PHYSIOLOGICAL REACTIONS OF DAIRY CATTLE
TO
RATIONS DERIVED PRINCIPALLY FROM THE ATLAS SORGO PLANT

by

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B. S., New Mexico College
of Agriculture and Mechanical Arts, 1939

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Dairy Husbandry

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1940

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

INTRODUCTION

Sorghums are the most important feed crop in Kansas and are widely used over the central and midwestern sections of the United States. Their adaptability to semi-arid climates has led to their increased popularity during the past several years of subnormal rainfall. Due to the failure of other crops, sorghums have come to form either the entire, or a major part of the, ration of dairy cows in many sections. Even though they are widely used, little is known of their nutritive value. The widespread evidences of malnutrition associated with the extensive feeding of sorghums suggested a systematic study of their feeding value over long periods of time.

For various reasons it was advisable to limit the investigation to one plant. The variety known as Atlas sorgo was chosen because of its popularity in Kansas. Atlas is classified as a sweet sorghum and has a compact head with white palatable seed.

The purpose of this investigation is to study the feeding value of dairy rations derived principally or wholly from the Atlas sorgo plant, and, as far as possible, the nutrient deficiencies of this plant by noting the value of various supplements to the ration.

This thesis is confined to investigations with cows, which form the major part of the sorghum project.

REVIEW OF LITERATURE

Practical stockmen have considered the sorghums as good feed and numerous popular articles appear in agricultural papers commending their use. Experimental evidence concerning their value, however, is meager. Since an attempt is being made to determine the deficiencies of a ration of which little is known, it was thought advisable to review the literature concerning a variety of topics in search of a clue that might be useful in solving the problem. A complete survey of literature relative to the nutrition of cattle is not possible; hence, an attempt has been made to confine the following review to investigations that may have a more direct bearing on the problem.

Experimental Work of Similar Nature

The first investigations with rations restricted to one plant source were the classical experiments of Hart and associates (74) reported in 1911. Three lots of four cows each were placed on rations consisting of the corn plant, the oat plant, and the wheat plant, respectively. The corn and wheat rations were made equal in protein content to the oat ration by adding corn gluten and wheat gluten to the respective diets. The rations had a nutritive ratio of 1:8 in all cases. A fourth, or control, group was fed equal parts of the three rations. The cattle were placed on the experimental rations at 5 to 6 months of age and continued for 4 years.

The animals of the corn-fed group grew, reproduced, and produced normally, with no evidence of malnutrition. The wheat-fed animals were unthrifty in appearance; weak, deformed calves were born; and milk production was extremely low. The only observed characteristics, other than general unthriftiness, wherein the wheat-fed animals differed from the corn-fed group were a lolling of the tongue and the excretion of acid urine. The group receiving the oat plant and the one receiving the mixture were intermediate in appearance, milk production, and reproduction, between the corn and wheat groups.

The experiment was repeated (75) but the wheat group heifers failed to come into heat and showed marked histological changes in the nervous tissue. More recently (76), the authors, in light of newer information, reinterpreted the results and concluded that the wheat plant was deficient in calcium and vitamin A activity. Cattle grew normally when fed the wheat plant supplemented with bone meal and cod liver oil.

Cunningham and Addington (33) fed a ration consisting of ground Hegari sorghum plant plus cottonseed meal, with and without calcium supplement. Cows on these rations produced approximately 70 per cent of their expected production and showed definite symptoms of vitamin A deficiency. Several of the cows developed a peculiar edematous condition in the rear legs that gradually spread over the entire rear portion of the cow. The uterus and placenta were apparently involved in some instances resulting in abortion. The calcium supplement did not improve the ration. Deficiencies other than vitamin A were suspected, but no indication as to their nature was given.

Copeland and Fraps of Texas (27) limited the ration of dairy cows to cottonseed meal and cottonseed hulls. Vitamin A deficiency symptoms were acute and no other results were noted.

Many investigators have restricted the ration of cows to the alfalfa plant (61) (68) (69) (70) (133) (185) with different results. Milk production varied from 45 to 85 per cent of normal. Cows suffered from phosphorus deficiency when fed hay from one area (69), but the use of a phosphorus supplement failed to raise milk production to a normal level. The quality of protein of alfalfa has also been questioned (68) (69) and has been shown to be deficient in cystine for rats (185). Huffman (87) has recently reported that the addition of cystine to a ration made up only of the alfalfa plant failed to increase milk production of cows.

Sorghums as Feed for Livestock

Few, if any, chemical analyses of the Atlas sorgo plant have been published. Undoubtedly it is similar to other sorghums, but likely varies in composition, especially minerals, with location, season, and other growing conditions.

Early feeding trials at the Kansas station (146) showed that sorghum silage was of only slightly less feeding value for dairy cows than corn silage, even though much of the sorghum grain passed through the cows largely undigested. This agrees closely with the value of other sorghums grown at the Arizona station (34). Sorgo fodder and sorgo silage were of about equal value (47) when fed in conjunction with hay and grain. From two series of double reversal trials (24) (25) it was concluded that ground sorgo grain or ground kafir grain was equal to ground corn when fed with hay and silage to dairy cows. It has been reported that the Nebraska station (60) found ground kafir grain equal to about 85 per cent of the feeding value of yellow corn for fattening steers.

Approximately 30 per cent of the grain in Atlas silage (48) passed through the digestive system of cows and was recovered from the feces by washing. Thirty-six per cent of the whole grain fed with hay was recovered from the feces by washing. Very little nutrient material was removed from the grain that passed through the cows.

Cox (32) of the Kansas station has made extensive investigations with lambs, using Atlas sorgo in the ration. He found it necessary to incorporate 40 per cent of cottonseed meal in the grain to secure good gains when Atlas fodder was used as roughage and Atlas grain as the concentrate. The ration was further improved by the addition of ground limestone. Atlas fodder was replaced by Atlas silage with similar results. When gains made on Atlas fodder, Atlas grain, limestone, and cottonseed meal were compared with gains made where alfalfa was used as a roughage, they were slightly lower but were made at less cost.

It is interesting to note that extensive experiments conducted by the Texas station (94) showed that marked beneficial results were obtained by the addition of ground limestone to the ration of fattening lambs where either red top, feterita, kafir, hegari or milo furnished the roughage.

The above experimental trials with both sheep and cattle were conducted over comparatively short periods of time and do not necessarily give an indication of the value of the plant over longer periods of time. The work of Cunningham and Addington (33) covered longer periods of time and was referred to in the first section of this review. Payne (135) reported the results of feeding orange sorgo, kafir, and milo to poultry as a scratch grain for several years. Orange sorgo was unpalatable and resulted in low production, while kafir and milo compared favorably with corn when fed in conjunction with a mash and sprouted oats.

Experimental work with rats has shown that hegari is deficient in protein, sodium, chlorine and calcium (160), and in vitamin A (160) (162). The quality of protein was also low for rats (161). Cottonseed meal or wheat gluten had no supplemental effect while dried skim milk, alfalfa leaf meal, soybean oil meal, meat scrap or gelatin gave definite supplemental effects. Pure lysine gave supplemental effects to some degree, whereas tryptophane and cystine did not (161). The protein of kafir grain was shown to be deficient in lysine and cystine (83).

The Effect of Low Protein Rations on Dairy Cattle

It is well known that a deficiency of protein in young animals retards growth. Other than poor growth and general unthriftiness, little is known concerning the effects of protein shortage since a diet low in protein would likely be deficient in other factors. It has been shown that calves, after 4 months of age, can utilize simple nitrogenous compounds as protein (6) (33) (41) to some extent.

Experimental work on the effects of feeding low protein rations to cows is meager. The most comprehensive work was reported by Hill et al of the Vermont station (82) in 1922. Different lots of cows were fed graduated amounts of protein in an attempt to determine the protein requirements. The "very low" protein ration was made by feeding a grain mix composed of 100 lbs. wheat, 100 lbs. oats, 300 lbs. corn and cob meal, and 100 lbs. hominy, in addition to 20 to 40 lbs. of silage and 8 to 20 lbs. of mixed hay. The very low protein ration contained about 6.5 per cent protein. The cows were maintained on this ration for five years. Table 1 summarizes their results.

Table 1. Milk production from different levels of protein intake

Lot	(Av.) Live Weight	Av. Daily Feed Intake		Nutritive Ratio	Average Daily Production		
		T. D. N.	D. P.		Milk	Total Solids	Butter Fat
	lbs.	lbs.	lbs.		lbs.	lbs.	lbs.
A	894	11.80	1.26	1:8.4	17.0	2.41	.84
B	906	11.70	1.64	1:7.1	16.4	2.38	.85
C	896	12.00	2.09	1:5.7	17.4	2.47	.86
D[1]	831	9.35	.75	1:12.5	14.9	2.21	.79
E	872	10.15	1.02	1:10.0	16.5	2.37	.80

[1] "Very low" protein group

The authors, in discussing the general thriftiness of the cows, stated that: "Aside from the fact that cows fed the very low protein ration were sparse in flesh as a result, their bodily vigor and serviceability were not impaired."

The Ohio station fed cows on a ration with a nutritive ratio of 1:13 over long periods of time with no evidence of malnutrition (130) (131) (139). The cows received an excess of feed, however, and protein intake was enough to meet body requirements. The observed coefficients of digestion for the wide-ratio ration were lower than those of a ration containing more protein.

Fraser and Hayden of the Illinois station (56) obtained somewhat different results from feeding a low protein ration. They placed milking cows on a ration with a nutritive ratio of 1:11 made up of 30 lbs. corn silage, 5 lbs. timothy hay, 3 lbs. of clover hay, and 8 lbs. ground corn. The cows were fed all they would consume. They became extremely emaciated, fell off in milk production, and showed poor utilization of feed by requiring a large amount of nutrient for each pound of milk produced. This test was discontinued at the end of 131 days.

Armsby (4) reviewed the work of early investigators and concluded that a ration with a wide nutritive ratio would show a low apparent digestibility of the carbohydrate portion of the ration. This conclusion has been borne out by work at the Ohio station (139) (141) (143) and by the extensive investigations of Ellet and co-workers in Virginia (42) (43)(44).

It has also been reported that increased utilization of feed resulted with increased amounts of protein in poultry (72) and swine (117) rations.

Protein, Total Digestible Nutrients, Energy and Fat Requirements of Cattle

Numerous reviews of the nutrient requirements of cattle have appeared. Most reviewers recommend the general practice of liberal feeding but much experimental evidence indicates that the more commonly used standards more than meet the actual minimum requirements (40) (82) (130) (131) (139) for normal body functions.

The well known and widely used Morrison Standard is partially reproduced below (124, P. 1004) in Table 2.

Table 2. Morrison feeding standard.

	Live Weight	Dig. Protein		T. D. N.		Net Energy	
		Minimum	Recommended	Minimum	Recommended	Minimum	Recommended
	lbs.	lbs.	lbs.	lbs.	lbs.	Therms	Therms
Growing Cattle	100	----	.24 - .40	----	1.2 - 2.0	-----	1.2 - 2.0
	200	----	.52 - .62	----	3.3 - 4.0	-----	3.2 - 3.8
	400	----	.80 - .90	----	6.1 - 6.6	-----	5.5 - 5.9
	600	----	.94 -1.06	----	7.7 - 8.7	-----	6.8 - 7.7
Mature Cows	700	.440	.476	5.13	5.81	4.10	4.65
	900	.547	.593	6.38	7.23	5.10	5.78
	1100	.652	.706	7.60	8.61	6.08	6.89
	1300	.754	.817	8.80	9.97	7.04	7.96
	1500	.854	.923	9.96	11.28	7.97	9.02
	1700	.952	1.032	11.11	12.58	8.89	10.06
For Milk Production, per pound of milk							
3%	----	.038	.046	.284	.300	.264	.279
4%	----	.041	.049	.307	.324	.286	.301
5%	----	.046	.056	.353	.373	.328	.347
6%	----	.052	.062	.399	.422	.371	.392
7%	----	.057	.068	.445	.470	.414	.437

Work at the Wisconsin station (73) and several foreign experiments (6) (41) have shown that simple nitrogenous compounds such as urea may be used in part as protein substitutes by calves after 4 months of age.

No evidence is available concerning the minimum fat requirements of cattle. In 1932 the Cornell station demonstrated that when the fat content (ether soluble fraction) was less than 4 per cent of the ration milk production was lowered but no pathological conditions were noted. This work has been confirmed recently at Cornell (110) (111) and at Michigan (57).

It is a well known fact that calves will grow normally when skim milk furnishes most of the ration, but a smoother coat and more pleasing appearance result from leaving some fat in the milk. Supplementing skim milk with various vegetable oils, however, has in one instance depressed growth and caused digestive disturbances (67). Animal fat and butter oil resulted in remarkable gains in weight.

Factors Affecting Utilization of the Ration

In general, a more liberal intake of nutrients will lower the digestibility of the ration (51) (184). Different digestion coefficients reported for certain feeds have led many investigators to suspect that there are associative effects in mixed rations that may increase their utilization. This view has been substantiated by the experimental evidence of Forbes and associates (52), by the Cornell station (168), and by Mitchell (118). Watson (180) (181) and co-workers have recently failed to show any associative effects from feeding different feeds in combination, with the exception that the digestibility of oat hulls was lowered when fed with other roughages.

Low protein content of the ration has been reported to decrease utilization (4) (42) (43) (44) (139) (141) (143). The quality of protein in the ration has also been reported, by English investigators, to affect utilization. They found that rations low in lysine, tryptophane, arginine and histidine were poorly utilized (54), and found a significant negative correlation between urine nitrogen and milk nitrogen output.

The Kansas station (150) (151) (152) has reported that phosphorus-deficient cattle showed a poor utilization of feed. This poor utilization apparently was due to faulty metabolism since digestibility was not lowered. Similar findings were reported by the California station (97).

Fineness of grinding may also affect digestibility. Corn was more digestible when finely ground (159) while oats were more digestible when medium ground.

Mineral Requirements and Deficiency Symptoms

Various mineral mixes are commonly recommended as cure-alls for cattle ailments. Definite deficiency symptoms for several minerals have been described, but the fact that mineral deficiency is not as serious a problem to the average dairyman as much literature would lead one to believe has been shown by Reed and Huffman (147) and more recently by Bechdel and associates (16). They fed ordinary rations, using timothy hay as the principal roughage, without mineral supplement and secured at least fairly liberal milk production with no evidence of malnutrition.

Calcium and Phosphorus. Mitchell (119, P. 131-133) after an extensive review of the literature has given the following estimated calcium and phosphorus requirements for a Holstein cow:

Table 3. Daily calcium and phosphorus requirements.

	Net Ca	Feed Ca	Net P	Feed P
	grams	grams	grams	grams
Growing Cattle				
300 lbs. body wt.	17.3	24.7	12.5	17.9
500 lbs. " "	14.5	20.7	11.7	16.7
700 lbs. " "	12.4	17.7	11.2	16.0
900 lbs. " "	10.6	15.1	10.7	15.3
1100 lbs. " "	9.1	13.0	10.4	14.9
Mature Cow				
1000 lbs. body wt.	4.1	6.0	7.2	10.4
Average Pregnancy Req.[2]	4.6	5.8	2.4	3.8

[2] During last five months of pregnancy.

Symptoms of uncomplicated phosphorus deficiency have been described as impaired fertility, anorexia, fragile bones, lameness, depraved appetite, lowered resistance to disease, and poor utilization of feed. Death occurs in severe cases (119, P. 13 and 14).

Lowered production, fragile bones, and low blood calcium have been reported as calcium deficiency symptoms (119, P. 13 and 14). Extremely low blood calcium may lead to convulsions (119). Practical dairy rations are seldom deficient in calcium.

Simultaneous deficiencies of calcium and phosphorus occur frequently, leading to rickets in young animals or osteomalacia in older animals. Rickets is characterized by low blood phosphorus and/or low blood calcium levels, stiffness, and soreness of joints. Calves assume a characteristic bowed-leg position in severe cases. The most common symptoms of osteomalacia are unthrifty appearance and depraved appetite, showing preference for bones (119, P. 16). The above conditions usually arise from a lack of vitamin D or a shortage of minerals. The importance formerly attached to the calcium-phosphorus ratio in dairy rations has been questioned (119, P. 30-34).

