

Miscellaneous Series # 195-A

A Report on
One Year's Study
of the
Middle Park Hay Problem.

by the

Animal Investigations Section

Colorado Agricultural Experiment Station

Colorado State College

Fort Collins, Colorado

(7845-43)

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Misc. T 195-A #

Nutrient Utilization by Cattle of Certain Native Mountain Meadow
Hays Showing a History of Toxic Properties.

OBJECTIVES

(1) To study nutrient utilization by growing cattle of certain Middle Park hays which in many instances have been known to exhibit toxic properties as well as a low phosphorus content.

(2) To find if possible the true cause for the toxic symptoms shown at times by animals fed such hays.

REASONS FOR THE STUDY

The county agent and various ranchers of the Middle Park area requested the Animal Investigations Section to conduct studies attempting to throw some light on the true cause of many and varied ill effects observed in cattle fed upon native hays grown in the district.

HISTORY

(1) Many times during the past few years the county agent and ranchers of the Middle Park district have reported illness and death among cattle receiving rations made up essentially of native meadow hays grown in the area. The usual symptoms were eye involvement (watering of the eye, sometimes encrustations of a blue gray color) diarrhea, emaciation, loss of weight, and frequently death.

(2) Extension Veterinarian diagnosed the trouble as vitamin A deficiency.

(3) At one time pathologists of the Veterinary Division thought trouble might be due to an infestation of intestinal parasites found in excreta from some of the cattle.

(4) County agent working on supposition that the trouble might be phosphorus deficiency advised feeding of bone meal. This seemed to be beneficial in some instances.

(5) Asdell of Cornell University and Weihng of Colorado School of Mines reported presence of selenium as well as phosphorus deficiency in some of the hay.

(6) Many animals of the region showed a condition of overgrowth of hooves which might be due to selenium toxicity as well as high alkalinity of soil.

(7) The Animal Investigations, Veterinary Pathology, and Chemistry sections found 50 p.p.m. of molybdenum in hay from one ranch in the Middle Park area. Cattle fed this hay did not do well and were troubled with a somewhat continuous looseness of the bowels which at no time could be labeled a true diarrhea or scours.

(8) The Animal Investigations Section found later in a short balance experiment with the same animals and hay as discussed above (7) that the animals were in negative phosphorus balance and were also storing molybdenum during the experiment. A fairly large quantity of molybdenum was found in the urine showing the animals were metabolizing the element. The above results suggested that the trouble might have been either a phosphorus deficiency, molybdenum toxicity, or the effect of both working together. The Animal Investigations Section also reported that this hay contained traces of lead, zinc, copper, silver, platinum, and vanadium as well as molybdenum.

(9) Animal Investigations Section found a phosphorus deficiency in nine (9) hay samples from different parts of the Middle Park area.

ARRANGEMENTS MADE FOR THE STUDY

Following preliminary discussions of the Middle Park problem by various ranchers; Mr. H. V. McCullah, the county agent of Grand and Summit counties; and College and Experiment Station personnel, the following arrangement was agreed upon:

I. The county commissioners of the counties concerned were to appropriate the sum of \$500 to be used for the expenses of baling and hauling of hay and the hauling of animals to the Experiment Station at Fort Collins where the experiments were to be conducted.

II. Certain ranchers located at points representative of the headwaters and mouths of the principal streams draining the Middle Park area agreed each to supply for the study one heifer calf and approximately two (2) tons of baled hay produced on their respective ranches.

III. The Agricultural Experiment Station agreed to supply the personnel, apparatus and materials necessary for such a study, and to conduct the study in such a manner as to find in the shortest possible time a solution for the problem. To do this the Experiment Station appropriated the sum of \$700 to be used to build metabolism stalls, purchase chemicals and apparatus, and to employ a part time graduate assistant to work on the problem.

The experimental work was placed under the direct supervision of L. E. Washburn, Associate in Animal Investigations.

A decision was reached early during the preliminary discussions of the Middle Park problem that chemical and vegetation analyses of the hays could not alone solve the problem. It would be necessary to find as nearly as possible just what the animals derived from the digestion of the hay in order to properly interpret the troubles previously reported. Hence, it was considered essential to conduct the experiment as a metabolism balance study in which critical analyses of excreta as well as of hay and water were made.

