Onderstepoort Journal of Veterinary Science and Animal Industry, Volume 8, Number 2, April, 1937.

Printed in the Union of South Africa by the Government Printer, Pretoria.

Chemical Blood Studies.

VII.—A Serial Study over a 12 months Period of some Organic and Inorganic Constituents in "Laked" and "Unlaked" Blood Filtrates of Healthy Bovines between 15 and 27 months old.

By P. J. HAMERSMA, Section of Chemical Pathology, Onderstepoort.

INTRODUCTION.

THIS article is a continuation of the work done by Graf (1933) and Hamersma (1934) on various domestic animals under stated conditions, both normal and pathological. It was pointed out that many of the figures recorded in the literature were of little value since they were often obtained from a small number of animals examined only a few times or from larger numbers but examined only once (slaughter house specimens) and that as a rule little information as regards breed, diet, environment, etc., was given.

The main purpose of the data here presented is, therefore, to give such figures for healthy cattle under stated conditions as will provide a comparative basis for pathological work. The following constituents have been determined: haemoglobin (Hb), total nitrogen (T.N.), sugar (S.), non-protein nitrogen (N.P.H.), urea nitrogen (U.N.), " total " creatinine nitrogen (T.C.N.), uric acid nitrogen (U.A.N.), and amino acid nitrogen (A.A.N.). In view of the facilities offered by the experiment, it was decided to determine also a number of inorganic constituents such as: Chlorine(Cl), Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca), Inorganic Phosphorus (P) and Iron (Fe). Cholesterol was also determined but the figures obtained were very variable and inaccurate judging from duplicate results. It was therefore decided to omit the cholesterol data and to present figures for the lipoid constituents of bovine blood at a later date.

Nine animals of different sexes, age from 15 to 27 months, were included in the experiment and kept on the rations for 2 months before the analyses were started. The analyses were done 18 times over a period of 12 months (August, 1933-July, 1934). The original plan was to do the analyses fortnightly but this proved to be impossible.

TECHNIQUE.

(*a*) RATION AND ENVIRONMENT.

The animals were arranged in three groups, each group being placed on a different ration as follows:—

Group A.—B. 4528, 5146,5184.*

Dry Grass (24 lb. per day).

Crushed Mealies (3 lb. per day).

Silage (30 lb. per day).

Salt ($\frac{1}{2}$ ounce per day).

Blood meal ($\frac{1}{2}$ lb. per day).

Bonemeal ($1\frac{2}{3}$ ounce per day).

Group B.—B. 4548, 4607, 4654.

Dry Grass (24 lb. per day).
Crushed Mealies (3 lb. per day).
Green Fodder (30 lb. per day) (only fed in December).
Salt ($\frac{1}{2}$ ounce per day).
Blood meal ($\frac{1}{2}$ lb. per day).
Bonemeal ($1\frac{2}{3}$ ounce per day).

Group C.—B. 4626, 4667, 4533.*

Dry Grass (24 lb. per day).
Crushed Mealies (3 lb. per day).
Salt ($\frac{1}{2}$ ounce per day).
Blood meal ($\frac{1}{2}$ lb. per day).
Bonemeal ($1\frac{2}{3}$ ounce per day).

As the first 10 months of 1933 represented one of the driest periods Onderstepoort has ever experienced, we could not feed these rations as regularly as we would have liked to. For only one month green fodder was available. The silage was fed during the whole period. Finally, when the experiment was concluded, the differences between the results of the three groups were so insignificant that it was decided to take the seven animals that survived as being in one group. However, we give the numbers of the animals in the three groups with their rations and from Tables 2 and 4-23 any individual differences can be noted.

The dry grass, green fodder and silage were given early in the morning (7 a.m.) and the mixture of crushed mealies, salt, bonemeal and blood meal at 2 o'clock in the afternoon.

These three groups were kept in three different kraals next to each other, each kraal having its own stable which was always left open. The animals in the same group were not separated from one another.

The bovines were all in a fine condition when the analyses were commenced (see weights of each animal under History of Experimental Animals).

(*b*) History of Experimental Animals.

D.O.B. 5146. *Heifer. Age:* 16 *months. Born* 4.4.32.

Negative for tuberculosis (22.5.33).

Weight: 13. 6.33—625 lb.
23. 9.33—725 lb.
23.12.33—730 lb.
23. 1.34—720 lb.
21. 3.34—765 lb.

* These two animals died of anthrax during the experiment and none of their data has been included. Their loss is regrettable because the remaining two animals of each respective group cannot be regarded as really representative for ration-group purposes.

D.O.B. 4528. *Ox. Age:* 27 *months. Born* 12.5.31.

Previous to inclusion in this experiment had been immunised against Anthrax, Black Quarter and Redwater. Proved to be negative for tuberculosis. Had been in metabolism experiments (Ca,P).

Weight: 13. 6.33—555 lb.
23. 9.33—665 lb.
23.12.33—740 lb.
23. 1.34—740 lb.
21. 3.34—785 lb.

D.0B. 4548. *Ox. Age:* 26 *months. Born* 10.6.31.

Metabolism experiments. Immunised against Anthrax, Black Quarter and Redwater. Negative for tuberculosis.

Weight: 13. 6.33—565 lb.
23. 9.33—703 lb.
23.12.33—706 lb.
23. 1.34—706 lb.
21. 3.34—635 lb.

D.O.B. 4607. *Heifer. Age:* 24 *months. Born* 20.7.31.

Immunised against Anthrax, Black Quarter, negative for Tuberculosis. Utilised in Theileria and Anaplasmosis Experiments.

Weight: 13. 6.33—620 lb.
23. 9.33—640 lb.
23.12.33—670 lb.
23. 1.34—671 lb.
21. 3.34—640 lb.

D.O.B. 4654. *Heifer. Age:* 22 *months. Born* 1.10.31.

Negative for tuberculosis.

Weight: 13. 6.33—450 lb.
23. 9.33—495 lb.
23.12.33—500 lb.
23. 1.34—502 lb.
21. 3.34—520 lb.

D.O.B. 4626. *Heifer. Age:* 23 *months. Born* 15.9.31.

Negative for tuberculosis.

Weight: 13. 6.33—550 lb.
23. 9.33—620 lb.
23.12.33—705 lb.
23. 1.34—700 lb.
21. 3.34—700 lb.

D.O.B. 4667. *Heifer. Age:* 21 *months. Born* 13.11.31.

Negative for tuberculosis and contagious abortion.

Weight: 13. 6.33—430 lb.
23. 9.33—435 lb.
23.12.33—465 lb.
23. 1.34—465 lb.
21. 3.34—550 lb.

(*c*) Methods of Analysis.

The methods utilized, except those for chlorine and the mineral constituents (sodium, potassium, magnesium, calcium, phosphorus and iron) have been described fully in the first paper of this series. (Chemical Blood Studies I. See under References.) It must be stated here, however, that the N.P.N. method was found not to be very satisfactory in our hands as duplicates did not always correspond too closely, especially when done a few hours or a day afterwards. This was found more particularly in the case of the " unlaked " filtrates.

The rest nitrogen was calculated by subtracting the sum of urea nitrogen, amino acid nitrogen, uric acid nitrogen, and the " total " creatinine nitrogen from the respective non-protein nitrogen. The figures for rest nitrogen are thus obviously not absolute but are influenced by the limits of experimental error of the various fractions.

For the elements mentioned above, except iron, a tri-chloroacetic acid filtrate was used. Chlorine was determined by adding excess silver nitrate to an aliquot and titrating the excess back with potassium thiocyanate, using ferro-alum as indicator.

For sodium, potassium, magnesium, calcium and inorganic phosphorus the methods described by Malan and van der Lingen (1931) were used. In some cases small deviations from these methods were found advisable. In the case of sodium the supernatant fluid was not syphoned, but poured off. Further the potassium precipitate was washed twice with a mixture of acetone and water (1 : 3) the third washing being with acetone alone. Magnesium was determined in the same aliquot as the calcium after this had been removed by precipitation as oxalate. The oxalate was dissolved by weak hydrochloric acid and the calcium determined as described in the above method.

Iron was determined by Wong's method as given by Hawk and Bergein (1931).

(*d*) Arrangement of Experimental Data.

The figures have been tabulated giving averages for each month (Tables 1 and 4-23) and for each individual animal (Table 2) as well as the means minimum and maximum values, etc. (Table 3).

The " laked " figures have been statistically analysed but not so the " unlaked ". The discussion of the separate tables, viz., from 6-16, is therefore only strictly applicable to the " laked " figures but as these are usually only proportionately higher than the " unlaked " such a statistical analysis was not considered necessary for the latter. Such findings would not differ appreciably from those of the " laked " figures.

As regards the other constituents, viz., the minerals and haemoglobin, these have also been statistically analysed.

A comparison with the results of other workers is included as far as such figures could be obtained.

The following abbreviations have been used both in the tables and in the text:—

L. and l.—" laked ".
U. and u.—" unlaked ".
S.—sugar.
Hb.—Haemoglobin.
T.N.—total nitrogen.
N.P.N.—non-protein nitrogen.
U.N.—urea nitrogen.
" T."C.N.—" total " creatinine nitrogen.
U.A.N.—uric acid nitrogen.
A.A.N.—amino acid nitrogen.
R.N.—rest nitrogen.
av.—average.
no.—number.
detms.—determinations.
diff.—difference.
an.—analyses.

EXPERIMENTAL DATA.

Tables 1-23 and Discussion.

Bovine No. 5146. Heifer.
,, 4528. Ox.
,, 4548. Ox.
,, 4607. Heifer.
,, 4654. Heifer.
,, 4626. Heifer.
,, 4667. Heifer.

TABLE 1.

Table of Averages (7 Animals) for each Month.