Magnesium. The magnesium requirements of mature cattle are not definitely known. Huffman and co-workers (86) produced magnesium deficiency in calves by feeding whole milk which normally contains about .055 grams of magnesium per pound of milk. Fifteen to twenty milligrams of magnesium in the form of magnesium oxide or 8 to 10 milligrams as feed magnesium per calf maintained normal magnesium blood levels.

Symptoms of magnesium deficiency in calves, as described by Huffman (86), are irritability, nervousness, anorexia, low blood magnesium, and, in advanced stages, convulsions.

Grass tetany in older cattle (119, P. 16 and 18) has been attributed by some authors to magnesium deficiency and is characterized by low blood magnesium and convulsions. Grass tetany usually occurs two or three weeks following calving.

Iron and Copper. All that is known concerning iron and copper requirements of ruminants may be summed up by saying that calves on an exclusive milk diet, containing approximately 0.14 mg. of Fe and 0.06 mg. of Cu per pound of milk, will develop nutritional anemia (81) (100) (119, P. 70), and that the daily addition to this diet of 400 mg. of Fe and 40 mg. of Cu will prevent its occurrence. It has been reported that a ration containing 0.0176 per cent Fe and 0.0013 per cent Cu furnished ample amounts of these minerals for normal growth and normal hemoglobin in blood of calves (99).

There has been reported a nutritional anemia in cattle from an area in Massachusetts where the iron content of hay was 0.0087 per cent as compared to 0.0111 per cent in hay grown in non-affected areas. The anemia was cured by administering Ferric Ammonium Citrate. The syndrome described was similar to that of "bush sickness" of New Zealand, Australia and Florida which was later shown to be due to a deficiency of cobalt (125) (129). The bush sickness had also been cured by feeding iron salts but the cure was due to traces of cobalt in these salts (129). The iron content of hay from New Zealand areas, which were later shown to be deficient only in cobalt, was lower than the values reported from Massachusetts, suggesting that a deficiency in iron did not exist.

Iodine. There have been numerous reports of iodine deficiency of cattle from various areas, but the quantitative requirements are not known. Mitchell and McClure (119, P. 72), on the basis of energy intake, have estimated the daily requirement to be between 400 and 800 micrograms for a milking cow.

The most striking symptom of iodine deficiency is goiter, or enlarged thyroid gland. Other symptoms include premature birth, retained placenta, hairless calves, big-necked calves, decreased fertility, and digestive disturbances

(30) (116) (126).

<u>Cobalt</u>. Cobalt deficiency is characterized by depraved appetite, anorexia, emaciation, anemia, diarrhea, and sometimes, loss of hair from certain areas (129). Ruminant requirements are extremely small for this element, one milligram per ewe per day being ample for sheep (119, P. 75). The exact requirements of dairy cattle are not known, but Wunsch (186) has compiled analyses of feeds from different areas and presents the following table:

Table 4. Reaction of livestock to varying levels of cobalt.

Cobalt Content of Pasture Grass	Livestock Reaction
0.01 P - P.M. (dry wt. basis)	Serious deficiency for sheep and cattle
0.04 " " " " "	Serious deficiency for sheep, some for cattle
0.04 to 0.07 " " "	Some deficiency for sheep, fair for cattle
0.07 + " " "	No deficiency for sheep or cattle

<u>Salt</u>. The daily intake of approximately 1.5 gm. of sodium and slightly less than 5 gm. of chlorine have been reported to be ample for growth of cattle to maturity (119, P. 74). Several instances have been reported where sodium and chlorine intake only slightly exceeded output in milk with no evidence of malnutrition. The voluntary salt consumption of cattle may vary widely and for no apparent reason. Ad libitum consumption has been reported to vary normally from 0.06 to 0.25 lbs. per day (119, P. 74); the smaller amount more than meets requirements.

<u>Other Minerals</u>. Manganese is the only other mineral that has been found to be essential for farm animals. Requirements of pigs are met by one part in 180,000 parts of ration (119, P. 75). No deficiency of manganese has been reported for cattle. Several other minerals are thought to be required in

extremely small amounts for proper animal nutrition.

Water. There has been no way devised for determining the actual total water requirements of animals. It has been suggested that 1 cc. of water is required for each calorie of heat produced (119, P. 77). This would give a requirement of 23 to 30 lbs. of water for a large dry cow. The voluntary intake of water by cows greatly exceeds this amount. Morrison (124) has given the voluntary intake of dry cows as 100 lbs. daily and of milking cows as 4.5 to 5.0 lbs. per pound of milk produced. This amount was in addition to water in the feed. Atkeson and Warren (5) state that: "Under relatively similar climatic and feeding conditions the total water requirements of dairy cows seem to depend on the water in milk plus a rather definite amount of water per pound of dry matter consumed." It has been shown elsewhere (119, P. 77), that water intake is influenced largely by temperature and that as much as 80 per cent more water may be consumed in hot weather than in cold weather.

Vitamin Requirements of Cattle

Vitamin A and Carotene. A deficiency of vitamin A activity in cattle is characterized by night blindness, associated with papillary edema (77) (120) (122) (123); low blood carotene (122), diarrhea in calves (92), calves born with or without eye lesions, and constriction of the optic nerves (120) (123), excitability (27), rough coat and in severe cases, emaciation. There have been a few reports (29) (33) (35) of edema associated with vitamin A deficiency. The peculiar symptom of cornified vaginal epithelial cells in rats (29) and a marked departure from the normal distribution of blood cell types in humans (1) have been reported in cases of vitamin A deficiency.

Guilbert and co-workers (62) (63) (64) (65) have reported the daily requirements to prevent the occurrence of night blindness to be 26 to 33 micrograms of carotene (43 to 55 I. U.) or 21 to 27 International Units of vitamin A (5.1 to 6.4 micrograms) per kilo of body weight. These requirements have been confirmed by Moore (122) and by Bechdel and associates (10) (177). The above determinations were made with calves or dry cows. More recently, Ward, Bechdel and Guerrant (178) have reported that the minimum requirements of calves are met by feeding 11 micrograms of carotene per pound of body weight (24.2 micrograms per kilo) when fed in the form of a carotene concentrate, but as much as 33 micrograms per pound of body weight (72.6 micrograms per kilo) was necessary when fed in alfalfa molasses silage.

Copeland of Texas (28) (29) has reported that as much as 55 micrograms of carotene per kilo of weight (25 micrograms per pound of body weight) did not prevent night blindness. Recent indications of his experiment are that the same amount will not support normal reproduction nor milk production in heifers.[3] Milking cows were estimated by Copeland (27) to receive approximately 106,000 units of carotene per day and showed symptoms of vitamin A deficiency. This exceeds Guilbert's requirements by at least 50,000 units of carotene per day. On a double reversal trial of 126 days, cows produced 10 per cent more milk when receiving 150 micrograms of carotene per pound of weight (33 micrograms per kilo of weight) than when receiving 15 micrograms per pound of weight.

The United States Bureau of Dairy Industry (29) (115) (169) has reported the requirements for normal reproduction to be about 80 mg. per cow per day. This is the equivalent of at least 120 micrograms of carotene per kilo of body weight for a 1,550-pound cow. Possibly, additional requirements for gestation and lactation may explain in part the higher requirements as reported by Copeland and the United States Bureau of Dairy Industry. However, Copeland (29) found Guilbert's requirements to be too low even for calves. Another possibility is a difference in absorption from the digestive tract. This appears to

[3] Personal communication

be more likely since Ward and associates (178) have reported requirements to be different when carotene was supplied by different feeds. The carrier of the carotene has been shown to affect absorption markedly in rats and in humans (39) (89) (90) (104) (183).

Whitnah et al (182) of the Kansas station reported results on carotene balances of heifers that had been on a low carotene ration for five months. Over a five-month period of time the daily carotene intake per heifer was 12 mg. per day. The carotene output in the feces was 26 mg. of carotene per calf per day. Error in analysis may or may not explain this discrepancy; however, several chemical determinations were made. Removal from body stores was unlikely as storage is low in newborn calves (122) (177). The possibility of synthesis presents itself and could conceivably offer an explanation. It is of interest to note that several organisms (7) (88) (105) (157), resembling the organism reported by Bechdel and associates (14) to comprise 90 per cent of the flora of a heifer's rumen, have been shown to synthesize carotene and vitamin A.

Cattle have been reported to store enough carotene to maintain them for several months on a depleted ration without showing symptoms of deficiency (3) (73).

Vitamin B Complex. In 1926 Bechdel, Eckles and Palmer (9) reported that calves fed on a vitamin B deficient ration that would not maintain rats for more than 2 to 5 weeks, grew normally to maturity and showed no evidences of malnutrition. Bechdel and associates at Pennsylvania State College later reported that vitamin B in the milk was not dependent on the vitamin in the feed of cows and that a vitamin B deficient ration fed to a heifer attained considerable vitamin B activity in the rumen (13) (14). This evidence suggests that at least part of the B Complex is synthesized in the digestive tract of the cow in some instances.

Within the last year Pearson (136) (138) has reported evidence indicating that the nicotinic acid requirement of the sheep is low, or that this substance is synthesized within the digestive system. More recent work at California has shown that thiamine, riboflavin, pantothentic acid and vitamin B_6 are all synthesized in the rumen of the sheep (108).

The above evidence strongly suggests that ruminants may synthesize part if not all of their needs of the B Complex under certain conditions. On the other hand, two Holland (8) investigators included the following in a report concerning vitamin E and sterility in cattle in which they referred to cows suffering from various digestive disturbances: "In some of the diseases, injection of vitamin B_1 preparation has proved therapeutically effective against loss of appetite and certain nervous symptoms sometimes present." The Cornell station (127) has shown that the addition of dried brewer's yeast to regular calf starter resulted in greater growth than attained by feeding unsupplemented starter. Holdaway et al of Virginia (84), working with cows, reported that yeast imporved a ration in which timothy hay furnished the roughage. Factors other than the B Complex could easily have been responsible for the results in the latter two instances, however.

Vitamin C. Thurston, Palmer and Eckles (166) (167) in 1929 presented conclusive evidence that heifer calves did not need vitamin C in the ration to grow and reproduce normally. Young cows that had received a vitamin C free ration since birth gave considerable amounts of vitamin C in the milk. No one has refuted this work. Recently, however, the Wisconsin station (145) has obtained beneficial results in a large percentage of cases from injecting vitamin C into sterile bulls. They were led to try this treatment by first noticing that semen of infertile bulls frequently contained no vitamin C whereas semen from fertile bulls contained measurable quantities. No evidence of impaired production was mentioned in the earlier work with heifers.

Vitamin D. Rickets has been known to occur in cattle for many years. The relation of vitamin D and sunshine to rickets, however, was not understood until 1922 or shortly thereafter. Since that time there have been publications concerning vitamin D too numerous to discuss even briefly in this paper. The following is a summary of what is known of vitamin D in relation to the nutrition of cattle.

There are several compounds that have vitamin D activity. The activity of these compounds varies among the different species of animals (107, P. 336-358). Vitamin D does not occur in measurable quantities in growing plant tissue (107, P. 152) but may be formed by ultra violet irradiation of several sterols after harvesting of the plant. Thus hay that is exposed to the sunshine for a few hours during curing has liberal amounts of vitamin D. Vitamin D activity is also secured when the animals are exposed to direct sunlight. It is now believed that this activity results from the irradiation of 7-dehydrocholesterol in the skin (107, P. 348) and not from ergosterol as formerly thought. The exact origin of 7-dehydrocholesterol is not known, but it comes from some plant sterol, probably cholesterol. Animals that consume appreciable amounts of sun-cured hay or are exposed to direct sunlight for a few hours per week receive ample vitamin D. Silage has also been shown to be a good source of vitamin D for cattle (18).

The sole functions of vitamin D in the body, as far as known, are the regulation of calcium and phosphorus metabolism and, to some extent, the general metabolism (107, P. 363-393).

The symptoms of vitamin D deficiency in calves are those typical of rickets, namely swollen joints and bowed forelegs accompanied by either low blood calcium, low blood phosphorus, or by both; anorexia, and in advanced stages stiffening of the hocks, drawn gaunt appearance, and sometimes tetany (15) (17) (66) (154). It is also interesting to note that vitamin D deficiency is often accompanied by a curvature of the spine similar to a condition often observed in calves at the Kansas station (15). A deficiency in mature cattle results in low blood calcium, low blood phosphorus, stiffness, buckled knees, rigid spine and failure to come into heat (172).

The exact requirements of vitamin D are not known. Many reports confirm the belief that the inclusion of ordinary amounts of sun-cured hay in the ration will prevent rickets when calves are kept from the sunlight (66) (103) (132) (154) (174). Olson (132) kept two cows away from sunlight from calfhood until they completed 3 lactations. No signs of malnutrition appeared. Growth, reproduction and milk production for one lactation were comparable to those of control animals. There was a marked decline in milk production of the no-sunlight group during the second and third lactations but the cows remained in good health. These cows were fed an ordinary ration containing alfalfa hay. Two hours of sunshine per day have prevented any symptoms of vitamin D deficiency from showing in calves (15).

In 1934 Wallis, Palmer and Gullickson (174) reported that roughly 365 U.S.P. Units (135 Steenbock units) of vitamin D daily from timothy hay more than met requirements of calves. The following year Huffman and Duncan (85) reported that the daily intake of 35 to 45 U.S.P. Units per day per 100 lbs. of body weight from winter milk more than met requirements of calves. Bechtel et al (18) reported that the intake of silage furnishing the equivalent of from 85 to 165 U.S.P. Units per 100 lbs. of weight prevented and cured rickets in yearling calves. More recently, Bechdel and associates (12) have presented evidence that 300 U.S.P. Units per day per 100 lbs. of weight, furnished either by cod liver oil or irradiated yeast, approximates the minimum requirement of calves up to seven months of age.

The variations in the above reports may be due to different sources of the vitamin; that is, the unitage determined by rats may not give an index to the potency for cattle.

Practically nothing is known of the requirements of mature cattle. Wallis (173) reported that 5,000 U.S.P. Units of vitamin D per cow per day more than met requirements for a period of 3 months. Olson (132), in an extended investigation, has shown that unstated amounts of alfalfa hay supported normal growth, reproduction, and production for one lactation.

Vitamin D can be stored in considerable quantities in the body of the cow (174).

Vitamin E. Very little is known of the vitamin E needs of ruminants. McCollum et al (107, P. 547) state that the "claims that reproductive ability is improved in humans, cattle and swine resulting from feeding wheat germ oil or other rich sources of the vitamin, suggest they need the nutrient." Bay and Vogt-Moller of Denmark (8) presented convincing evidence that the injection of wheat germ oil into sterile but otherwise apparently normal cows was at least partly responsible for subsequent reproduction in 49 of 70 cows treated. These authors stated that "cows kept exclusively on meadow pasture apparently needed more vitamin E than cows on clover pasture." Since wheat germ oil contains substances other than vitamin E, however, it cannot be said with assurance that vitamin E was responsible for improvement in reproduction.

The Iowa station (165) fed goats for 4 generations on a ration in which the vitamin E was thought to have been destroyed by treating with ethereal $FeCl_3$. The goats on the ration reproduced normally but body tissues and milk were depleted of the vitamin. More recent preliminary work with sheep on a similar ration showed that the group receiving wheat germ oil supplement had better reproduction than the unsupplemented group. Though evidence was not available to be conclusive, but indications were that sheep may require vitamin E or some other factor present in wheat germ oil.

Experimental work has shown that the addition of wheat germ oil to an ordinary dairy ration resulted in no beneficial effects (93).

Other Vitamin Factors. Several other factors have been reported to be essential for proper nutrition of laboratory animals, but nothing is known of their relation to farm animals. Vitamin K has been reported to be necessary for proper blood clotting (107, P. 552) and is likely needed by the cow. Its synthesis having been demonstrated in the intestines of the chicken and by bacterial action on feeds (107, P. 552) would indicate that its deficiency in cattle would be rare.

