mg. The values for both aborter and normal does are higher than the results of Brown & De Wet (1963). It falls in the range of 45 to 60 mg quoted by Dukes (1955), but is considerably lower than the means of 81·4 and 82 mg submitted by Murty & Kehar (1951) and Robinson & Wilber (1956) respectively.

The average concentration of plasma sodium and potassium during the test period was 150 and 158 m eq/l sodium and 4·4 and 4·1 m eq/l potassium for normal and aborter animals respectively. The sodium values are higher in both groups than those reported by Brown & De Wet (1963) and Walker & Dziemann (1950), while the potassium concentrations were lower. The levels of both these plasma electrolytes are well outside the averages given by Albritton (1952).

The plasma calcium values compare well with the results of Marck-Mocsy (1951) Mazzocco (1921) and Hutyra-Marek & Manninger (1945), but proved to be lower than the figures of Gowda (1954) and Hofferber & Dienemann (1954), and higher than the results of Ssobkewitsch (1925). The plasma inorganic phosphorus is lower than that of Gowda (1954), Petr (1928) and Marck-Mocsy (1951) higher than the figures of Brown & De Wet (1963). It compares well with Hutyra-Marek & Manninger (1954) and Hofferber & Dienemann (1954), who quoted the authors above.

It is well known that an elevation of adrenocortical hormones produce lymphocytopaenia, neutrophilia and eosinopenia (Valentine, Cradock & Lawrence, 1948) in addition to hyperglycaemia, a decrease in the plasma potassium, and an increase in the sodium values (Sayers, 1950; Soffer, Dorfman & Gabrilove, 1961). Although the adrenal cortex is an important factor influencing certain cellular and chemical constituents of the blood, it is not the only one. If the concentrations of these components are determined with the object of establishing the degree of adrenal activity, it must be borne in mind that it is only an indirect assessment of adrenal function. However, it may provide a firm indication of cortical function if the levels of all the constituents of the blood influenced by the adrenal be considered. These haematological changes could therefore provide additional support to other more direct criteria of adrenal function, such as hormonal determinations.

Considerable physiological disturbances are present during pregnancy, and especially at parturition. It has been established that the activity of the adrenal increases as term approaches, (Cassano, Torantino & Ciampolini, 1958; Saba, 1965) and this activity is reflected in the chemical components of the blood and blood picture of the female. This could be interpreted as part of the general adaptation syndrome (Selye, 1950). Various researchers have described this blood picture in a number of species before, during and after parturition (Kerr, Robertson & McGirr, 1951; Straub, Schalm, Hughes & Theiler, 1954; Merrill & Smith, 1954; Hofferber & Dienemann, 1953; Moberg, 1955).

The same manifestations of the stress syndrome were observed in both groups of Angora does during the parturient period. A decrease in activity occurred, as reflected by the blood analyses, before the increased activity of the adrenal in the parturient normal doe. This started at approximately 13 weeks gestation. The decline in activity was evidenced by a decrease of blood sugar from a concentration of 50·8 mg per 100 ml at 13 weeks to 47 mg at 17 weeks ($P < 0{\cdot}05$), before an increase to 53 mg at 21 weeks ($P < 0{\cdot}05$). The decrease in blood sugar coincided with a decrease in the percentage neutrophils (from 53 per cent at 13 weeks to 47 at 17 weeks, ($P < 0{\cdot}05$), an increase in lymphocytes (from 40 per cent at 13 weeks to 47 at 17 weeks, $P < 0{\cdot}05$) an increase of plasma potassium (from 4·1 at 13 weeks to 4·6 at 19 weeks) and a decrease in plasma sodium (from 160 m eq/l at 15 weeks to 154 m eq/l at 17 weeks). The aborter animals exhibited the same pattern at the same stage of gestation with a significant decrease ($P < 0{\cdot}05$) of blood glucose at 11 weeks, and this lower concentration was maintained until the glucose rose again at 17 weeks gestation. At 15 weeks the concentration of glucose was low, the plasma sodium content decreased, accompanied by a decrease of potassium, an increase in the percentage of eosinophils and total eosinophils. These differences in concentration were not significant due to variation of the values, and the percentage neutrophils and lymphocytes at no stage indicated any decline in adrenal activity. It could thus be assumed that, if blood analyses could be employed to assess adrenal activity, there was a decrease of adrenal function starting at 13 weeks gestation in the control does with the same, but less significant, trend in the aborter. On this evidence it appears that the prepartum decrease of adrenal activity occurs earlier in the goat than the drop in cortisol levels exhibited by sheep (Saba, 1965) 14 days pre-partum.