EXPERIMENTAL

Eight heifer calves (Hereford) were delivered to the Animal Investigations Section on November 27, 1941. Immediately thereafter was begun the training of these animals to lead by halter and to accept the new conditions imposed upon them in the metabolism stalls. The calves and hay were contributed by the following ranchers:

<u>Subject No.</u>	<u>Rancher</u>	<u>Location</u>
11	Fay DeBerard	Troublesome
12	Fred Grimes	Troublesome
13	F. C. DeBerard	Kremmling
14	Mike Hinman	Kremmling
15	James Short	Kremmling
16	Andrew Lindstrom	Dillon
17	Ed Yust	Kremmling
18	Taussig Bros.	Parshall

(The subject numbers given in the above list are used throughout this report to identify the calves and their respective hays.)

Each day (weather permitting), except when they were being used in metabolism experiments, the calves were kept out of doors in a dry-lot. At night they were housed in individual stalls in the Horse Barn adjacent to the room in which metabolism experiments were conducted. The animals were fed their respective hays twice each day and watered (Fort Collins city water) once a day. Common salt (NaCl) was placed before the animals so that they could consume it at liberty.

Three separate metabolism balance experiments each of 14-15 days duration were run on all of the calves. In the first two experiments the animals were fed hay supplemented only with salt. During the third balance trial phosphoric acid (Phosilage-Montsanto Chemical Co., St. Louis, Mo.) supplements were given to each calf by drenching in amounts to bring the phosphorous intake to 10 grams per head per day.

During the metabolism balance trials feed, water, refuse, and excreta were accurately separated, measured, and sampled. Hence, it was essential to confine the animals in the metabolism stalls continuously during these periods. Analyses for moisture, dry matter, nitrogen, ash, silica, calcium, phosphorous, molybdenum, and carotene in accordance with accepted methods were run on the metabolism trial samples in order to calculate metabolic balance data.

TABLE I

ANALYSIS OF MIDDLE PARK WATERS

SAMPLE No.	RESIDUE FROM		pH	CALCIUM Mgs./500 ml.	PHOSPHORUS Mgs./500 ml.	PRINCIPAL TOXIC ELEMENTS		ELEMENTS (Decreasing order of Magnitude)	
	500 ml. gms.					Principal	Average	Trace	
1	0.2808	8.47	10.20	0.07	Vanadium	Magnesium Calcium	Copper Lead	Aluminum Barium	
(Fred DeBerard, Peak Ranch Spring Water)									
2	0.2752	8.60	24.00	0.12	Vanadium Molybdenum	Magnesium Calcium	Copper Lead	Silver Barium	
(Fay DeBerard, Troublesome Spring Water)									
3	0.4822	8.36	52.08	0.08	Vanadium Molybdenum	Magnesium Calcium	Copper Lead	Silver Barium	
(Mike Hinaman Well Water)									
4	0.0616	8.18	4.80	0.08	Vanadium Molybdenum	Magnesium Calcium	Lead Silver	Barium Boron	
(Taussig Ranch Well Water)									
5	0.1814	8.13	20.40	0.16	Vanadium Molybdenum	Magnesium Calcium	Copper Lead	Barium Boron	
(Grimes Ranch, Troublesome River Water)									
6	0.1006	8.21	7.80	0.07	Vanadium Molybdenum	Magnesium Calcium	Lead Chromium	Silver Barium	
(Taussig Ranch Creek Water)									
7	0.1007	8.15	10.56	0.06	Vanadium Molybdenum	Magnesium Aluminum	Copper Chromium	Lead Silver	
(Fred DeBerard, House, Lower Ranch City Water)									
8	0.1697	8.07	15.60	0.03	Vanadium Molybdenum	Magnesium Calcium	Copper Silver	Barium Boron	
(Fred DeBerard, Peak Ranch Creek Water)									
9	0.0831	9.21	6.60	0.04	Vanadium Molybdenum	Magnesium Calcium	Copper Lead	Barium Boron	
(Yust Ranch, Blue River Bridge River Water)									
10	0.7738	8.03	60.24	0.04	Vanadium	Magnesium Calcium	Copper Chromium	Lead Silver	
(Jim Short, Muddy River Sample River Water)									