Factors L_1 and L_2 have been reported to be necessary to support lactation in the rat (107, P. 526) and were absent from a ration that gave normal growth and reproduction. Lactation could be practically prevented by withholding the factors. Upon the addition of liver and yeast milk flow returned to normal. The factors have not been observed with other animals.

The "grass juice factor" of Wisconsin (107, P. 524-525), present in growing grass and in silage, induces increased growth in laboratory animals, but nothing is known of its value to cattle.

The other factors that have been reported are too remotely connected with ruminant nutrition, or too little is known of their importance to justify their discussion here.

The Blood Picture

The blood picture as determined by present techniques may or may not give an index to the physiological condition and the state of nutrition of an animal. Certain conditions such as rickets, phosphorus deficiency, etc., may cause

Table 5. Chemical constituents of normal blood.

Ca mg.	P[4] mg.	Mg mg.	K mg.	Na mg.	Cl mg.	Hb gm.	Carotene micrograms	Per 100 cc. of	Author
11.3-11.8	5.2-5.6	1.7-2.0	24.0-25.2	351-350	------	----------	-----	Serum	Reihart (148)
11.0	5.8	2.16	27.3	------	32.9	----------	-----	Serum	Robinson and Huffman (153)
-------	------	2.6	--------	------	------	----------	-----	Plasma	Duncan et al (38)
-------	------	1.3-2.0	--------	------	------	----------	-----	Serum	Sjollema (156)
-------	4.3-4.9	------	--------	------	------	----------	-----	Serum	Van Landingham (171)
-------	5.9	------	--------	------	------	----------	-----	Plasma	Palmer et al (134)
10.91	4.5	------	--------	------	------	----------	-----	Serum	Kennedy et al (96)
-------	------	------	--------	------	------	----------	13.0+[5]	Plasma	Moore (122)
-------	------	------	--------	------	------	10.53-11.85	-----	Blood (21)	Brooks and Hughes
-------	------	------	--------	------	------	7.3—10.8[5]	-----	Blood	Krauss (99)
-------	------	------	--------	------	------	12.8[6]	-----	Serum	Gillam (58)
11.2	5.2	2.1	25.9	365	32.9	11.1	13.0+[5]		(Average)

Total Non-Prot. N mg.	Urea N mg.	Uric Acid mg.	Preformed Creatine mg.	Amino Acid N mg.	Lactic Acid mg.	NaCl mg.	Per 100 cc. of	Author
20-40	6-27	.05-2.08	1.0-2.07	4-8.5	5-20	440-550	Plasma	Dukes (36)
32.82	----	--------	--------	-----	----	------	Plasma	Kennedy (96)

[4] Applies to cows only.

[5] Calves

[6] Bulls

definite changes in the composition of the blood, while in many instances, an animal may be in poor health, suffering from a deficiency of one or more nutrients and still maintain a normal blood picture. Chemical analysis of the blood of experimental animals are commonly made. For this reason normal values for certain of the constituents are given in the accompanying table. In general the values apply to both cows and calves. Where differences occur they are noted in the following discussion.

The mineral constituents of calf blood do not differ materially from those of cow blood with the exception of phosphorus. Phosphorus in the blood of young calves is normally about 6 mg. per 100 cc. of serum (1) (134) (170) and increases for a few months up to as high as 10 mg. per 100 cc. of serum (114) in some cases. It then gradually decreases until maturity (91) (114) (134) (170).

Blood magnesium (38) gradually increases with age from about 2.4 mg. to 2.6 mg. per 100 cc. of serum. Magnesium also varies with the season of the year, ranging from 2.26 mg. in early spring to 2.55 mg. in late winter.

The hemoglobin of blood varies considerably between individual animals. It is markedly affected by the intake of cobalt (129), and of iron and copper (99), being low during prolonged periods of insufficient intake. The protein of the diet of the dog has also been shown to affect hemoglobin formation (137). Low protein diets resulted in improper regeneration of hemoglobin.

The carotene content of blood of cows depends in part upon the carotene intake in the feed. Values as high as 24.3 micrograms per cubic centimeter of blood have been reported for cows on pasture (121), whereas 0.13 micrograms per cubic centimeter seems to be the critical low level (122) (178).

Nothing concerning the blood phosphatase of cattle has been published in this country. Foley of England (50) has reported that the normal blood phosphatase of the cow was from 6 to 7 King and Armstrong units per 100 cc. of blood.

Very little variation was noted in a normal cow. Low phosphorus and calcium levels, however, were accompanied by a rise to 9.3 King and Armstrong units per 100 cc. of blood. McCollum (107, P. 370) states that from 5 to 14 Bodansky units is normal for humans. Determinations at this station on cow's blood have varied from less than one to almost 10 Bodansky units with no apparent significance attached to the variations.

Dukes (36) gives the following normal values for the cellular constituents of ox blood:

Table 6. Cellular constituents of ox blood.

Constituents		Amount
Total Cell Volume,		30 to 40 per cent
Erythrocytes,		6,325,000 per cc. of blood
White Corpuscles,		7,900 per cc. of blood
Lymphocytes	64%	
Monocytes	10%	
Neutrophiles	21%	
Eosinophiles	5%	
Basophiles	1%	

Urine Analysis

Although much has been published on the urine analysis of the fasting steer, no extensive study of the constituents of normal urine could be found. The exhaustive work of Benedict and Ritzman (19) and of Carpenter (22) shows that the urine of fasting steers was markedly different from the urine of the same steers at the onset of fasting. Urine from individual cows, however, varies so widely (19) (95) (101) (140) (179) that little can be said about what constitutes normal urine.

The reaction of cow's urine is usually slightly alkaline (22) (53) (95) (101). Cows on over-ripe hay have been shown to have neutral to slightly acid urine (179), while wheat straw possesses the peculiar property of causing a distinctly acid urine (74) (179).

The total nitrogen content of urine seems to depend almost entirely on the amount of protein ingested (95) (179). The nitrogen partitions also vary but nothing could be found reported that gives any clue as to the cause.

The volume of urine voided has been shown to vary normally from 12 to 50 liters per day for the same cow (95). The volume of urine output is influenced more by protein intake than by water intake (95) (101). The output of chlorides in the urine has been reported to vary from 100.8 gm. to 134.5 gm. per day (95). A high grain ration was reported in one case to be associated with a marked increase in loss of phosphorus in urine, apparently due to acidosis.

The following table is given to show the difference in the nitrogen partitions resulting from feeding two ordinary rations (101).

Table 7. Nitrogen output from different rations.

	Unit	Ration A	Ration B
Volume of Urine	cc.	5,079	10,460
N per 100 cc. of Urine	grams	.6136	1.522
Total N	grams	50.42	96.82
NH_4N	grams	2.43	9.20
Urea N	grams	8.08	44.86
Hippuric Acid N	grams	10.45	14.37
Undetermined N	grams	16.07	33.99

Summary of Review of Literature

A survey of the literature has revealed that little information is available concerning the nutritive value of the sorghum plant. The feeding trials reported have extended over short periods of time or in conjunction with other feeds. Literature has been cited indicating that under such conditions sorghum grain is of slightly less feeding value than corn. Sorghum silage is about equal to corn stover silage. From 20 to 30 per cent of the grain of sorghum silage has been recovered from the feces by washing.

The work reported by Hart et al concerning rations derived from the oat, wheat, or corn plant indicates that a restricted ration is not necessarily an inferior one. A ration consisting only of the corn plant gave fair results.

The feeding of rations low in protein content has resulted in thin fleshing of the cows. Further than this the reactions of the cattle have varied according to different authors.

The requirements and deficiency symptoms of protein, total digestible nutrients, fat, minerals and vitamins have been reviewed. Certain of the normal constituents of blood and urine are also given.

EXPERIMENTAL PROCEDURE

Animals Used

Sixteen cows of average producing ability were selected from the College herd for this investigation. All animals had completed at least one lactation record previous to being placed on the experiment. Four cows were placed on the project on December 22, 1938. Other animals were added as they became available.

Breed distribution and other information regarding cows placed in each lot are shown in Table 8.

Table 8. Arrangement into lots, entry on experiment, and freshening dates of cows on project.

Cow	Breed	Lactations Previously Completed	Date placed on experiment	Freshening Dates: 1st Lactation on experiment	Freshening Dates: 2nd Lactation on experiment
Lot 1					
Tease, 374	Jersey	5	12-24-38	2-12-39	2-5-40
Wanda, 126	Holstein	3	12-24-38	1-26-39	2-10-40
E44	Holstein	3	12-22-38	12-5-38	12-26-39
E40	Holstein	3	5-27-39	7-18-39	--------
Petal, 275	Ayrshire	2	9-22-39	11-18-39	--------
Caprice, 282	Ayrshire	1	10-3-39	11-8-39	--------
Lot 2					
Daffodil, 492	Guernsey	2	12-22-38	11-8-38	11-18-39
Laura, 273	Ayrshire	1	12-24-38	1-30-39	1-25-40
June, 113	Holstein	5	1-17-39	3-8-39	3-4-40
E42	Holstein	3	5-7-39	7-22-39	7-3-40
Idol, 141	Holstein	2	9-14-39	10-9-39	--------
Lot 3					
Milla, 235	Ayrshire	4	12-22-38	12-6-38	3-11-40
Tempest, 381	Jersey	3	1-17-39	3-16-39	4-6-40
E41	Holstein	3	3-9-39	5-1-39	4-25-40
Hallie, 139	Holstein	2	7-18-39	8-27-39	--------
Lily, 495	Guernsey	3	9-29-39	12-4-39	--------

Sources of Feed

All Atlas sorgo silage used in this feeding trial was produced on the College dairy farm. A portion of the Atlas stover and Atlas grain came from the same source as the silage. It was necessary to purchase the alfalfa hay and the remainder of Atlas stover and Atlas grain from nearby farmers. Alfalfa hay came from several different lots and averaged about U. S. No. 2 grade on color and leafiness. Wheat bran, salt and steamed bone meal were purchased from local feed dealers.

Since March 15, 1940, iodized salt has replaced the stock salt in grain mixes of Lots 2 and 3. The stabilized preparation of KI for preparing the iodized salt was furnished by Merck and Company.

Rations Used

The rations of the three groups were made up of the following ingredients:

Lot 1. Chopped Atlas stover
- Atlas silage
- Grain mix made up of
  - 100 parts ground Atlas grain
  - 1 part stock salt
- Block salt and water

Lot 2. Chopped Atlas stover
- Atlas silage
- Grain mix made up of
  - 150 parts ground Atlas grain
  - 100 parts cottonseed meal
  - 2½ parts steamed bone meal
- Block salt and water

Lot 3. Chopped alfalfa hay
- Atlas silage
- Grain mix made up of
  - 400 parts ground Atlas grain
  - 200 parts wheat bran
  - 50 parts cottonseed meal
  - 6½ parts steamed bone meal
  - 6½ parts stock salt
- Block salt and water

Feeding Practices

The cows were fed in individual mangers. All feeds were weighed in at each feeding and weights recorded. Any refuse was weighed back and recorded. The cows were fed twice daily and were given ample time to clean up the roughage. The grain was fed on the silage. After the grain and silage were cleaned up or the refuse weighed back, fodder and alfalfa hay were fed.

Atlas silage was fed to all animals at the rate of 2 lbs. per 100 lbs. of body weight. Atlas stover and alfalfa were fed ad libitum. More stover and hay were fed than the cows would clean up and any refuse feed was weighed back. From December of 1938 to September of 1939, grain was fed to Holsteins and Ayrshires at the rate of 1 lb. of grain to 4 lbs. of milk; or to Guernseys and Jerseys at the rate of 1 lb. of grain to 3 lbs. of milk. The amount of grain fed to each cow was adjusted at two or three-month intervals during this time. Since September of 1939 the nutrient intake from roughage has been calculated for each cow at 10-day intervals and enough grain mix supplied to meet the minimum requirement for total digestible nutrients as suggested by Morrison (124). In no case, however, has the grain been reduced to less than one pound daily while a cow was milking. For two months prior to expected calving, liberal quantities of grain were fed in an attempt to increase body weight in preparation for the following lactation. Grain was withheld during any dry period preceding this two-month interval, and for a day or so at time of freshening.

General Management

The cows were housed in the experimental dairy barn separate from the main building, and were kept indoors in stanchions during unfavorable weather. The animals were turned into a bare exercise lot for at least two hours daily when the weather permitted. Since January of 1940 the cows in Lot 1 have been muzzled before being turned into the exercise lot, to prevent drinking of urine and eating of foreign material while in the lot. Also, feed mangers were lined with boards in January 1940 to prevent licking of concrete. Wood shavings have been used for bedding since the beginning of the experiment. Minor deviations from the above procedures were made for cows that were isolated for short periods of time pending Bang's test results.

The cows have been milked twice daily and all milk weights recorded. All cows were dried off two months prior to expected calving, or if one failed to lactate that long, until milk production was reduced to one pound daily.

All animals were weighed two days in succession at monthly intervals. If any animal varied more than 15 lbs. between the two days' weights, the cow was weighed on the third day. Body weight was determined by averaging the weights for two days.

Any animals with signs of illness were treated by a veterinarian from the college if thought advisable. All animals that died, or were slaughtered, were posted and specimens of various glands preserved for histological study. Certain bones from posted animals have also been kept and observed for abnormalities. Breaking strength has been determined on bones from two mature cows that died or were removed from the experiment.

The attendants made notes daily of treatment of animals and other pertinent items.

Chemical Analyses of Blood

Chemical determinations of blood constituents have been made as indicated in Table 19. Procedures for determinations were taken from the following authors:

Constituent	Author
Total calcium	Wang (175)
Inorganic phosphorus	Fiske and Subarow (46)
Magnesium	Hawk and Bergeim (79)
Hemoglobin	Shenk et al (155)
Carotene[7]	Peterson (144)
Phosphatase	Bodansky (20)

Differential blood cell counts were made at monthly intervals until March of 1940. No abnormal cell counts were noted, and this work will not be reported.

Feed Analyses

Composite samples of feed have been submitted for analyses as shown in Tables 20 to 25. With the exception of carotene, all feed analyses were made according to A. O. A. C. methods (158). Carotene determinations were made by the procedure published by Peterson (144). The composite samples were prepared by taking stated amounts of feed from each batch or at regular intervals, and allowing them to accumulate for three or more months. The samples submitted for analyses were taken from these composites.

Samples were submitted at monthly intervals for carotene and moisture determinations. Nutrient intakes have been calculated by taking the values reported for the composite samples and correcting for variations in moisture content as shown by monthly analyses.

Urine Analyses

Twenty-four-hour urine samples were collected from individual cows on January 28, 1940 for analyses. This work was preliminary in nature and will not be reported.

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[7] Procedure modified since publication. Blood serum saponified in aqueous KOH, extracted with petroleum ether, washed, dried, and amounts determined with photo-electric calorimeter.

Feces Analyses

No chemical analyses of feces have been made. However, feces from two cows in each group were collected at two different times over a period of three days each and the grain in the feces determined by repeated mixing with water in a deep barrel, allowing the grain to settle out and decanting off the liquid containing foreign material. The grain was then dried and weighed.

RESULTS

The results reported in this thesis cover the period of time from December 22, 1938 through May 31, 1940. The reproduction history is extended through July 15, 1940, to include calves that are of interest to the project.

Due to the fact that the experiment is still in progress and much of the data will be resummarized at a later date, detailed data on feed consumption is omitted. Intakes of calcium, magnesium, and carotene are also omitted to simplify tables. In all cases calcium and magnesium intakes were in excess of requirements as given by Mitchell (119). During April and May of 1940 carotene intake was slightly less than the requirements as given by the United States Bureau of Dairy Industry (169) to be necessary for normal reproduction. Previous to April 1940 carotene intakes were in excess of this amount and have at all times been in excess of the requirements as given by Guilbert (64) to be necessary to prevent night blindness.

The more important results of this experiment are shown graphically in Figures 1 to 16, inclusive.