If the haematological analyses were employed as a criterion of adrenal activity, it would be evident from the results of this investigation that the adrenal activity is higher in the aborter ewes than the controls throughout pregnancy, and the differences between the various cellular and chemical components of the blood of aborter and control ewes are most significant from approximately the 13th week of gestation to term. Significant differences in decreasing order were found in the differential white blood cell count, blood glucose, plasma sodium and potassium content.

It was previously stated that the group of ewes designated as " aborters " are animals which had aborted the season prior to or aborted the season after this investigation. The haematology of two does which aborted in the course of this study was identical to the " aborter " group except that the neutrophilia, lymphocytopenia, eosinopaenia and differences in the chemical constituents of the plasma, as affected by elevated adrenal cortical hormone levels, were more pronounced. Their data are not included in the aborter group due to the incomplete period of gestation and their small number.

These haematological indications of a hyperactivity of the adrenals support the results of Van Rensburg, (1964, 1965) who reported hyperplastic adrenals and high cortisol values in the plasma of the aborter ewes.

Summary

The differential leucocyte count, total eosinophil count, blood sugar, plasma sodium, potassium, calcium, inorganic phosphorus and haemoglobin concentrations of the blood of 18 normal and 11 habitual aborter Angora does were studied during pregnancy. The results were compared with the existing information on the goat. It was found that the percentage lymphocytes of the normal does increased during gestation with a concomitant decrease in neutrophils, eosinophils and plasma potassium, and an increase of plasma sodium and blood glucose values. These variations in the normal constituents of the blood and plasma were attributed to the influence of the hormones of the adrenal cortex, which exhibited maximal function in the parturient female. A decline of adrenal function after 13 weeks gestation appeared to precede parturient elevation. It thus appears that the pre-partum decline of adrenal function occurs earlier in gestation of the goat than the drop of cortisol levels demonstrated 14 days pre-partum in sheep.

Significant differences in the haematology between aborter does and the controls were observed. The percentage neutrophils was found to be higher and the lymphocytes and eosinophils lower than the controls at all stages of gestation. Similarly the values for blood glucose and plasma sodium were higher and plasma potassium lower than the corresponding values of the normal doe. These differences support the concept that adrenal hyperfunction may be intimately associated with gestational failure in goats, and these procedures can be useful in detecting animals liable to abort.

Acknowledgements

The author owes a special debt of gratitude to Dr. S. J. van Rensburg who gave invaluable guidance and attention to this work and the preparation of the manuscript.

References

ALBRITTON, E. C., 1952. Standard values in blood. Philadelphia: W. B. Saunders & Co.

BROWN, J. M. M. & DE WET, P. J., 1963. Chemical studies on blood and tissues from Angora goats carrying to normal term and from habitually-aborting animals. *Onderstepoort J. Vet. Res.* 30 (2), 169–178.

BROWN, J. M. M., VAN RENSBURG, S. J. & GRAY, R., 1963. The urinary excretion of 5B–Pregnane–α: 20α–Diol and gestational failure in Angora goats. *Onderstepoort J. Vet. Res.* 30 (2), 179–189.

CASSANO, F., TARANTINO, C. & CIAMPOLINI, C., 1958. The function of the adrenal cortex in normal pregnancy. *Endocrinoology* 35 (5), 301–317.

CLARK, R., 1959. A study of the plasma sodium and potassium levels in normal Merino sheep. *Onderstepoort J. Vet. Res.* 28 (2), 229–236.

CROSBY, W. H., MUNN, J. I. & FURTH, F. W., 1954. Standardizing a method for clinical hemoglobinometry. *U.S. Armed Forces Med. J.* 5, 693.

DUKES, H. H., 1955. The physiology of domestic Animals (7th ed.) Ithaca, New York: Cornell University Press.

FISH, P. A. & HAYDEN, C. E., 1926. A comparison of the blood of a normal and two castrated billy goats. *Cornell Vet.*, 6, 82.

FOLIN & WU (1920) Quoted by Lehman & Silk (1952).

GOWDA, H. S. L., 1954. Seasonal variation of serum calcium, magnesium and inorganic phosphorus in sheep, buffaloes and goats. *Indian Vet. J.* 30, 366–371.

HOFFERBER, O. & DIENEMANN, R., 1954. Der Gehalt des Blutserums klinisch gesunder Ziegen an Kalzium, Phosphor und Magnesium. *Mh. Vet. Med.* 8, 428–431.

HOFFERBER, O. & SCHOLZ I., 1953. Blutbild bei gesunden und kranken Ziegen. *Mh. Vet. Med.* 8, 243–248, 272–274.

HOLMAN, H. H. & DEW, S. M., 1963. The blood picture of the goat. I–The two-year-old female goat. *Res. Vet. Sci.* 4, 121–130.

KERR, W. R., ROBERTSON, M. & McGIRR, J. C., 1951. A study of the reaction of the white blood corpuscles in bovines at partus, with a consideration of the action of the adrenal cortical hormone cortisone. *J. Hyg.* 49, 67–80.