	1933.					1934.						
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
Hb. gm. per 100 cc....	13·64	13·80	13·17	13·68	13·40	13·99	13·11	12·17	12·04	12·41	13·59	12·56
T.N. gm. per 100 cc....	3·014	3·098	2·912	2·916	2·890	2·940	2·727	2·714	2·643	2·665	2·719	2·635
Sugar mgm. per cent.												
L.....	55·5	54·8	59·4	55·4	67·8	60·8	57·3	59·1	64·7	55·1	54·6	53·8
U.....	50·5	48·0	50·4	48·1	54·0	52·4	46·4	52·3	47·8	45·0	49·5	45·0
N.P.N. mgm. per cent.												
L.....	19·8	19·0	21·2	23·3	30·0	18·4	22·3	20·7	17·2	20·4	20·9	20·3
U.....	12·3	13·2	15·2	15·8	20·9	12·1	13·2	13·6	11·9	13·2	14·2	14·0
Urea N. mgm. per cent.												
L.....	4·8	5·4	5·1	5·5	10·1	5·6	7·0	4·5	3·4	6·0	5·0	6·5
T.C.M. mgm. per cent.												
L.....	2·31	2·30	2·43	2·63	2·16	2·46	2·57	2·47	2·44	2·51	2·46	2·54
U.....	1·95	1·88	2·08	2·22	1·97	2·10	2·28	2·19	2·48	2·18	2·10	2·16
U.A.N. mgm. per cent.												
L.....	0·62	0·53	0·51	0·58	0·45	0·59	0·43	0·37	0·53	·036	0·45	0·45
U.....	0·12	0·13	0·11	0·25	0·14	0·19	0·19	0·14	0·28	0·19	0·18	0·21
A.A.N. mgm. per cent.												
L.....	5·62	5·37	5·01	4·90	4·46	6·26	5·13	5·42	5·52	4·66	5·46	5·46
U.....	4·52	4·70	4·10	4·50	3·90	4·57	4·29	5·02	5·04	4·11	4·66	4·15
Cl. mgm. per cent.....	311	322	304	299	292	310	298	295	304	296	290	286
Na. mgm. per cent..	300	284	285	286	289	284	292	307	317	294	310	290
K. mgm. per cent.....	37·5	40·6	40·8	40·3	41·6	39·8	39·8	37·2	36·7	35·7	37·5	33·4
Ca. mgm. per cent.....	12·5	10·2	10·0	9·8	9·9	10·2	9·3	10·9	12·1	11·0	12·4	10·4
Mg. mgm. per cent..	5·55	4·46	4·54	4·43	4·79	4·20	4·07	4·70	4·93	4·59	4·70	—
Inorg. P. mgm. per cent.....	7·84	7·26	8·04	7·25	7·49	6·25	6·53	6·42	7·24	6·72	7·41	6·82
Fe. mgm. per cent..	50·0	49·0	49·0	51·0	56·0	50·0	46·0	55·5	45·0	43·0	45·0	49·0

In the above table the average value for the seven animals are given for each month and constituent separately. The table, therefore, illustrates such tendencies over the experimental year as may exist in each of these constituents.

TABLE 2.

Table of Averages for Each Animal over the Year.

No.	5146	4528	4548	4607	4654	4626	4667
Hb. gm. per 100 cc.	14·87	12·79	12·18	12·89	13·04	13·47	12·68
T.N. gm. per 100 cc.	3·054	2·759	2·681	2·841	2·808	2·857	2·771
Sugar mgm. per cent. L.	63·1	56·8	55·5	55·7	61·3	53·9	58·1
U.	56·4	49·5	46·7	46·4	51·7	44·8	48·5
N.P.N. mgm. per cent. L.	21·9	23·2	20·8	18·9	21·9	19·7	21·7
U.	12·5	15·8	13·2	15·4	15·6	13·3	15·3
Urea N. mgm. per cent. L.	5·31	6·19	4·98	5·60	6·56	5·23	6·33
T.C.N. mgm. per cemt. L.	2·48	2·51	2·51	2·61	2·45	2·36	2·57
U.	2·04	2·21	2·14	2·20	2·08	2·07	2·17
U.A.N. mgm. per cent. L.	0·63	0·50	0·53	0·37	0·49	0·48	0·45
U.	0·20	0·19	0·17	0·16	0·24	0·16	0·17
A.A.N. mgm. per cent. L.	5·55	5·42	5·20	4·49	5·19	5·29	5·34
U.	4·56	4·72	4·39	4·03	4·49	4·46	4·56
Cl. mgm. per cent.	291	296	304	308	309	297	305
Na. mgm. per cent.	298	293	291	297	290	291	304
K. mgm. per cent.	36·4	40·6	38·8	39·8	35·4	38·6	35·0
Ca. mgm. per cent.	10·6	11·4	10·6	11·0	10·9	10·3	10·7
Mg. mgm. per cent.	4·6	4·4	4·4	4·3	4·6	4·4	4·7
Inorganic P. mgm. per cent.	7·4	7·2	7·5	6·1	6·2	6·6	8·1
Iron mgm. per cent.	53·0	45·0	47·0	49·0	50·0	52·0	48·0

In the above table the average value over the experimental year is given for each animal and constituent separately. This table illustrates the existing differences between averages for separate animals in each constituent.

TABLE 3.

Total Average over a Year, S.D., C. of Var., Range and Number of Observations.

Constituent.	Mean.	S.D.	C. of Var. %	Range for 95 % Probability.	No. of Observations.
Hb.	Gm. p. 100 cc. 13·13	± 1·396	10·6	9·90–16·36	126
T.N.	Gm. p. 100 cc. 2·824	± 0·223	7·9	2·38–3·27	123
Sugar L.	*Mgm. p.* 100 cc. 58·2	± 8·517	14·6	39·1–77·3	126
U.	48·6	—	—	—	126
N.P.N. L.	21·1	± 2·879	13·6	12·6–29·6	120
U.	14·0	—	—	—	122
Urea N. L.	5·74	—	—	—	115
T.C.N. L.	2·50	± 0·2476	9·9	1·98–3·02	113
U.	2·13	—	—	—	115
U.A.N. L.	0·49	± 0·132	27·0	0·17–0·81	119
U.	0·18	—	—	—	—
A.A.N. L.	5·27	± 0·408	7·7	4·04–6·50	126
U.	4·41	—	—	—	124
Cl.	301	±7·415	2·5	274–325	113
Na.	295	±14·67	5·0	260–330	123
K.	38·6	± 3·282	8·5	29·8–47·4	113
Ca.	10·7	± 1·006	9·4	8·0–13·4	119
Mg.	4·64	± 0·524	11·3	3·41–5·87	115
Inorganic P.	7·10	± 0·6559	9·2	5·00–9·21	119
Fe.	49·0	± 4·775	9·8	37–61	125

In columns 2, 3 and 4 are given the mean, standard deviation and coefficient of variability, respectively. These values are calculated from all the observations given in the respective tables for the constituents. The coefficients of variabilities, column 4, indicate the relative variation in the observations for each constituent.

Column 5 gives the range within which approximately 95 per cent. of similar observations may be expected to fall.

TABLE 4.

Haemoglobin (Hb) gm. per 100 *c.c. Blood.*

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	13·03	15·91	15·57	16·14	14·28	13·68	15·10	12·79	14·26	15·07	16·29	16·29
4528.....	14·31	14·55	10·87	11·67	11·40	11·96	12·37	11·67	12·94	12·82	14·49	14·49
4548.....	12·23	13·01	13·50	12·95	14·28	12·42	11·70	11·96	11·14	11·08	11·98	9·94
4607.....	12·95	13·21	12·50	13·05	13·87	14·08	11·24	13·31	12·42	12·76	13·31	11·96
4654.....	15·79	14·83	13·98	15·46	15·98	14·72	12·27	10·60	10·87	10·30	11·67	9·97
4626.....	15·18	13·61	13·90	14·38	12·59	14·49	15·40	12·04	11·24	11·38	14·08	13·31
4667.....	11·97	11·51	11·90	12·12	11·39	16·60	13·70	12·83	11·39	13·48	13·31	11·96
AVERAGE	13·64	13·80	13·17	13·68	13·40	13·99	13·11	12·17	12·04	12·41	13·59	12·56

Haemoglobin.

The average through the course of the year remained fairly constant, showing no significant variation between monthly averages. The differences between the mean values for individual animals show that bovine 5146 has a considerably higher mean value than the other animals (Table 2). Except for the first animal there is a reasonable agreement between the other means in the sense that there is not a single significant difference between any two of them.

The data hardly warrants a sex comparison when the animals are so few and no definite conclusions can be drawn although it may be noted that the two oxen (4528 and 4548), being incidentally also the oldest animals in the group have the lowest averages while both of these animals were fed better food than 4626 and 4667. Animal 5146, the youngest, has the highest mean. Here, however, 4667, being the second youngest, has the second lowest Hb mean (Table 2). Note that animals 5146 and 4528 were both fed silage.

In all 126 analyses have been done, 18 per animal (see Table 3).

TABLE 5.

Total Nitrogen (T.N.) gm. per 100 *c.c. Blood.*

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	3·038	3·199	3·318	3·271	2·982	3·080	2·709	3·045	2·961	3·024	2·971	(2·92)
4528.....	2·954	2·992	2·768	2·646	2·590	2·618	2·856	2·667	2·744	2·712	2·968	2·562
4548.....	2·810	2·856	3·033	2·891	2·884	2·702	2·433	2·604	2·485	2·525	2·429	2·548
4607.....	3·020	2·912	2·816	2·800	2·905	3·122	2·772	2·786	2·674	2·747	2·667	2·870
4654.....	3·164	3·157	3·168	3·157	3·031	3·102	2·569	2·618	2·422	2·425	2·324	2·562
4626.....	3·213	3·059	2·765	2·965	2·870	3·094	2·794	2·590	2·653	2·492	2·934	(2·71)
4667.....	2·901	2·712	2·548	2·712	2·968	2·863	2·945	2·691	2·562	2·732	2·842	(2·63)
AVERAGE	3·014	3·098	2·912	2·916	2·890	2·940	2·727	2·714	2·643	2·665	2·719	2·64

Total Nitrogen.

The total nitrogen varies from 2·24 to 3·35 grams nitrogen per 100 c.c. blood with an average of 2·83 gram per 100 c.c.

A definite decrease in T.N. towards the end of the experiment is noticed (Table 1 or 5).

As in the case of the haemoglobin, 5146, the youngest animal in the group, has the highest T.N. figure, while 4528 and 4548, the oldest animals, have the lowest T.N. figures. These two are also the only oxen in the group (Table 2). The above differences are significant.