Feed Consumption and Nutrient Intake

With the exception of Petal, No. 275, in Lot 1, no difficulty was experienced in getting the cows to consume enough feed to meet the minimum requirements for total digestible nutrients as suggested by Morrison (124). Intakes and requirements for total digestible nutrients, digestible protein and phosphorus are shown in Figures 1 to 16, inclusive. These data have been summarized for cows that have completed lactation records on the project and are shown in Table 9. A study of the data shows that in Lot 1 the intakes of digestible protein and phosphorus have been less than the requirements as given by Morrison (124) and Mitchell (119), respectively.

Depraved Appetite

Depraved appetite has been noted in animals of Lots 1 and 2 at more or less frequent intervals ever since September 1939 when this condition was first observed. The affected animals have shown a desire to lick other cattle, in some cases to the extent of actually gnawing the hair. They were also observed eating dirt, licking mangers and drinking urine. As urine was being voided, animals in Lots 1 and 2 would gather around and lap up the urine from hoof marks in the ground. Another sign of abnormal appetite was the larger amounts of salt consumption by cows in Lots 1 and 2. Depraved appetite has been more severe in Lot 1 than in Lot 2.

Milk Production

Lactation curves for cows while on experiment are compared with previous lactations in Figures 1 to 16, inclusive. A study of these graphs shows marked group differences in amount of milk produced and in persistency of lactation, which changes are even more evident in the case of those cows which have entered their second lactation period since being placed on experiment.

Milk production and persistency have decreased in Lot 2, also, but to a

Table 9. Summary of daily nutrient intakes and requirements of cows that have completed lactations on project.[8]

Cow		Lactation Period				Dry Period		Calving Interval			
		D.P.	T.D.N.	Ca	P	D.P.	T.D.N.	D.P.	T.D.N.	Ca	P
E 40	Intake	.76	11.2	22.2	14.5	.51	10.1	.73	11.0	26.0	14.0
	% of req.	73	107	194	87	80	135	72	109	205	86
Tease, 374	Intake	.74	9.0	16.5	13.3	.68	9.76	.72	9.3	17.1	13.3
	% of req.	74	97	123	88	148	181	90	118	169	108
E 44	Intake	1.07	13.4	28.4	18.9	.97	13.5	1.04	13.4	28.6	18.8
	% of req.	79	106	152	90	147	175	88	117	197	94
Wanda, 126	Intake	1.09	12.3	26.3	19.2	.79	11.9	.98	12.8	27.5	17.7
	% of req.	73	94	141	76	117	153	82	108	191	87
Lot 1 Average											
	Intake	.92	11.7	24.3	18.5	.74	11.3	.87	11.6	24.8	16.0
	% of req.	75	101	153	85	123	161	83	133	191	94
Daffodil, 492	Intake	1.88	15.0	50.3	40.7	1.82	14.3	1.86	14.8	49.8	41.0
	% of req.	138	116	266	190	264	179	149	124	198	208
June, 113	Intake	2.01	16.9	56.9	43.8	1.37	14.3	1.94	16.5	54.4	42.7
	% of req.	118	106	231	163	176	151	123	110	250	171
E 42	Intake	1.63	15.5	49.5	38.1						
	% of req.	95	99	202	143						
Laura, 273	Intake	1.65	12.9	43.6	35.7	1.27	11.8	1.53	12.6	42.0	33.7
	% of req.	116	98	224	162	190	151	130	110	268	180
Lot 2 Average											
	Intake	1.79	15.1	49.8	39.7	1.49	13.5	1.77	14.5	48.7	39.1
	% of req.	117	105	231	145	210	162	134	115	239	186
Tempest, 381	Intake	2.00	12.9	71.1	42.8	2.16	13.2	2.03	13.0	72.8	43.0
	% of req.	133	96	332	186	348	180	144	101	368	198
Milla, 235	Intake	2.52	16.4	99.2	49.1	2.22	13.5	2.48	16.0	97.5	48.2
	% of req.	161	112	449	200	300	155	169	116	480	209
E 41	Intake	3.13	18.5	133.7	51.5	3.02	17.3	3.11	18.4	133.0	51.4
	% of req.	162	108	477	173	387	190	176	114	526	186
Lot 3 Average											
	Intake	2.55	16.0	101.3	47.8	2.47	14.7	2.54	15.8	101.1	47.5
	% of req.	154	105	419	186	345	175	163	110	458	198

[8] Intake of digestible protein and total digestible nutrients given in pounds; Ca and P in grams.

less marked degree than in Lot 1. Cows in Lot 3 have produced normally.

Lactation records of cows, both previous to, and while on, the experiment, are shown in Table 15. These data are summarized by groups in Tables 10 and 17. Nutrients required per pound of milk produced while on experiment are shown in Table 11.

General Thriftiness and Body Weight

Shortly after being placed on the experiment, cows in Lots 1 and 2 began to lose body weight and to appear unthrifty; however, unthrifty appearance has been more exaggerated in the former. Cows in Lot 3 have remained thrifty in appearance. Photographs of representative animals near time of going on the experiment and again on July 15, 1940 are shown in Figures 17 to 19. Emaciation and rough coats of cows that have been in Lots 1 and 2 will be noted.

Even though cows in Lots 1 and 2 have appeared unthrifty, severe illness has not been prevalent. Wanda, No. 126, in Lot 1, showed signs of nervous disorder in the rear legs during the early part of 1940. She had difficulty in standing and had to be helped in order to get on her feet in the mornings. She was given 20 gm. of pure nicotinic acid and the condition cleared up within a few days. Coincident with the giving of nicotinic acid there were several warm spring days. The cause of her condition or its disappearance is not known. During severe cold weather in January and February, two other cows in Lot 1 showed some signs of stiffness and soreness of the limbs, but not of a severe nature.

Wanda, No. 126, in Lot 1, died during the early part of July 1940 from severe peritonitis, apparently caused by a puncture of the reticulum by wire. Several pieces of wire and nails were taken from the reticulum, with one piece of wire extending into the peritoneal cavity. Daffodil, No. 492, in Lot 2, de-

Table 10. Summary of production performance by lots. Comparisons based on last records prior to project.

	Lot 1	Lot 2	Lot 3
Number of cows in comparison	4	4	3
Actual production - 4% milk			
Av. of last records prior to project	7,851 lbs.	8,526 lbs.	6,867 lbs.
Av. of first records on project	3,975 "	6,426 "	8,098 "
Difference	-3,876 lbs. -49.4%	-2,100 lbs. -24.6%	+672 lbs. +9.1%
Mature equiv. Class C - 4% milk			
Av. of last records prior to project	8,255 lbs.	9,996 lbs.	7,712 lbs.
Av. of first records on project	4,026 "	6,579 "	8,226 "
Difference	-4,229 lbs. -51.2%	-3,417 lbs. -34.2%	+534 lbs. +7.0%
Per cent of fat in milk			
Av. of last records prior to project	3.91%	4.17%	4.27%
Av. of first records on project	3.78%	4.16%	4.49%
Difference	-.13%	-.01%	+.22%
Length of lactation record			
Av. of last records prior to project	309 days	317 days	312 days
Av. of first records on project	259 days	293 days	344 days
Difference	-50 days	-34 days	+32 days
Number of days in dry period			
Av. of last periods prior to project	83 days	70 days	92 days
Av. of first periods on project	112 days	64 days	50 days
Difference	+29 days	-6 days	-42 days
Times bred per conception			
Number of cows in comparison	5	5	5
Av. for last pregnancies prior	2.60 times	1.40 times	1.60 times
Av. for first pregnancies on project	1.40 "	1.00 "	1.20 "
Difference	-1.20 times	-.40 times	-.40 times

Table 11. Efficiency of utilization of total digestible nutrients by cows that have completed lactations on project.

Cow	ACTUAL LACTATION PERIOD					DRY PERIOD			
	4% milk	Per Cent of require-ments met	T.D.N. intake per lb. of milk produced: Total intake	T.D.N. intake per lb. of milk produced: In excess of maint. req.	Daily gain in body wt.	Daily gain in body wt.	Per Cent of require-ments met	T.D.N. intake per lb. of body weight gain: Total intake	T.D.N. intake per lb. of body weight gain: In excess of maint. req.
	lbs.		lbs.	lbs.	lbs.	lbs.		lbs.	lbs.
E 40	10.3	107	1.09	.38	-0.48	+0.86	135	11.7	3.02
Tease, 374	12.6	97	.71	.29	-1.35	+1.16	181	8.4	3.76
Wanda, 126	19.2	94	.69	.27	-1.53	+0.99	153	12.0	3.10
E 44	17.8	106	.75	.35	-0.72	+1.49	175	9.1	3.89
Lot 1 Average	15.0	101	.81	.32	-1.02	+1.13	161	10.3	3.44
Daffodil, 492	17.7	116	.85	.42	-0.10	+1.44	179	9.9	4.38
June, 113	23.5	106	.72	.35	-0.38	+3.70	157	3.9	1.41
E 42	24.8	99	.63	.30	-0.68	----	----	----	----
Laura, 273	18.7	98	.69	.29	-0.34	+1.20	151	9.8	3.53
Lot 2 Average	21.2	105	.72	.34	-0.38	+2.11	162	7.9	3.04
Tempest, 381	22.6	96	.57	.28	-0.12	+1.56	180	8.5	3.78
Milla, 235	21.7	112	.76	.39	+0.22	+0.98	155	13.8	4.90
E 41	29.7	108	.64	.36	+0.22	+2.04	190	8.4	4.02
Lot 3 Average	24.6	105	.66	.34	+0.08	+1.53	175	10.2	4.23

Table 12. Efficiency of utilization of total digestible nutrients by cows that have completed lactations on project.

Cow	CALVING INTERVAL[9]				
	4% milk	Per Cent of require- ments met	T.D.N. intake per lb. of milk produced		Daily Gain In Body Weight
			Total intake	In excess of maint. req.	
	lbs.		lbs.	lbs.	lbs.
E 40	9.2	109	1.20	.40	-.33
Tease, 374	8.0	118	1.16	.49	-.45
Wanda, 126	12.2	108	1.05	.38	-.61
E 44	13.5	117	.99	.44	-.21
Lot 1 Average	10.7	113	1.10	.43	-.40
Daffodil, 492	14.6	124	1.01	.51	+.20
June, 113	20.2	110	.82	.39	+.10
Laura, 273	12.6	110	1.00	.39	+.16
Lot 2 Average	15.8	115	.94	.43	+.15
Tempest, 381	20.2	101	.64	.31	+.15
Milla, 235	19.0	116	.84	.42	+.31
E 41	25.5	114	.72	.39	+.49
Lot 3 Average	21.6	110	.73	.37	+.32

9 Includes lactation period and dry period

veloped severe diarrhea about 4 months after the beginning of her second lactation on the experiment. She did not return to full feed and was removed from the experiment 4 months later due to a positive Bang's reaction.

Body weight curves are shown in Figures 1 to 16. Cows in Lots 1 and 2 have become lighter in weight with the progress of the experiment. It will be noted that cows that have completed lactations gained some weight during the dry period but not in amounts sufficient to compensate for all weight lost during the lactation. Cows in Lot 2 more nearly returned to their former weight, but they began the second lactation lighter in weight than the initial weight of first lactation on the experiment. The average daily loss of body weight during lactation and gains made during the dry period are shown in Table 11.

Breeding and Reproduction

The breeding history of the cows is presented in Table 18. These data are summarized by groups in Table 10. A study of the tables shows that breeding difficulties have not occurred in any group, with the exception of two animals that were irregular previous to going on the experiment.

Calves that have been dropped on the experiment have, for the most part, been normal. In size, general appearance and thrift, calves from Lot 1 have equalled or excelled calves from Lot 3.

Information regarding calves born on the experiment is shown in Table 13. Due to the fact that the calves from Lot 1 were normal, it is doubtful if the high mortality of the calves in Lot 2 is of significance.

Table 13. Calves born on experiment after dams had completed one lactation on experiment.

Dam	Breed	Sex	Weight	Date Born	Remarks
Lot 1			lbs.		
Tease, 374	Jersey	F	49	2-5-40	Normal
Wanda, 126	Holstein	M	106	2-10-40	Normal
B44	Holstein	F	81	12-26-39	Normal
Lot 2					
Daffodil, 492	Guernsey	M	70	11-18-39	Normal
June, 113	Holstein	F	54	3-4-40	Twin, born dead, 10 days premature
June, 113	Holstein	M	82	3-4-40	Twin, born dead, 10 days premature
Laura, 273	Ayrshire	M	107	1-25-40	Normal
B42	Holstein	F	50	7-3-40	Twin, died at birth
B42	Holstein	F	49	7-3-40	Twin, lived one day
Lot 3					
Tempest, 381	Jersey	F	58	4-6-40	Died of scours, 4-10-40
Milla, 235	Ayrshire	M	71	5-11-40	Normal

Blood Picture

The results on chemical analysis of blood are shown in Table 19, and graphically in Figures 1 to 16.

The blood picture for the most part has been normal. Inorganic blood phosphorus has been low in Lot 1 but with a few exceptions has been within the normal range. Blood carotene has fluctuated greatly and has been comparable in the three lots. The average blood carotene for cows on winter pasture as shown in Tables 1 to 16 was taken from limited unpublished data and should not be regarded necessarily as a normal value.

Grain Recovered from Feces

Data concerning the amount of grain recovered from the feces of two cows in each group are shown in Table 14.

Table 14. Grain recovered from feces. (Average of 2 cows from each group)

Group	Condition of Grain	Dates Feces Collected 1940	Grain Intake lbs.[10]	Silage Intake lbs.	Grain Recovered lbs.	Grain Recovered %
Lot 1	Coarse ground	3-8 to 11	3.0	17.0	.73	24.4
	Fine ground	3-20 to 23	3.0	16.9	.37	12.2
Lot 2	Coarse ground	3-8 to 11	4.5	20.0	.42	10.4
	Fine ground	3-20 to 23	4.5	18.4	.20	4.4
Lot 3	Coarse ground	3-8 to 11	10.0	21.0	.27	2.7
	Fine ground	3-20 to 23	9.1	18.0	.17	1.8
Herd Cows						
	Coarse ground	3-8 to 11	10.0	----	0.5	5.0
	Fine ground	3-20 to 23	8.2	----	0.1	1.2

[10] Includes ground Atlas grain ingested from grain mix. Does not include Atlas grain consumed in stover and silage.

DISCUSSION OF RESULTS

The results obtained from this experiment to date point out three facts:

1. A ration made up of the Atlas sorgo plant is deficient in certain nutrients needed by the dairy cow.

2. The addition of bone meal and cottonseed meal, while evidently improving the ration to some extent, did not correct all the deficiencies of the Atlas ration.

3. The addition of alfalfa hay and wheat bran, as well as cottonseed meal and bone meal, composed a ration that has given good results thus far in the experiment. In view of the fact that longer periods of dry lot feeding usually

result in a gradual decline of thrift and production, it cannot be said that the latter ration is adequate in every respect.

Reference to the literature does not give much information of value in interpreting the results of this experiment. Cunningham and Addington (32) and Copeland (27) have reported work of a similar nature, but their results have been inconclusive, with the exception of vitamin A deficiency in both cases. The low blood carotene values associated with extensive sorghum feeding, as has been reported previously from the Kansas station (149), and the frequent low levels shown in this experiment suggest that insufficient carotene intake may have entered into the results from Lots 1 and 2. The usual conditions associated with vitamin A deficiency that has reached the pathological stage have not been noted during this experiment. It should be borne in mind, however, that optimum intake, and intake enough to prevent clinical deficiency symptoms from appearing, may be widely different.

The early work of Hart and associates (73) (74) (75) indicates that a restricted ration is not necessarily an inferior one since the corn plant gave what they termed normal results. Judging from pictures presented in these publications, however, the corn-fed group did not maintain the bloom and finish usually associated with cows on good pasture. Another point is that the animals used in the experiments of Hart were restricted to the rations at an early age and were well accustomed to the ration before reproduction and lactation occurred. Observation has shown that the dietary habits of cattle may enter into results.

