TABLE 12.

Calcium in milk given monthly in mgm. per 100 c.c.

Group.	D.O.B. No.	First Lactation 1931.				Second Lactation 1932.					Comments.
		Month.			Average for 3 Months.	Month.			Average for 3 Months.	Average for 6 Months.	
		1st.	2nd.	3rd.		1st.	2nd.	3rd.			
Low Ca and P	3641	115	126	135	125	133	—	—	—	—	Died of styfsiekte.
	3648	127	144	145	139	130	149	—	—	—	
	Average	121	135	140	132	131	149	—	139	133	
Low Ca	3643	115	119	134	123	133	146	135	138	—	
	3655	116	108	133	119	129	155	144	143	—	
	Average	115	114	133	121	131	150	139	140	130	
Low Ca	3640	115	—	—	115	127	162	156	148	—	Calf died first lactation.
Low Mg	3650	106	119	125	117	128	142	134	135	—	
	Average	110	119	125	116	127	152	145	141	128	
All min. suff.	3639	119	108	139	122	—	—	—	—	—	No calf second lactation.
	3645	—	134	136	135	135	155	143	—	—	
	Average	119	121	137	128	135	155	143	144	136	
All min. def. exc. Ca and P.	3642	114	130	—	122	134	150	141	—	—	
	3649	124	131	125	127	102	159	133	—	—	
	Average	119	130	125	124	118	154	137	136	130	
Low Na	3672	—	—	—	—	—	—	—	—	—	Group not included in Ca studies.
	3653	—	—	—	—	123	155	152	—	—	
	Average	—	—	—	—	—	—	—	—	143	
All min. suff. + KI	3677	107	123	144	125	140	156	138	—	—	Died of metritis.
	3652	114	131	133	126	—	—	—	—	—	
	Average	110	127	138	125	—	—	—	145	135	

TABLE 13.

Inorganic phosphorus in milk given monthly in mgm. per 100 c.c.

Group.	D.O.B. No.	First Lactation 1931.				Second Lactation 1932.					Comments.
		Month.			Average for 3 Months.	Month.			Average for 3 Months.	Average for 6 Months.	
		1st.	2nd.	3rd.		1st.	2nd.	3rd.			
Low Ca and P...........	3641	120	98·0	105	—	85·0	—	—	—	—	Died of styfsiekte samples spilt.
	3648	93	93·6	105	—	76·0	—	—	—	—	
	Average	106	95·8	105	102·2	85·0	—	—	85·0	93·6	
Low Ca..................	3643	70	68·8	80·6	—	61·0	79·0	66·0	—	—	
	3655	74	80·7	77·2	—	98·0	65·0	61·4	—	—	
	Average	72	74·7	78·9	75·2	79·5	72·0	63·7	71·7	73·4	
Low Ca..................	3640	27·5	—	—	—	90·0	69·0	67·6	—	—	Calf died first lactation.
Low Mg..................	3650	96·7	87·5	107	—	69·0	76·0	71·0	—	—	
	Average	62·1	87·5	107	85·5	79·5	72·5	69·3	73·8	79·6	
All min. suff..............	3639	86·0	86·8	86·0	—	—	—	—	—	—	No calf second lactation.
	3645	—	95·5	105	—	73·0	70·1	76·0	—	—	
	Average	86·0	91·1	95·5	90·9	73·0	70·1	76·0	73·02	81·9	
Low P..................	3659	78·0	79·6	84·2	80·6	84·0	—	—	84·0	82·3	Died of styfsiekte.
All min. def. exc. Ca and P.	3642	98·8	94·9	93·3	—	78·0	71·0	85·0	—	—	
	3649	88·1	99·0	83·3	—	123·0	72·0	69·0	—	—	
	Average	93·4	96·9	88·3	96·2	100·5	71·5	77·0	83·0	89·6	
Low Na..................	3672	—	—	—	—	—	—	—	—	—	Tuberculosis.
	3653	—	—	—	—	69·0	72·0	87·0	—	—	
	Average	—			—	69·0	72·0	87·0	76·0	76·0	
All min. suff. + KI.......	3677	91·2	95·0	103	—	80·0	84·0	82·0	—	—	
	3652	90·8	93·3	88·2	—	—	—	—	—	—	Metritis.
	Average	91·0	94·1	95·6	93·8	80·0	84·0	82·0	82·0	87·9	

TABLE 14.

Total milk phosphorus given monthly in mgm. per 100 c.c.

Group.	D.O.B. No.	First Lactation 1931. Month. 1st.	First Lactation 1931. Month. 2nd.	First Lactation 1931. Month. 3rd.	First Lactation 1931. Average for 3 Months.	Second Lactation 1932. Month. 1st.	Second Lactation 1932. Month. 2nd.	Second Lactation 1932. Month. 3rd.	Second Lactation 1932. Average for 3 Months.	Second Lactation 1932. Average for 6 Months.	Comments.
Low Ca and P............	3641	176	140	167	—	191	—	—	—	—	Died of styfsiekte.
	3648	158	136	141	—	191	167	—	—	—	
	Average	167	138	154	153	191	167	—	179	166	
Low Ca..................	3643	151	119	136	—	165	145	192	—	—	
	3655	130	134	139	—	138	207	128	—	—	
	Average	140	126	137	134	151	176	160	162	148	
Low Ca..................	3640	134	—	—	—	115	152	135	—	—	Calf died first lactation.
Low Mg..................	3650	177	138	142	—	166	144	110	—	—	
	Average	155	138	142	145	140	148	122	137	141	
All min. sufficiency........	3639	155	140	133	—	—	—	—	—	—	No calf second lactation period.
	3645	—	160	136	—	122	143	154	—	—	
	Average	155	150	134	146	122	143	154	139	142	
Low P....................	3659	123	140	131	134	123	—	—	123	128	Died of styfsiekte.
All min. def. exc. Ca and P.	3642	162	130	133	—	121	121	183	—	—	
	3649	151	158	126	—	140	143	186	—	—	
	Average	156	144	129	143	130	132	184	149	146	
Low Na..................	3672	—	—	—	—	—	—	—	—	—	Tuberculosis.
	3653	—	—	—	—	104	126	153	—	—	
	Average	—	—	—	—	104	126	153	128	—	
All min. suff. + KI.......	3677	145	141	152	—	157	178	148	—	—	
	3652	192	141	120	—	—	—	—	—	—	Metritis.
	Average	168	141	136	148	157	178	148	161	154	

TABLE 15.

Magnesium in milk given monthly in mgm. per 100 c.c.

Group.	D.O.B. No.	First Lactation 1931. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Second Lactation 1932. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Average for 6 Months.	Comments.
Low Ca and P............	3641	12·7	12·7	14·7	—	13·2	—	—	—	—	Died of styfsiekte.
	3648	13·8	13·2	14·0	—	14·3	16·8	—	—	—	
	Average	13·2	12·9	14·3	13·5	13·2	16·8	—	15·7	14·6	
Low Ca..................	3643	10·5	12·5	16·8	—	13·5	12·3	11·8	—	—	
	3655	—	14·3	14·4	—	12·8	13·2	13·6	—	—	
	Average	10·5	13·6	15·6	13·2	13·1	12·7	12·7	12·8	13·0	
Low Ca..................	3640	19·2	—	—	—	11·4	12·7	12·2	—	—	Calf died first lactation.
Low Mg..................	3650	11·9	13·9	12·7	—	12·0	14·0	14·3	—	—	
	Average	15·2	13·9	12·7	13·9	11·7	13·3	13·2	12·7	13·3	
All min. sufficiency.........	3639	14·0	15·8	14·0	—	—	—	—	—	—	No calf second time.
	3645	13·1	13·2	14·9	—	14·0	12·8	12·7	—	—	
	Average	13·5	14·5	14·4	14·1	14·0	12·8	12·7	13·2	13·6	
Low P..................	3659	10·5	11·5	11·5	11·2	10·9	—	—	10·9	11·0	Died of styfsiekte.
All min. def. exc. Ca and P.	3642	13·7	12·0	12·9	—	13·1	12·7	14·0	—	—	
	3649	11·7	15·5	11·3	—	13·3	16·0	12·4	—	—	
	Average	11·7	13·7	12·1	12·3	13·2	14·3	13·2	13·6	12·9	
Low Cl..................	3658	10·0	—	—	—	14·5	—	—	—	—	Tuberculosis.
	3675	—	—	—	—	—	—	—	—	—	Peritonitis.
	Average	10·0	—	—	10·0	14·5	—	—	14·5	12·2	
Low Na..................	3672	11·8	—	—	—	—	—	—	—	—	Tuberculosis.
	3653	—	—	—	—	11·3	12·6	13·0	—	—	
	Average	11·8	—	—	11·8	11·3	12·6	13·0	12·3	12·0	
All min. suff. + KI.......	3677	11·5	13·9	14·2	—	13·9	13·6	12·2	—	—	Peritonitis.
	3652	10·9	16·8	15·0	—	—	—	—	—	—	
	Average	11·1	15·3	14·6	13·7	13·9	13·6	12·2	13·2	13·4	
Low K..................	3656	—	—	—	—	—	—	—	—	—	Metritis.
	3673	10·5	—	—	—	11·9	12·0	—	—	—	
	Average	10·5	—	—	10·5	11·9	12·0	—	11·9	11·2	

TABLE 16.

Potassium in milk given monthly in mgm. per 100 c.c.

Group.	D.O.B. No.	First Lactation 1931. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Second Lactation 1932. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Average for 6 Months.	Comments.
Low Ca and P............	3641	204	193	199	—	—	—	—	—	—	Died of styfsiekte.
	3648	202	256	227	—	—	—	—	—	—	Sample spilt.
	Average	203	224	213	213	—	—	—	—	213	
Low Ca..................	3643	170	224	171	—	190	208	213	—	—	
	3655	167	228	165	—	176	227	227	—	—	
	Average	168	226	168	187	183	217	220	207	197	
All min. sufficiency........	3639	202	253	168	—	—	—	—	—	—	
	3645	199	247	—	—	170	241	207	—	—	
	Average	200	250	168	206	170	241	207	206	206	
Low P..................	3659	226	256	190	224	185	—	—	185	204	Died of styfsiekte.
All min. def. exc. Ca and P.	3642	—	242	256	—	170	170	229	—	—	
	3649	185	196	168	—	156	204	227	—	—	
	Average	185	219	212	205	163	187	228	193	199	
Low NaCl................	3651	—	—	—	—	—	—	—	—	—	No calf.
	3646	274	190	159	—	—	—	—	—	—	Pneumonia.
	Average	—	—	—	208	—	—	—	—	208	
Low Cl..................	3658	199	230	247	—	165	—	—	—	—	Tuberculosis.
	3675	262	230	191	—	—	—	—	—	—	Peritonitis.
	Average	230	230	219	226	165	—	—	165	195	
Low Na..................	3672	244	224	168	—	—	—	—	—	—	
	2653	227	196	191	—	179	207	221	—	—	
	Average	235	210	179	208	179	207	221	202	205	
All min. suff. + KI.........	3677	199	167	185	—	167	190	204	—	—	
	3652	176	222	226	—	—	—	—	—	—	Peritonitis.
	Average	187	194	205	195	167	190	204	187	191	
Low K..................	3656	—	—	—	—	—	—	—	—	—	Metritis.
	3672	193	207	222	—	194	209	207	—	—	
	Average	193	207	222	207	194	209	207	203	205	

TABLE 17.