By comparing the T.N. and Hb values in Table 2 there seems to be a relationship. 123 Determinations have been done, approximately 18 per animal (Table 3).

TABLE 6.

Sugar ("Laked") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	71·0	65·4	65·7	58·6	85·2	67·1	61·5	84·7	56·8	57·0	61·3	58·8
4528.....	55·0	56·5	60·4	53·2	71·4	60·6	54·3	70·4	48·3	47·6	54·3	51·0
4548.....	54·2	52·0	61·6	55·7	62·5	61·7	60·5	42·0	57·1	54·2	51·3	52·6
4607.....	47·7	52·0	58·4	53·0	57·1	58·5	56·3	73·6	47·3	50·5	48·8	65·4
4654.....	53·7	55·5	59·8	52·9	72·5	55·9	59·9	50·2	98·0	54·6	55·9	67·1
4626.....	51·9	49·7	52·7	52·9	64·5	57·1	52·7	46·0	68·0	53·5	56·8	40·6
4667.....	55·3	52·3	57·0	61·5	61·7	64·9	56·2	46·8	78·0	68·6	54·0	41·3
AVERAGE	55·5	54·8	59·4	55·4	67·8	60·8	57·3	59·1	64·7	55·1	54·6	53·8

TABLE 7.

Sugar ("Unlaked") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	64·6	54·9	55·2	50·7	72·5	61·0	48·2	71·4	53·7	41·5	50·5	52·6
4528.....	49·0	48·4	52·0	48·4	62·9	51·3	42·2	68·0	39·5	38·6	44·8	49·3
4548.....	49·1	44·6	48·8	49·6	46·5	49·0	49·6	38·3	42·4	48·1	52·6	41·7
4607.....	43·8	46·1	49·1	44·8	46·7	49·3	46·4	67·6	30·3	47·0	43·1	42·9
4654.....	45·1	48·4	51·4	44·1	53·5	46·5	53·8	37·7	75·2	43·3	58·5	62·5
4626.....	48·4	43·9	44·7	44·2	45·7	50·0	41·2	42·0	51·3	44·4	48·3	33·0
4667.....	53·3	49·5	51·7	55·1	50·0	59·5	43·5	41·3	42·5	51·8	50·0	33·3
AVERAGE	50·5	48·0	50·4	48·1	54·0	52·4	46·4	52·3	47·8	45·0	49·5	45·0

Sugar "Laked" and "Unlaked". Discussion.

The percentage difference between "laked" and "unlaked" figures varies from 0 per cent. to 46 per cent. with an average difference of 8·1 mgm. per cent., i.e., the average percentage difference is 14 per cent. (56·7-48·6). In one case the "laked" figure was smaller than the "unlaked" but usually the "laked" figure is the higher of the two.

There seems to be a slight tendency to a rise in the sugar content towards the summer months, the difference of the highest and lowest averages being 20 per cent. in the case of the "laked" figures and 17 per cent. in the case of the "unlaked" figures (see Tables 1 or 6 and 7).

There is not a significant difference between the monthly averages (see Tables 1 or 6 and 7), but a significant difference between mean values for the individual animals, 5146 being significantly above all others except 4654 which is again above 4626 (Table 2).

TABLE 8.

Non-protein Nitrogen ("Laked") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	21·4	19·1	22·4	23·4	30·0	16·9	20·9	19·2	20·0	24·6	23·5	22·0
4528.....	16·5	19·5	22·2	21·0	42·0	15·4	34·4	18·8	16·9	22·8	24·0	24·6
4548.....	24·3	23·2	21·1	23·0	31·6	19·9	15·9	21·7	16·2	17·4	17·5	17·7
4607.....	17·5	15·8	15·5	22·9	26·9	17·8	19·5	19·0	16·6	20·1	18·0	17·2
4654.....	22·1	20·5	25·9	25·1	28·6	18·9	22·7	22·7	19·6	18·8	18·4	20·0
4626.....	17·3	17·5	20·0	24·2	25·0	21·4	18·0	—	14·6	16·9	21·8	—
4667.....	19·3	17·6	21·1	23·4	25·9	—	25·0	22·7	16·7	21·9	23·0	—
AVERAGE	19·8	19·0	21·2	23·3	30·0	18·4	22·3	20·7	17·2	20·4	20·9	20·3

TABLE 9.

Non-protein Nitrogen ("Unlaked") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	11·8	14·3	14·9	12·2	15·8	9·7	11·1	9·8	13·5	13·6	11·9	11·2
4528.....	8·5	14·7	16·9	16·2	36·4	11·4	16·2	11·4	13·9	15·3	15·0	14·3
4548.....	14·4	15·0	14·8	14·2	20·3	12·2	10·8	12·8	9·7	11·2	11·3	11·3
4607.....	11·8	11·0	11·3	16·2	22·2	11·7	13·0	13·3	13·8	14·7	12·6	12·2
4654.....	15·4	13·9	17·3	17·0	21·8	13·0	15·3	17·6	15·0	12·4	14·0	14·3
4626.....	11·2	10·6	15·3	16·9	14·0	14·6	11·0	14·6	7·8	11·1	16·2	16·7
4667.....	15·0	13·1	15·8	17·9	15·9	—	15·1	15·6	9·4	14·3	18·3	18·2
AVERAGE	12·3	13·2	15·2	15·8	20·9	12·1	13·2	13·6	11·9	13·2	14·2	14·0

As is the case with the Hb and T.N. the sugar is also the highest for animal 5146. Younger animals usually have a higher blood sugar content, but here 4626 and 4648 (ox) have the lowest blood sugar content, 4528 (ox), the oldest animal, coming fourth on the list (Table 2). Note that 5146 and 4528 were also fed on silage, 4548 was fed in December on green fodder and 4626 was on the dry ration.

Non-protein Nitrogen " Laked " and " Unlaked ". Discussion.

The difference between the " laked " and " unlaked " figures varies from 12·1 per cent. to 49 per cent. with an average of 34 per cent. and an average difference of 7·1 mgm. N. per cent (21·1-14 mgm. per cent.).

The only striking feature here is the exceedingly high figure for December (Tables 1 or 8 and 9). The explanation might be that three animals, viz., 4548, 4607 and 4654 were fed green fodder in December and from Table 8 and 9 it will be noticed that the figures for these animals in December are rather higher than those not fed on silage, viz., 4626 and 4667. For the rest the N.P.N. remained practically constant throughout the year.

No significant difference is noticed in the case of the individual animals (Table 2). As far as the age is concerned the youngest animal, 5146, together with 4654, have the second highest N.P.N. In the case of the " laked " figures the oldest animal, 4528, has the highest N.P.N. Animals 5146 and 4528 were fed silage, and as the N.P.N. usually tends to fluctuate according to the ration, the high figures of these two animals might be ascribed to this cause.

Nothing can be concluded about the sex influence and there is altogether no correlation between the N.P.N. and the T.N., Hb and sugar.

TABLE 10.

Urea Nitrogen (" Laked ") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	5·31	4·27	4·60	4·14	9·81	—	3·74	2·51	2·64	7·51	5·66	8·26
4528.....	3·37	3·95	6·99	5·18	17·19	—	7·70	2·45	1·67	7·70	—	5·66
4548.....	6·05	6·67	3·59	4·57	11·65	5·55	3·42	4·26	2·73	2·01	3·44	5·87
4607.....	5·56	4·77	3·48	6·44	8·52	5·66	6·54	3·65	4·13	5·78	—	7·00
4654.....	5·24	5·10	7·97	5·62	9·69	5·66	9·65	7·33	5·37	6·40	6·69	6·02
4626.....	3·40	6·20	4·80	6·47	7·00	—	6·66	4·75	3·08	4·40	4·13	6·69
4667.....	4·94	6·84	4·05	6·23	7·00	—	11·12	6·41	4·26	8·30	4·99	5·66
AVERAGE	4·84	5·40	5·07	5·52	10·12	5·62	6·98	4·48	3·41	6·01	4·98	6·45

Urea Nitrogen (" Laked " and " Unlaked "). Discussion.

The " laked " urea nitrogen varies from 1·67 to 17·18 mgm. nitrogen per 100 c.c. with an average of 5·74.

A table of the " unlaked " figures is not given because the amount of urea in each of the two different filtrates is practically the same. The minimum-maximum variation is 1·67-16·86 mgm. urea nitrogen per 100 c.c.

As the urea nitrogen is that part of the N.P.N. which is the most variable it can be seen from the tables (viz. 1 or 8, 9 and 10) that the N.P.N. fluctuates as the urea increases or decreases (cf. December and April).

Since the " laked " and " unlaked " figures are usually very nearly the same it is concluded that the urea nitrogen is approximately equally divided between the blood cells and the plasma.

There is not an appreciable difference between the mean values for the individual animals (Tables 2), nor is there a marked correlation between the urea nitrogen and non-protein nitrogen, but as has been said under " Methods of Analyses " the N.P.N. method was not very satisfactory.

The sex and age appears to exert no definite influence on the composition of the blood.

TABLE 11.

" Total " Creatinine Nitrogen (" Laked ") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	2·44	2·22	2·45	2·57	—	1·97	2·62	2·35	2·66	2·66	—	2·66
4528.....	2·16	2·19	2·62	2·66	—	1·97	2·75	2·66	2·66	2·85	—	2·35
4548.....	2·42	2·58	2·66	2·57	—	2·76	2·75	2·27	2·27	2·35	2·35	—
4607.....	2·50	2·23	2·99	2·63	—	2·96	2·48	2·16	3·08	2·60	2·42	—
4654.....	2·35	2·41	2·14	2·85	—	2·25	2·38	2·85	2·23	1·92	2·11	—
4626.....	2·11	2·19	2·02	2·46	2·10	2·42	2·41	2·42	2·35	2·50	2·66	2·41
4667.....	2·23	2·25	2·16	2·65	2·23	2·85	2·58	2·60	2·85	2·66	2·76	2·76
AVERAGE	2·31	2·30	2·43	2·63	2·16	2·46	2·57	2·47	2·44	2·51	2·46	2·54

TABLE 12.