TABLE I, Continued

SAMPLE No.	RESIDUE FROM		pH	CALCIUM Mgs./500 ml.	PHOSPHORUS Mgs./500 ml.	PRINCIPAL TOXIC ELEMENTS		ELEMENTS		
	500 ml.	gms.				(Decreasing order of Magnitude)	Average	Principal	Trace	
11	0.0800		8.23	7.20	0.07	Vanadium Molybdenum	Magnesium Calcium	Copper Lead	Barium Lithium	
	(Ten Mile Creek, Bridge East of Dillon Creek Water)									
12	0.0683		8.25	4.20	0.03	Vanadium Molybdenum	Magnesium Calcium	Copper Lead	Silver Barium	
	(Snake River, 2 Miles East of Dillon River Water)									
13	0.0696		7.95	5.40	0.06	Vanadium Molybdenum	Magnesium Calcium	Lead* Chromium	Silver Barium	
	(Lindstrom Ranch, Blue River Bridge River Water)									
14	0.1048		8.53	2.52	0.04	Vanadium Molybdenum	Magnesium Aluminum	Copper Silver	Potassium Lithium	
	(Blue River below Bridge East of Dillon River Water)									
15	0.0323		8.18	4.80	0.03	Vanadium Molybdenum	Magnesium Calcium	Lead Boron	Silver Barium	
	(Fort Collins City Water Laboratory Sample)									

*Might be present to the extent of 10-20 percent of the residue in these samples.

TABLE II

ANALYSIS OF MIDDLE PARK HAYS

Hay Sample	Moisture %	Dry Matter %	Crude Protein %	Ash %	Ca %	P %	Ca:P Ratio
1. Earl Rice, Dillon	7.11	92.89	---	---	0.414	0.179	2.31
2. Ed Linke, Granby	6.55	93.45	---	---	0.451	0.131	3.44
3. F. C. DeBerard (Alf.), Kremmling	6.62	93.38	---	---	2.316	0.073	31.73
4. F. C. DeBerard (Bingo), Kremmling	6.13	93.87	---	---	0.554	0.106	5.23
5. F. C. DeBerard (Wild Hay-Peak), Kremmling	6.53	93.47	---	---	0.558	0.082	6.80
6. Bill Zwahlen, Troublesome	6.23	93.77	---	---	0.470	0.133	3.53
7. No name	6.00	94.00	---	---	0.385	0.095	4.05
8. James Short, Kremmling	5.70	94.30	---	---	0.602	0.078	7.72
9. E. Fulscher, Granby	6.23	93.77	---	---	0.598	0.117	5.11
10. Glenn Sherriff (2), Hot Sulphur	7.39	92.61	7.49	5.82	0.559	0.151	3.70
11. Walton Bumgarner(N), Kremmling	6.73	93.27	8.28	7.05	0.719	0.156	4.61
12. Welton Bumgarner(S), Kremmling	6.97	93.03	5.32	5.86	0.316	0.155	2.04
13. Glenn Sherriff(1), Hot Sulphur	7.26	92.74	7.30	6.14	0.379	0.208	1.82
14. Taussig Bros., Parshall	6.78	93.22	5.98	5.03	0.458	0.175	2.62
15. W. E. Daxton, Frazer	7.32	92.68	8.99	8.01	0.754	0.221	3.41
16. Bazle Kasack (4), Hot Sulphur	6.24	93.76	5.76	6.39	0.483	0.118	4.09
17. E. C. Black, Parshall	6.40	93.60	7.23	6.64	0.797	0.146	5.46
18. Glenn Sherriff (3), Hot Sulphur	7.12	92.88	6.27	4.81	0.540	0.137	3.94
19. J. A. Murphy, Frazer	5.78	94.22	11.29	7.48	0.949	0.235	4.04
20. J. A. Murphy, Frazer	7.33	92.67	8.73	8.01	0.866	0.114	7.60