Sodium in milk given monthly in mgm. per 100 *c.c.*

Group.	D.O.B. No.	First Lactation 1931. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Second Lactation 1932. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Average for 6 Months.	Comments.
Low Ca and P............	3641	49·7	37·0	50·0	—	37·8	—	—	—	—	Died of styfsiekte.
	3648	54·3	34·0	41·7	—	43·0	—	—	—	—	
	Average	51·9	35·5	45·8	44·3	40·4	—	—	40·4	42·3	
Low Ca..................	3643	39·7	34·0	62·3	—	46·0	42·0	54·0	—	—	
	3655	48·6	38·5	37·5	—	46·0	42·4	44·0	—	—	
	Average	44·1	36·2	49·9	43·4	46·0	42·2	49·0	44·3	43·9	
Low Ca and Mg...........	3640	—	—	—	—	58·0	39·0	43·0	—	—	Calf died first lactation.
	3650	55·0	37·5	40·4	—	64·0	50·0	64·0	—	—	
	Average	55·0	37·5	40·4	44·3	61·0	44·5	53·5	53·0	48·6	
All min. sufficiency........	3639	39·1	45·8	61·2	—	—	—	—	—	—	No calf second lactation.
	3645	48·2	33·2	37·8	—	48·6	47·0	56·0	—	—	
	Average	43·6	39·5	49·5	44·2	48·6	47·0	56·0	50·5	47·3	
Low P....................	3659	40·2	36·4	50·0	42·2	54·0	—	—	—	48·1	Died of styfsiekte.
All min. def. exc. Ca and P.	3642	44·6	34·3	55·3	—	54·0	45·0	56·0	—	—	
	3649	46·2	44·0	40·4	—	48·0	42·0	50·0	—	—	
	Average	45·4	39·1	36·9	40·5	51·0	43·5	63·0	49·8	44·2	
Low NaCl................	3651	—	—	—	—	—	—	—	—	—	No calf.
	3646	38·9	35·0	41·7	—	—	—	—	—	—	Pneumonia.
	Average	—	—	—	39·6	—	—	—	—	—	
Low Cl..................	3658	40·0	32·7	45·5	—	52·0	—	—	—	—	Tuberculosis.
	3675	46·2	48·4	57·1	—	—	—	—	—	—	Peritonitis.
	Average	43·1	40·5	56·3	46·6	—	—	—	—	—	
Low Na..................	3672	36·2	38·5	45·5	—	—	—	—	—	—	Tuberculosis.
	3653	41·2	38·7	50·0	—	48·0	41·6	54·0	—	—	
	Average	38·7	38·7	47·7	41·7	48·0	41·6	54·0	47·8	44·7	
All min. suff. + KI........	3677	43·0	37·5	55·3	—	74·0	55·6	55·0	—	—	
	3652	40·0	37·5	37·5	—	—	—	—	—	—	Peritonitis.
	Average	—	—	—	—	—	—	—	—	—	
Low K...................	3656	—	—	—	—	—	—	—	—	—	Metritis.
	3673	44·6	35·0	37·5	—	40·1	38·0	41·0	—	—	
	Average	—	—	—	39·0	—	—	—	39·7	39·3	

TABLE 18.

Chlorine in milk given monthly in mgm. per 100 c.c.

Group.	D.O.B. No.	First Lactation 1931. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Second Lactation 1932. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Average for 6 Months.	Comments.
Low Ca and P............	3641	—	—	—	—	—	—	—	—	—	Group not considered in Cl studies.
	3648	—	—	—	—	96·2	—	—	—	—	
	Average	—	—	—	—	96·2	—	—	96·2	96·2	
Low Ca..................	3643	—	—	—	—	106·0	75·0	80·3	—	—	Group not considered in Cl studies.
	3655	—	—	—	—	132·0	101·0	76·0	—	—	
	Average	—	—	—	—	119·0	88·0	78·1	95·0	95·0	
Low Ca and Mg..........	3640	—	—	—	—	106·0	96·2	75·0	—	—	Group not considered in Cl studies.
	3650	—	—	—	—	115·0	106·0	111·0	—	—	
	Average	—	—	—	—	110·5	101·1	93·0	101·5	101·5	
All min. sufficiency........	3639	96·0	92·7	93·7	—	—	—	—	—	—	No calf second lactation.
	3645	—	113·4	90·6	—	107·0	111·0	111·0	—	—	
	Average	96·0	103·0	92·1	97·0	107·0	111·0	111·0	109·7	103·3	
All min. def. exc. Ca and P.	3642	82·0	81·6	124·0	—	126·0	101·0	96·0	—	—	
	3649	83·4	83·0	82·5	—	131·0	86·1	76·0	—	—	
	Average	82·7	82·3	103·2	89·4	128·5	93·5	86·0	102·7	96·0	
Low NaCl................	3651	—	—	—	—	—	—	—	—	—	No calf.
	3646	135·0	105·2	80·0	—	—	—	—	—	—	Pneumonia.
	Average	—	—	—	101·4	—	—	—	—	101·4	
Low Cl..................	3658	99·0	100·0	89·6	—	115·0	—	—	—	—	Tuberculosis.
	3675	120·0	112·0	122·0	—	—	—	—	—	—	Peritonitis.
	Average	109·5	106·0	105·8	107·1	115·0	—	—	115·0	111·0	
Low Na..................	3672	117·0	126·0	115·0	—	—	—	—	—	—	Tuberculosis.
	3653	114·0	103·8	101·0	—	103·0	111·0	96·2	—	—	
	Average	115·5	114·9	108·0	112·8	103·0	111·0	96·2	103·4	108·1	
All min. suff. + Kl.......	3677	—	—	—	—	112·0	111·0	75·0	—	—	
	3652	—	—	—	—	—	—	—	—	—	Peritonitis.
	Average	—	—	—	—	112·0	111·0	75·0	99·3	99·3	
Low K...................	3656	123·0	66·3	81·2	—	109·0	103·0	98·0	—	—	Metritis.
	3673	—	—	—	90·2	—	—	—	100·0	95·1	
	Average	123·0	66·3	81·2	90·2	109·0	103·0	98·0	—	—	

TABLE 19.

Daily mineral intake in feed and output in milk for first lactation.

Group.	D.O.B. No.	CaO.		P_2O_5.		MgO.		K_2O.		Na_2O.		Cl.		Comments.
		In-take.	Out-go.	In-take.	Out-go.	In-take.	Out-go.	In-take.	Out-go.	In-take.	Out-go.	In-take.	Out-go.	
Low Ca and P...........	3461	6·8	16·4	15·4	30·0	21·4	18·4	76·3	22·6	18·9	6·7	51·4	9·3	
	3648	6·8	11·7	15·4	21·7	21·4	1·3	76·3	16·1	18·9	4·8	51·4	6·6	
Low P..................	3659	51·6	17·1	15·4	32·0	21·4	1·9	76·3	24·6	18·9	7·0	57·4	9·8	
Low Ca.................	3643	6·8	14·8	45·1	27·5	21·4	1·7	101·3	20·4	18·9	6·2	48·9	8·4	
	3655	6·8	13·2	45·1	24·6	21·4	1·5	101·3	18·3	18·9	5·4	48·9	7·5	
Low Ca and Mg..........	3640	—	—	—	—	—	—	—	—	—	—	—	—	No calf first lactation.
	3650	6·8	15·6	45·1	29·0	11·1	1·8	101·3	21·5	18·9	6·4	49·9	8·9	
All min. low exc. Ca and P.	3642	47·1	11·7	45·1	21·7	21·4	1·3	29·3	16·1	5·7	4·8	6·7	6·6	
	3649	47·1	11·7	45·1	21·7	21·4	1·3	29·3	16·1	5·7	4·8	6·7	6·6	
Low NaCl...............	3651	51·6	10·9	45·1	20·3	21·4	1·2	75·0	15·0	5·7	4·5	6·7	6·2	
	3646	51·6	16·4	45·1	30·4	21·4	1·8	75·0	22·6	5·7	6·7	6·7	9·3	
Low Cl.................	3658	51·6	15·6	45·1	29·0	21·4	1·8	76·3	21·5	18·9	6·4	6·7	8·9	
	3675	51·6	14·8	45·1	27·9	21·4	1·7	76·3	20·4	18·9	6·2	6·7	8·4	
Low Na.................	3653	51·6	17·2	45·1	32·0	21·4	1·9	76·3	23·6	5·7	7·0	57·4	9·8	
Low K..................	3656	—	—	—	—	—	—	—	—	—	—	—	—	Died of metritis.
	3673	51·6	10·9	45·1	20·2	21·4	1·2	29·3	15·0	18·9	4·5	57·4	7·1	
All min. suff. + KI.......	3677	47·1	12·5	45·1	23·2	21·4	1·4	76·3	17·2	18·9	5·1	57·4	6·2	
	3652	47·1	11·7	45·1	23·2	21·4	1·3	76·3	16·1	18·9	4·8	57·4	6·7	
All min. sufficiency.......	3645	47·1	12·5	45·1	23·6	21·4	1·7	76·3	17·2	18·9	5·1	57·4	7·1	
	3639	47·1	—	45·1	—	21·4	—	76·3	—	18·9	—	57·4	—	No calf second lactation.

TABLE 20.

Daily mineral intake in feed and outgo in milk for second lactation.

Group.	D.O.B. No.	CaO.		P_2O_5.		MgO.		K_2O.		Na_2O.		Cl.		Comments.
		In-take.	Out-go.	In-take.	Out-go.	In-take.	Out-go.	In-take.	Out-go.	In-take.	Out-go.	In-take.	Out-go.	
Low Ca and P..........	3641	14·8	—	17·4	—	18·1	—	81·0	—	27·5	—	63·3	—	Died—Styfsiekte.
	3648	14·8	—	17·4	—	18·1	—	81·0	—	27·5	—	—	—	Died—Styfsiekte.
Low P..................	3659	59·1	—	18·0	—	20·1	—	83·0	—	25·6	—	65·3	—	Died—Styfsiekte.
Low Ca.................	3643	15·1	18·7	56·7	35·0	23·1	2·1	110·0	25·8	28·7	7·8	56·0	10·6	
	3655	15·1	21·0	56·7	39·1	23·1	2·4	110·0	29·0	28·7	8·6	56·0	12·0	
Low Ca and Mg.........	3640	15·1	13·0	56·7	33·3	12·8	2·0	110·0	24·8	28·7	7·4	56·0	10·2	
	3650	15·1	20·3	56·7	37·7	12·8	2·3	110·0	28·0	28·7	8·3	56·0	11·3	
All min. low exc. Ca and P.	3642	55·4	17·2	56·7	32·0	23·1	1·9	38·0	23·6	15·5	7·0	13·8	9·8	
	3649	55·4	18·0	56·7	33·3	23·1	2·0	38·0	24·8	15·5	7·3	13·8	10·2	
Low NaCl...............	3651	59·9	—	56·7	—	23·1	—	80·0	—	15·5	—	13·8	—	No calf.
	3646	59·9	—	56·7	—	23·1	—	80·0	—	15·5	—	13·8	—	Died pneumonia.
Low Cl..................	3658	59·9	—	56·7	—	23·1	—	80·0	—	28·7	—	—	—	Tuberculosis.
	3675	59·9	—	56·7	—	23·1	—	80·0	—	28·7	—	13·8	—	Peritonitis.
Low Na.................	3653	59·9	23·4	56·7	43·5	23·1	2·4	80·0	32·2	15·5	9·6	64·5	13·3	
	3672	—	—	—	—	—	—	—	—	—	—	—	—	Tuberculosis.
Low K..................	3656	59·9	—	56·7	—	23·1	—	38·0	—	—	—	—	—	Metritis.
	3673	59·9	—	56·7	—	23·1	—	38·0	—	28·7	—	64·5	—	
All min. suff. + KI......	3677	55·4	13·2	56·7	24·6	23·1	1·5	85·0	18·2	—	5·4	53·8	7·5	
	3652	55·4	—	56·7	—	23·1	—	85·0	—	28·7	—	—	—	Peritonitis.
All min. sufficiency.......	3639	—	—	—	—	23·1	—	85·0	—	28·7	—	—	—	No calf second lactation.
	3645	55·4	18·0	56·7	33·3	23·1	2·0	85·0	24·8	28·7	7·3	64·5	10·2	

TABLE 21.

Monthly milk yield in lb.

Group.	D.O.B. No.	First Lactation 1931. Months. 1st.	2nd.	3rd.	Total lb.	Average per Day in lb.	Second Lactation 1932. Month. 1st.	2nd.	3rd.	Total lb.	Daily Average.	Comments.
Low Ca and P......	3641	733·7	654·1	469·5	1,857·3	21	—	—	—	—	—	Died—Styfsiekte.
	3648	452·3	438·6	439·7	1,330·6	15	719·4	662·8	—	—	—	Died—Styfsiekte.
Low P.............	3659	770·6	676·2	577·3	2,024·1	22	817·6	—	—	—	—	Died—Styfsiekte.
Low Ca............	3643	654·4	583·3	505·4	1,743·1	19	771·7	703·2	652·6	2,127·5	24	
	3655	542·7	505·0	458·2	1,505·9	17	798·1	845·7	790·1	2,433·9	27	
Low Ca and Mg....	3640	—	—	—	—	—	672·9	738·4	661·7	2,073·0	23	No calf first lactation.
	3650	621·0	682·6	526·2	1,829·8	20	858·1	766·9	736·1	2,361·1	26	
All min. low exc. Ca and P	3642	714·8	419·1	240·7	1,374·6	15	719·7	692·0	617·3	2,029·0	22	
	3649	663·5	470·3	254·1	1,387·9	15	730·9	660·4	659·6	2,050·9	23	
Low Na and Cl.....	3651	554·4	426·5	306·9	1,287·8	14	—	—	—	—	—	No calf.
	3646	684·4	669·6	556·3	1,910·3	21	—	—	—	—	—	Pneumonia.
Low Cl............	3758	703·2	649·7	492·1	1,845·0	20	487·8	—	—	—	—	Tuberculosis.
	3675	715·5	557·3	483·0	1,755·8	19	—	—	—	—	—	Peritonitis.
Low Na............	3653	1,010·9	645·3	470·8	2,127·0	22	938·8	929·2	853·7	2,716·7	30	
Low K.............	3656	—	—	—	—	—	—	—	—	—	—	
	3673	536·1	492·9	271·9	1,300·9	14	885·6	—	—	—	—	Metritis.
All min. suff. + KI..	3677	465·4	634·6	482·2	1,482·2	16	601·4	413·0	488·0	1,502·4	17	
	3652	512·5	428·8	382·1	1,323·4	15	—	—	—	—	—	
All min. sufficiency..	3639	—	—	—	—	—	—	—	—	—	—	No calf.
	3645	500·4	498·5	447·3	1,446·2	16	746·1	698·7	611·2	2,056·0	23	

TABLE 22.