" Total " Creatinine Nitrogen (" Unlaked ") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	1·88	1·86	2·29	2·20	—	1·64	2·16	1·35	2·66	2·23	—	2·01
4528.....	1·78	1·72	2·38	2·45	—	1·82	2·37	2·16	2·66	2·75	—	2·04
4548.....	2·33	2·04	1·86	2·19	—	2·49	2·18	2·58	2·10	1·82	1·86	—
4607.....	1·95	2·07	2·12	2·20	—	2·11	2·24	2·10	3·04	2·35	1·86	—
4654.....	1·91	1·84	2·16	2·26	—	2·23	2·05	2·66	1·90	1·80	2·01	—
4626.....	1·78	1·76	1·89	1·97	1·97	2·15	2·35	2·15	1·86	2·10	2·48	2·23
4667.....	2·00	1·84	1·84	2·30	1·97	2·23	2·58	2·34	2·10	2·20	2·28	2·35
AVERAGE	1·95	1·88	2·08	2·22	1·97	2·10	2·28	2·19	2·48	2·18	2·10	2·16

" Total " Creatinine Nitrogen " Laked " and " Unlaked ".

Discussion.

The difference between " laked " and " unlaked " " total " creatinine nitrogen lies between 0 and 42·4 per cent., the average difference being 15 per cent., and expressed in mgm. it is 0·37 (2·50-2·13).

There is no significant seasonal variation. Note that many values for December and July are missing (Tables 1 or 11 and 12).

There is no significant difference between individual animals, the averages being very nearly equal (Table 2).

There is no obvious correlation between the " total " creatinine nitrogen and urea nitrogen or T.N., Hb or sugar nor does sex and age appear to exert an influence.

TABLE 13.

Uric Acid Nitrogen (" Laked ") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	·98	·61	·59	·98	·22	·76	·61	·59	·67	·42	·48	·63
4528.....	·90	·67	·47	·50	·37	·51	·42	·38	·60	·28	·41	·39
4548.....	·53	·51	·75	·64	·67	·63	·42	·39	·56	·42	·36	·43
4607.....	·51	·33	·34	·37	·26	·39	·35	·27	·48	·34	·39	·38
4654.....	·73	·87	·44	·60	·53	·48	·38	·28	·44	·31	·31	·51
4626.....	·28	·36	·52	·45	·67	·76	·45	·37	·46	·37	·60	·41
4667.....	·40	·36	·47	·50	·44	·63	·38	·29	·51	·37	·60	·41
AVERAGE	·62	·53	·51	·58	·45	·59	·43	·37	·53	·36	·45	·45

TABLE 14.

Uric Acid Nitrogen (" Unlaked ") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	·11	·17	·21	·48	·11	·27	·11	·10	·33	·15	·14	·17
4528.....	·10	·29	·05	·30	·09	·20	·20	·11	·44	·13	·14	·22
4548.....	·09	·10	—	·26	·14	·15	·25	·16	·24	·18	·18	·18
4607.....	·15	—	—	·18	·13	·11	·18	·12	·23	·15	·17	—
4654.....	·13	—	—	·25	·20	·15	·26	·22	·41	·28	·23	·26
4626.....	—	·05	·08	·19	—	·19	·16	·16	·15	·21	·21	·22
4667.....	·11	·04	·08	·21	·17	·24	·18	·14	·17	·21	·21	·23
AVERAGE	·12	·13	·11	·25	·14	·19	·19	·14	·28	·19	·18	·21

Uric Acid Nitrogen, " Laked " and " Unlaked ". Discussion.

The difference of the " laked " and " unlaked " figures vary from 0 to 93 per cent. with an average of 64 per cent. There is a significant difference between the months but no seasonal tendency is noticed (Table 1 or 13 and 14).

By the study on bovines it was soon obvious that uric acid figures could usually be obtained from the " unlaked " filtrates, but these are very much lower than the " laked " figures. It was thus possible that a table for these figures could be drawn up. In the case of sheep it was often impossible to determine the uric acid content in the unlaked filtrates but in the present instance this was only occasionally the case (Hamersma, 1934).

There is a significant difference between animals as regards the " laked " figures, which is mainly due to 5146 (0·63) being relatively high and 4607 (0·37) rather low (Table 2).

The youngest animal (5146) here again has the highest uric acid figure, but 4548 and 4528 the oldest animals have the second and third highest figure, these also being the only oxen in the group. There is not a correlation between the uric acid and the separate constituents already considered.

TABLE 15.

Amino Acid Nitrogen (" Laked ") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	5·71	5·43	5·57	5·19	4·00	6·93	4·87	5·55	5·83	4·87	5·83	6·73
4528.....	5·51	5·47	5·09	5·00	4·12	7·61	5·20	5·18	4·93	4·77	5·60	6·54
4548.....	5·77	5·35	4·88	4·76	3·89	6·25	5·23	5·46	5·74	4·68	5·46	4·89
4607.....	5·79	5·00	4·49	4·21	4·10	5·60	4·83	5·26	5·14	4·25	5·38	5·18
4654.....	5·83	5·58	4·93	4·92	4·67	6·03	5·14	5·38	5·46	4·39	5·22	4·73
4626.....	5·40	5·38	5·17	5·19	5·26	5·83	5·38	5·81	5·60	4·44	5·38	4·66
4667.....	5·34	5·41	4·93	5·02	5·18	5·60	5·26	5·32	5·93	5·19	5·38	5·46
AVERAGE	5·62	5·37	5·01	4·90	4·46	6·26	5·13	5·42	5·52	4·66	5·46	5·46

TABLE 16.

Amino Acid Nitrogen (" Unlaked ") mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	4·52	5·15	4·32	4·57	2·80	5·38	5·02	5·18	4·60	4·37	4·24	4·63
4528.....	3·85	5·00	4·45	4·90	3·68	5·83	4·55	5·07	4·93	4·50	5·38	5·00
4548.....	4·86	4·37	3·48	4·06	3·68	4·29	4·56	5·83	5·46	3·90	5·00	3·18
4607.....	4·72	4·13	3·68	3·95	3·68	4·51	3·95	4·07	4·37	3·76	4·04	3·50
4654.....	5·34	4·47	4·57	4·05	4·24	4·16	4·53	4·37	5·00	3·96	4·82	4·37
4626.....	4·16	4·84	4·14	5·19	5·26	3·18	3·74	5·83	5·00	4·11	4·16	3·89
4667.....	4·19	4·95	4·10	4·75	4·00	4·66	3·68	4·77	5·93	4·18	5·00	4·51
AVERAGE	4·52	4·70	4·10	4·50	3·90	4·57	4·29	5·02	5·04	4·11	4·66	4·15

Amino Acid Nitrogen ("Laked" and "Unlaked"). Discussion.

The percentage difference between "laked" and "unlaked" figures varies from 0 to 42 per cent. In two cases the "laked" figure was found smaller than the "unlaked" and in three cases equal to each other. The average difference is 15·5 per cent. and in mgm. 0·8 (5·2-4·4).

There is no significant seasonal variation, the highest figure being that of January (6·26) and the lowest that of December (4·46), in the case of the "laked" filtrates, Tables 1 or 15 and 16).

The significant differences between individual animals are caused by the relatively high average for 5146 and low value for 4607. The others agree fairly well (Table 2). (Compare uric acid nitrogen.) The oldest animal in the group 4528 (ox) has the second highest value in the case of the "laked" and the highest in the case of the "unlaked". As in the case of the two previous constituents, no correlation exists between amino acid nitrogen and the other constituents.

The percentage of amino acid nitrogen in the respective N.P.N. is very variable.

It is the following:—

"Laked."

Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
28	28	24	21	15	34	23	26	32	20	25	27

"Unlaked."

Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
36	36	27	28	19	38	35	36	42	31	33	36

Rest Nitrogen.

"Laked" filtrates.	"Unlaked" filtrates.
Min.-max. variation in mgm. N %	Min.-max. variation in mgm. N %
2·11–13·16	−2·42–+5·94

Discussion.

From the rest nitrogen it can be seen that one or possibly more of the methods are not very exact, because not infrequently the sum of the different nitrogen fractions of the blood are more than their respective non-protein nitrogen. This applies only to the "unlaked" filtrates and in the writer's opinion is chiefly associated with the N.P.N. determination. (See also under Methods of Analyses.)

TABLE 17.

Chlorine mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	299	321	287	288	281	303	286	277	296	285	282	271
4528.....	311	318	292	306	287	314	295	282	289	285	282	280
4548.....	309	325	296	301	289	308	303	305	312	303	293	296
4607.....	312	328	314	307	308	305	295	298	311	306	303	295
4654.....	314	325	315	298	305	302	312	308	323	305	289	302
4626.....	304	318	306	290	289	314	—	302	298	293	286	273
4667.....	329	321	317	303	287	321	—	296	302	296	295	282
AVERAGE	311	322	304	299	292	310	298	295	304	296	290	286

Chlorine. Discussion.

There is no seasonal tendency, the monthly differences being significant (Table 1 or 17).

The differences between the mean values are insignificant. Note that 5146 has here again the lowest chlorine content.

No specific tendency is noticeable as regards age and sex.

The chlorine figure is not correlated with that of any of the other constituents.

TABLE 18.

Sodium mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	314	298	305	273	284	297	289	305	307	300	312	294
4528.....	294	302	255	304	266	305	303	305	305	287	297	298
4548.....	266	268	289	295	284	263	290	312	325	301	309	294
4607.....	299	274	297	300	280	278	302	301	347	289	321	278
4654.....	320	259	283	259	284	263	295	312	321	297	297	294
4626.....	302	296	296	268	304	280	272	297	299	284	312	278
4667.....	307	289	268	305	321	305	294	314	316	300	323	294
AVERAGE	300	284	285	286	289	284	292	307	317	294	310	290

Sodium. Discussion.

In some cases there is a significant variation between the monthly averages (Table 1 or 18).

The animals can be considered as homogeneous as regards this constituent, the individual differences being small. Here again animal 5146 has a high figure, being only second to 4667 (Table 2). Nothing is noticeable about the age or sex. There is no correlation between the sodium figures and that of any of the other constituents.

TABLE 19.