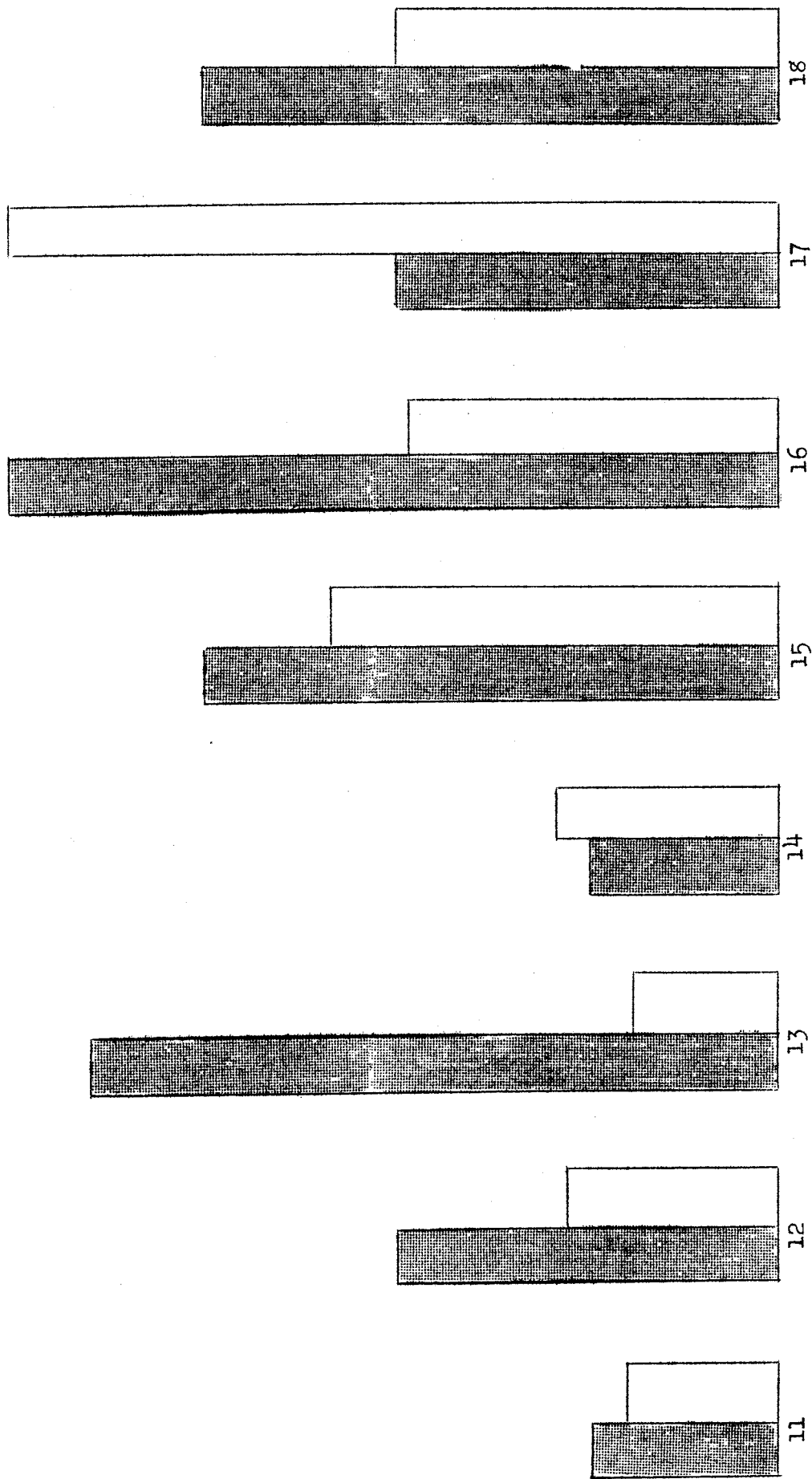
TABLE III
ANALYSIS OF EXPERIMENTAL HAYS

Hay Sample	Moisture %	Dry Matter %	Crude		Ash %	Ca %	P %	Ca:P Ratio	Molybdenum p.p.m.	Ash pH	Carotene y per gm.
			Protein %	Protein %							
1. Fay DeBerard, Troublesome	16.65	83.35	7.66	7.56	0.441	0.149	2.96	5.8	10.58	4.13	
2. Fred Grimes, Troublesome	12.80	87.20	6.62	7.27	0.294	0.167	1.76	3.5	10.55	5.60	
3. F. C. DeBerard, Kremmling	12.76	87.24	7.11	6.12	0.339	0.156	2.17	23.3	10.59	3.94	
4. Mike Hinaman, Kremmling	16.66	83.34	6.84	5.99	0.332	0.139	2.39	23.6	10.90	5.88	
5. James Short, Kremmling	12.46	87.54	11.39	8.15	0.309	0.126	2.45	13.9	9.30	11.60	
6. Andrew Lindstrom, Dillon	9.49	90.51	10.31	6.58	0.386	0.154	2.51	28.6	11.10	9.53	
7. Ed Yust, Kremmling	9.71	90.29	7.69	5.86	0.403	0.120	3.36	12.2	11.48	20.77	
8. Taussig Bros., Parshall	12.81	87.19	6.06	5.37	0.245	0.137	1.79	9.2	10.85	10.00	