Monthly butter-fat percentages.

Group.	D.O.B. No.	First Lactation, 1931.				Second Lactation, 1932.					Comments.
		Month.			Average for 3 Months.	Month.			Average for 3 Months.	Average for 6 Months.	
		1st.	2nd.	3rd.		1st.	2nd.	3rd.			
Low Ca. and P...........	3641	2·5	3·0	3·3	—	—	—	—	—	—	Died—Styfsiekte.
	3648	3·0	3·3	3·1	—	2·4	2·9	—	—	—	Died—Styfsiekte.
	Average	2·7	3·2	3·2	3·0	2·4	2·9	—	2·6	2·8	
Low Ca...................	3643	3·8	2·5	2·1	—	2·6	3·4	3·0	—	—	
	3655	3·0	2·2	2·7	—	3·8	3·2	3·5	—	—	
	Average	3·4	2·4	2·4	2·7	3·7	3·3	3·2	3·4	3·0	
Low Ca and Mg............	3640	—	—	—	—	3·1	3·3	3·5	—	—	
	3650	3·0	2·7	2·2	—	3·1	3·0	3·5	—	—	
	Average	3·0	2·7	2·2	2·6	3·1	3·1	3·5	3·3	3·0	
All min. sufficiency........	3639	3·5	2·6	2·7	—	—	—	—	—	—	
	3645	3·8	3·1	2·9	—	3·1	3·7	2·9	—	—	
	Average	3·6	2·8	2·8	3·1	3·1	3·7	2·9	3·2	3·1	
Low P....................	3659	4·3	4·2	3·2	3·9	4·0	—	—	4·0	3·9	Died—Styfsiekte.
All min. def. exc. Ca and P..	3642	3·8	3·4	2·4	—	2·5	2·9	2·6	—	—	
	3649	3·5	3·2	3·1	—	4·0	3·1	2·9	—	—	
	Average	3·6	3·3	2·7	3·2	3·2	3·0	2·7	3·0	3·1	
Low NaCl.................	3651	2·6	2·3	2·6	—	—	—	—	—	—	No calf.
	3646	3·3	3·0	3·6	—	—	—	—	—	—	Pneumonia.
	Average	2·9	2·6	3·1	2·9	—	—	—	—	2·9	
Low Cl...................	3658	3·0	3·0	2·9	—	4·2	—	—	—	—	Tuberculosis.
	3675	2·6	2·4	2·7	—	—	—	—	—	—	Peritonitis.
	Average	2·8	2·7	2·8	2·8	4·2	—	—	4·2	3·5	
Low Na..................	3672	2·7	2·5	2·4	—	—	—	—	—	—	Tuberculosis.
	3653	2·8	1·7	2·0	—	2·3	2·9	2·6	—	—	
	Average	2·7	2·1	2·2	2·3	2·3	2·9	2·6	2·6	2·4	
All min. suff. + KI........	3677	2·7	2·9	1·8	—	3·7	4·1	3·0	—	—	
	3652	2·6	2·3	2·0	—	—	—	—	—	—	Peritonitis.
	Average	2·6	2·6	1·9	2·4	3·7	4·1	3·0	3·6	3·0	
Low K...................	3656	—	—	—	—	—	—	—	—	—	Metritis.
	3673	2·6	2·5	4·4	—	3·1	2·9	—	—	—	
	Average	2·6	2·5	4·4	3·2	3·1	2·9	—	3·0	3·1	

TABLE 23.

Monthly solids-not-fat percentages.

Group.	D.O.B. No.	First Lactation, 1931. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Second Lactation, 1932. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Average for 6 Months.	Comments.
Low Ca. and P...........	3641	7·9	7·9	7·8	—	8·0	—	—	—	—	Died—Styfsiekte.
	3748	8·5	8·9	8·0	—	8·1	8·3	—	—	—	Died—Styfsiekte.
	Average	8·2	8·4	7·9	8·2	8·0	8·3	—	8·1	8·1	
Low Ca..................	3643	8·4	8·1	8·3	—	8·2	8·5	8·6	—	—	
	3655	8·4	8·4	8·3	—	8·2	8·1	8·0	—	—	
	Average	8·4	8·2	8·3	8·3	8·2	8·3	8·3	8·3	8·3	
Low Ca and Mg...........	3640	—	—	—	—	8·4	8·7	8·5	—	—	
	3650	8·1	7·9	7·8	—	8·3	8·2	7·8	—	—	
	Average	8·1	7·9	7·8	7·9	8·4	8·4	8·1	8·3	8·1	
All min. sufficiency........	3639	8·4	8·3	8·5	—	—	—	—	—	—	No calf second lactation.
	3645	8·7	8·0	8·1	—	8·2	8·5	8·2	—	—	
	Average	8·5	8·1	8·3	8·4	8·2	8·5	8·2	8·3	8·3	
Low P..................	3659	7·8	8·3	7·8	8·0	7·7	—	—	7·7	7·9	Styfsiekte.
All min. def. exc. Ca and P..	3642	8·2	7·9	7·5	—	8·4	8·5	8·4	—	—	
	3649	8·4	8·3	8·3	—	8·3	8·4	8·3	—	—	
	Average	8·3	8·1	7·9	8·1	8·3	8·4	8·4	8·4	8·3	
Low NaCl................	3651	8·0	8·5	8·4	—	—	—	—	—	—	No calf.
	3646	8·0	8·0	7·8	—	—	—	—	—	—	Pneumonia.
	Average	8·0	8·2	8·1	8·1	—	—	—	—	8·1	
Low Cl..................	3658	8·2	8·0	7·6	—	8·9	—	—	—	—	Tuberculosis.
	3675	7·9	8·2	8·0	—	—	—	—	—	—	Peritonitis.
	Average	8·0	8·1	7·7	8·0	8·9	—	—	8·9	8·4	
Low Na..................	3672	8·1	8·1	7·9	—	—	—	—	—	—	Tuberculosis.
	3653	8·5	8·3	8·3	—	8·0	8·1	8·3	—	—	
	Average	8·3	8·2	8·1	8·2	8·0	8·1	8·3	8·1	8·1	
All min. sufficiency + KI..	3677	8·0	8·5	8·4	—	8·5	8·8	8·7	—	—	
	3652	8·2	8·1	8·0	—	—	—	—	—	—	Peritonitis.
	Average	8·1	8·3	8·2	8·2	8·5	8·8	8·7	8·7	8·5	
Low K..................	3656	—	—	—	—	—	—	—	—	—	Metritis.
	3673	8·3	8·3	8·8	—	8·0	8·4	—	—	—	
	Average	8·3	8·3	8·8	8·5	8·0	8·4	—	8·2	8·3	

TABLE 24.

Monthly Protein percentages of milk.

Group.	D.O.B. No.	First Lactation, 1931. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Second Lactation, 1932. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Average for 6 Months.	Comments.
Low Ca and P............	3641	2·5	2·8	3·0	—	3·0	—	—	—	—	Died—Styfsiekte.
	3648	2·8	3·0	2·9	—	2·8	2·9	—	—	—	Died—Styfsiekte.
	Average	2·6	2·9	2·9	2·8	2·9	2·9	—	2·9	2·8	
Low Ca..................	3643	3·3	2·5	2·2	—	3·2	3·1	2·8	—	—	
	3655	2·8	2·3	2·6	—	3·3	2·9	3·1	—	—	
	Average	3·0	2·4	2·5	2·6	3·2	3·0	2·9	3·0	2·8	
All min. sufficiency........	3639	3·1	2·6	2·6	—	—	—	—	—	—	No calf second lactation.
	3645	3·3	2·9	2·8	—	2·9	3·3	2·8	—	—	
	Average	3·2	2·7	2·7	2·9	2·9	3·3	2·8	3·0	2·9	
Low P..................	3659	3·6	3·6	2·9	3·4	3·5	—	—	3·5	3·4	Died—Styfsiekte.
All min. def. exc. Ca and P..	3642	3·3	3·1	2·4	—	2·5	2·8	2·6	—	—	
	3649	3·1	2·9	2·9	—	3·5	2·9	2·8	—	—	
	Average	3·2	3·0	2·6	2·8	3·0	2·8	2·7	2·8	2·8	
Low NaCl................	3651	2·6	2·4	2·6	—	—	—	—	—	—	No calf.
	3646	3·0	2·8	3·2	—	—	—	—	—	—	Pneumonia.
	Average	2·8	2·6	2·9	2·8	—	—	—	—	2·8	
Low Cl..................	3658	2·8	2·8	2·6	—	3·6	—	—	—	—	Tuberculosis.
	3675	2·6	2·4	2·6	—	—	—	—	—	—	Peritonitis.
	Average	2·7	2·6	2·7	2·7	3·6	—	—	3·6	3·1	
Low Na..................	3672	2·6	2·5	2·4	—	—	—	—	—	—	Tuberculosis.
	3653	2·7	2·0	2·2	—	2·4	2·8	2·6	—	—	
	Average	2·6	2·2	2·3	2·4	2·4	2·8	2·6	2·6	2·5	
All min. suff. + KI........	3677	2·6	2·8	2·0	—	3·3	3·5	2·8	—	—	
	3652	2·6	2·4	2·2	—	—	—	—	—	—	Peritonitis.
	Average	2·6	2·6	2·1	2·4	3·3	3·5	2·8	3·2	2·8	
Low K..................	3656	—	—	—	—	—	—	—	—	—	
	3672	2·6	2·5	3·7	—	3·2	2·9	3·0	—	—	
	Average	2·6	2·5	3·7	3·0	3·2	2·9	3·0	3·0	3·0	

TABLE 25.

Monthly total ash percentages of milk.

Group.	D.O.B. No.	First Lactation, 1931. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Second Lactation, 1932. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Average for 6 Months.	Comments.
Low Ca and P............	3641	0·63	0·67	0·69	—	0·69	—	—	—	—	Died—Styfsiekte.
	3647	0·67	0·69	0·68	—	0·70	—	—	—	—	Died—Styfsiekte.
	Average	0·65	0·67	0·68	0·67	0·69	—	—	—	0·68	
Low Ca..................	3642	0·72	0·63	0·60	—	0·71	0·70	0·67	—	—	
	3655	0·67	0·61	0·65	—	0·72	0·68	0·70	—	—	
	Average	0·69	0·62	0·62	0·64	0·71	0·69	0·68	0·69	0·68	
Low Ca and Mg..........	3640	—	—	—	—	0·68	0·69	0·70	—	—	No calf first lactation.
	3650	0·67	0·65	0·61	—	0·68	0·67	0·70	—	—	
	Average	0·67	0·65	0·61	0·66	0·68	0·68	0·70	0·69	0·67	
All min. sufficiency........	3639	0·70	0·65	0·65	—	—	—	—	—	—	No calf second lactation.
	3645	0·72	0·68	0·67	—	0·68	0·72	0·67	—	—	
	Average	0·71	0·66	0·66	0·68	0·68	0·72	0·67	0·69	0·68	
Low P..................	3659	0·75	0·75	0·68	0·72	0·74	—	—	0·74	0·73	Died—Styfsiekte.
All min. def. exc. Ca and P.	3642	0·72	0·70	0·62	—	0·63	0·69	0·65	—	—	
	3649	0·75	0·68	0·68	—	0·74	0·68	0·67	—	—	
	Average	0·73	0·69	0·65	0·69	0·68	0·68	0·66	0·67	0·68	
Low NaCl................	3651	0·65	0·62	0·65	—	—	—	—	—	—	No calf.
	3646	0·69	0·67	0·71	—	—	—	—	—	—	Pneumonia.
	Average	0·67	0·65	0·68	0·67	—	—	—	—	0·67	
Low Cl..................	3658	0·67	0·67	0·67	—	0·75	—	—	—	—	Tuberculosis.
	3675	0·65	0·62	0·65	—	—	—	—	—	—	Peritonitis.
	Average	0·66	0·66	0·66	0·68	0·75	—	—	0·75	0·71	
Low Na..................	3672	0·65	0·63	0·62	—	—	—	—	—	—	Tuberculosis.
	3652	0·66	0·58	0·60	—	0·62	0·69	0·65	—	—	
	Average	0·65	0·60	0·61	0·63	0·62	0·69	0·65	0·68	0·66	
All min. suff. + KI.......	3677	0·65	0·67	0·58	—	0·72	0·74	0·67	—	—	Tuberculosis.
	3652	0·65	0·62	0·60	—	—	—	—	—	—	Peritonitis.
	Average	0·65	0·64	0·59	0·63	0·72	0·74	0·67	0·71	0·67	
Low K..................	3656	—	—	—	—	—	—	—	—	—	
	3673	0·65	0·63	0·78	—	0·70	0·68	0·69	—	—	Metritis.
	Average	0·65	0·63	0·78	0·69	0·70	0·68	0·69	0·69	0·69	

TABLE 26.