Potassium mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	30·1	41·5	43·2	36·3	42·7	34·4	36·2	33·6	35·7	36·5	33·7	31·0
4528.....	44·9	41·6	41·9	43·3	44·2	38·3	44·5	40·8	42·3	40·2	43·7	36·8
4548.....	—	41·2	40·2	42·2	43·2	42·9	44·8	40·8	34·8	34·0	36·9	34·4
4607.....	—	41·9	42·9	43·8	43·2	46·8	43·3	40·2	38·4	37·7	32·8	36·8
4654.....	—	38·3	38·6	42·3	39·8	35·1	32·8	30·0	35·7	30·6	40·7	(30·9)
4626.....	37·5	43·8	40·6	38·6	39·0	47·7	40·3	39·6	36·5	35·7	39·3	32·2
4667.....	—	35·7	38·0	35·8	39·0	33·8	36·6	35·2	33·8	35·4	34·4	31·8
AVERAGE	37·5	40·6	40·8	40·3	41·6	39·8	39·8	37·2	36·7	35·7	37·5	33·4

Potassium. Discussion.

According to Table 19 (or 1) there seems to be a slight downward tendency towards winter in potassium; it is, however, insignificant.

The differences between the values for individual animals are not at all very marked, 4528, the oldest animal and one of the two oxen have the highest figure and 4548, the other ox, come third on the list, while the three youngest animals have the lowest potassium figures (Table 2).

There is no correlation between the potassium figures and any of the other constituents.

TABLE 20.

Calcium mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	13·4	10·1	9·2	9·0	8·5	8·9	8·9	10·4	—	11·4	11·6	10·4
4528.....	13·7	11·0	9·8	9·5	10·1	14·2	9·9	12·0	12·1	11·0	12·3	10·6
4548.....	11·7	11·2	11·1	10·4	9·9	9·5	9·4	9·2	11·6	11·3	12·3	9·9
4607.....	12·2	11·2	10·2	10·6	9·8	11·6	10·5	11·0	10·7	11·5	12·3	10·4
4654.....	11·7	10·0	10·5	10·7	9·8	8·7	8·6	12·7	12·4	11·4	13·6	9·8
4626.....	12·2	9·1	9·5	9·0	13·1	8·6	9·0	10·9	11·6	9·7	12·1	10·6
4667.....	—	9·1	9·9	9·7	8·0	9·8	9·0	10·2	14·3	10·5	—	10·8
AVERAGE	12·5	10·2	10·0	9·8	9·9	10·2	9·3	10·9	12·1	11·0	12·4	10·4

Calcium. Discussion.

There is no significant variation between the monthly averages except that the figures for August, April and June are rather on the high side (Table 1 or 20).

The differences between the figures for individual animals are insignificant though 4528 has again the highest value, and 5146 comes third (Table 2).

Nothing can be concluded about the sex and the age differences.

No obvious correlation between the calcium and other constituents exists.

TABLE 21.

Magnesium mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	5·38	4·87	3·99	4·88	3·95	3·75	4·47	4·20	7·24	4·89	4·98	—
4528.....	5·54	4·27	4·87	4·32	4·27	3·89	4·07	3·45	5·25	4·72	4·66	—
4548.....	5·84	4·50	4·30	4·24	5·36	4·57	3·95	5·05	4·10	4·34	4·12	—
4607.....	5·53	4·30	4·29	4·18	4·86	4·04	3·80	4·45	4·34	4·60	4·49	—
4654.....	5·65	4·24	5·32	4·58	5·20	4·20	3·94	5·25	5·36	4·28	4·04	—
4626.....	5·28	4·28	4·32	4·30	5·14	4·04	4·13	5·12	4·20	4·50	5·14	—
4667.....	5·62	4·75	4·72	4·52	4·72	4·91	4·10	5·36	4·04	4·80	5·46	—
AVERAGE	5·55	4·46	4·54	4·43	4·79	4·20	4·07	4·70	4·93	4·59	4·70	—

Magnesium. Discussion.

The monthly variation is insignificant (Table 1 or 21).

As regards the magnesium values for individual animals the group of animals can be considered as homogeneous (Table 2).

Nothing can be concluded about the sex and age.

No correlation between magnesium values and that of the other constituents is apparent.

TABLE 22.

Inorganic Phosphorus mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	7·95	7·16	8·97	7·46	7·53	6·42	8·19	7·44	7·71	6·81	7·71	6·12
4528.....	7·98	7·73	9·10	7·49	8·19	6·06	6·33	6·24	6·67	6·90	7·28	7·44
4548.....	7·79	8·24	7·62	7·47	8·74	6·68	7·01	6·90	7·20	7·25	8·62	7·89
4607.....	7·45	6·16	6·67	6·90	6·06	5·24	5·35	5·24	5·70	5·88	7·53	4·52
4654.....	7·58	7·04	7·45	6·15	7·28	4·52	5·77	5·46	7·28	6·46	6·42	7·36
4626.....	6·76	6·29	7·62	7·20	5·90	7·12	—	6·11	7·71	6·13	6·42	6·55
4667.....	9·36	8·22	8·85	8·09	8·74	7·53	—	7·56	8·40	7·61	7·89	7·89
AVERAGE	7·84	7·26	8·04	7·25	7·49	6·25	6·53	6·42	7·24	6·72	7·41	6·82

Inorganic Phosphorus. Discussion.

There is no significant variation between the monthly averages (Table 1 or 22).

In connection with the values for individual animals 4667 is rather high in comparison with 4607, 4654 and 4626, the last three being on the lower side.

Nothing can be concluded about the sex and age and no correlation exists between inorganic phosphorus values and that of the other constituents.

TABLE 23.

Iron mgm. per cent.

No.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.
5146.....	44	56	59	61	56	52	51	48	56	49	50	48
4528.....	43	47	41	44	45	41	41	54	46	43	52	45
4548.....	50	47	51	48	56	46	42	54	44	40	37	44
4607.....	51	49	51	48	56	54	48	50	42	43	41	54
4654.....	54	51	54	55	64	52	47	64	38	33	35	48
4626.....	58	50	47	53	56	57	48	56	42	46	52	54
4667.....	47	43	42	48	56	48	47	58	44	49	45	50
AVERAGE	50	49	49	51	56	50	46	55	45	43	45	49

Iron. Discussion.

No seasonal tendency is noticed (Table 1 or 23).

Considering the individual averages (Table 2) we notice that the two males 4528 and 4548, being also the oldest animals in the group, have the lowest iron values, and 5146, being the youngest animal, has the highest figure.

By comparing the iron figures with the haemoglobin figures there seems to be a relationship. Graphs plotted on the values of these constituents for individual animals will show the same tendency (Table 2).

COMPARISON WITH RESULTS OF OTHER WORKERS.

In reviewing the literature, one finds fairly considerable quantitative differences of content in respect of the various constituents of the blood, but whether these differences are mainly due to climatic, dietetic, environmental, etc., factors or chiefly expression of the different methods of analyses or the same methods in the hands of different workers, it is difficult to say.

In spite of quite a number of analyses from various countries, there are still many gaps and too large a diversity of methods employed to enable one to analyse accurately the significance of the divergency of analytical data from various different areas.

Much of the data that is available represents analyses done only once on a relatively small number of individuals and occasionally on mixed slaughter-house blood; data extended over a large period being restricted to only a few cases. No other comparative figures for all the constituents enumerated here for both " laked " and " unlaked " bovine blood filtrates could be found.

For comparative purposes some data from the available literature, together with the writer's own, have been tabulated for a number of the constituents; for others the range of data was deemed too small to warrant tabulation (e.g. T.N.).

The compilation should, however, not be considered exhaustive, the period covered being largely from 1919-1935.

HAEMOGLOBIN.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Gm. per 100 cc.	Remarks.
1927	Theiler, Green, and du Toit	Newcomer disc method	S.A.....	7 5 animals	19·7–23·8 Av.: 22·6	From border-line to ample phosphorus and calcium, normal animals.
1928	van Gelder.....	Sahli Beerwald Haemometer	Switzerland	Many	Av.: 10·36 Av.: 7·77	Summer. Winter.
1928	van Gelder.....	Sahli Beerwald Haemometer	Switzerland	Many	Av.: 7·55 Av.: 7·15	Summer. Winter.
1930	Green and Macaskill	Newcomer disc method	S.A.....	13 3 animals	15·5–25·9 Av.: 18·4	Veld-bred cattle, from 24 hours to 10 weeks after calving.
1931	McCay.....	Cohen and Smith.....	U.S.A.....	1073 90 animals	Av.: 10·9 $\pm$ 0·86	60 cows and 21 younger animals.
1931	McCay.....	Cohen and Smith.....	U.S.A.....	70 6 animals	Av.: 12·8 $\pm$ 0·8	Mature bulls.
1932	Brooks and Hughes	Newcomer disc method	U.S.A.....	335 297 animals	Av.: 10·96 $\pm$ 0·064	College herd dairy cattle: 103 cows, 59 heifers, 111 calves, and 24 bulls.
1933	Neal and Becker...	Newcomer disc method, and Cohen and Smith	U.S.A.....	Many Many animals	10·94–11·06	Sampled at 2½-hours intervals, healthy cows.
1933	Graf.....	Newcomer disc method	S.A.....	50–60 Many animals	12·1–23·2 Av.: 17·1	Various breeds and ages.
1935	This paper.....	Newcomer disc method	S.A.....	126 7 animals	9·94–17·51 Av.: 13·13	Age about 2 years; animals of both sexes examined periodically over 1 year.