CHART I.

RELATIVE GREEN AND CAROTENE VALUES

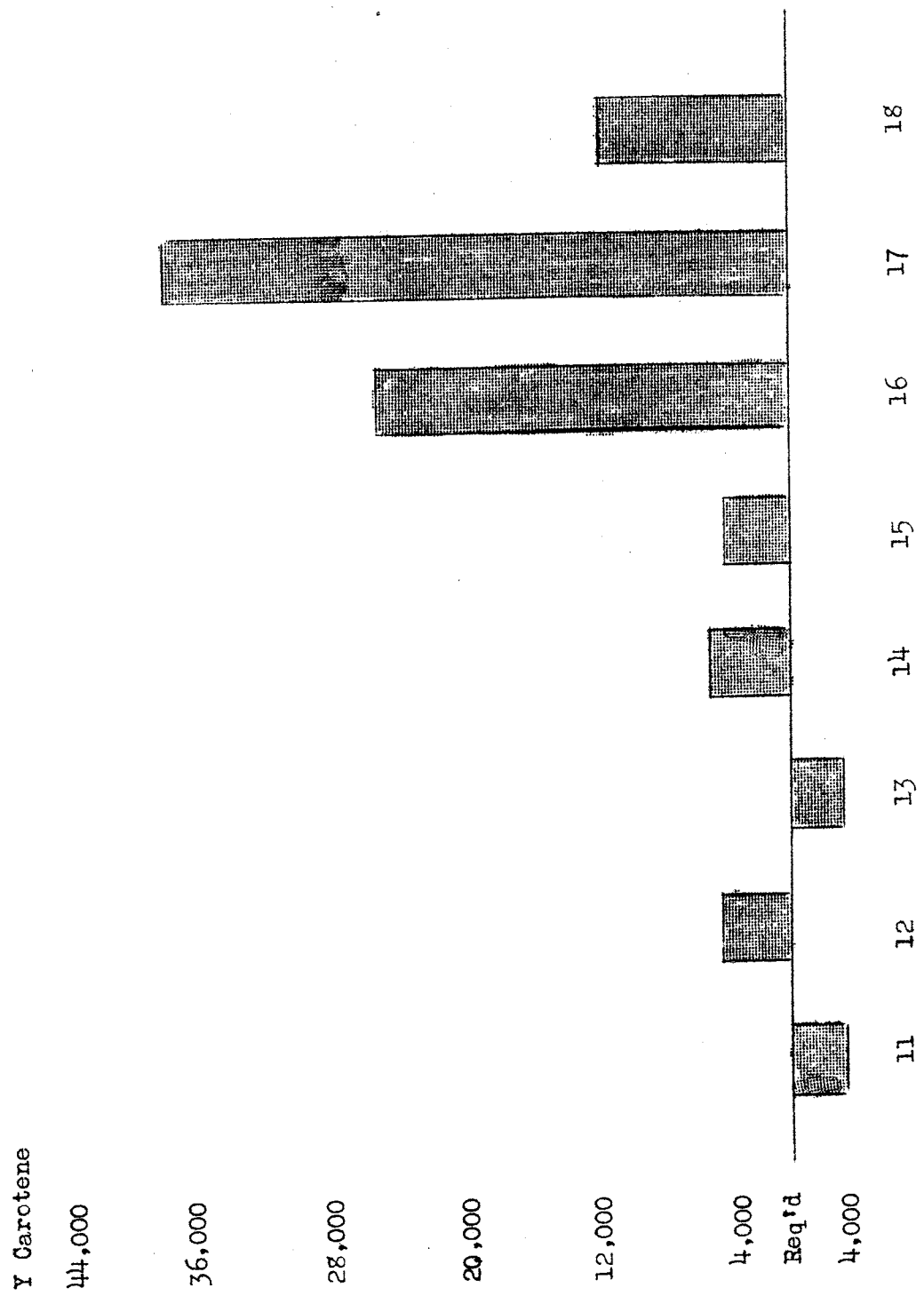
Middle Park Experimental Hays



Solid Black = Judged Green Value

Open = Actual Carotene Value

CHART II
CAROTENE INTAKE BY EXPERIMENTAL CALVES



Y Carotene

44,000

36,000

28,000

20,000

12,000

4,000

Req'd

4,000

11

12

13

14

15

16

17

18

TABLE IV

SUMMARY TABLE
FEED, WATER, AND EXCRETA DATA
MIDDLE PARK HAY EXPERIMENT

1941-42

Calf No.	Experiment No.*	Average Daily					Urine (Gms.)
		Hay Fed (Gms.)	Hay Refused (Gms.)	Hay Consumed (Gms.)	Water Consumed (Gms.)	Feces (Gms.)	
11	1	3241	904	2337	5642	3915	1216
	2	4654	1155	3499	11664	7054	1355
	3	4672	477	4195	11329	8256	2035
12	1	3791	478	3313	8094	5788	1976
	2	4449	219	4230	11280	7035	1969
	3	4635	424	4211	8696	6648	1322
13	1	3900	989	2911	5323	3825	1341
	2	5142	882	4260	13131	7573	1877
	3	5628	903	4725	11677	8212	1993
14	1	3945	608	3337	7809	6243	1417
	2	4687	566	4121	10815	6948	2252
	3	4307	191	4116	10356	8164	1028