Monthly lactose percentages of milk.

Group.	D.O.B. No.	First Lactation, 1931. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Second Lactation, 1932. Month. 1st.	2nd.	3rd.	Average for 3 Months.	Average for 6 Months.	Comments.
Low Ca and P............	3641	—	—	—	—	—	—	—	—	—	Cl. not determined.
	3648	—	—	—	—	5·32	—	—	—	—	Cl not determined.
	Average	—	—	—	—	5·32	—	—	—	—	
Low Ca..................	3643	—	—	—	—	5·16	5·72	5·62	—	—	First lactation Cl. not done.
	3655	—	—	—	—	4·69	5·25	5·70	—	—	
	Average	—	—	—	—	4·92	5·48	6·66	5·35	—	
Low Ca and Mg...........	3640	—	—	—	—	5·16	5·34	5·72	—	—	
	3650	—	—	—	—	5·00	5·16	5·07	—	—	
	Average	—	—	—	—	5·08	5·25	5·39	5·24	—	
All min. sufficiency........	3639	5·34	5·40	5·38	—	—	—	—	—	—	No calf second lactation.
	3645	—	5·03	5·44	—	5·14	5·07	5·07	—	—	
	Average	5·34	5·21	5·41	5·32	5·14	5·07	5·07	5·09	5·20	
Low P....................	3659	—	—	—	—	4·69	—	—	—	—	Cl. not done.
All min. def. exc. Ca and P.	3642	5·59	5·60	4·84	—	4·80	5·25	5·34	—	—	
	3649	5·57	5·58	5·58	—	4·71	5·52	5·70	—	—	
	Average	5·58	5·59	5·21	5·46	4·75	5·38	5·52	5·22	5·34	
Low NaCl................	3651	5·29	5·48	5·25	—	—	—	—	—	—	No calf.
	3646	4·64	5·18	5·63	—	—	—	—	—	—	Pneumonia.
	Average	4·96	5·29	5·44	5·23	—	—	—	—	—	
Low Cl..................	3658	5·29	5·27	5·46	—	5·00	—	—	—	—	Tuberculosis.
	3675	4·91	5·04	4·87	—	—	—	—	—	—	Peritonitis.
	Average	5·10	5·15	5·16	5·14	5·00	—	—	—	—	
Low Na..................	3672	4·96	4·80	5·00	—	—	—	—	—	—	Tuberculosis.
	3653	5·02	5·20	5·25	—	5·22	5·07	5·32	—	—	
	Average	4·99	5·00	5·12	5·04	5·22	5·07	5·32	5·20	5·12	
All min. suff. + KI.......	3677	—	—	—	—	5·05	5·07	5·72	—	—	
	3652	—	—	—	—	—	—	—	—	—	Peritonitis.
	Average	—	—	—	—	5·05	5·07	5·72	5·28	—	
Low K...................	3656	—	—	—	—	—	—	—	—	—	Metritis.
	3673	4·86	5·88	5·61	—	5·61	5·05	5·32	—	—	
	Average	4·86	5·88	5·61	5·45	5·61	5·05	5·32	5·32	5·38	

It is interesting to compare the daily intake of calcium, phosphorus, magnesium, potassium, sodium, and chlorine in the feed with the amounts of these elements excreted in the milk supply daily during the two three-month lactation periods. The figures showing the daily intake and loss of minerals are given in tables 19 and 20.

From the above tables it is apparent that in all groups the actual intake of minerals, where such was intended to be low in a ration, was actually reduced to a lower level than the daily output in the milk, the only exceptions being in the case of the group receiving a ration low in potassium and also of the group receiving a ration low in magnesium. The groups on a low calcium intake actually excreted in the milk more than twice the amount of calcium ingested daily.

The actual significance of these figures is, however, difficult to interpret when it is remembered that according to Crichton (1930) the system assimilates only about 15 to 20 per cent. of the minerals ingested daily. These figures nevertheless show the tremendous drain to which the organism may be subjected without a corresponding lowering of any mineral in the milk.

III. Further Studies on Milk.

In order to demonstrate the severe drop in milk flow during the first lactation period, tables are given for the monthly milk yield of each cow and the influence of such a decrease on constituents such as butter-fat, solids-not-fat, sugar, protein, and ash. The formulae that were previously given were of course used in compiling the data given for the protein, sugar, and total ash of milk.

(*a*) *Total milk production.*—The monthly as well as the total milk production for each cow is given in table 21, in order not only to allow group comparisons to be drawn showing the effect of low minerals on production, but also to compare the first lactation periods with the second lactation periods, during which latter period more protein was given. A record of the amount of milk produced also enable the calculation of total mineral output in the milk of each cow as given in tables 19 and 20.

The figures representing the milk yields for the cows during the first lactation (table 21), were corrected so as to enable direct comparisons to be made with the yields of the second lactation period. The corrections were effected according to the proposals of Macandlish (1921), i.e. that the milk yields of the first lactation period were multiplied by 1·143.

Attention should be drawn to the fact that the cows, without exception, produced more milk during the second lactation period. Unfortunately the death of a number of cows rendered the records rather incomplete.

(*b*) *Butter-fat percentages.*—All the butter-fat percentages were compiled from morning and evening determinations over a forty-eight hour period, and are given in table 22.

The butter-fat percentages, as may be seen from table 22, are surprisingly low throughout both the first and second lactation periods for all the groups, regardless of which mineral was low in the daily ration. Deplorably low as these figures may appear to a dairyman, the averages are nevertheless comparable with those of thousands of veld cattle in South Africa.

(*c*) *Solids-not-fat percentages.*—These readings were taken on all milk samples collected, and are given in table 23.

As may be seen from table 23, there is no appreciable difference between different groups or between the two lactation periods in regard to the percentage of solids-not-fat content. The average figure, 8·2 per cent. is, however, definitely lower than the normal figure obtained in other countries or with cows of high milking qualities.

(*d*) *Protein, lactose and ash in milk.*—From the following tables giving the data collected for protein, lactose, and ash in monthly milk samples, determined according to the previously described formulae, it will be seen that nutritional deficiencies produced by lowered mineral constituents in different groups had no effect on these substances in milk.

There is, however, a general uniformly lowered protein and ash throughout the whole experimental period in all the groups, regardless of their variations in rations in regard to mineral intake. This circumstance is easily explicable on the ground that the protein and ash values were calculated directly from the butter-fat percentages and would obviously tend to be low if the latter were low, as was the case (seen in table 22). The average protein was found to be 2·8 per cent., ash 0·68 per cent., and lactose 5·2 per cent., as shown in tables 24, 25 and 26.

IV. The Mineral Content of Calf Blood.

Determinations of calcium, inorganic phosphorus, magnesium, potassium, sodium and chlorine, were made on the calves as often as possible, with the result that a set of figures was obtained stretching over the three-month period, i.e. values for calves from 1 to 85 days old. To determine the general course in which a mineral element moved, seven-day period values were averaged successively and plotted in weekly periods. Three-weekly averages were then taken as the first point, that is weeks Nos. 1, 2, and 3; to obtain the second point an average was taken of weeks Nos. 2, 3 and 4; third point Nos. 3, 4 and 5, and so on for all the points. There were 15 calves, 12 of which were heifers, all were remarkably uniform, and as no group differences as affected by nutrition occurred, they were studied collectively as normal calves.

The trend of blood calcium of calf blood for the first three months of a calf's life is given in figure 1.

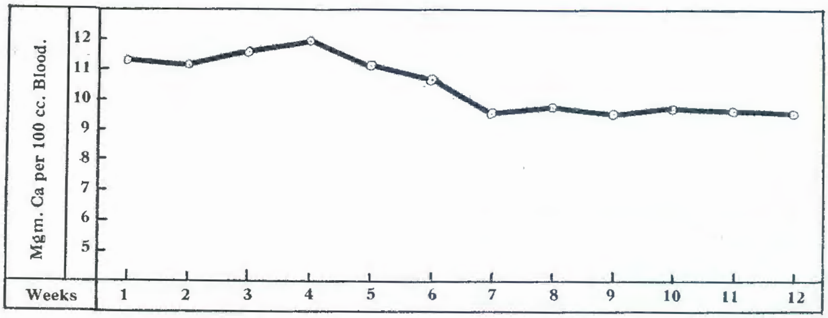

Fig. 1.

From Fig. 1 it will be noticed that the calcium of calf blood is relatively high for the first month of the calf's life. Then there is a gradual decline, until it finds its final level after seven weeks.

In a similar manner the inorganic blood phosphorus content of the calves was determined and plotted in figure 2.

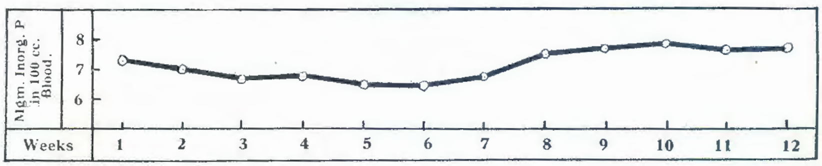

Fig. 2.

A glance at the curve shows that the inorganic phosphorus content of the blood of the young calf is relatively high and that there is no drop appreciable during the first three months of life.

The magnesium content of calf blood is shown in figure 3.

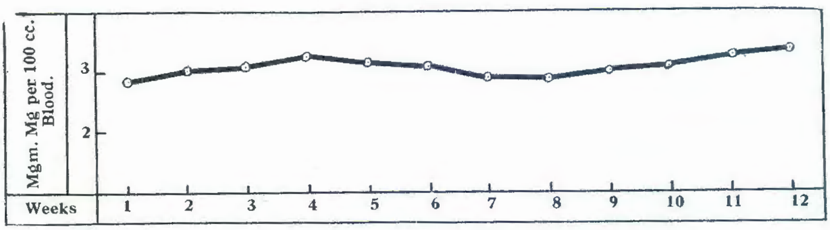

Fig. 3.

From figure 3 it is apparent that the magnesium content of calf blood is slightly higher than that of the cow's blood, and that there is no decline in the blood magnesium content for the first three months of a calf's life.

The potassium content of calves' blood is given in figure 4.

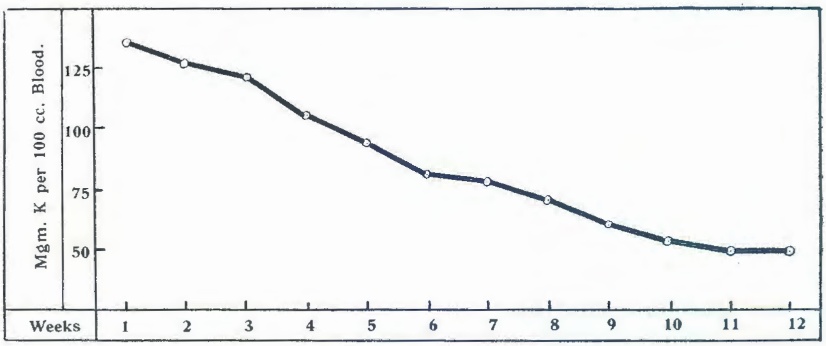

Fig. 4.

A study of the curve shows a truly remarkable behaviour of the potassium. In week-old calves the potassium of blood is about 130 mgm. per 100 c.c. blood, there is a steady decline as the animal advances in age until at about ten weeks the potasssium is approximately 50 mgm. per 100 c.c. of blood, which may be taken as normal for adult bovines.

Figure 5 gives the sodium content of calves' blood.