The earlier work of Hills (82) with low protein rations gave results similar to this experiment. On the other hand, the Vermont station maintained cows on low protein rations for long periods of time with no harmful effects. Body weight was low, however. The response of cows in Lot 2 indicates that additional protein to the Atlas ration partly alleviated some of the deficiencies. It is certain that the low protein content of sorghums could not support heavy milk production without protein supplement.

The low blood phosphorus levels of cows in Lot 1, and the higher levels for cows in Lot 2 suggest that phosphorus intake in Lot 1 has been near the suboptimal level at least. The bones of the two cows that have left the experiment, however, have shown no gross evidences of removal of phosphorus from the bones.

The data shown in Tables 11 and 12 indicate poor utilization of nutrients by cows in Lots 1 and 2. In this connection it is interesting to note the large amounts of grain recovered from the feces of these two lots as compared to grain recovered from feces of Lot 3. There is a possibility that for some reason the cows in Lots 1 and 2 are not properly digesting their feed. Digestion trials would answer this question.

In spite of the fact that from previous observations the results obtained could have been predicted to some extent, the information obtained from the investigation thus far is fundamental and should be of value in determining the deficiencies of the Atlas sorgo plant.

SUMMARY AND CONCLUSIONS

1. Sixteen dairy cows have been used in a long-time experiment to determine the feeding value of the Atlas sorgo plant, and if possible its nutrient deficiencies.

2. Lot 1 was fed a ration made up exclusively from the Atlas sorgo plant. This ration resulted in a lowered plane of milk production, decreased persistency of lactation, emaciation, and general unthriftiness. Reproduction, however, has been normal.

3. Lot 2 was fed the same ration supplemented with steamed bone meal and

cottonseed meal. Results were similar to those in Lot 1 but to a less marked degree. Mortality of calves born on the experiment, coincident with two sets of twins, has been higher than in Lot 1.

4. Lot 3 received a ration which included alfalfa hay and wheat bran in addition to the ingredients of the Lot 2 ration. This group has produced normally, maintained body weight and remained thrifty.

5. While on the experiment, average milk production in three lots was 48.8 per cent, 65.8 per cent, and 107 per cent, respectively, of the previous year's average production.

6. Depraved appetite of cows has occurred in Lot 1, and to a lesser degree in Lot 2.

7. The Atlas sorgo plant is evidently deficient in certain nutrients needed by the dairy cow. Thus far the deficiencies were apparently corrected by supplementing the Atlas ration with bone meal, cottonseed meal, wheat bran, and alfalfa hay.

ACKNOWLEDGMENT

The writer wishes to express appreciation to all members of the Department of Dairy Husbandry for making possible the writing of this thesis.

To Professor F. W. Atkeson and Dr. H. Ernest Bechtel special thanks are due for making available data from this investigation prior to September of 1939. To them gratitude is also expressed for their guidance and encouragement during the collection of data and preparation of this manuscript.

Appreciation is expressed also to Mr. Glen H. Beck for the use of certain data from his files.

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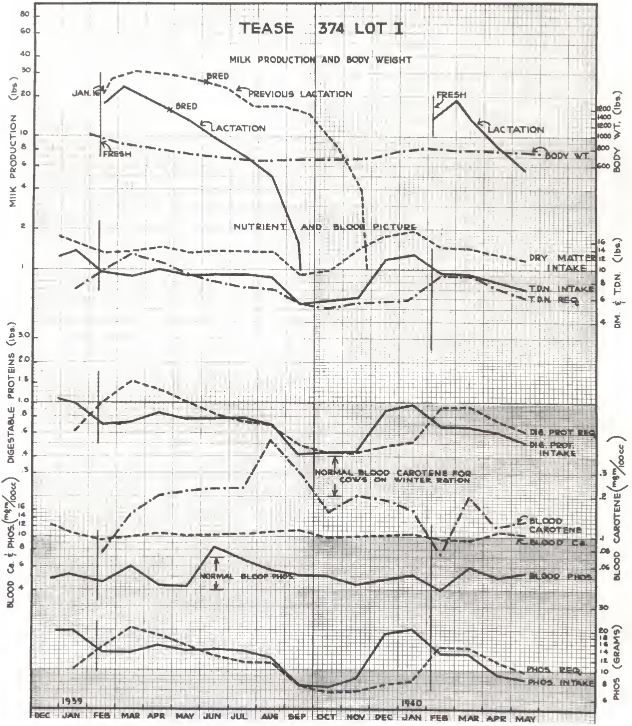


Fig. 1. Milk production, body weight, nutrient intake and requirement, and blood picture of Tease, No. 374, Lot 1. Placed on experiment 12-24-38 after completing fifth lactation.

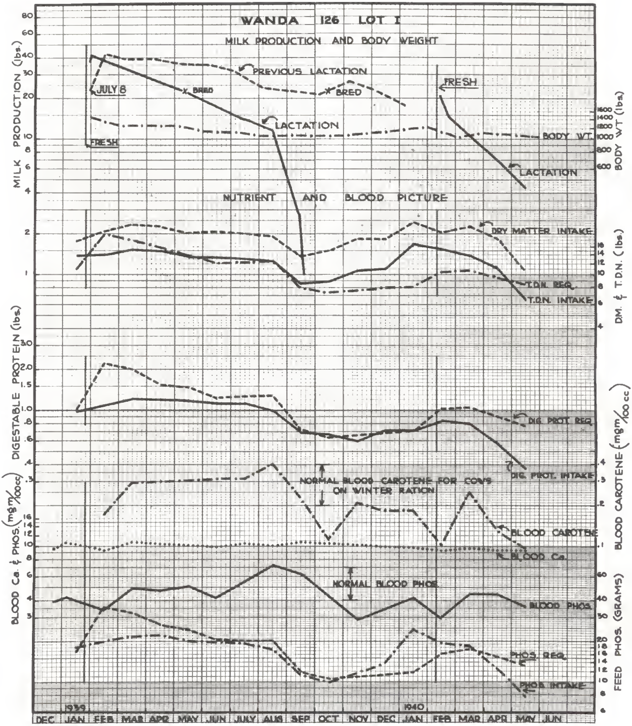


Fig. 2. Milk production, body weight, nutrient intake and requirement, and blood picture of Wanda, No. 126, Lot 1. Placed on experiment 12-22-38 after completing third lactation.

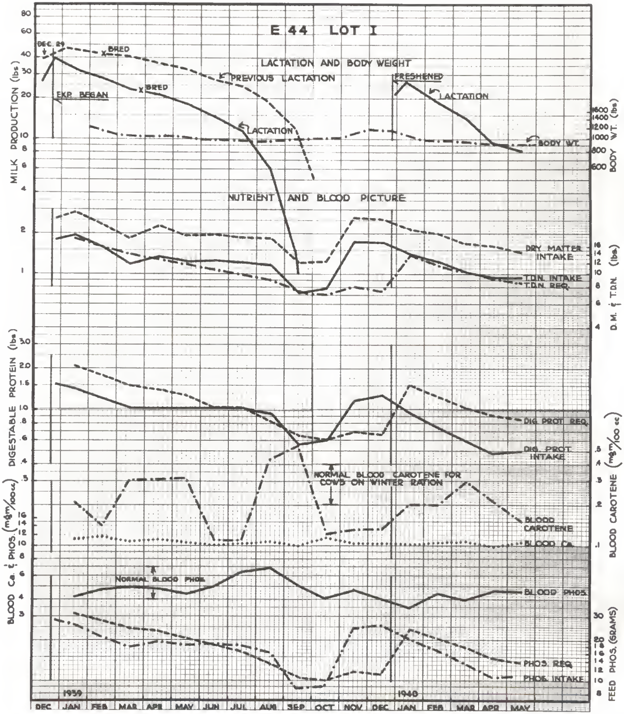


Fig. 3. Milk production, body weight, nutrient intake and requirement, and blood picture of E 44, Lot 1. Placed on experiment 12-22-38 after completing third lactation.

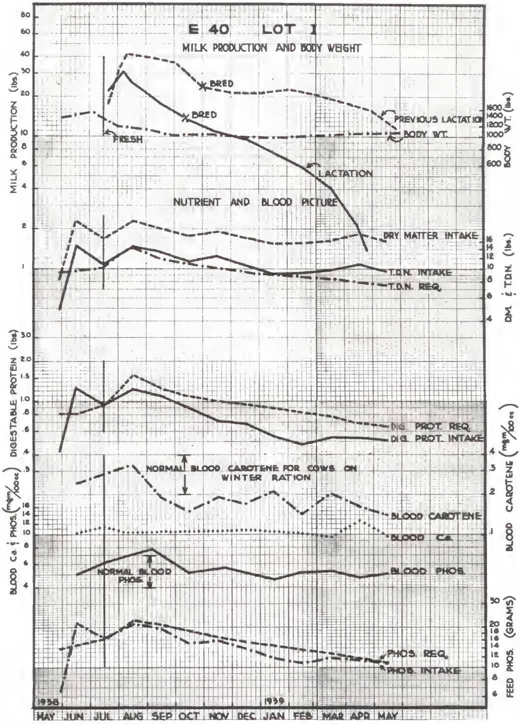


Fig. 4. Milk production, body weight, nutrient intake and requirement, and blood picture of E 40, Lot 1. Placed on experiment 5-27-39 after completing third lactation.

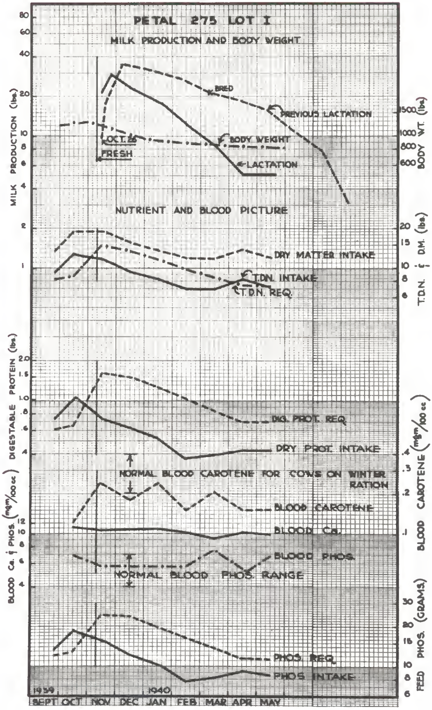


Fig. 5. Milk production, body weight, nutrient intake and requirement, and blood picture of Petal, No. 275, Lot 1. Placed on experiment 9-22-39 after completing second lactation.

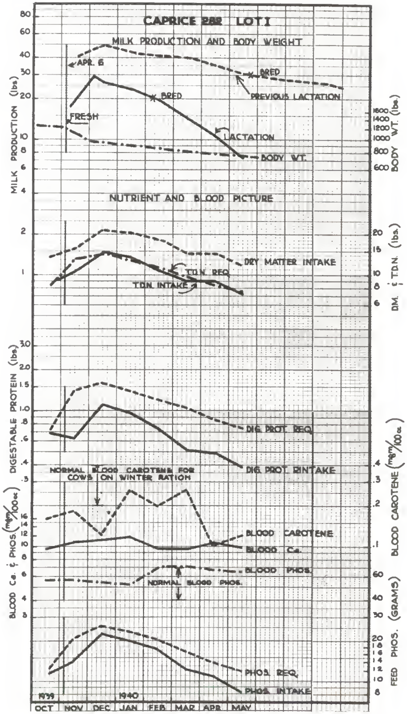


Fig. 6. Milk production, body weight, nutrient intake and requirement, and blood picture of Caprice, No. 282, Lot 1. Placed on experiment 10-3-39 after completing first lactation.

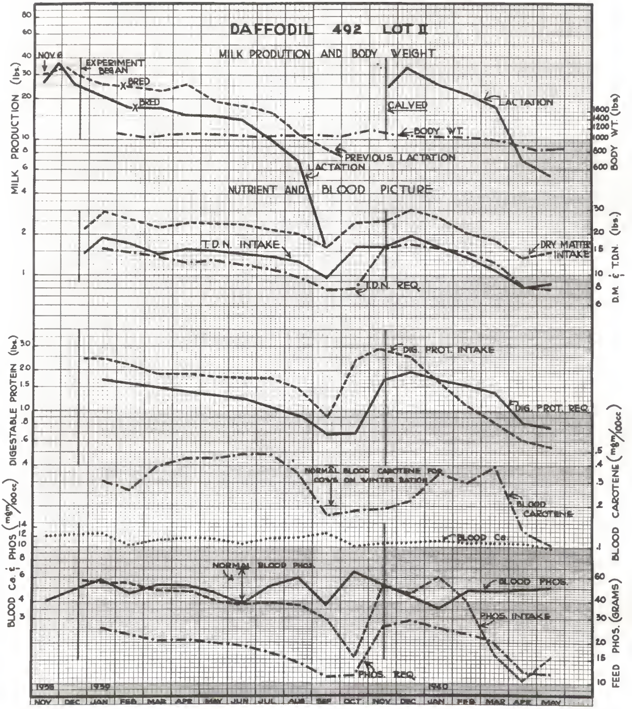


Fig. 7. Milk production, body weight, nutrient intake and requirement, and blood picture of Daffodil, No. 492, Lot 2. Placed on experiment 12-22-38 after completing second lactation.

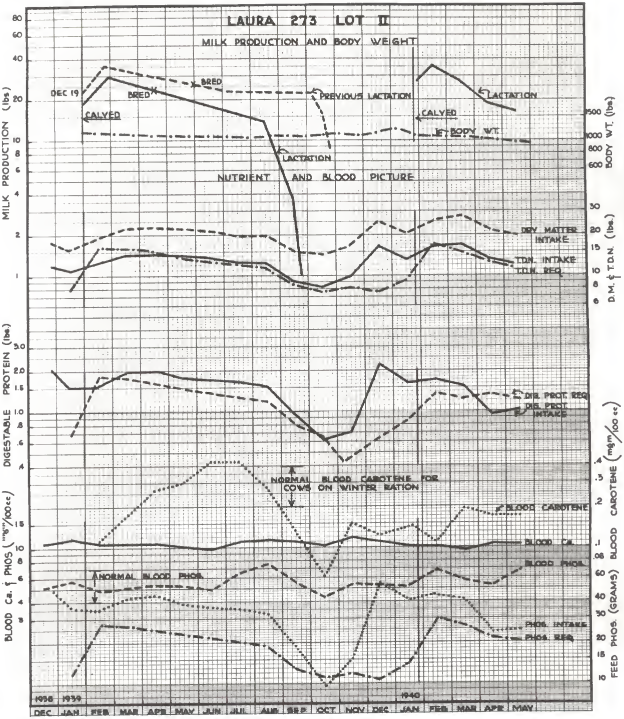


Fig. 8. Milk production, body weight, nutrient intake and requirement, and blood picture of Laura, No. 273, Lot 2. Placed on experiment 12-24-38 after completing first lactation.

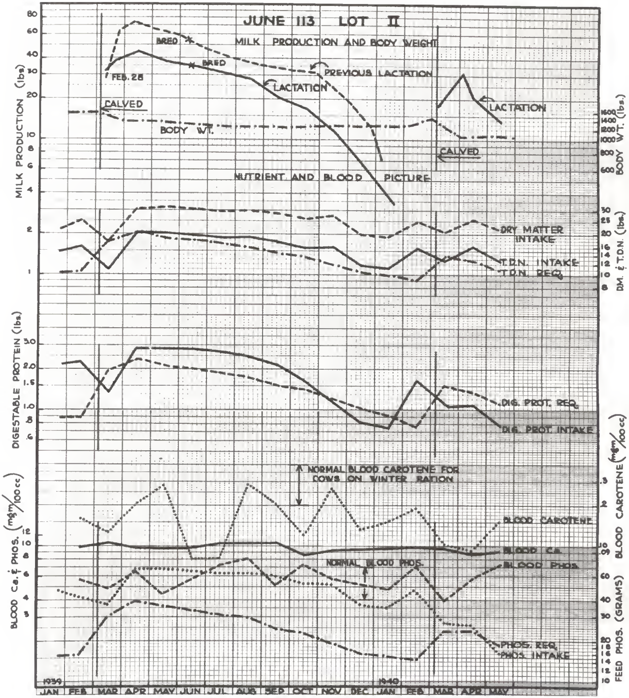


Fig. 9. Milk production, body weight, nutrient intake and requirement, and blood picture of June, No. 113, Lot 2. Placed on experiment 1-17-39 after completing fifth lactation.