SUGAR.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1923–1924	Hayden and Scholl..	Report not obtainable..	U.S.A.....	75 44 animals	Av.: 52·0	Cows.
1928	Hayden and Fish...	Benedict.....	U.S.A.....	16 2 animals	Av.: 45·6	2 Dry cows, done over 13 months.
1928	Hayden and Fish..	Benedict.....	U.S.A.....	27 3 animals	Av.: 46·1	3 Milk cows, done over a period.
1928	Hayden and Fish..	Benedict.....	U.S.A.....	68 5 animals	30–70 Av.: 46·5	Cows, 4 calves during experiment, done over 13 months.
1929	Hayden.....	Newer Benedict method	U.S.A.....	253 23 animals	Av.: 41	Cows done over 11 months.
1930	Anderson, Gayley, and Pratt	Folin and Wu.....	U.S.A.....	58 36 animals	43·2–142·0 Av.: 84·1	Animals from 9 months to 9 years, both sexes, done during late summer, fall, and winter.
1930	Allardyce, Fleming, Fowler, and Clark	Benedict.....	Canada....	65 21 animals	47·3–73·5 Av.: 57·6	Dairy cows and heifers, blood drawn 4–5 hours after morning feeding; done over 3 and 4 months; ± 3 analyses on each animal.
1932	Hodgson, Riddel, and Hughes	Folin.....	U.S.A.....	40 16 animals	Av.: 55	20–47 Months-old dairy cattle, done during winter months.
1932	Hodgson, Riddel, and Hughes	Folin.....	U.S.A.....	222 74 animals	35–74 Av.: 53	Cattle between 2 and 8 years, done during winter months.
1933	Demmel.....	Hagedorn–Jensen.....	Switzerland	12 12 animals	86–120 Av.: 102	Normal cows, 5–10 years old, slaughter-house blood.
1933	Demmel.....	Fugita Iwatake.....	Switzerland	12 12 animals	72–100 Av.: 87·2	Normal cows, 5–10 years old, slaughter-house blood.

SUGAR (*continued*).

Year.	Author.	Methoed.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1933	Demmel.....	Fugita Iwatake.....	Switzerland	20 20 animals	55–141 Av.: 95	Non-Pregnant cows, slaughter-house blood.
1933	Demmel.....	Fugita Iwatake.....	Switzerland	210 40 animals	68–134 Av.: 88	Pregnant cows, slaughter-house blood.
1933	Demmel.....	Fugita Iwatake.....	Switzerland	60 60 animals	55–141 Av.: 90	Two previous groups taken together.
1933	Allcroft.....	Hagedorn-Jensen.....	England...	72 6 animals	± 60–± 78	Non-lactating cows, bled over a period of 24 days with intervals of 26 hours.
1933	Graf.....	Folin.....	S.A.....	50–60 Many animals	37–95 Av.: 60	'Laked' filtrates, animals of various breeds and ages.
1933	Graf.....	Folin.....	S.A.....	50–60 Many animals	31–83 Av.: 48	'Unlaked' filtrates, animals of various breeds and ages.
1935	This Paper.....	Folin.....	S.A.....	126 7 animals	41–98 Av.: 57	'Laked' filtrates, animals 2 years old, different breeds and sex, done over 1 year.
1935	This Paper.....	Folin.....	S.A.....	126 7 animals	30–75 Av.: 49	'Unlaked' filtrates, animals 2 years old, different breeds and sex, done over 1 year.

Some of the figures here are much higher than the South African figures. In the cases where the same method was used the figures agree fairly well.

NON-PROTEIN NITROGEN.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1928	Hayden and Fish....	Folin.....	U.S.A.....	67 5 animals	25–35	Cows, 4 calved during experiment, done over 13 months.
1930	Anderson, Gayley, and Pratt	Folin and Wu.....	U.S.A.....	59 37 animals	20·7–42·1 Av.: 30·1	Age from 1 month to 9 years, different breeds, both sexes; average of all groups close to average of all; done during late summer, fall, and winter.
1930	Allardyce, Fleming, Fowler and Clark	Folin and Wu.....	Canada....	63 21 animals	25·7–43·4 Av.: 33·5	Dairy cows and heifers, blood drawn 4–5 hours after morning feeding; done over 3 months, ± 3 analyses on each animal.
1932	Godden and Allcroft	Folin.....	U.S.A.....	37 12 animals	20·1–37·7 Av.: 29·9 (calculated)	Cows from 4 to 7 days after calving.
1933	Graf.....	Folin and Wu.....	S.A.....	50–60 Many animals	12·5–25·0 Av.: 18·2	'Laked' filtrates of various breeds and ages.
1933	Graf.....	Folin and Wu.....	S.A.....	50–60 Many animals	9·4–18·7 Av.: 13·5	'Unlaked' filtrates of above.
1935	This Paper.....	Folin and Wu.....	S.A.....	120 7 animals	14·3–42·0 Av.: 21·1	'Laked' filtrates, animals ± 2 years, different breeds, both sexes, done over 1 year.
1935	This Paper.....	Folin and Wu.....	S.A.....	122 7 animals	7·8–36·4 Av.: 14·0	'Unlaked' filtrates of above.

This constituent is very variable and fluctuates according to the kind of diet. A comparison is thus not of any value when the diets are not stated.

UREA NITROGEN.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1930	Anderson, Gayley, and Pratt	van Slyke and Cullen...	U.S.A.....	50 37 animals	4·40–21·64 Av.: 12·94	Age from 1 month to 9 years, different breeds both sexes, done during late summer, fall, and winter.
1930	Hayden and Fish...	Folin-Wu's filtrates used	U.S.A.....	67 5 animals	2·4–12·4 Av.: 5·6	Cows, 4 calved during experiment, done over 13 months.
1930	Allardyce, Fleming, Fowler and Clark	Not stated.....	Canada....	61 21 animals	7·2–21·3 Av.: 15·7	Dairy cows and heifers, blood drawn 4–5 hours after morning feeding; done over 3 and 4 months, ± 3 analyses on each animal.
1933	Graf.....	Folin and Svedberg....	S.A.....	50–60 Many animals	3·0–9·0 Av.: 5·7	'Laked' and 'unlaked' filtrates, animals of different ages and breeds, normal ration.
1935	This Paper.....	Folin and Svedberg.....	S.A.....	113 7 animals	1·67–17·2 Av.: 5·67	'Laked' filtrates; age ± 2 years, various breeds, both sexes, done over 1 year.
1935	This Paper.....	Folin and Svedberg.....	S.A.....	115 7 animals	1·67–16·9 Av.: ± 5·67	'Unlaked' filtrates of above.

"TOTAL" CREATININE NITROGEN.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1914	Folin and Denis....	Folin.....	U.S.A.....	2	4·07	Beef blood.
1918	Greenwald and McQuire	Folin and Denis.....	U.S.A.....	2	3·27	Beef blood oxalated.
	,, ,,	Authors' methods.....	U.S.A.....	2	1·94	Beef blood oxalated.
1930	Anderson, Gayley, and Pratt	Folin and Wu.....	U.S.A.....	59 37 animals	1·23–3·21 Av.: 1·90 (calculated)	Age from 1 month to 9 years, different breeds, both sexes; done during late summer, fall, and winter.
1930	Allardyce, Fleming, Fowler, and Clark	Folin and Wu.....	Canada....	64 21 animals	1·71–2·31 Av.: 2·00 (calculated)	Dairy cows and heifers, blood drawn 4–5 hours after morning feeding; done over 3 and 4 months; ± 3 analyses on each animal.
1933	Graf.....	Folin and Wu.....	S.A.....	50–60	1·9–2·9 Av.: 2·3	'Laked' filtrated; animals of different ages and breeds, both sexes.
1933	Graf.....	Folin and Wu.....	S.A.....	50–60	1·4–2·6 Av.: 1·9	'Unlaked' filtrates of above.
1935	This Paper.....	Folin and Wu.....	S.A.....	113 7 animals	1·86–3·08 Av.: 2·51	'Laked' filtrates; animals of ± 2 years, different breeds, both sexes, done over 1 year.
1935	This Paper.....	Folin and Wu.....	S.A.....	115 7 animals	1·35–3·08 Av.: 2·13	'Unlaked' filtrates of above.

URIC ACID NITROGEN.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1928	Hayden and Fish...	Folin direct method....	U.S.A.....	73 5 animals	Av.: 0·68	Cows, 4 calved during experiment, done over 13 months.
1928	Hayden and Fish...	Isolation method of Folin	U.S.A.....	34	Av.: 0·208	Blood of above animals.
1930	Anderson, Gayley, and Pratt	Benedict.....	U.S.A.....	59 37 animals	0·50–1·07 Av.: 0·69 (calculated)	Age from 1 month to 9 years, different breeds, both sexes; done during late summer, fall, and winter.
1933	Graf.....	Folin.....	S.A.....	50–60	0·33–0·73 Av.: 0·46	'Laked' filtrates; animals of different breeds, ages, and both sexes.
1933	Graf.....	Folin.....	S.A.....	50–60	0·14–0·56 Av.: 0·23	'Unlaked' filtrates of above animals.
1935	This Paper.....	Folin.....	S.A.....	119 7 animals	0·18–1·25 Av.: 0·50	'Laked' filtrates; animals ± 2 years, different breeds, both sexes, done over 1 year.
1935	This Paper.....	Folin.....	S.A.....	119 7 animals	0·08–0·71 Av.: 0·18	'Unlaked' filtrates of above.

AMINO ACID NITROGEN.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1930	Allardyce, Fleming, Fowler, and Clark	Folin and Wu.....	Canada....	64 21 animals	5·0–8·6 Av.: 6·3 (calculated)	Dairy cows and heifers; blood drawn 4–5 hours after morning feeding; done over 3 and 4 months; ± 3 analyses on each animal.
1933	Danielson.....	Folin.....	—	1	5·23	Whole blood of calf.
1933	Graf.....	Folin.....	S.A.....	50–60	4·3–8·4 Av.: 5·8	'Laked' filtrates; animals of different breeds and ages.
1933	Graf.....	Folin.....	S.A.....	50–60	2·1–5·6 Av.: 3·8	'Unlaked' filtrates of above animals.
1935	This Paper.....	Folin.....	S.A.....	126 7 animals	3·89–7·61 Av.: 5·21	'Laked' filtrates; animals ± 2 years, different breeds, both sexes; done over 1 year.
1935	This Paper.....	Folin.....	S.A.....	124 7 animals	2·44–5·83 Av.: 4·41	'Unlaked' filtrates of above.

The methods used for the above constituent are, with the one exception, the same. The average in all instances agree fairly well, except of course that of the 'unlaked' filtrates.