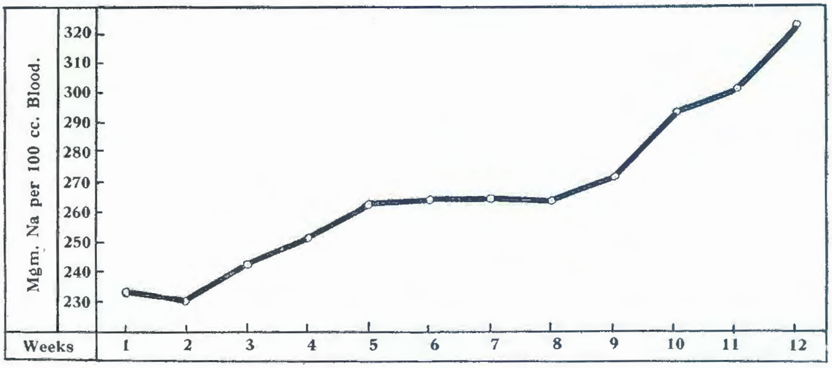

Fig. 5.

Again from the curve an upward trend as age advances, is noticeable in the sodium content of calf blood; although the sodium of blood is subject to greater fluctuations than is potassium, the upward trend is nevertheless significant.

The chlorine content of calf blood is given in figure 6.

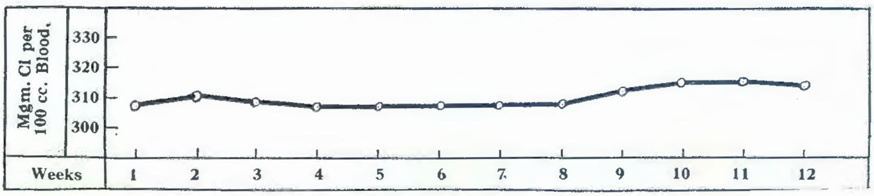

Fig. 6.

From figure 6 it is apparent that the chlorine in calf blood is not subject to variation with increasing age. There is no appreciable difference between calf blood chlorine content and the chlorine content of adult bovine blood.

It has been mentioned that during the first week of life each calf received its mother's milk. The mother's milk, however, had no influence on the mineral constituents of the calf's blood, as may be seen by comparing the figures for different calves during the first week. Changes in the calf blood are not to be expected when there were no changes in the composition of the milk (as may be seen from the various tables), so the analyses of the calf blood was continued after the first week when all the calves were receiving the mixed milk from the cows, substituted in due course by the proper amounts of grain and hay usually given to calves according to Weaver, Shaw and Ely (1924).

GENERAL DISCUSSION.

At the outset it must be mentioned that the rations low in various minerals had apparently no effect upon the animal so far as could be judged by any corresponding lowering of the blood mineral element concerned in the blood or milk. For this reason, as stated before, it was preferable to deal with all the animals collectively in respect of all the substances determined (except phosphorus) rather than to involve unnecessary repetition by considering each group separately.

In order to substantiate the results in the tables and illustrate these more clearly, curves are presented for mineral analyses of the blood of groups receiving rations low in the element plotted. The object is, of course, to show what direct effect certain deficiencies in the rations had on the blood and milk.

Deficiencies such as one of general protein, which occurred in all the groups during the first lactation period (as may be seen from table 21, where the milk production was considerably lowered), had no effect on the composition of the blood and milk.

It was likewise observed that a cow which gives birth to a weakling has nevertheless a normal mineral content of blood and milk.

The abnormal conditions, may therefore, be discarded when considering the curves and tables illustrating the blood and milk composition, because higher protein, plus ensilage in the rations, resulting in good gains in weight (seen in table 5) and normal calves during the second season did not bring about the slightest changes in the composition of the blood and milk as compared with that of the first season.

(*a*) *Calcium*.—By comparing the daily intake of calcium (table 3) and the intake and output in milk (tables 19 and 20) with the results for blood and milk calcium (tables 6 and 14), it will be noticed that, although considerable fluctuations in calcium content from month to month are manifest, these fluctuations may easily fall within the limit of experimental error or even of normal variation. Notwithstanding the fact that table 19 shows that during a certain period of the animal's life it was actually losing more than twice the calcium in the milk than was ingested in the daily ration, this shortage was not reflected by a lowering of the blood or milk calcium. The groups on the rations low calcium (D.O.B. 3643 and 3655), low calcium low magnesium (D.O.B. 3640 and 3650), and all mineral deficiency except calcium and phosphorus (D.O.B. 3642 and 3649) were not subjected to disease and lasted for the whole experimental period. The blood calcium of these groups is plotted in the curves together with that of the normal controls in figures 7, 8 and 9.

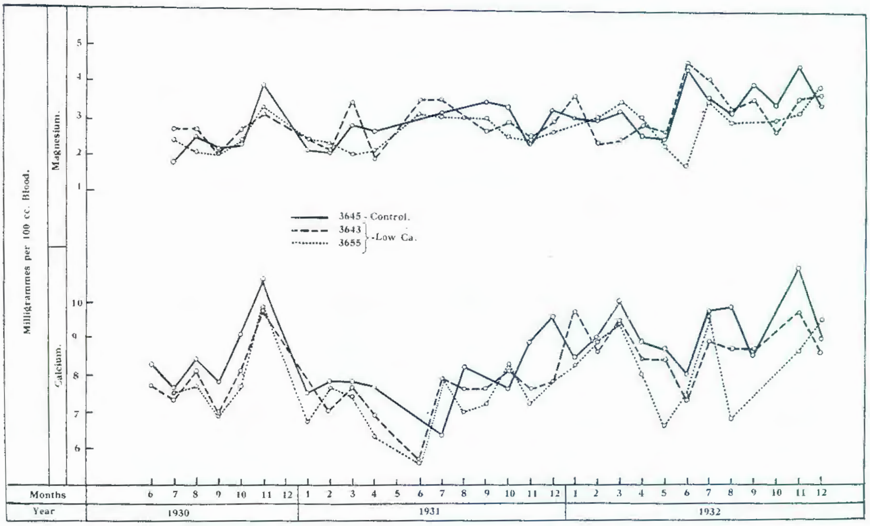

Fig. 7.—Calcium and magnesium in the blood of cows.

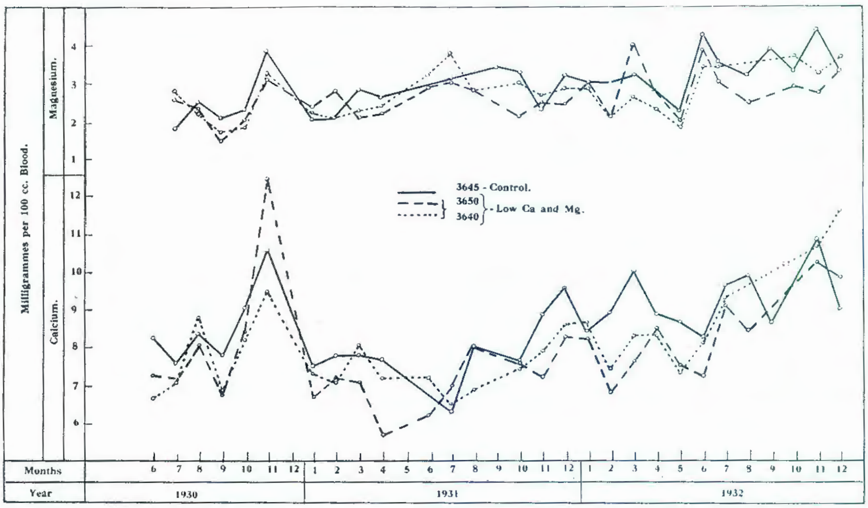

Fig. 8.—Calcium and magnesium in the blood of cows.

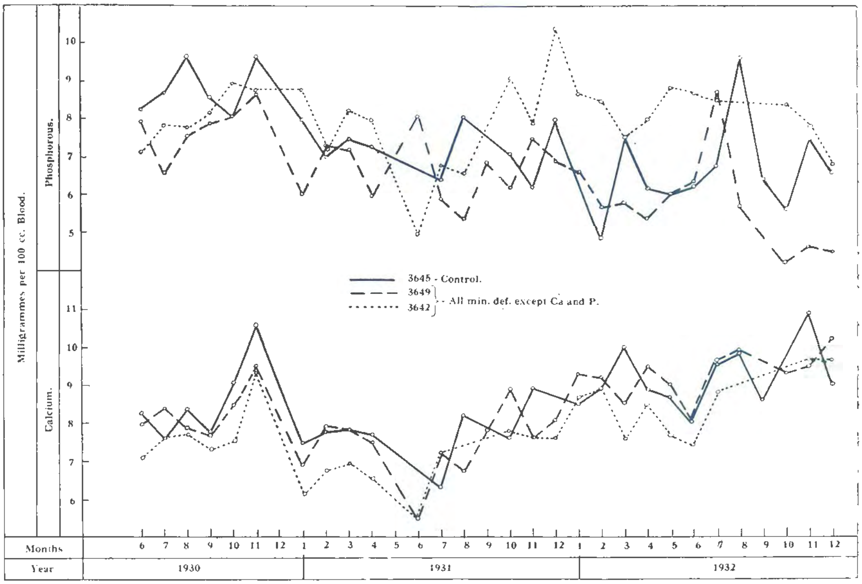

Fig. 9.- Calcium and inorganic phosphorus in the blood of cows.

Although a rise in calcium is shown during the 11th month 1930, followed by a depression which reaches its lowest level during the 6th month 1930, careful study of the curves will show that all the levels fall well within the normal range of blood calcium. Moreover the gradual rise in blood calcium commences at a time when it would be expected to be at its lowest, namely, the first lactation period, when the animals showed a pronounced drop in weight, as may be seen from table 5. In regard to its blood calcium content the control animal behaved in exactly the same manner as did the other animals.

It should be stated here that at times the animals suffered from sore feet from the concrete floors, and for this reason were rested in a sand floored paddock where earth-eating occurred to a slight extent. The soil in this paddock showed a CaO content of 0·2 per cent.; an amount which could not be of any great importance as it would not seriously affect the already very low intake.

There must, therefore, have been a tremendous drain on the calcium of the system in order to maintain a normal blood calcium. This shows that in times of inadequate intake of calcium the body makes good use of its natural storehouses, such as bone trabeculae. The adult animal is then able to cope with conditions of low calcium intake for considerable periods, but will more easily succumb to conditions such as milk fever or low blood calcium during paturition.

The importance of calcium in bone building should not be lost sight of, and is clearly illustrated in young calves, as may be seen from figure 1. The calcium content of calf blood is higher than that of cow's blood. Especially is this true for the first month of life. When the calf starts to feed for itself there occurs a gradual lowering of the calcium content of the blood, although during the first three months of life the level remains relatively higher than in the blood of the cow.

(*b*) *Phosphorus.*—That the importance of inorganic blood phosphorus has not been over-estimated in the past is clearly borne out by table 6, which shows the ease with which this element may fluctuate in the blood stream. The groups on low phosphorus intakes exhibited a notably low inorganic blood phosphorus level. A glance at figure 10 is necessary to clearly illustrate this. The first fall in inorganic phosphorus was due to the first lactation period during the 6th, 7th and 8th months. Unfortunately animals died during the second month of the second lactation. The decline observed from the second month of 1932 was caused by the substitution of five pounds of mealies by five pounds of fanko, resulting in a grain ration of 10 pounds of fanko The phosphorus in five pounds of mealies was, therefore, sufficient to carry the cows over the first lactation, although it is hardly likely that they would have survived had the lactation lasted for more than three months, as an average inorganic blood phosphorus content of 4·0 mgm. may be regarded as on the safety borderline.

Although subject to decided monthly fluctuations in inorganic blood phosphorus, all the other groups may be considered to have shown a relatively high level in their blood. It is noteworthy, however, that there was a general lowered level during the lactation periods, indicating the greater drain of inorganic phosphorus during these periods as shown in figure 9.

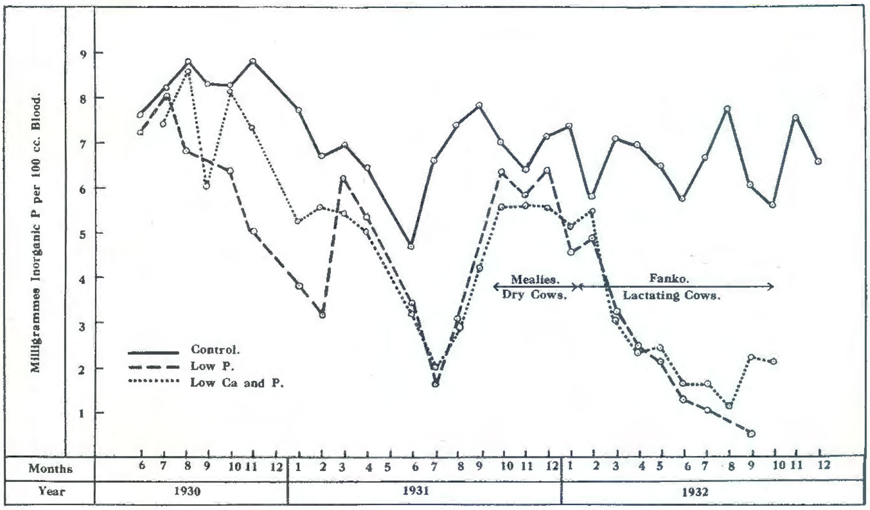

Fig. 10.—Inorganic phosphorus in the blood.