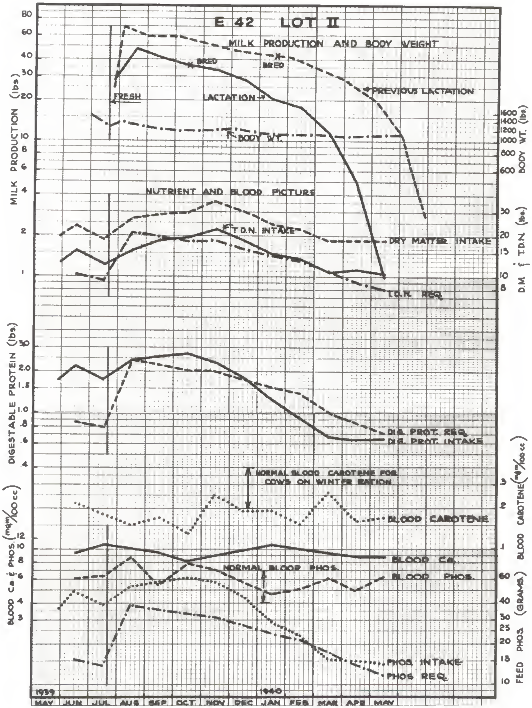


Fig. 10. Milk production, body weight, nutrient intake and requirement, and blood picture of E 42, Lot 2. Placed on experiment 5-27-39 after completing third lactation.

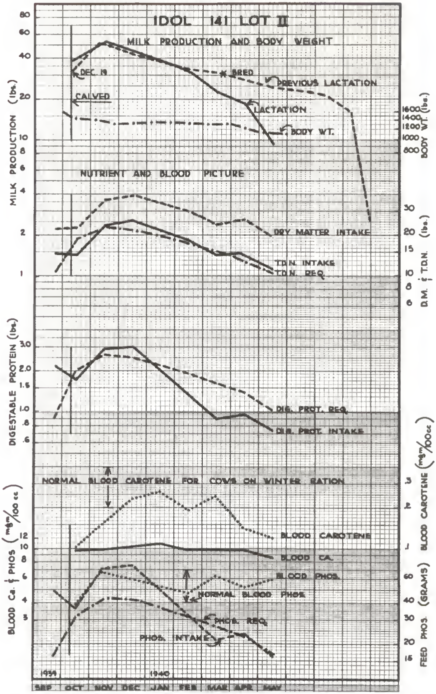


Fig. 11. Milk production, body weight, nutrient intake and requirement, and blood picture of Idol, No. 141, Lot 2. Placed on experiment 9-14-39 after completing second lactation.

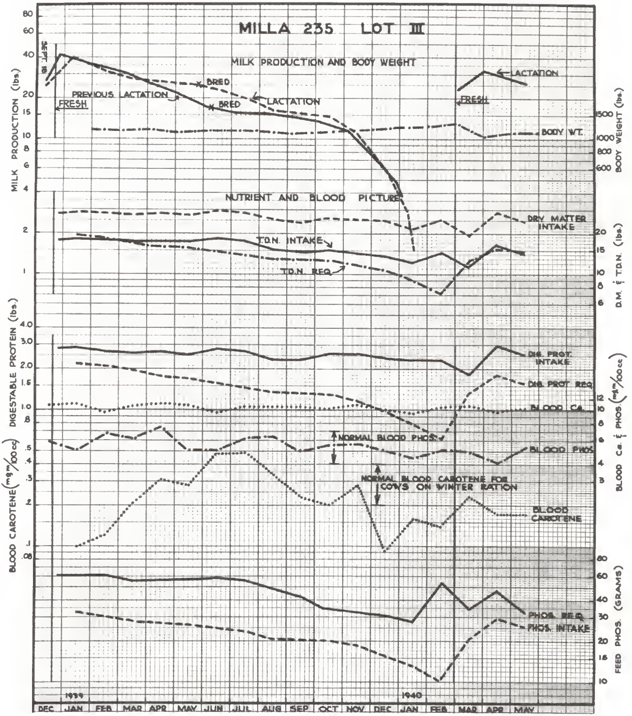


Fig. 12. Milk production, body weight, nutrient intake and requirement, and blood picture of Milla, No. 235, Lot 3. Placed on experiment 12-22-38 after completing fourth lactation.

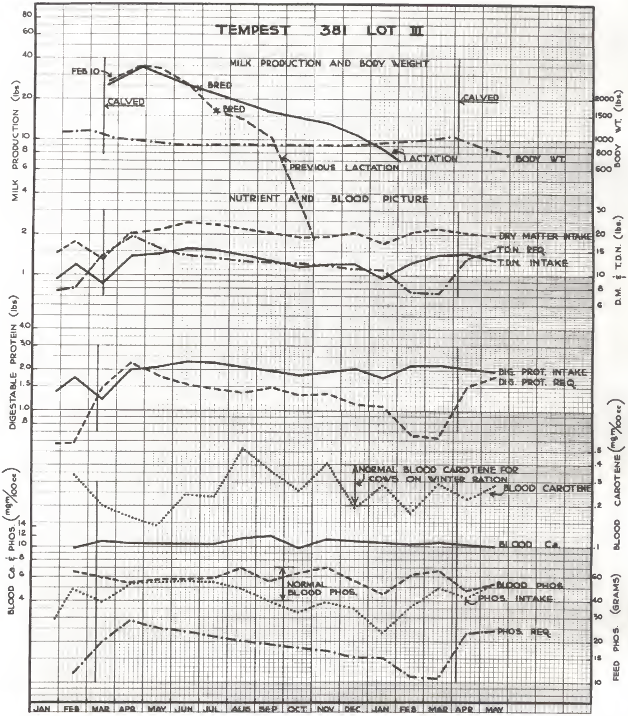


Fig. 13. Milk production, body weight, nutrient intake and requirement, and blood picture of Tempest, No. 381, Lot 3. Placed on experiment 1-17-39 after completing third lactation.

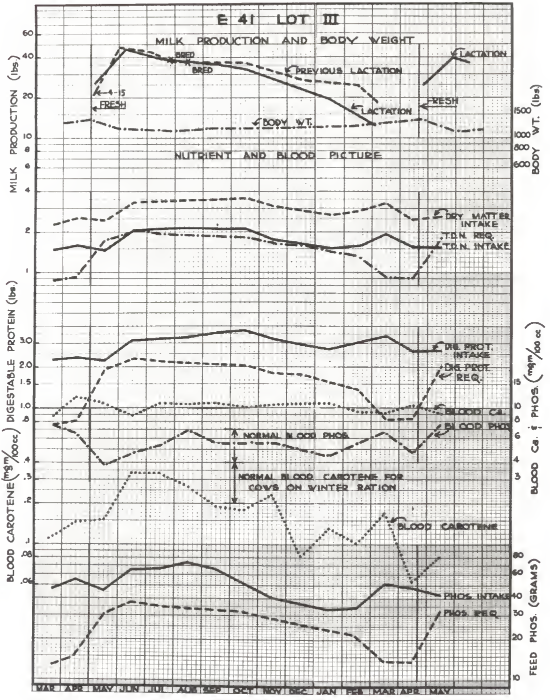


Fig. 14. Milk production, body weight, nutrient intake and requirement, and blood picture of E 41, Lot 3. Placed on experiment 3-9-39 after completing third lactation.

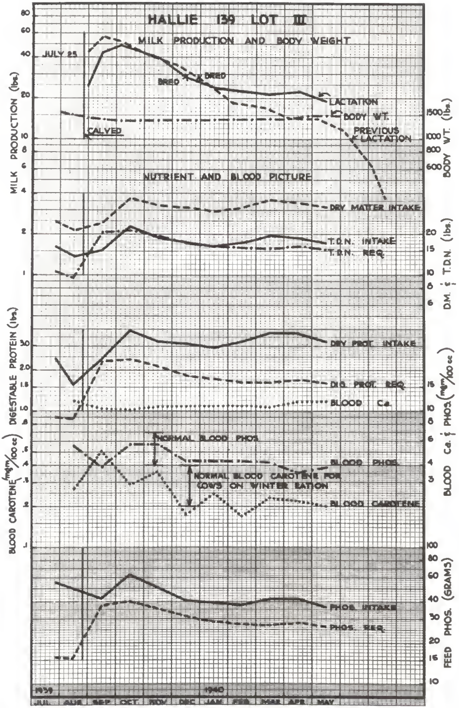


Fig. 15. Milk production, body weight, nutrient intake and requirement, and blood picture of Hallie, No. 139, Lot 3. Placed on experiment 7-18-39 after completing second lactation.

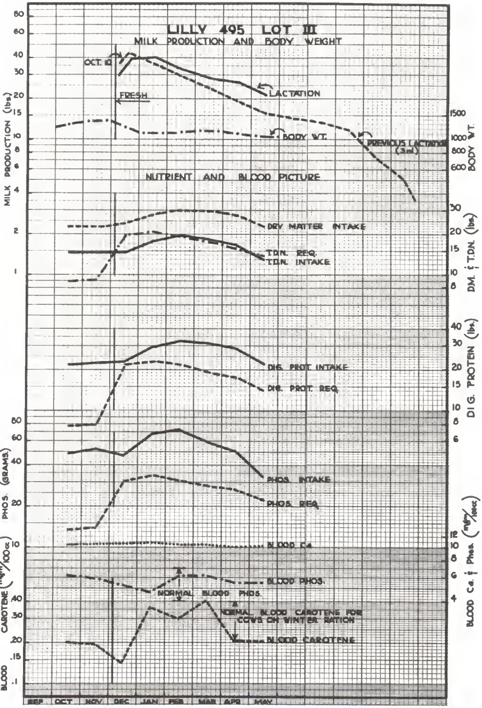


Fig. 16. Milk production, body weight, nutrient intake and requirement, and blood picture of Lily, No. 495, Lot 3. Placed on experiment 9-29-39 after completing third lactation.

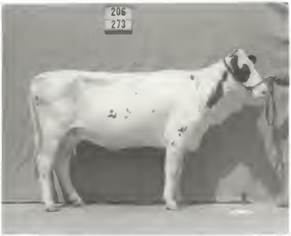
3-14-39 Tease, No. 374 7-15-40

12-14-38 E 44 7-15-40

11-28-39 Petal, No. 275 7-15-40

Fig. 17. Photographs of representative animals from Lot 1 near time of going on experiment and again on 7-15-40.

12-14-38 Daffodil, No. 492 7-15-40



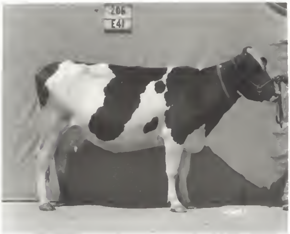
3-14-39 Laura, No. 273 7-15-40

3-14-39 June, No. 113 7-15-40

Fig. 18. Photographs of representative animals from Lot 2 near time of going on experiment and again on 7-15-40.

3-14-39 Tempest, No. 381 7-15-40

12-14-38 Milla, No. 235 7-15-40



6-9-39 E 41 7-15-40

Fig. 19. Photographs of representative animals from Lot 3 near time of going on experiment and again on 7-15-40.

Table 15. Lactation records of cows completed previous to, and while on, experiment.

Cow	Lactation	Fresh Age Yrs.	Mo.	Times Milked Daily	305-day actual prod. Milk	Test	Fat	Mature equiv. Class C 4% Milk
					lbs.	%	lbs.	lbs.
Lot 1								
Petal, 275	1st	2	9	3	7,983	4.23	337.3	7,923
	2nd	3	10	2	5,170	4.32	223.4	5,983
	Av. of first 2 lactations				6,577	4.28	280.4	6,953
	3rd[11]	Now in progress						
E 40	1st	2	5	2	3,379	3.65	123.2	3,994
	2nd	3	6	2	6,389	3.25	207.8	6,263
	3rd	4	5	2	7,434	3.48	258.5	7,344
	Av. of first 3 lactations				5,734	3.46	196.5	5,867
	4th[11]	5	6	2	3,218	3.32	101.7	2,963
Tease, 374	1st	2	0	3	4,880	5.33	260.3	5,857
	2nd	3	1	2	3,363	5.41	181.8	4,691
	3rd	4	4	2	5,252	5.26	276.1	6,691
	4th	5	5	2	5,411	5.28	285.7	6,605
	5th	6	5	2	5,448	5.01	273.1	6,276
	Av. of first 5 lactations				5,871	5.26	255.4	6,024
	6th[11]	7	6	2	2,676	4.33	115.9	2,809
Wanda, 126	1st	2	7	3	8,522	3.61	307.8	7,705
	2nd	3	7	2	9,194	3.54	325.1	9,444
	3rd	4	10	2	9,616	3.60	345.7	9,466
	Av. of first 3 lactations				9,111	3.55	326.2	8,872
	4th[11]	6	0	2	4,990	3.50	174.7	4,617
E 44	1st	2	2	2	4,593	3.75	172.3	5,519
	2nd	3	1	2	6,411	3.73	239.2	7,087
	3rd	4	1	2	9,954	3.54	352.3	9,933
	Av. of first 3 lactations				6,787	3.67	254.6	7,513
	4th[11]	5	0	2	5,595	3.98	222.8	5,714
Caprice, 273	1st	2	6	3	10,681	3.83	409.5	10,415
	2nd[11]	Now in progress						

Table 15. Lactation records of cows completed previous to, and while on, experiment. (Continued)

Cow	Lactation	Fresh Age Yrs.	Mo.	Times Milked Daily	305-day actual prod. Milk	Test	Fat	Mature equiv. Class C 4% Milk
					lbs.	%	lbs.	lbs.
Lot 2								
Daffodil, 492	1st	2	8	3	5,985	4.76	285.0	6,402
	2nd	4	5	2	6,690	5.11	341.7	8,364
	Av. of first 2 lactations				6,338	4.94	313.4	7,383
	3rd[11]	5	3	2	5,343	4.96	264.9	6,262
June, 113	1st	2	5	3	11,684	3.70	431.2	11,142
	2nd	3	9	2	10,565	3.46	365.9	10,725
	3rd	4	9	2	10,576	3.80	401.4	10,743
	4th	5	9	2	12,046	3.56	428.3	11,514
	5th	6	9	2	12,604	3.53	445.8	11,729
	Av. of first 5 lactations				11,595	3.61	414.5	11,171
	6th[11]	7	9	2	7,960	3.59	286.4	7,480
E 42	1st	2	6	2	5,302	3.99	211.5	6,352
	2nd	3	7	2	7,031	3.39	238.5	7,055
	3rd	4	7	2	12,567	3.59	451.4	12,364
	Av. of first 3 lactations				8,300	3.66	300.4	8,590
	4th[11]	5	10	2	7,561	4.0	302.5	7,561
Idol, 141	1st	2	1	3	10,209	3.46	353.1	9,380
	2nd	3	7	2	9,601	3.41	327.7	9,667
	Av. of first 2 lactations				9,905	3.44	340.4	9,524
	3rd[11]	Now in progress						
Laura, 273	1st	3	1	3	7,685	4.43	340.6	7,528
	2nd[11]	4	2	2	4,461	4.07	181.5	4,832
Lot 3								
Hallie, 139	1st	2	5	3	10,358	3.27	338.8	9,225
	2nd	3	8	2	7,483	3.18	238.2	7,249
	Av. of first 2 lactations				8,921	3.23	288.5	8,237
	3rd[11]	Now in progress						

Table 15. Lactation records of cows completed previous to, and while on, experiment. (Continued)

Cow	Lactation	Fresh Age Yrs.	Fresh Age Mo.	Times Milked Daily	305-day actual prod. Milk	305-day actual prod. Test	305-day actual prod. Fat	Mature equiv. Class C 4% Milk
					lbs.	%	lbs.	lbs.
Lot 3 (Cont'd)								
Tempest, 381	1st	2	0	3	4,400	6.26	275.6	5,894
	2nd	3	3	2	4,570	5.08	232.4	6,122
	3rd	4	5	2	4,717	5.18	244.3	5,951
	Av. of first 3 lactations				4,562	5.51	250.8	5,989
	4th[11]	5	6	2	5,952	5.42	323.1	7,4[illegible]
Lily, 495	1st	2	8	3	6,080	5.01	304.5	6,720
	2nd	3	9	2	6,404	5.35	342.8	8,505
	3rd	4	10	2	6,111	4.89	299.0	7,262
	Av. of first 3 lactations							
	4th[11]	Now in progress						
Milla, 235	1st	2	5	3	8,861	4.09	362.6	8,983
	2nd	3	8	2	8,456	3.96	335.1	7,400
	3rd	4	9	2	5,634	4.01	225.6	5,909
	4th	6	2	2	7,138	3.95	282.0	7,085
	Av. of first 4 lactations							
	5th[11]	7	4	2	7,681	4.28	329.1	8,013
E 41	1st	2	5	2	6,022	3.70	223.1	7,182
	2nd	3	5	2	7,318	3.77	275.7	8,137
	3rd	4	8	2	10,141	3.67	372.0	10,099
	Av. of first 3 lactations				7,827	3.71	290.3	8,473
	4th[11]	5	8	2	9,372	3.76	353.3	9,265

[11] On experiment.