CHLORINE.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1926	Robinson and Huffmann	van Slyke.....	U.S.A.....	110 110 animals	294–357 Av.: 329	Various ages and breeds, both sexes; done over 8 days on plasma.
1927	Theiler, Green, and du Toit	Not stated.....	S.A.....	5 5 animals	280–305 Av.: 288	From border-line to ample P. and Ca.; normal animals.
1928	Green and Macaskill	Volhard Volumetric method	S.A.....	12 3 animals	295–305 Av.: 300	Veld-bred cattle; analysis done on whole blood over 2 months.
1928	Hayden and Fish...	—	U.S.A.....	Many	267–303	Range for horse, cow, goat, and chicken.
1930	Anderson, Gayle, and Pratt	Whitehorn.....	U.S.A.....	55 37 animals	260–299	Animals from 1 month to 9 years, different breeds, both sexes; done during late summer, fall, and winter.
1930	Allardyce, Fleming, Fowler, and Clark	Whitehorn.....	Canada....	64 21 animals	255–302 Av..: 288 (calculated)	Dairy cows and heifers; blood drawn 4–5 hours after morning feeding; done over 3 and 4 months; ± 3 analyses on each animal.
1930	Sjollema.....	Not stated.....	Holland...	4 4 animals	319–332 Av.: 326	Normal cows.
1935	Groenewald.....	Smirk.....	S.A.....	312 12 animals	217–369 Av.: 314	Yearling heifers, done over 2½ years.
1935	This Paper.....	Method described in text	S.A.....	113 7 animals	250–336 Av.: 301	Age ± 2 years, different breeds, both sexes; done over 1 year.

SODIUM.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1923	Briggs.....	Kramer and Tisdall....	U.S.A.....	2 1 animal	322–325 Av.: 323	Determined on plasma, done on same sample.
1927	Theiler, Green, and du Toit	Not stated.....	S.A.....	5 5 animals	280–301 Av.: 289	From border-line to ample Ca. P.; done on normal animals.
1928	Green and Macaskill	Gravimetrically as pyro-antimonate	S.A.....	13 13 animals	240–295 Av.: 267	Veld-bred cattle from 24 hours to 10 weeks after calving.
1930	Sjollema.....	Not stated.....	Holland...	5 5 animals	303–349 Av.: 330	Normal cows.
1935	Groenewald.....	Malan and v. d. Lingen..	S.A.....	312 12 animals	110–519 Av.: 302	Yearling heifers, done over $2\frac{1}{2}$ years.
1935	This Paper.....	Malan and v. d. Lingen..	S.A.....	123 7 animals	240–349 Av.: 293	Age $\pm$ 2 years, different breeds, both sexes; done over 1 year.

POTASSIUM.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1923	Briggs.....	Doisy and Bell modified	U.S.A.....	2 1 animal	17·0–18·1 Av.: 18·0	Determined on plasma, same blood sample.
1926	Robinson and Huffman	Briggs.....	U.S.A.....	Many Many animals	16·4–41·3 Av.: 27·3	Various breeds and ages, both sexes; done over 8 days.
1927	Theiler, Green, and du Toit	Not stated.....	S.A.....	6 6 animals	49–64 Av.: 55·5	From border-line to ample P. and Ca., normal animals.
1928	Green and Macaskill	Volumetrically by $KMnO_4$ titration	S.A.....	13 3 animals	34–43 Av.: 38·7	Veld-bred cattle, from 24 hours to 10 weeks after calving.
1935	Groenewald.....	Malan and v. d. Lingen..	S.A.....	312 12 animals	28·7—114·0 Av.: 58·7	Yearling heifers, done over 2½ years.
1939	This Paper.....	Malan and v. d. Lingen..	S.A.....	113 7 animals	30–47 Av.: 38·5	Age ± 2 years, different breeds, both sexes; done over 1 year.

CALCIUM.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1919	Meigs, Blatherwick, and Cary	Abderhalden, combined with McCrudden	U.S.A.....	11 11 animals	8·9–10·2 Av.: 9·6	Plasma Ca., 4 only pregnant, 3 pregnant and lactating, 4 only lactating.
1919	Cowie and Calhoun..	Modified Lyman's method	U.S.A.....	28 3 animals	Av.: 7·8	Healthy oxen, done on whole blood.
1923	Briggs.....	Ppt. as oxalate and titration	U.S.A.....	2 1 animal	12·4–12·6 Av.: 12·5	Determined on plasma.
1926	Robinson and Huffman	Ppt. as oxalate and titration	U.S.A.....	117 ± 40 animals	7·7–14·7 Av.: 11·0	Various ages and breeds, both sexes; done over 8 days.
1927	Theiler, Green, and du Toit	Ppt. as oxalate and titration	S.A.....	9 5 animals	8·7–10·4 Av.: 9·5	From border-line to ample P. and Ca., normal animals.
1928	Hayden and Fish...	Clark–Collip modification of Kramer–Tisdall	U.S.A.....	56 5 animals	7·5–14·0 Av.: 10·88	4 Animals calved during experiment done over 13 months.
1928	Green and Macaskill	Titration of oxalate....	S.A.....	13 3 animals	8·9–10·8 Av.: 10·1	Veld-bred cattle, from 24 hours to 10 weeks after calving.
1930	Anderson, Gayley, and Pratt	Modification of Kramer–Tisdall	U.S.A.....	55 ± 37 animals	9·96–16·18 Av.: 12·63	Age from less than 1 month to 9 years, different breeds, both sexes.
1930	Allardyce, Fleming, Fowler, and Clark	Clark and Collip.....	Canada....	64 21 animals	8·7–12·8 Av.: 10·4 (calculated)	Dairy cows and heifers, blood drawn 4–5 hours after morning feeding; done over 3–4 months, ± 3 analyses on each animal.
1933	Hambrock.....	—	Germany..	49 49 animals	8·0–13·8 Av.: 10·9	Done on serum of healthy animals.
1934	Allcroft and Green..	Modified method of Kramer and Tisdall	England...	139 139 animals	8·56–11·65	108 Samples from cows and heifers and 31 random samples.
1935	Groenewald.....	Malan and v. d. Lingen..	S.A.....	364 13 animals	5·5–15·5 Av.: 8·4	Yearling heifers, done over 2½ years.
1935	This Paper.....	Malan and v. d. Lingen..	S.A.....	119 7 animals	7·61–14·3 Av.: 10·5	Age ± 2 years, different breeds, different sexes; done over 1 year.

Many of the above figures agree very closely with the Author's, though many different methods have been applied, but most of these, if not all, are based on the oxalate precipitation.

MAGNESIUM.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1923	Briggs.....	Briggs.....	U.S.A.....	2 1 animal	2·4–2·7 Av.: 2·55	Done on plasma of same blood sample.
1926	Robinson and Huffman	Briggs.....	U.S.A.....	26 Many animals	0·31–3·08 Av.: 2·16	Various breeds and ages, both sexes; done over 8 days.
1928	Theiler, Green, and du Toit	Not stated.....	S.A.....	4 3 animals	4·3–5·4 Av.: 4·7	From border-line to ample Ca and P, normal animals.
1928	Green and Macaskill	Gravimetrically as pyrophosphate	S.A.....	12 3 animals	3·8–4·7 Av.: 4·2	Veld-bred cattle, from 24 hours to 10 weeks after calving.
1930	Sjollema.....	Not stated.....	Holland	Not stated	Av.: 1·66	Normal animals.
1931	Allcroft and Green.	Modification of Denis method	England...	139 139 animals	1·85–3·17	Done on serum; 108 normal cows and heifers, 32 random normal samples.
1932	Dryerre.....	Gravimetrically as pyrophosphate	England...	Not stated	1·8–3·12 Av.: 1·9	Normal cows.
1932–1933 (see 1934)	Blakemore and Stewart	—	England...	70 cattle	1·04–3·17 Av.: 2·13 2·4 — Av.: 2·97	Cows on farms with history of lactation tetany.
1935	Groenewald.....	Malan and v. d. Lingen..	S.A.....	338 13 animals	1·5–4·9 Av.: 2·7	Yearling heifers, done over 2½ years, different breeds.
1935	This Paper.....	Malan and v. d. Lingen..	S.A.....	115 7 animals	3·55–7·24 Av.: 4·59	Age ± 2 years, different breeds, both sexes; done over 1 year.

Though the method used by Groenewald is the same the Author used, the figures of Groenewald are rather on the low side, comparing the figures of other South African workers. It must be stated, however, that the above method was not used exactly by the Author as Malan and v. d. Lingen pescribe it (see under " Methods of Analyses ").

INORGANIC PHOSPHORUS.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1923	Briggs.....	Modification of Bell–Doisy	—	2 1 animal	7·1	Determined on plasma on same blood sample.
1926	Robinson and Huffman	Briggs modification of Bell-Doisy	U.S.A.....	122 40 animals	3·0–9·0 Av.: 5·9	Various ages and breeds, both sexes; done over 8 days.
1927	Theiler, Green, and du Toit	Not stated.....	S.A.....	5 5 animals	4·0–6·2 Av.: 5·2	Sufficient P. and Ca., normal animals.
1928	Green and Macaskill	Green.....	S.A.....	13 3 animals	4·3–5·6 Av.: 4·7	Veld-bred cattle, from 24 hours to 10 weeks after calving.
1928	Hayden and Fish...	Fish and Subbarow.....	U.S.A.....	34	2·31–9·63 Av.: 5·7	Cows.
1930	Anderson, Gayley, and Pratt	Briggs modification of Bell-Doisy	U.S.A.....	20 Many animals	3·09–6·17 Av.: 4·46	Age from 1 month to 9 years, different breeds, both sexes; done during late summer, fall, and winter.
1930	Allardyce, Fleming, Fowler, and Clark	Fish and Subbarow.....	Canada....	64 21 animals	2·67–6·70 Av.: 4·2	Dairy cows and heifers; blood drawn 4–5 hours after morning feeding; done over 3–4 months; ± 3 analyses on each animal.
1930	Sjollema.....	Not stated.....	Holland...	Not stated	4–6 Av.: 4·6	Normal animals.

INORGANIC PHOSPHORUS (*continued*).