The inorganic phosphorus content, as well as the total phosphorus content of the milk (tables 13 and 14) remained unaffected by lowering the phosphorus intake to a quantity less than that excreted in the milk over the two three-month lactation periods (c.f. tables 19 and 20).

A consideration of figure 2 shows that the blood of the young calves was relatively high in inorganic blood phosphorus and remained so during the three months under observation. It is in this case rather difficult to draw direct comparisons between the inorganic phosphorus levels of cow and calf bloods, because the blood of the cows may be considered to be higher than the average, due to the greater intake of phosphorus in their rations. The general upward trend of inorganic blood phosphorus of the calves during the first week of life, as indicated by other workers, is eclipsed by averaging all the values for the first three weeks and plotting them as one point, as indicated previously.

Because of the immediate reflection in the blood of a phosphorus shortage, the supply of this element should be adequate in order to prevent mortality. The method of phosphorus supplementation being of course purely an economic question, we shall here content ourselves by drawing attention to the fact (shown in figure 10) that five pounds of mealies supplied sufficient phosphorus to maintain a normal level of inorganic blood phosphorus in dry cows.

(*c*) *Magnesium.*—The abundance of magnesium in nature and the small amount utilised by the animal (as shown in the milk secretion tables 19 and 20) makes it difficult to lower this element sufficiently in the ration to cause obvious stress or even to be sure of a deficiency at any time. The data collected in table 8, and more plainly shown in figures 7, 8 and 11 (low Ca 3643 and 3655): (low Ca low mg.—3640 and 3650), and all minerals deficient except Ca and P—3642 and 3649), indicate that, although there appears to be a minimum fluctuation of magnesium content in the blood stream and no apparent group variations, there is nevertheless a slight tendency for higher values to obtain during lactation periods. This fact, together with the relatively high magnesium content of milk (table 15) as compared with blood, as well as the generally higher calf blood magnesium values, suggest that during periods of need magnesium may be increased for some purpose or other, presumably to supplement calcium and in this way to maintain the normal acid-base equilibrium. The data may not, however, be considered conclusive enough to substantiate the above theory, especially in view of the fact that the absence of group variations shows that the blood magnesium was definitely not influenced by the nutritional factor.

(*d*) *Potassium.*—The abundant occurrence of this element in nature is probably the reason that it has not received such intensive study as have certain of the other elements, such as calcium and phosphorus that have figured more prominently in investigations. A glance at table 9, as well as figures 11 and 12 (all minerals low except Ca and P) D.O.B. 3642 and 3649 and low K—3656 and 3673) plotted with the curve for the normal control animal (D.O.B. 3645) shows that there is a wide range of monthly blood potassium fluctuation, but there is no indication that the blood potassium may be lowered by lowering the daily intake in the ration. From tables 19 and 20 it is evident that to devise a low potassium ration is no easy matter. Indeed, the ration given, although as low in this element as possible under these conditions, gives no indication of having been deficient in potassium.

Attention should be drawn to the high blood potassium content of D.O.B. 3642 shown in figure 11. Similarly the behaviour of potassium in calf blood may be studied from figure 5. In the day-old calf the potassium content of the blood is nearly three times as high as it is in the case of the normal adult cow. The normal level of adolescence is reached in about ten weeks when the blood potassium is approximately 50 mgm. per 100 c.c. This phenomenon stresses the close relationship existing between the blood potassium content and the blood corpuscles. Potassium is, of course, intracorpuscular and as there is a higher corpuscular count in newly born young (Fraser 1929), it is quite obvious why the potassium content of the blood would be higher at that age. This may be the reason why in the case of exceptional individuals a higher value for blood potassium is evidenced, as for example in the case of D.O.B. 3642. This argument bears out the statement of Peters and van Slyke (1931) that " Potassium is the chief mineral constituent of the muscles and of most other tissues and apparently can be replaced only to a limited extent by sodium; while the latter is the chief cation of the plasma and is incapable of any considerable replacement by potassium without fatal results ".

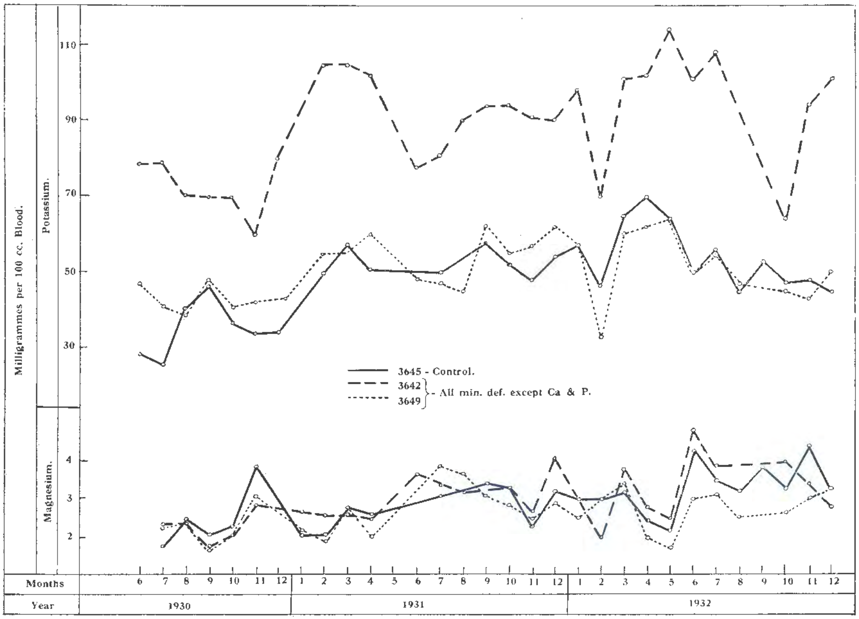

Fig. 11.—Magnesium and potassium in blood of cows.

Although lowering the potassium intake in the daily ration did not (as may be seen from table 18) affect the potassium content of the milk in the groups concerned, the concentration of potassium in milk is much higher than in the blood stream.

All the indications are, therefore, that although a potassium deficiency may not readily be brought about, this element nevertheless plays a very important role in the animal organism.

(*e*) *Sodium*.—The behaviour of sodium in the blood of cows is somewhat similar to that of the potassium, except that the range of fluctuation (as may be seen from table 10) is not as great as that of the latter element. Blood sodium curves have been drawn of the following: normal animal in low Na group compared with normal control animal (3653 against 3645), low Na and Cl (D.O.B. 3646 and 3651) with D.O.B. 3645, and all minerals low except Ca and P (D.O.B. 3642 and 3649). All these curves show plainly that during the lactation periods the average blood values for sodium were lower than during the other periods, although not sufficiently low to attach any special importance to this. However, it would be interesting to enquire more closely into the question of low sodium. The low sodium animal (3653 in figure 13) does tend to have a slightly lower blood sodium level than does D.O.B. 3645, the control animal. Unfortunately the figures for her mate D.O.B. 3672 which contracted tuberculosis, could not be considered in deciding this important question. Further figures 14 and 15 do not sufficiently substantiate the evidence of figure 13 to be of any definite assistance in throwing light on the matter. During the lactation periods the sodium output in the milk was actually greater than the intake in the ration as may be seen from tables 19 and 20.

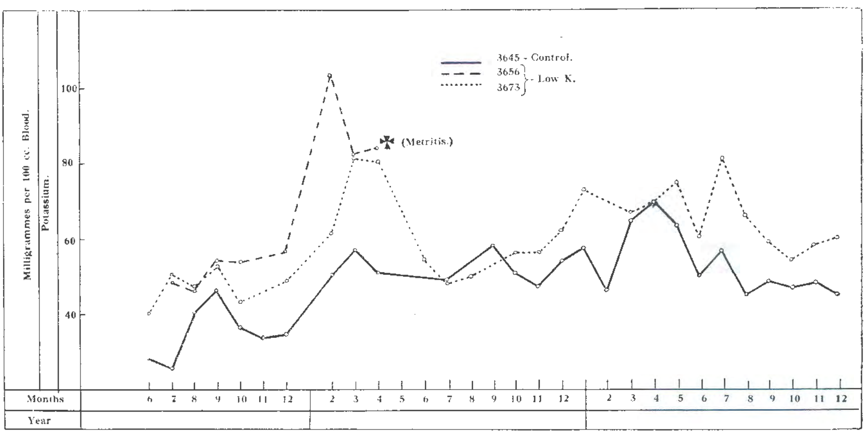

Fig. 12.—Potassium in the blood of cows.

No variation occurred in milk composition in the sodium low groups.

In the calf blood sodium there appeared a steady though slow rise. The progressive rise in blood sodium corresponds to the fall in blood potassium as calves grow older, due to increase in serum content of the blood. It may therefore be expected that D.O.B. 3642 which showed the extraordinary high blood potassium previously referred to, would show a correspondingly lower sodium content of the blood, a circumstance borne out in figure 13.

The degree of correlation between the rise in sodium and the fall in the potassium of the calf blood amounted to ·5315. Hence the probability that this correlation is coincidental is less than 1 in 100; the relationship is very significant.

(*f*) *Chlorine*.—The fluctuations in blood chlorine content of the various groups and during the different experimental phases as shown in table 11, may be considered to fall within the range of normal monthly variation. For this reason it would appear questionable whether values giving curves consistently lower than those of the control should be regarded as significant. The curves plotting the blood chlorine of the group low in chlorine (D.O.B. 3658 and 3675) are compared with the control 3645 in figure 16, and in figure 15 is likewise given the curve giving the chlorine in all the minerals deficient except Ca and P group (D.O.B. 3642 and 3649).

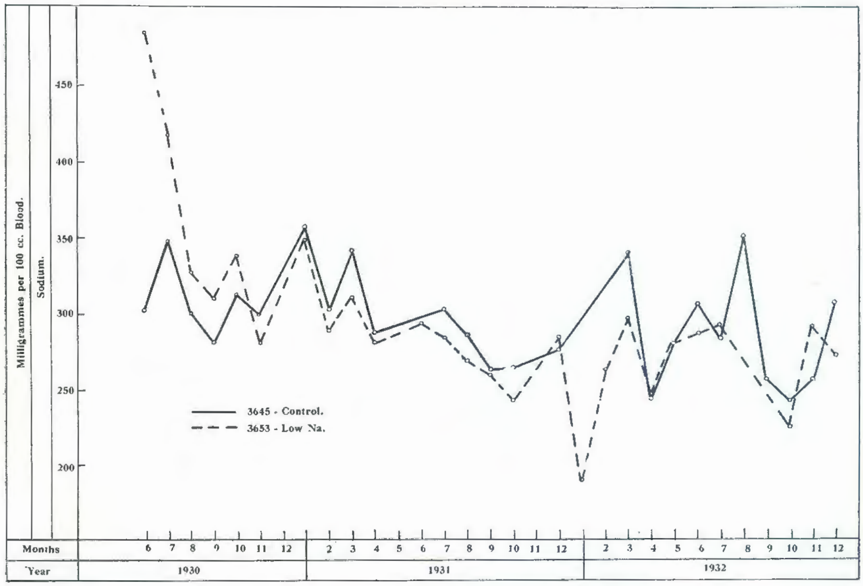

Fig. 13.—Sodium in the blood of cows.

Although the intake of chlorine was lower than the output in milk during the lactation periods (tables 19 and 20) the milk chlorine showed no variations in any of the groups. The chlorine content of the calf blood (figure 6) was remarkably constant and did not differ from that of the cow blood.

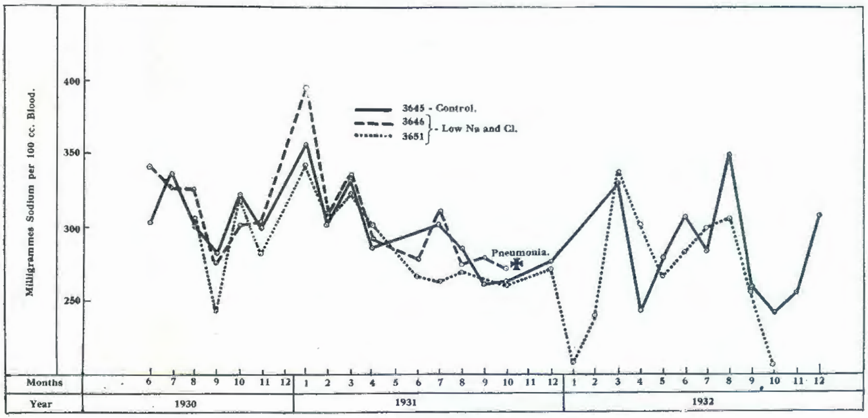

Fig. 14.—Sodium in the blood of cows.