15	1	1995	968	1027	1692	1514	791
	2	2828	565	2263	6112	3369	1154
	3	3946	1263	2683	8101	4556	2319
16	1	5664	1528	4136	12038	9127	2375
	2	5283	776	4507	15765	8252	2750
	3	4935	463	4472	14329	9544	2173
17	1	2861	657	2204	4529	3504	1210
	2	3692	968	2724	7271	3934	1586
	3	3837	768	3069	8237	6235	1397
18	1	3317	1056	2261	6520	4610	1498
	2	3764	338	3426	10400	6805	1387
	3	4134	637	3497	7759	6222	1581

*Phosphoric acid supplemented in Expt. 3.

TABLE V

TABLE OF LIVE WEIGHTS

(Average Weight in Pounds)

CALF NUMBER	11	12	13	14	15	16	17	18
<u>DATE</u>								
11/27/41	390	440	425	420	260	430	235	320
1/23-26/42	358	402	405	410	220	408	228	315
3/3-5/42	383	433	436	429	204	440	229	335
4/16-18/42	398	453	452	467	264	474	256	358
5/20-22/42	408	480	470	472	270	517	268	365
7/23-25/42	447	527	530	503	290	567	288	402
9/3-5/42	450	527	547	501	308	572	292	393
TOTAL GAIN (Initial to Maximum)	60	87	122	83	48	142	57	82
RATE OF GAIN (Percent of Original)	15.38%	19.77%	28.71%	19.76%	18.46%	33.02%	24.26%	25.63%