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1931	Hambrock.....	Original not available..	Germany	49 49 animals	3·0–10·6 Av.: 6·3	Done on serum of healthy animals.
1931	Malan and Bekker No. 1	Green, with slight modification	S.A.....	108 8 animals	1·6–7·5 Av.: 4·82	Pregnant, 2 and 3 years old; done over 1 year; different breeds; fed bonemeal.
1931	Malan and Bekker, No. 2	Green, with slight modification	S.A.....	104 10 animals	0·9–6·1 Av.: 2·53	Control for above pregnant, no bonemeal.
1931	Malan and Bekker, No. 1	Green, with slight modification	S.A.....	76 8 animals	4·0–9·9 Av.: 6·7	New-born calves of No. 1, above; done over 8 weeks.
1931	Malan and Bekker, No. 2	Green, with slight modification	S.A.....	81 9 animals	3·1–8·1 Av.: 6·6	New-born calves of No. 2 above; done over 8 weeks.
1932	Malan and du Toit..	Green, with slight modifi-	S.A.....	24 7 animals	3·1–7·0 Av.: 5·6	Age 9 months; done over 2 years; fed 2 oz. bonemeal per day.
1935	Groenewald.....	Malan and v.d. Lingen..	S.A.....	54 2 animals	4·7–9·7 Av.: 7·2	All mineral sufficiency, yearling heifers; done over 2½ years.
1935	This Paper.....	Malan and v. d. Lingen..	S.A.....	119	4·5–10·6 Av.: 7·17	Age ± 2 years, various breeds, both sexes done over 1 year.

A comparison of the above figures reveals the position that exists. The only figure that closely agrees with the Author's is that of Groenewald, done in the same institution and by the same method.

IRON.

Year.	Author.	Method.	Country.	No. of Analyses and No. of Animals.	Mgm. per 100 cc.	Remarks.
1931	McCay.....	Wong.....	U.S.A.....	113 113 animals	Av.: 39·0	Cows, done during May.
1931	McCay.....	Wong.....	U.S.A.....	113 113 animals	Av.: 38·7	Cows, same as above; done during July
1935	This Paper.....	Wong.....	S.A.....	125 7 animals	28–64 Av.: 49	Age ± 2 years, different breeds, both sexes; done over 1 year.

In compiling the data of the comparative tables it was found that very little has been done on the iron content of bovine blood. The only comparative figures found being the above. A comparison can hardly be warranted, though the methods used are the same. The figures of McCay are representative, being from many animals, but the analyses were not done over a period.

SUMMARY.

In this paper, the seventh of a series of bloodstudies of domestic animals, data in respect of normal bovines have been presented. Determinations of Hb, T.N., S., N.P.N., U.N., " T "C.N., U.A.N., and A.A.N., as well as Cl, Na, K, Mg, Ca, P (inorg.), and Fe in the case of seven bovines are submitted and the salient differences briefly touched upon. Comparative data of other workers from different countries have been appended.

ACKNOWLEDGMENTS.

In conclusion I wish to acknowledge gratefully my indebtedness to Dr. P. J. du Toit, Director of Veterinary Services, for his permission to undertake and to publish this work and for the facilities placed at my disposal in the persuance thereof.

Further I wish to express my appreciation to Dr. H. Graf, Head of this Section, for his very helpful suggestions and his interest shown in the completion of this article.

To Mr. A. P. Malan, statistician, my thanks are due for the statistical analyses and for his suggestions as to the presentation of the data.

REFERENCES.

ALLARDYCE, J., FLEMING, R. H., FOWLER, F. L., AND CLARK, R. H. (1930). Blood Normals for Cattle. Some Pathological values. *Canadian Journal of Research.* Vol. 3, pp. 120–124.

ALLCROFT, W. M. (1933). Decinormal Variations in the Blood-Sugar Level of the Lactating Cow. *Biochem. J.* Vol. 27, pp. 1820–1823.

ALLCROFT, W. M., AND GREEN, H. H. (1934). Blood Calcium and Magnesium of the Cow in Health and Disease. *Biochem. J.*, Vol. 28, pp. 2220–2228.

ANDERSON, A. K., GAYLEY, H. E., AND PRATT, A. D. (1930). Studies on the Chemical Composition of Bovine Blood. *J. of Dairy Science.* Vol. 13, pp. 336–348.

BLAKEMORE AND STEWART (1932–1933) (1934) *cit. Biochem. J.* Vol. 28, pp. 2220.

BRIGGS, H. P. (1923). A Study of the Inorganic Elements of Blood Plasma. *J. Biol. Chem.* Vol. 57, pp. 351–357.

BROOKS, H. J., AND HUGHES, J. S. (1932). The Haemoglobin content of the Blood of Dairy Cattle. *J. of Nutrition.* Vol. 5, pp. 35–38.

COWIE, D. M., AND CALHOUN, H. A. (1919). The Presence of Calcium in the Red Blood Corpuscles of Ox and Man. *J. Biol. Chem.* Vol. 37, pp. 505–509.

DANIELSON, J. S. (1933). Amino acid in Blood and its Determination. *J. Biol. Chem.* Vol. 101, pp. 505–522.

DEMMEL, M. (1933). Comparative Estimation of Blood-Sugar in Cattle by Different Methods. *Biochem. Ztschr.*, 1933. Vol. 262, pp. 294–299.

DRYERRE, H. (1932). Lactation Tetany. *The Vet. Record.* Vol. 12, pp. 1163–1168.

FOLIN, O. (1914). On the Determination of Creatinine and Creatine in Blood, Milk and Tissues. *J. Biol. Chem.* Vol. 17, pp. 475–481.

FOLIN, O., AND DENIS, W. (1914). On the Creatinine and Creatine Content of Blood. *J. Biol. Chem.* Vol. 17, pp. 487–491.

GODDEN, W., AND ALLCROFT, W. M. (1932). Changes in the composition of Cow's Blood at the Time of Calving and a Comparison of the Blood of the Calf with that of its Dam. *Biochem. J.* Vol. 26, pp. 1640–1646.

GRAF, H. (1933). Chemical Blood Studies. *Onderstepoort Journal of Veterinary Science and Animal Industry.* Vol. 1, No. 1, 371–401.

GREEN, H. H., AND MACASKILL, E. H. (1928). Studies in Mineral Metabolism VI. Comparison of the Blood of Cow and Calf in respect of Mineral Constituents. *J. Agric. Science.* Vol. 18, Part 3.

GREENWALD, I., AND MCQUIRE, G. (1918). The Estimation of Creatinine and of Creatine in the Blood. *J. Biol. Chem.* Vol. 34, pp. 103–118.

GROENEWALD, J. W. (1935). The Influence of Rations Low in Certain Minerals on the Composition of the Blood and Milk of Cows, and on the Blood of their Progeny. *The Onderstepoort Journal.* Vol. 4, No. 1.

HAMBROCK, H. (1931). Calcium and Phosphorus of Serum and Urine in Healthy and Sick Cattle (translated title). *Dissertation Hannover (Vet. Coll. Hannover).*

HAMERSMA, P. J. (1934). Chemical Blood Studies. *Onderstepoort Journal of Vet. Science and Animal Industry.* Vol. 2, No. 1, pp. 153–226.

HART, E. B., STEENBOCK, H., AND HUMPHREY, G. C. (1920). *Wisconsin* Agric. Exp. Station, Research Bull. No. 49, p. 19.

HART, E. B., STEENBOCK, H., HOPPERT, C. A., BOTHKE, R. M., AND HUMPHREY, G. C. (1922). *J. Biol. Chem.* Vol. 54, p. 82.

HAWK, P. B., AND BERGEIM, O. (1931). Practical Physiological Chemistry, 10th edition, p. 466.

HAYDEN, C. E., AND SHOLL, L. B. (1925). A study of the extractives of Blood of the Cow. *N.Y. State Vet. Col. Rpt.*, 1923–1924, pp. 102–110 (*cit. J. Agric. Res.* Vol. 44, pp. 357–365).

HAYDEN, C. E., AND FISH PIERRE, A. (1928). The Normal Blood of some Domesticated animals. *The Cornell Veterinarian,* Vol. 18, pp. 197–203.

HAYDEN, C. E. (1929). Sugar, Guanidine, and Cholesterol in the Blood in Milk fever. *The Cornell Veterinarian.* Vol. 19, pp. 285–293.

HODGSON, R. E., RIDDEL, W. H., HUGHES, J. S. (1932). Factors Influencing the Blood-Sugar Level of Dairy Cattle. *J. Agric. Res.* Vol. 44, pp. 357–365.

MALAN, A. I. AND VAN DER LINGEN, G. W. B. (1931). Studies in Mineral Metabolism XVI. The Micro-determination of Some Inorganic Elements in Blood and Vegetation. *17th Report Dir. Vet. Serv. and Anim. Indust.*, pp. 443–452.

MALAN, A. I., BEKKER, J. G. (1931). Inorganic Phosphorus in the Blood of Pregnant Heifers. *17th Rpt. of Dir. Vet. Serv. and Anim. Industry, Onderstepoort*, pp. 433–438.

McCAY, C. M. (1931). The Haemoglobin and Total Phosphorus in the Blood of Cows and Bulls. *J. of Dairy Science*. Vol. 14, p. 373.

MEIGS, E. B., BLATHERWICK, N. R. AND CARY, C. A. (1919). Contributions to the Physiology of Phosphorus and Calcium Metabolism as Related to Milk Secretion. *J. Biol. Chem.* Vol. 37, pp. 1–75.

NEAL, W. M., AND BECKER, R. B. (1933). The Haemoglobin Content of the Blood of Healthy and Anaemic "Salt-sick" Cattle. *J. Agric. Research*. Vol. 46, pp. 557–563.

ROBINSON, C. S., HUFFMAN, C. F. (1926). Studies on the Chemical Composition of Beef Blood. The Concentration of Certain Constituents in Normal Beef Plasma. *J. Biol. Chem.* 67, pp. 245–255.

SJOLLEMA, B. (1930). On the Nature and Therapy of Grass Staggers. *Vet. Rec.* Vol. 10, No. 20, pp. 425–430.

THEILER, A., GREEN, H. H., AND DU TOIT, P. J. (1927). Minimum Mineral Requirements in Cattle. *J. of Agric. Science*. Vol. 17, pp. 291–314.

VAN GELDER, R. H. (1928). Blutbeschaffenheit und Körperbau bei Hochgebirgs-und Niederungsvieh. *Tydschrift voor Diergeneeskunde*. Vol. 55, pp. 699–703.