KING, E. J. & WOOTTON, I.D.P. 1956. Microanalysis in Medical Biochemistry. 3rd. ed. London: J. & H. Churchill, Ltd.

LEHMAN, H. & SILK, E., 1952. The prevention of colour fading in the Folin and Wu stimulation of blood sugar. *Biochem. J.* 50, XXXI.

MACGREGOR, R. G. S., RICHARDS, W. & LOH, G. L., 1940. The differential leucocyte count. *J. Pathol.* 51, 337.

MERRILL, W. G. & SMITH, V. R., 1954. A comparison of some cellular and chemical constituents of blood at time of partus and after administration of A.C.T.H. *J. Dairy Sci.* 37, 546–550.

MOBERG, R., 1955. The white blood picture in sexually mature female cattle with special reference to sexual conditions. A clinical and experimental study. Thesis. Stockholm, Sweden.

MURTY, V. N. & KEHAR, N. D., 1951. Physiological studies on the blood of domestic animals. Pt. II—Goats. *Indian J. Physiol. and Allied Sciences* 5, 71–78.

PILOT, M. L., 1950. Use of base in fluids for counting eosinophils. *Amer. J. Clin. Path.* 20, 870.

PURUSHOTHAM, N. P. & MAHENDAR, M. A., 1963. A note on the comparative study of the blood picture in domestic animals. *Indian Vet. J.* 40, 553–558.

ROBINSON, P. F. & WILBER, C. G., 1956. Effect of atropine and glucose metabolism in goats. *Amer. J. Phys.* 181, 481–483.

SABA, N., 1965. Plasma cortisol levels in pregnant ewes. *J. Agric. Sci.* 64, 11–14.

SAYERS, G., 1950. The adrenal cortex and homeostasis. *Physiol. Rev.* 30, 241–307.

SCHALM, O. W., 1961. Veterinary Hematology. Philadelphia, Pa.: Lea and Febiger.

SELYE, H., 1950. The physiology and pathology of exposure to stress. Montreal: Acta, Inc.

SOFFER, L. J., DORFMAN, R. I. & GABRILOVE, J. L., 1961. The Human Adrenal gland. Philadelphia, Pa.; Lea and Febiger.

STRAUB, O. C., SCHALM, O. W., HUGHES, J. P. & THEILER, G. H., 1959. Bovine Hematology. II. Effect of parturition and retention of fetal membranes on blood morphology. *J. Amer. Vet Med. Ass.* 135, 618.

ULLREY, D. E., MILLER, E. R., LONG, C. H. & VINCENT, B. H., 1965a. Sheep haematology from birth to maturity. I. Erythrocyte population, size and hemoglobin concentration. *J. Animal Sci.* 24, 135–140.

ULLREY, D. E., MILLER, E. R., LONG, C. H. & VINCENT, B. H., 1965b. Sheep hematology from birth to maturity. II. Leucocyte concentration and differential distribution. *J. Animal Sci.* 24, 141–144.

VALENTINE, W. N., CRADOCK, C. G. & LAWRENCE, J. S., 1948. Relation of adrenal cortical hormones to lymphoid tissue and lymphocytes. *Blood* 3, 729–754.

VAN HEERDEN, K. M., 1961a. Luteal failure as a cause of abortion in Angora goats in South Africa. *Proc. IVth Int. Congr. Anim. Reprod.* 486–589.

VAN HEERDEN, K. M., 1961b. Investigation into the cause of abortion in Angora goats in South Africa. *J. S. Afr. Vet. Med. Ass.* 32, 211.

VAN HEERDEN, K. M., 1963. Investigations into the cause of abortions in Angora goats in South Africa. *Onderstepoort J. Vet. Res.* 30, 23–84.

VAN RENSBURG, S. W. J. & VAN RENSBURG, S. J., 1961. Regression of the corpus luteum graviditatis in Angora ewes. *Proc. IVth Int. Congr. Anim. Reprod.* 597–600.

VAN RENSBURG, S. J., 1963. Endocrinological aspects of habitually aborting Angora-goat ewes. *S. Afr. Med. J.* 37, 1114–1115.

VAN RENSBURG, S. J., 1964. Possible endocrine mechanisms in gestational failure. *Proc. Vth Int. Congr. Anim. Reprod. and A.I.* 3, 375–378.

VAN RENSBURG, S. J., 1965. Adrenal function and fertility. *J. S. Afr. Vet. Med. Ass.* 36, 491–500.

WALKER, J. & DZIEMAN, A. J., 1950. Biochemical and physiological data on the normal goat. *Med. Division Res. Report No.* 31, *Army Chemical Centre, U.S.A.*