From the data collected here, it is difficult to show precisely what influence one mineral element exerts over another. That intimate relationships do exist clearly emerges from the behaviour of the sodium and potassium in calf blood, and the slight calcium depletion during lactation periods giving rise to a raised blood magnesium. Precise reasons for the higher blood calcium and inorganic phosphorus content of calf blood cannot be given at this stage. It is possible that the form in which these elements are ingested makes them more easily available, and that greater use is made of these elements at an important period of bone-building.

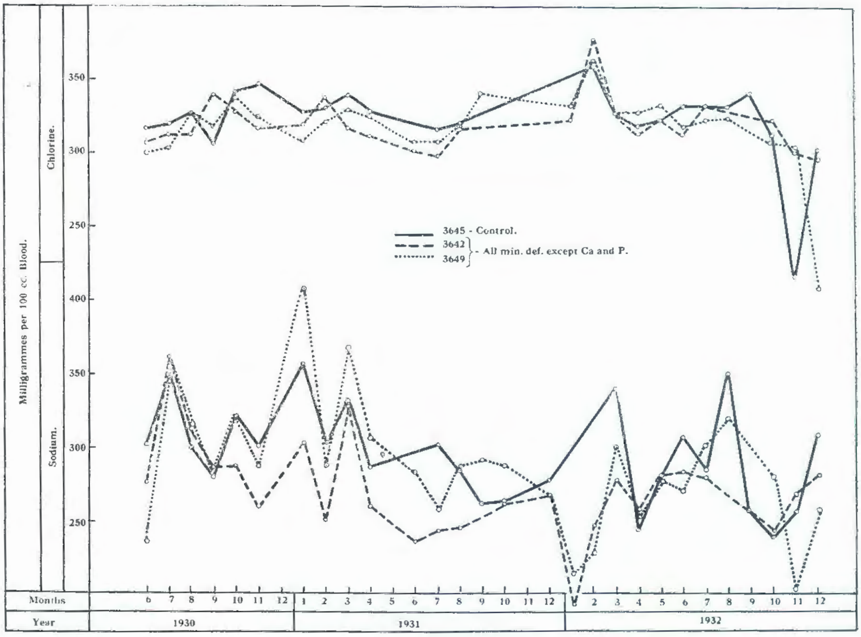

Fig. 15.—Sodium and chloride in the blood of cows.

Generally speaking, therefore, the animal body, once afforded an opportunity for storing mineral reserves, is able to withstand conditions of short intake for considerable periods. If under these laboratory conditions no mineral deficiency other than inorganic phosphorus could be reflected to any great degree, in the blood stream, there is little likelihood that any of the other mineral elements in the blood would ever be of clinical significance under practical veld conditions. It is interesting at this juncture to tabulate the normal blood and milk constituents of bovines as given by other investigators. The blood analyses are given in table 27.

TABLE 27.—*Normal bovine blood analyses (percentages).*

Investigator.	CaO.	In. P_2O_5.	MgO.	K_2O.	Na_2O.	Cl.
Robinson and Huffman (1926)..	·0154	·01344	·00424	·0327	—	·329
Abderhalden (1898)...........	·008	·016	·003	·041	·366	·307
Theiler, Green, and du Toit (1927)	·0124	·0168	·0071	·0605	·405	·302
Groenewald..................	·0117	·0164	·0044	·0710	·407	·314
Average.............	·0119	·0156	·004	·0513	·391	·317

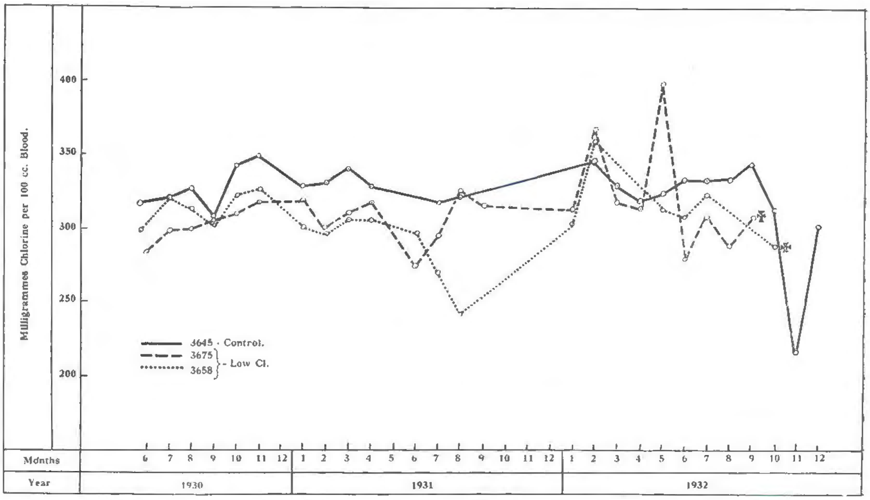

Fig. 16.—Chlorine in the blood of cows.

It should be borne in mind that analytical methods have changed considerably since the time of Aberhalden (1898) which probably accounts for the low blood calcium figure given by him. Table 27 shows that the final figures arrived at in this investigation for normal bovine blood analyses are in close agreement with the findings of other workers, and indicates the correctness of the averages as taken for different groups. Definite and final proof is here offered that with the exception of phosphorus, no other constituent could be lowered sufficiently in the ration to be reflected in a lowering of that element in the blood stream of cows.

In table 28 are given similar analyses of milk by different investigators.

TABLE 28.

Normal bovine milk analyses (percentages).

Investigator.	CaO.	In. P_2O_5.	Total P_2O_5.	MgO.	K_2O.	Na_2O.	Cl.
Harrington and Kinnicutt (1920)...	·157	—	·107	·019	·298	·114	·201
Babcock (1922).......	·140	—	·170	·017	·175	·070	·100
Leach (1907).........	·200	—	·241	·024	·250	·100	·142
van Slyke and Bosworth (1914)....	·128	·096	·125	·012	·120	·055	·081
Richmond (1920).....	·203	—	·293	·028	·287	·066	—
Babcock (1920).......	·200	—	·243	·024	·250	·100	—
Fleischman (1907)....	·247	—	·216	·031	·257	·119	·163
Halt, Courtenay and Tales (1927)........	·235	—	·265	·028	·249	·072	·136
Groenewald..........	·131	·199	·327	·020	·246	·061	·101
Average.....	·171	·147	·221	·022	·237	·072	·132

It is apparent from a study of table 28 that the different investigators give figures which in most cases are in close agreement for all the minerals in milk excepting calcium and phosphorus. The latter elements show a rather wide range of normal variation, which Rodgers (1928) gives as: CaO = 0·132 to 0·210 and P_2O_5 = 0·193 to 0·294. All the milk minerals as shown by the average values in table 28 fall within the limits given for these elements in normal cow's milk. Total phosphorus, however, is the only exception, and may be seen from this table to be slightly higher than the highest range given by Rodgers. The slightly elevated total milk phosphorus accounts for the wider CaO : P_2O_5 ratio given in table 30 (1 : 1·79) which is, of course, wider than is generally believed. For example, Richmond (1920) gives 1 : 1·4, Stocking (1922) 1 : 1·21, Hawk (1931) 1 : 1·13, and Rogers (1928) 1 : 1·46. In the present work 69 milk samples were analysed. The range of CaO : P_2O_5 ratio was found to vary from 1 : 1·4 to 1 : 2·2 with an average of 1 : 1·79. Strictly speaking, determinations of Ca on the trichloracetic acid solution might not be comparable to total Ca determined from the same milk samples as shown in table 28(*b*).

TABLE 28(*b*).

* *Total milk Ca compared with trichloracetic Ca.*

Sample.	Ca ashed from Whole Milk.	Ca by Trichloracetic Acid Method.
1.............	·280	·262
2.............	·262	·227
3.............	·227	·198
4.............	·198	·176
Average......	·242 per cent.	·216 per cent.

* The figures in Table 28 (*b*) were kindly supplied by J. S. Otto, M.Sc.

Judging from the figures in the above table it is, therefore, apparent that Ca determined in milk by means of the trichloracetic acid method is lower than when determined by the total ashing of the milk.

As the various mineral elements in the milk remained constant throughout the experimental period, each was averaged and may be considered as the normal figure for milk as given in table 29.

TABLE 29.

Mineral constituents in the blood and milk in mgm./100 c.c.

	Ca.	In. P.	Total P.	Mg.	K.	Na.	Cl.
Blood........	8·4	7·2	—	2·7	58·7	302·0	314
Milk.........	131·0	87·2	143	12·6	204·0	45·6	101

A great deal of importance is attached to the study of ratios in mineral metabolism. The ratios of some of the elements that occur in blood and milk are derived from table 29 and given in table 30.

TABLE 30.

Mineral ratios in blood and milk.

Substance.	CaO. : P_2O_5.	CaO. : MgO.	Na_2O. : K_2O.	Na_2O. : Cl.
Blood.......	1 : 1·40	1 : 0·38	1 : 0·174	1 : 0·77
Milk........	1 : 1·79	1 : 0·114	1 : 4·00	1 : 1·64

The figures in table 30 are interesting in that they enable one readily to read off the concentration of one element in relation to another in both the blood and the milk. For instance, potassium and chlorine are much more abundant relatively to sodium in milk than in blood, whereas the relationship of calcium to phosphorus may be said to be fairly constant in both blood and milk.

MILK PRODUCTION.

From the figurese in table 21,it will be seen that, although the milk yield per cow was fairly good for the first month, a definite drop became apparent in the succeeding months. Lowered yield is especially marked during the first lactation period and is in fact the reason why the lactation periods were as short as in those cows which dried off spontaneously. The other animals were artificially dried off in order to make the experimental conditions as uniform as possible.

Table 21 is especially interesting from the point of view of milk secretion because the figures show that apparently the sudden stoppage of milk flow during the first lactation periods may be attributed to the secretion by the cows of normal milk of constant composition at the expense of body-weight until the limit of some essential element was reached, when the milk flow is stopped rather than continued with an abnormal secretion. The slight additional mineral elements added in the additional protein and ensilage of the second lactation periods may have been sufficient to tide the animals over for a longer period of production than was the case during the first lactation period.

The protein content of the original ration of the first lactation period, 472 grams daily, was definitely inadequate for production, but 1,026 grams daily proved to be sufficient as may also be seen by studying the figures in table 21.

BUTTER-FAT PERCENTAGES.

By studying the butter-fat content of the milk from table 22, one would naturally conclude that although the percentages covering the two lactation periods may be considered as average for many Frieslands under normal veld conditions in South Africa, they would be very low.

Nutrition had no effect upon the butter-fat content of the milk as may be seen by comparing the groups such as the low calcium and phosphorus group (3641 and 3648) or the low phosphorus animal 3659 suffering from extreme deficiency of some essential element. In fact the last reading in the latter group was 4·0 per cent. but was taken when the animal was suffering from " styfsiekte " and may thus not be considered as significant. The same applies to some of the other high readings in cases where the animals died or were suffering from some or other abnormality as may be seen from the " Comments " column.

SOLIDS-NOT-FAT PERCENTAGES.

The findings in regard to solids-not-fat corroborate substantially the past investigations in this country. From table 23 it may be seen that the rations had no effect of lowering the reading in any group, all group readings may, therefore, be regarded as equally low, averaging 8·2 per cent. There is, therefore, no doubt that both the butter-fat and solids-not-fat percentages of many of our herds are below the normal standards usually prescribed by municipalities. Having, therefore, established a relationship between these substances, it becomes desirable to calculate protein, sugar, and total ash in order to determine, if possible, the factor responsible for lowering the solids-not-fat in the milk.

PROTEIN.

The protein estimation given in table 24 may be seen to be below the normal average which is generally given as 3·3 per cent. In no group, however, was the protein level considerably lower than in the others illustrating again that although there was such a shortage of protein in the ration during the first lactation period the values for protein in the milk of that period compare very favourably with those of the second lactation period where the protein intake level was very much higher. As the formula for the protein calculation is derived directly from the butter-fat percentages, the low fat test milks may be expected to show correspondingly low protein percentages. For this reason several milk samlpes were actually tested for protein by means of the Kjeldahl method (table 31).

TABLE 31.

Protein in milk by the Kjeldahl test.

Date.	D.O.B.	% Protein.	Date.	D.O.B.	% Protein.
25/10/32............	3640	3·2	25/10/32.........	3655	2·9
	3643	2·5		3677	3·6
	3645	3·0	18/10/32.........	3641	2·5
	3649	3·2		3642	2·9
				3653	2·7
Average......	—	3·0%	Average......	—	2·9%

The above table bears out the fact that a low protein content of the milk is evidently correlated with the low butter-fat percentages. The formula, when not supplemented by actual chemical tests, is not of much use, because it is dependent upon the butter-fat level.