Table 16. Daily production of milk in pounds by calendar month for all lactation records of cows.

Cow	Lactation	First day's Prod.	Peak Prod.	Daily production in pounds by calendar months: 1	2	3	4	5	6	7	8	9	10	11	12	Total Days Milked
Lot 1																
Petal, 275	1st	25.3	37.2	32.9	34.4	30.9	27.5	24.2	24.1	25.4	24.0	22.0	18.7	7.7	——	326
	2nd	9.7	35.9	17.3	31.5	31.6	27.5	21.7	19.0	16.2	10.8	7.5	3.9	——	——	270
	3rd[12]	22.3	28.0	27.3	23.0	17.3	12.2	8.7	6.1	——[13]	——	——	——	——	——	
E 40	1st	1.1	21.6	17.9	16.0	12.2	9.4	10.3	11.2	11.4	10.3	8.2	4.8	2.1	——	330
	2nd	17.2	29.6	23.3	27.8	25.6	23.3	22.5	22.3	21.2	19.1	14.9	9.1	——	——	303
	3rd	17.2	40.9	30.3	38.9	36.1	24.3	21.5	21.3	22.7	20.7	18.0	15.6	11.5	——	312
	4th[12]	20.0	30.9	20.8	25.2	17.9	13.4	11.0	9.8	7.8	4.2	2.1	——	——	——	280
Tease, 374	1st	15.1	26.3	23.6	22.0	20.3	20.2	19.2	14.1	14.7	12.1	9.5	5.9	3.8	——	352
	2nd	13.2	22.3	18.6	21.0	18.7	12.9	10.5	10.5	9.0	8.9	7.1	1.6	——	——	290
	3rd	20.4	——	29.4	28.0	27.4	25.4	21.9	17.9	14.5	7.9	2.4	——	——	——	265
	4th	19.6	28.5	21.2	25.7	24.2	21.3	22.0	20.3	15.6	14.2	12.3	11.2	3.9	——	309
	5th	20.9	31.5	26.9	29.8	29.5	26.7	23.8	17.0	17.0	14.9	8.2	4.0	——	——	272
	6th[12]	17.4	23.6	19.9	21.9	17.8	13.3	9.8	8.2	6.0	1.6	——	——	——	——	223
	7th[12]	14.2	18.9	16.4	13.4	8.2	——[13]	——	——	——	——	——	——	——	——	
Wanda, 126	1st	33.1	46.2	38.7	40.5	41.5	34.1	29.9	26.1	25.5	25.3	20.2	10.3	3.1	——	306
	2nd	22.9	42.0	25.0	38.9	39.5	36.5	36.2	32.0	24.0	22.4	21.4	25.3	22.8	17.7	411
	3rd	8.0	41.5	21.9	33.9	37.2	38.2	37.4	41.1	34.6	28.2	25.6	25.1	20.6	9.0	348
	4th[12]	37.5	41.4	37.6	31.6	26.0	21.9	17.4	13.8	11.7	2.8	——	——	——	——	240
	5th[12]	20.4	——	14.7	10.7	7.1	——[13]	——	——	——	——	——	——	——	——	
E 44	1st	16.3	32.3	24.6	25.8	23.7	18.9	18.1	15.5	12.5	10.6	6.8	7.9	6.9	——	294
	2nd	31.2	29.3	27.4	31.4	30.4	28.8	21.3	17.7	13.3	9.8	5.8	3.7	——	——	301
	3rd	39.7	47.6	43.1	44.1	42.9	41.2	37.7	33.8	28.3	25.9	19.8	12.1	5.0	——	305
	4th[12]	26.8	34.5	35.3	32.4	28.5	23.2	21.4	18.3	14.7	11.5	6.0	1.5	——	——	292
	5th[12]	25.1	26.3	21.4	23.6	18.4	14.1	9.3	——[13]	——	——	——	——	——	——	
Caprice, 282	1st	33.0	49.3	41.5	43.6	43.6	41.7	40.1	34.3	30.1	28.1	27.0	25.4	21.7	19.6	401
	2nd[12]	17.1	29.0	24.7	26.2	23.7	19.6	14.5	10.6	——[13]	——	——	——	——	——	

Table 16. Daily production of milk in pounds by calendar month for all lactation records of cows. (Cont'd)

Lot 2																
Daffodil, 492	1st	19.4	29.2	21.1	26.3	25.2	22.6	21.2	20.1	15.5	14.1	16.9	15.3	15.4	11.4	444
	2nd	27.2	34.1	30.8	30.7	25.9	24.2	22.8	25.7	19.7	18.0	17.1	11.1	8.7	——	326
	3rd[12]	26.6	37.6	32.3	25.1	21.7	17.2	17.1	15.2	14.2	10.5	6.8	2.4	——	——	307
	4th[12]	24.6	33.8	27.7	30.4	25.3	21.7	17.5	6.9	——[13]	——	——	——	——	——	
June, 113	1st	39.7	53.1	47.8	52.0	49.5	48.8	46.2	43.2	35.8	30.9	27.8	23.8	19.4	8.1	369
	2nd	26.5	61.2	55.2	54.5	52.3	49.6	42.4	32.6	28.7	27.0	22.3	16.7	9.5	5.6	335
	3rd	48.4	62.5	54.0	59.5	56.8	44.2	37.0	31.2	27.5	28.8	17.7	6.1	2.2	——	306
	4th	25.8	67.4	69.8	62.1	60.3	47.4	41.5	32.6	36.3	24.9	20.4	10.8	——	——	305
	5th	28.0	74.1	65.2	68.0	59.8	48.0	40.1	36.2	34.6	31.3	20.7	12.3	7.9	——	313
	6th[12]	32.2	45.3	38.3	42.7	37.9	35.0	31.3	28.7	20.4	17.3	11.8	6.8	4.4	——	318
	7th[12]	17.8	30.7	24.5	20.7	——[13]	——	——	——	——	——	——	——	——	——	
E 42	1st	27.4	37.0	32.4	33.1	28.4	24.6	19.4	15.1	11.7	12.7	9.2	5.8	1.9	——	317
	2nd	30.7	41.9	36.3	38.5	34.4	34.0	27.4	27.8	17.1	12.6	6.3	——	——	——	265
	3rd	24.4	69.7	65.9	58.1	59.1	52.4	47.0	43.8	41.7	30.4	27.9	20.1	10.9	3.8	322
	4th[12]	28.0	47.5	37.6	43.6	41.0	36.5	33.7	28.4	20.7	18.0	11.5	4.9	1.1	——	305
Idol, 141	1st	33.7	49.9	44.9	44.9	45.8	38.9	33.0	29.8	27.7	24.3	24.2	23.6	17.1	13.7	451
	2nd	35.7	50.7	32.5	45.7	44.1	40.3	34.6	32.8	29.7	25.3	23.3	21.5	15.5	2.6	327
	3rd[12]	38.7	52.6	40.7	49.1	46.6	38.5	31.3	22.4	18.9	——[13]	——	——	——	——	
Laura, 273	1st	22.5	35.4	29.3	33.8	31.8	27.9	26.8	23.0	22.9	22.9	22.6	20.8	16.2	——	305
	2nd[12]	19.0	29.1	26.1	26.3	23.4	21.1	18.2	16.1	13.7	3.7	——	——	——	——	241
	3rd[12]	27.1	35.3	27.2	32.1	27.5	18.9	——[13]	——	——	——	——	——	——	——	
Lot 3																
Hallie, 139	1st	41.2	54.3	46.2	50.0	47.0	40.4	35.4	31.7	27.2	35.2	24.0	23.0	17.6	9.8	358
	2nd	43.5	57.3	48.4	52.4	42.1	35.1	26.6	19.7	17.2	14.7	14.1	11.5	6.3	——	305
	3rd[12]	24.5	48.7	27.8	42.6	43.5	40.0	28.6	24.0	22.3	21.8	22.4	——[13]	——	——	

Table 16. Daily production of milk in pounds by calendar month for all lactation records of cows. (Cont'd)

Lot 5 (Cont'd)

Tempest, 381	1st	20.5	24.8	19.0	22.9	22.6	17.7	16.2	15.0	14.4	12.7	12.5	5.6	2.6	——	305
	2nd	26.5	33.1	26.2	27.9	26.9	22.6	20.7	19.6	16.1	9.9	3.8	——	——	——	229
	3rd	27.0	34.9	32.8	33.4	33.5	25.7	16.5	14.3	10.6	3.5	——	——	——	——	230
	4th[12]	25.1	33.6	29.8	31.3	27.0	25.0	21.0	18.4	15.9	14.7	13.1	10.9	8.6	7.0	322
	5th[12]	23.4	——	30.4	——[13]	——	——	——	——	——	——	——	——	——	——	
Lily, 495	1st	22.7	33.9	24.7	31.8	33.2	28.3	24.4	20.2	15.7	10.7	10.0	11.0	9.3	9.3	323
	2nd	33.1	39.3	37.1	34.1	28.0	22.6	19.8	17.1	17.3	17.3	13.6	11.9	12.2	10.6	352
	3rd	36.8	43.8	42.0	36.9	29.4	24.5	19.3	15.9	14.3	13.1	11.9	7.2	5.2	——	317
	4th[12]	29.7	40.6	39.8	37.7	33.1	28.1	26.9	——[13]	——	——	——	——	——	——	
Milla, 235	1st	16.1	39.5	34.2	36.5	36.2	34.0	30.5	29.3	27.5	22.8	21.8	20.6	14.2	11.6	400
	2nd	29.6	46.5	41.4	39.9	36.7	32.6	30.0	28.5	25.7	19.6	18.6	15.9	14.9	10.6	336
	3rd	26.9	37.5	34.0	33.1	28.5	27.3	20.5	17.1	13.5	9.1	6.8	4.2	——	——	292
	4th	26.9	41.7	35.2	38.9	34.2	30.3	25.0	21.2	16.3	15.1	15.2	14.6	13.2	11.3	394
	5th[12]	24.7	40.0	25.9	36.1	31.9	27.8	26.3	25.2	23.3	20.2	16.4	15.6	14.6	11.0	404
	6th[12]	23.2	32.0	27.4	30.2	——[13]	——	——	——	——	——	——	——	——	——	
E 41	1st	23.5	35.9	30.8	30.1	26.2	25.9	22.5	20.8	17.4	16.2	16.3	13.8	7.4	——	285
	2nd	27.6	37.7	28.0	33.5	34.1	31.6	23.3	22.0	20.1	18.9	17.8	14.7	11.8	7.7	372
	3rd	20.7	48.0	39.8	45.4	43.1	36.5	35.7	35.8	32.5	26.7	25.8	24.6	18.4	——	312
	4th[12]	25.7	46.3	35.6	42.8	39.4	37.4	35.8	33.2	27.1	23.5	19.3	14.6	13.8	——	305
	5th[12]	24.8	27.4	——[13]	——	——	——	——	——	——	——	——	——	——	——	

12 on experiment.

13 Lactation not yet completed.

Table 17. Summary of production performance by lots. Comparisons based on all records prior to project.

	Lot 1	Lot 2	Lot 3
Number of cows in comparison	4	4	3
Actual production - 4% milk			
Av. of all records prior to project	6,544 lbs.	8,517 lbs.	6,867 lbs.
Av. of first records on project	3,975 "	6,426 lbs.	8,096 "
Difference	-2,569 lbs.	-2,091 lbs.	+1,229 lbs.
	-39.3%	-24.5%	+17.9%
Mature equiv. Class C - 4% milk			
Av. of all records prior to project	7,069 lbs.	8,668 lbs.	7,269 lbs.
Av. of first records on project	4,026 "	6,579 lbs.	8,226 "
Difference	-3,043 lbs.	-2,089 lbs.	+957 lbs.
	-43.0%	-24.1%	+13.2%
Per Cent of fat in milk			
Av. of all records prior to project	3.93%	4.18%	4.31%
Av. of first records on project	3.78%	4.18%	4.49%
Differ nce	-0.15%	0.00%	+0.18%
Length of lactation record			
Av. of all records prior to project	318 days	329 days	311 days
Av. of first records on project	259 days	293 days	344 days
Difference	-59 days	-36 days	+33 days
	-18.6%	-10.9%	+10.6%
Number of days in dry period			
Av. of all periods prior to project	63 days	68 days	104 days
Av. of first periods on project	112 days	64 days	50 days
Difference	+49 days	-4 days	-54 days
Times bred per conception			
Number of cows in comparison	5	5	5
Av. for all pregnancies prior	2.15 times	2.74 times	2.12 times
Av. for first pregnancies on project	1.40 times	1.00 times	1.20 times
Difference	-.75 times	-1.74 times	-.92 times

Table 13. Breeding history of cows (as of 5-31-40.)

Cow	Preg-nancy	Times Bred	Placenta Retained	Remarks
Lot 1				
Petal, 275	1st	7	No	Given ovarian ext. twice, wheat germ oil once prior to pregnancy
	2nd	3	Yes	Given ovarian ext. once prior to pregnancy
	3rd	2	No	Given ovarian ext. twice prior to pregnancy
	---[14]	5	---	Probably not pregnant
Wanda, 126	1st	2	No	
	2nd	1	No	Pus in uterus following calving
	3rd	2	Yes	10 cc. gonadin prior to pregnancy
	4th	3	No	
	5th[14]	1	No	Pus in uterus following calving
	---[14]	1	---	Not known if pregnant
E40	1st	2	No	
	2nd	2	No	
	3rd	1	No	
	4th	1	No	
	---[14]	1	---	Now pregnant
Tease, 374	1st	1	No	
	2nd	1	No	
	3rd	5	No	
	4th	1	No	
	5th	2	No	
	6th	2	No	
	7th[14]	2	No	
	---	2	---	Not known if pregnant
E44	1st	1	No	
	2nd	2	No	
	3rd	1	No	
	4th	1	No	
	4th	1	No	
	5th[14]	1	No	
	---	1	---	Pregnancy now questionable
Caprice, 273	1st	2	No	
	2nd	6	Yes	
	---[14]	2	---	Now Pregnant

Table 18. Breeding history of cows (as of 5-31-40) (cont'd.)