SUMMARY TABLE -- FEED AND EXCRETA DATA

Calf No.	Exp. No.	Hay Consumed gms.	Hay Refused %	Hay per 100 lbs. Body Wt. gms.	Average Daily			Total Excretion gms.	Urine Per Gram Water gms.	pH	Sp. Gr.
					Hay Consumed per 100 lbs. Gram Hay gms.	Feces Excreted per Gram Hay Cons. gms.	Phosphoric Acid as Phos-phoric Acid gms.				
11	1	2337	27.89	653	2.41	1.68	1216	0.22	7.95	1.0416	
	2	3499	24.82	783	3.33	2.02	1355	0.12	8.50	1.0432	
	3	4195	10.21	932	2.70	1.97	2035	0.18	8.45	1.0430	
12	1	3313	12.61	824	2.44	1.75	1976	0.24	8.15	1.0396	
	2	4230*	4.92	803	2.67	1.66	1969	0.17	8.10	1.0388	
	3	4211*	9.15	799	2.07	1.58	1322	0.15	7.68	1.0469	
13	1	2911	25.36	719	1.83	1.31	1341	0.25	8.13	1.0465	
	2	4260	17.15	804	3.08	1.78	1877	0.14	8.19	1.0492	
	3	4725	16.04	864	2.47	1.74	1993	0.17	7.73	1.0434	
14	1	3337	15.41	814	2.34	1.87	1417	0.18	8.05	1.0421	
	2	4121	12.08	819	2.62	1.69	2252	0.21	8.41	1.0362	
	3	4116	4.43	822	2.52	1.98	1028	0.10	7.98	1.0461	
15	1	1027	48.52	503	1.65	1.47	791	0.47	8.50	1.0500	
	2	2263	19.98	780	2.70	1.49	1154	0.19	8.98	1.0589	
	3	2683	32.01	871	3.02	1.70	2319	0.29	8.46	1.0418	
16	1	4136	26.98	940	2.91	2.21	2375	0.20	8.58	1.0464	
	2	4507	14.69	795	3.50	1.83	2750	0.17	8.88	1.0488	
	3	4472	9.38	782	3.20	2.13	2173	0.15	8.67	1.0433	
17	1	2204	22.96	962	2.05	1.59	1210	0.27	8.75	1.0420	
	2	2724	26.22	946	2.67	1.44	1586	0.22	8.84	1.0453	
	3	3069	20.02	1051	2.68	2.03	1397	0.17	7.64	1.0379	
18	1	2261	31.84	675	2.88	2.04	1498	0.23	8.55	1.0309	
	2	3426	8.98	852	3.04	1.99	1387	0.13	8.12	1.0343	
	3	3497	15.41	890	2.22	1.78	1581	0.20	7.60	1.0307	

*No. 12 fed No. 18 Hay in Expts. 2 and 3.

TABLE VII

DIGESTION BALANCE DATA
(Taken from Expt. I)

Calf No.	Digestibility		Retention			
	<u>Dry Matter</u> %	<u>Nitrogen</u> %	<u>Nitrogen</u> gms.	<u>Ca</u> gms.	<u>P</u> gms.	<u>Mo</u> gms.
11	67.78	21.68	-2.554	-0.084	0.425	-0.0018
12	66.34	42.48	4.356	4.815	1.939	0.0011
13	69.47	48.17	2.644	-2.318	0.587	0.0747
14	74.99	37.06	2.823	0.414	1.290	0.0620
15	79.28	72.12	2.797	-0.094	0.480	0.0095
16	77.97	52.14	16.000	1.248	2.447	0.0481
17	66.70	43.13	4.391	1.380	0.507	-0.0139
18	71.63	36.23	-1.155	-0.699	0.526	0.0013

CONCLUSIONS

1. A mild looseness of the bowels of calf number 16 which could not be called diarrhea or scours but which persistently recurred throughout all three experiments; and a poor appetite shown by calf number 15 are the only symptoms similar to those previously reported, which occurred in these experiments. At no time during the period of experimentation could the health of any of the calves be labeled as poor from casual gross inspection.

2. All waters of the Middle Park region analyzed prior to these experiments were alkaline, carried appreciable residue, were high in calcium and low in phosphorous, and contained molybdenum and vanadium, so-called toxic elements.

3. All experimental hays yielded ash residues which were quite highly alkaline in reaction. In general hays produced south of the Colorado River exhibited greatest alkalinity of ash.

4. In general the analyses of Middle Park hays show high calcium and low phosphorous content. The experimental hays presented a somewhat narrower range between calcium and phosphorous than did hays produced in the preceding season.

5. According to accepted standards all calves except numbers 11 and 13 received adequate intakes of carotene. During the period of experimentation no apparent signs of vitamin A deficiency were presented by any of the calves. In general highest carotene content was shown in those hays produced south of the Colorado River.

6. Molybdenum was present in all of the experimental hays, reaching highest levels in numbers 13, 14, and 16. The only toxic symptom thought to be produced by molybdenum was the looseness of bowels shown by calf number 16.

7. The feeding of phosphoric acid supplement in Experiment 3 definitely improved the appetite of calves 11, 15, and 17 as shown by the increased intake of feed.

Report respectfully submitted by

L. E. Washburn

L. E. Washburn
April 24, 1943.