SUGAR.

The relationship between lactose and chlorine in milk has made a formula possible by means of which the lactose content may be estimated, as shown in table 26. The figures in this table indicate that there are no group or periodical differences in lactose conient. The averages may be considered normal in all cases. Chemical determinations of lactose in milk as compared with the formulae estimations are given in table 32.

TABLE 32.

Lactose in cows milk.

Date.	D.O.B.	Folin-Wu Method.	Formula.
25/10/32.....................	3640	5·25	5·3
	3643	5·07	5·1
	3645	5·25	5·2
	3649	5·52	5·5
	3655	5·20	5·2
	3677	5·28	5·1
Average............................		5·26	5·2

The above table fully endorses the accuracy of the formula method of estimating lactose.

TOTAL ASH.

The calculation of ash in milk is derived from a formula based on protein values and is thus similar to the calculation of protein from fat values. Consequently a study of table 25 shows that the values of total ash are uniformly low in all groups for all periods. The depression as shown for total ash levels is so slight that it would scarcely call for comment were it not that chemical determinations were made to check these values. This shows the accuracy of these formulae. By dry combustion the total ash was determined as given in table 33.

TABLE 33.

Total ash of milk.

Date.	D.O.B.	Chemical.	Formula.
25/10/32....................	3643	0·78	0·70
	3655	0·76	0·68
	3645	0·77	0·69
	3649	0·73	0·62
	3640	0·76	0·69
	3677	0·75	0·74
Averages............................		0·76	0·68

The above table shows that in the case of ash, as indicated in table 25, the slight depression was caused by the low protein values. The ash values as seen in table 33 compared with the normal of 0·7 per cent. may, therefore, be considered normal for all the groups.

There are, therefore, strong indications that the butter-fat and protein levels have a tendency to be on the low side. The chemical data are not enough to warrant definite conclusions, but are nevertheless encouraging for further researches along these lines. Investigators have in the past been inclined to believe that adverse feeding conditions may possibly be reflected on a lowered milk casein content. This idea may be attributed largely to the fact according to Hawk and Bergeim (1927) that casein contains 0·7 per cent. of phosphorus. A lowered casein might thus not unreasonably be expected to reflect a lowered milk phosphorus content. It appears, therefore, that all indications point in a direction other than a nutritional factor. It is here that the genetic factor steps in. In the past not enough attention has been given to improving the butter-fat percentages of our cows, as may be judged from the small number of good sires used [Bosman (1932)]. Further, climatic and veld conditions render it essential that improvement in breeding and feeding should proceed together, neither being allowed to advance too far ahead of the other. Failure to realise this has resulted in disappointment for many stockmen. The question of breeding and feeding under the conditions of this country necessarily focuses more attention on indigenous breeds, which are accustomed to their environment.

The importance of increasing butter-fat production is emphasised because of the very close relationship existing between butter-fat and protein. In increasing butter-fat production, protein production will automatically be increased and the solids-not-fat automatically corrected. It is generally accepted that the fats and proteins play an important role in the physiological interchange of mineral elements between the blood and the milk. The complexity of the ultimate blood chylomicron as it appears in the glycerides of volatile and non-volatile fatty acids of the milk, as well as the intricacies of the protein molecule and its synthetic power of combining vast numbers of essential amino-acids into the main groups in milk-casein and lactalbumin, have given opportunities of demonstrating the linkage of mineral elements.

The existence of a shortage of casein and butter-fat in milk and normal quantities of minerals and total ash, shows that minerals may be secreted in the milk not only attached to the protein, but also in the form of combination with the fat and possibly also with other milk constituents.

It is suggested that the normal physiological osmotic relationship in milk is maintained by free soluble mineral elements that are able to pass through the tissue spaces.

In the milk certain mineral element combinations may again take place giving such known combinations at $CaHPO_4$ $MgH_4P_2O_8$, $CaCl_2$, $Na_3C_6H_5O_7$ and K_2HPO_4. These substances are probably not at all stable in milk.

In regard to minimum mineral requirements it may be suggested that, although lactating cows are known to be on negative balances for months at a time, such a condition cannot be expected to last. Consequently, in this case certain mineral elements are lowered to a plane considered to be below the normal requirements—to the best of our knowledge—as may be seen in table 3, and the intake is actually less than the daily output in milk for certain periods, as may be seen from tables 19 and 20.

In view of the great importance of the part played by minerals in normal bodily functions, it may be supposed that, although no immediate effects are seen, rations constituted to be as low in certain elements as those described, will ultimately deplete the animal body to a state of prostration. A minimum requirement should, therefore, allow for a margin over and above loss in normal production.

SUMMARY.

Twenty-one grade Friesland heifers, divided into groups of two animals each, except one animal that was alone, and was fed a basal ration adequate in all constituents except mineral elements.

The necessary minerals were supplemented in such a way that each group was purposely fed as low a ration as possible in some element or other, in order that the influence could be studied of such a deficiency upon the blood and milk of the animals.

The experiment lasted for a period of thirty months, being ultimately discontinued due to the loss from various causes of eleven of the original experimental animals during the course of the work.

A record is also presented of the general trend of certain calf blood minerals, which were determined daily for the first 85 days of life of the calf while fed on the mixed milk of the cows.

Useful information is also presented in regard to the mineral analysis of milk.

1. Phosphorus.—(*a*) Phosphorus was the only mineral element, a shortage of which in the ration was found to be reflected by a subsequent lowering of the inorganic phosphorus of cows.

(*b*) Five pounds of maize were found to supply an adequate amount of phosphorus to " dry " cows receiving rations otherwise low in phosphorus. The animals ultimately succumbed to debility as a sequel to " styfsiekte " upon the substitution of fanko (maize endosperm) for the maize during the lactation period.

2. The blood mineral element determinations in the various groups did not differ from those of the control group, except in the case of the low phosphorus group. An average for all animals, except those on low phosphorus intakes, is given as follows:—

(*a*) Ca = 8·4, P = 7·2, Mg = 2·7, K = 58·7, Na = 302, and Cl = 314 mgm. per 100 c.c. of blood.

(*b*) During lactation periods slight depressions were noticeable in some cases: Ca = 8·3, P = 6·2, Mg = 3·1, K = 50·2, Na = 273, and Cl = 310·0 mgm. per 100 c.c. blood.

3. The rations definitely had no influence on the composition of milk, which was found to be:—

(*a*) Ca = 131, Inor. P = 87·2, Total P = 143, Mg = 12·6, K = 204, Na = 45·6, and Cl = 101 mgm. per 100 c.c. of milk.

(*b*) Butter-fat percentage was 3·1, solids-not-fat 8·2, protein 3·0, ash 0·76, and sugar 5·2, indicating that butter-fat and protein were slightly lower than reported for dairy cows.

(*c*) The formulae employed (Kahlenberg and Richmond) in the ash and protein calculations proved to be unreliable because these calculations are based upon the butter-fat percentages, which in this case were low, resulting in low readings being obtained for these constituents.

(*d*) The $CaO : P_2O_5$ ratio of milk was found to be 1 : 1·79 when Ca determinations were made by means of the trichloracetic acid method.

4. Curves are given illustrating the trend of mineral elements in the blood of calves from one day to three months of age.

(*a*) Calcium was found to be higher than in the blood of the cows for the first month of the calf's life.

(*b*) Inorganic phosphorus during the first three months of life remained relatively higher than in the blood of the cows.

(*c*) Magnesium was slightly higher in calf blood than in the blood of the cows. No great significance is attached to this, however, because the increase is not marked.

(*d*) Potassium was three times as high in the blood of day-old calves as in the blood of cows, and declined steadily, reaching the level for adult cow blood in about ten weeks.

(*e*) Sodium in calf blood showed a steady increase which was correlated with the decrease in the potassium, a phenomenon attributed to the fact that potassium is intracorpuscular, whereas sodium is carried with the blood plasma.

(*f*) Chlorine showed no change and had the same blood level in calves as in cows.

5. The relationship between low butter-fat and solids-not-fat percentages is clearly illustrated and bears out the advisability of paying more attention to breeding for increased butter-fat, a procedure which would in time automatically eliminate the low solids-not-fat contents of South African milks.

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APPENDIX.

Mineral Elements in Calf Blood of different ages given in mgm./100 c.c.

Days after Birth.	No. of Calves.	Ca.	P.	K.	Mg.	Na.	Cl.
1	3	11·6	8·9	177·6	2·8	272	293·0
2	3	11·2	7·1	187·0	3·2	226	295·0
3	2	13·0	7·4	171·4	3·6	252	303·8
4 12	2	11·1	7·5	114·3	2·3	308	299·5
5	1	12·9	7·3	116·1	3·7	224	334·0
6	1	12·8	7·0	109·0	2·8	300	313·4
7	—	—	—	—	—	—	—
8	2	10·5	7·5	153·2	2·9	228	309·0
9	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—
11 3	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—
14	1	11·0	7·3	89·9	2·6	200	318
15	2	10·0	6·9	142·6	2·7	192	301
16	1	9·5	6·5	163·3	2·7	190	289
17	2	12·0	6·8	150·0	3·4	300	339
18 6	—	—	—	—	—	—	—
19	1	11·5	6·4	114·3	2·7	206	294
20	—	—	—	—	—	—	—
21	—	—	—	—	—	—	—
22	1	13·4	6·9	96·7	2·8	250	309
23	—	—	—	—	—	—	—
24	1	13·0	7·5	99·7	3·5	254	318
25 4	—	—	—	—	—	—	—
26	1	12·0	6·3	112·1	3·5	242	344
27	—	—	—	—	—	—	—
28	1	9·0	6·2	158·3	3·3	260	294
29	—	—	—	—	—	—	—
30	—	—	—	—	—	—	—
31	—	—	—	—	—	—	—
32 5	1	12·4	6·2	99·4	3·6	268	30[illegible]
33	2	11·7	6·8	100·8	3·1	232	321
34	1	11·3	6·3	112·1	2·9	282	289
35	1	11·7	7·5	132·7	2·9	228	28[illegible]
36	—	—	—	—	—	—	—
37	1	13·2	6·3	75·2	3·2	238	294
38	—	—	—	—	—	—	—
39 4	—	—	—	—	—	—	—
40	1	12·7	6·3	92·3	3·3	242	31[illegible]
41	—	—	—	—	—	—	—
42	2	11·5	7·2	96·1	3·8	272	30[illegible]
43	—	—	—	—	—	—	—
44	1	9·0	5·5	80·2	3·1	294	309
45	—	—	—	—	—	—	—
46 2	—	—	—	—	—	—	—
47	1	9·7	6·7	89·9	2·9	276	318
48	—	—	—	—	—	—	—
49	—	—	—	—	—	—	—
50	1	8·9	5·2	78·1	2·9	262	294
51	—	—	—	—	—	—	—

APPENDIX—(continued).

Days after Birth.	No. of Calves.	Ca.	P.	K.	Mg.	Na.	Cl.
52	1	11·5	7·6	75·9	3·0	236	304
53 3	—	—	—	—	—	—	—
54	—	—	—	—	—	—	—
55	—	—	—	—	—	—	—
56	1	11·5	7·7	74·5	2·9	266	314
57	—	—	—	—	—	—	—
58 4	1	9·0	7·6	75·9	2·6	236	304
59	1	9·2	6·7	71·0	3·3	268	314
60	—	—	—	—	—	—	—
61	2	8·9	7·2	78·0	2·7	266	301
62	—	—	—	—	—	—	—
63	—	—	—	—	—	—	—
64	—	—	—	—	—	—	—
65	—	—	—	—	—	—	—
66	1	10·2	9·0	63·9	2·8	248	318
67 2	—	—	—	—	—	—	—
68	1	9·8	7·8	54·7	3·0	312	309
69	—	—	—	—	—	—	—
70	—	—	—	—	—	—	—
71	—	—	—	—	—	—	—
72	—	—	—	—	—	—	—
73	1	9·2	9·0	63·9	2·7	248	318
74	1	9·8	7·2	44·0	3·1	296	304
75 5	2	9·8	7·4	54·3	3·5	282	319
76	1	10·2	7·3	444·0	3·1	286	318
77	—	—	—	—	—	—	—
78	1	8·3	6·7	51·0	2·8	294	299
79	1	10·3	8·4	68·8	3·8	324	334
80	—	—	—	—	—	—	—
81	1	9·7	6·0	44·0	2·9	398	309
82 5	1	9·8	8·6	44·0	3·4	294	318
83	—	—	—	—	—	—	—
84	—	—	—	—	—	—	—
*85	1	9·8	9·3	44·7	4·2	312	318

* For convenience the curves have been slightly extended to three months.