Cow	Preg-nancy	Times Bred	Placenta Retained	Remarks
Lot 2				
Daffodil, 492	1st	5	No	Ovarian extract once prior to breeding.
	2nd	7	No	Uterus small. Ovarian extract given twice prior to pregnancy
	3rd	1	No	Vaginitis following calving
	4th[14]	1	No	
	——[14]	6	——	Not pregnant
Idol, 141	1st	2	No	
	2nd	1	Yes	Discharge from uterus following calving.
	3rd	2	No	Given ovarian extract prior to breeding.
	——[14]	1	——	Now pregnant.
E42	1st	5	Yes	Pus in uterus following calving.
	2nd	1	Yes	Necessary to flush uterus several times. Given tonic
	3rd	1	Yes	
	4th	2	No	
	——[14]	1	——	Now pregnant.
Laura, 273	1st	7	No	Water in fallopian tubes. Given wheat germ oil and ovarian extract prior to pregnancy.
	2nd	1	No	
	3rd[14]	1	No	Pus in uterus following calving.
	——[14]	1	——	Not known if pregnant.
June, 113	1st	3	No	
	2nd	1	No	
	3rd	1	No	
	4th	2	No	
	5th	1	No	
	6th	1	No	
	7th[14]	1	Yes	Necessary to flush uterus several times following calving.

Table 18. Breeding history of cows (as of 5-31-40). (cont'd.)

Cow	Preg-nancy	Times Bred	Placenta Retained	Remarks
Lot 3				
Hallie, 159	1st	3	No	Given wheat germ oil twice, ovarian txtract twice prior to pregnancy
	2nd	1	No	Given wheat germ oil during early pregnancy
	3rd	1	No	Given wheat germ oil during early pregnancy
	---[14]	2	---	Now pregnant
Tempest	1st	1	No	
	2nd	5	No	Given wheat germ oil once prior to pregnancy
	3rd	2	No	
	4th	1	No	
	5th[14]	1	No	
Lily, 495	1st	3	No	Given ovarian extract twice before pregnancy
	2nd	2	No	
	3rd	1	No	
	4th	2	No	
	---[14]	1	---	Now pregnant
Milla, 255	1st	4	No	
	2nd	3	No	Given ovarian extract once prior to pregnancy
	3rd	2	Yes	
	4th	3	No	
	5th	2	No	
	6th[14]	2	No	
	---[14]	1	---	Now known if pregnant
E41	1st	3	---[15]	
	2nd	1	---[15]	
	3rd	2	---[15]	
	4th	2	No	
	5th	1	No	

14 On experiment at time of breeding.
15 No record available.

Table 19. Chemical constituents of blood

Date	Ca[16]	P[16]	Mg[16]	Hb[17]	Caro-tene[18]	Ca[16]	P[16]	Mg[16]	Hb[17]	Caro-tene[18]	Ca[16]	P[16]	Mg[16]	Hb[17]	Caro-tene[18]
	Tease, 574 -- Lot 1					Wanda, 126 -- Lot 1					E 44 -- Lot 1				
12-12-38	12.2	4.9	—	—	—	9.6	3.9	—	—	—	—	—	—	—	—
1- 9-39	10.9	5.2	—	—	—	10.6	4.2	—	10.65	—	11.1	4.2	—	10.48	.209
2-13-39	9.4	4.6	—	12.7	.075	9.42	3.4	—	—	.171	11.60	4.7	—	11.77	.140
3-17-39	9.9	6.1	—	—	.147	10.6	4.9	—	—	.297	10.60	4.9	—	—	.302
4-13-39	10.6	4.4	—	—	.202	10.51	4.8	—	—	—	11.21	4.8	—	—	.316
5-12-39	10.2	4.3	—	—	.22	10.18	5.13	—	—	.313	10.62	4.41	—	—	.320
6-12-39	—	8.3	—	8.04	.23	9.9	4.2	—	8.33	.320	10.20	5.00	—	7.89	.111
7-17-39	10.3	6.8	—	—	.23	10.80	5.5	—	—	.320	10.36	6.4	—	—	.110
8- 8-39	10.8	5.7	—	7.81	.54	10.20	7.2	—	8.62	.402	10.80	6.64	—	6.76	.440
9- 5-39	11.1	5.2	—	10.2	.30	10.7	3.6	—	10.00	.230	9.95	5.1	—	9.54	.550
10-16-39	9.79	5.1	—	8.62	.15	10.30	4.1	—	8.62	.110	11.44	4.1	—	8.15	.100
11-14-39	10.0	4.4	2.32	10.68	.20	10.20	2.9	2.00	9.29	.207	10.40	4.7	2.22	8.39	.134
12-12-39	—	—	—	—	.190	—	—	—	—	.164	—	—	—	—	.133
1-15-40	10.6	5.2	—	7.22	.160	9.8	4.1	—	7.22	.100	10.2	3.5	—	8.73	.200
2-15-40	9.64	4.0	—	9.79	.073	9.04	3.0	—	7.81	.100	11.46	4.4	—	8.97	.200
3-15-40	9.45	5.9	—	10.94	.200	9.63	4.4	—	9.90	.250	10.70	4.0	—	9.43	.297
4-19-40	10.75	5.0	—	11.23	.120	9.35	4.4	—	9.30	.130	9.94	4.6	—	9.87	.210
5-20-40	10.30	5.5	—	11.06	.130	9.28	3.7	—	9.78	.090	10.82	4.6	—	10.48	.150

Table 19. Chemical constituents of blood. (Continued)

	E 40 — Lot 1					Petal, 235 — Lot 1					Caprice, 282 — Lot 1				
6-12-39	10.1	5.0	—	10.95	.248	—	—	—	—	—	—	—	—	—	—
7-17-39	11.44	6.1	—	—	—	—	—	—	—	—	—	—	—	—	—
8- 8-39	11.1	6.93	—	9.79	.334	—	—	—	—	—	—	—	—	—	—
9- 5-39	10.3	7.7	—	11.00	.190	—	—	—	—	—	—	—	—	—	—
10-16-39	10.21	5.1	—	9.08	.150	11.28	6.9	—	10.71	.120	9.68	5.6	—	10.48	.160
11-14-39	10.40	5.6	2.30	9.79	.188	10.42	5.7	2.12	13.16	.241	10.60	5.6	1.89	11.15	.179
12-12-39	—	—	—	—	.174	—	—	—	—	.180	—	—	—	—	.119
1-15-40	10.2	4.6	—	8.51	.210	10.8	5.7	—	9.56	.237	11.4	5.2	—	8.73	.257
2-15-40	9.64	5.2	—	8.04	.140	10.18	5.7	—	9.90	.147	9.62	6.8	—	8.04	.200
3-15-40	9.53	5.3	—	9.32	.200	9.30	7.8	—	10.13	.210	9.63	7.1	—	9.67	.263
4-19-40	12.48	4.8	—	8.80	.160	10.24	5.2	—	10.30	.150	10.60	6.7	—	10.17	.100
5-20-40	9.64	5.1	—	9.20	.137	9.88	6.7	—	11.06	.153	9.85	6.8	—	10.89	.120
	Daffodil, 492 — Lot 2					Laura, 273 — Lot 2					June, 113 — Lot 2				
12-12-38	—	—	—	—	—	10.80	5.10	—	—	—	—	—	—	—	—
1- 9-39	12.50	5.80	—	11.50	.308	10.60	5.70	—	11.00	—	—	—	—	—	—
2-13-39	10.20	4.60	—	12.79	.260	10.80	4.90	—	14.07	.109	9.82	5.60	—	12.34	.161
3-17-39	11.1	5.30	—	—	.390	—	—	—	—	—	10.50	4.90	—	—	.124
4-13-39	11.63	5.30	—	—	.445	10.81	5.40	—	—	.265	9.79	6.50	—	—	.207
5-12-39	11.52	4.68	—	—	.450	10.39	5.31	—	—	.279	9.73	4.50	—	—	.280
6-12-39	10.50	3.90	—	11.12	.478	9.90	5.00	—	10.49	—	9.70	5.70	—	9.84	.080
7-17-39	11.50	5.30	—	—	.480	11.10	6.60	—	—	.450	10.32	7.20	—	—	.080
8-8-39	11.70	6.12	—	10.25	.346	11.40	7.47	—	9.44	.266	10.60	8.10	—	9.20	.288
9- 5-39	12.70	3.80	—	12.30	.170	11.20	5.60	—	13.10	.130	10.70	5.10	—	11.20	.200
10-16-39	10.21	6.60	—	10.94	.140	10.38	4.40	—	11.29	.060	8.83	7.30	—	9.55	.120
11-14-39	10.60	5.50	2.00	12.20	.190	11.60	5.40	2.17	12.73	.149	9.30	5.70	2.06	10.95	.273
12-12-39	—	—	—	—	.218	—	—	—	—	.217	—	—	—	—	.125
1-15-40	11.20	3.60	—	11.65	.347	10.00	5.20	—	13.15	.143	9.60	4.80	—	9.08	.150
2-15-40	10.66	4.80	—	10.83	.300	10.04	6.90	—	12.47	.103	9.84	7.10	—	8.04	.187
3-15-40	10.70	4.90	—	12.00	.393	9.63	5.80	—	12.70	.198	9.63	3.90	—	10.83	.100
4-19-40	10.48	4.80	—	8.87	.130	10.44	5.30	—	9.60	.170	8.77	5.70	—	10.43	.090
5-20-40	9.70	5.10	—	8.73	.100	10.45	6.90	—	11.88	.170	9.20	7.20	—	9.90	.150

Table 19. Chemical constituents of blood. (Continued)

	E 42 — Lot 2					Idol, 141 — Lot 2				
6-12-39	9.50	6.10	—	9.59	.222	—	—	—	—	—
7-17-39	10.90	6.40	—	—	—	—	—	—	—	—
8- 8-39	10.20	8.82	—	8.27	.146	—	—	—	—	—
9- 5-39	9.45	5.50	—	9.30	.170	—	—	—	—	—
10-16-39	8.34	7.90	—	8.51	.130	9.68	3.90	—	11.53	.100
11-14-39	9.02	7.10	2.11	8.62	.250	9.80	6.70	2.08	10.57	—
12-12-39	—	—	—	—	.191	—	—	—	—	.234
1-15-40	10.60	4.70	—	7.91	.193	10.80	5.30	—	9.32	.257
2-15-40	9.86	5.20	—	8.27	.153	9.94	4.70	—	9.55	.187
3-15-40	9.30	6.20	—	8.73	.263	9.82	6.40	—	—	.240
4-19-40	9.84	5.00	—	8.10	.160	9.86	5.20	—	11.00	.140
5-20-40	8.82	6.30	—	8.73	.170	8.70	5.90	—	10.59	.123

	Mills, 235 — Lot 3					Tempest, 381 — Lot 3					Lily, 495 — Lot 3				
1- 9-39	11.10	5.10	—	10.37	.095	—	—	—	—	—	—	—	—	—	—
2-13-39	9.62	6.70	—	11.18	.119	9.82	6.60	—	11.77	.340	—	—	—	—	—
3-17-39	10.50	6.30	—	—	.213	10.90	5.90	—	—	.204	—	—	—	—	—
4-13-39	11.02	7.60	—	—	.310	10.71	5.40	—	—	.135	—	—	—	—	—
5-12-39	10.62	5.13	—	—	.280	10.62	5.67	—	—	.440	—	—	—	—	—
6-12-39	9.70	5.10	—	10.02	.514	10.40	5.50	—	9.22	.242	—	—	—	—	—
7-17-39	10.36	6.20	—	—	.510	10.50	5.90	—	—	.230	—	—	—	—	—
8- 8-39	10.50	6.57	—	7.57	.336	11.70	7.02	—	8.97	.534	—	—	—	—	—
9- 5-39	10.50	5.00	—	11.10	.230	12.00	5.60	—	9.85	.360	—	—	—	—	—
10-16-39	10.21	5.50	—	10.59	.200	9.90	6.40	—	9.78	.260	10.33	6.20	—	10.37	.200
11-14-39	10.80	5.60	2.17	12.90	.276	11.20	6.90	2.30	9.82	.409	10.50	5.90	2.05	14.06	.193
12-12-39	—	—	—	—	.094	—	—	—	—	.181	—	—	—	—	.134
1-15-40	9.60	4.50	—	9.43	.157	10.80	4.50	—	8.84	.280	10.80	4.70	—	9.90	.370
2-15-40	10.46	6.10	—	9.79	.137	10.38	6.20	—	9.20	.167	10.54	6.10	—	10.83	.300
3-15-40	10.30	5.00	—	10.01	.233	10.89	6.70	—	11.76	.290	10.42	6.20	—	10.94	.400
4-19-40	9.72	4.20	—	10.50	.170	10.51	4.70	—	12.67	.220	10.01	5.70	—	10.20	.200
5-20-40	10.25	5.40	—	11.41	.170	10.10	5.20	—	12.12	.280	10.15	5.50	—	11.18	.203

Table 19. Chemical constituents of blood. (Continued)

	E 41 -- Lot 3					Hallie, 139 -- Lot 3				
3-17-39	8.70	7.70	----	----	.113	----	----	----	----	----
4-13-39	12.14	6.20	----	----	.145	----	----	----	----	----
5-12-39	10.62	3.81	----	----	.150	----	----	----	----	----
6-12-39	8.90	4.70	----	9.47	.329	----	----	----	----	----
7-17-39	10.90	5.40	----	----	.330	----	----	----	----	----
8- 8-39	10.60	6.93	----	7.69	.260	12.00	5.67	----	6.52	.274
9- 5-39	10.80	5.60	----	10.20	.190	10.80	3.90	----	10.20	.510
10-16-39	10.21	5.60	----	11.48	.180	10.19	5.70	----	9.32	.290
11-14-39	10.40	5.60	2.13	13.95	.239	10.70	5.70	2.24	11.63	.366
12-12-39	----	----	----	----	.076	----	----	----	----	.170
1-15-40	10.90	4.50	----	8.84	.150	11.00	4.40	----	10.71	.253
2-15-40	9.76	5.60	----	9.79	.100	10.94	4.30	----	12.12	.170
3-15-40	9.20	6.70	----	11.06	.177	10.59	4.20	----	11.65	.223
4-19-40	10.33	4.70	----	12.00	.040	11.61	3.70	----	13.13	.220
5-20-40	9.10	7.50	----	12.12	.080	10.75	3.90	----	12.92	.200

16 Mg. per 100 cc. of blood serum.

17 Gm. per 100 cc. of blood.

18 Mg. per 100 cc. of blood plasma.

Table 20. Analyses of Atlas fodder butts used in calculating nutrient intake

	Moist. %	Dry Matter	D.P. %	T.D.N. %	Ca %	P %	Mg %	Fe %	Carotene (wet) mgms/100 gms.	Crude Fat %	Crude Fiber %
December 1938	54.5	45.5	1.65	26.64	0.204	0.053	0.081	0.0087	1.000	1.15	14.08
January 1939	43.8	56.2	2.04	32.94	0.253	0.066	0.101	0.0108	0.741	1.40	17.41
February 1939	43.8	56.2	2.04	32.94	0.253	0.066	0.101	0.0108	0.741	1.40	17.41
March 1939	43.8	56.2	2.04	32.94	0.253	0.066	0.101	0.0108	0.741	1.40	17.41
April 1939	33.0	67.0	2.43	39.23	0.301	0.079	0.120	0.0128	0.481	1.67	20.74
May 1939	23.5	76.5	2.78	44.79	0.344	0.090	0.137	0.0145	0.451	1.91	23.68
June 1939	14.0	86.0	3.12	50.35	0.386	0.101	0.154	0.0162	0.420	2.14	26.62
July 1939	12.0	88.0	3.19	51.49	0.395	0.103	0.157	0.0168	0.018	2.19	27.23
August 1939	14.5	85.5	3.11	50.04	0.384	0.100	0.153	0.0164	0.175	2.13	26.45
Sept. 1939	12.5	87.5	3.18	51.22	0.393	0.103	0.157	0.0168	0.163	2.18	27.08
October 1939	10.5	89.5	3.25	52.40	0.402	0.105	0.16	0.0171	0.15	2.23	27.70
November 1939	28.0	72.0	1.60	42.7	0.30	0.08	0.12	0.014	0.92	1.34	21.65
December 1939	53.5	46.5	1.00	27.3	0.19	0.05	0.08	0.009	0.205	0.9	13.85
January 1940	54.5	45.5	1.00	26.8	0.19	0.05	0.08	0.009	0.100	0.8	13.60
February 1940	58.0	42.0	0.76	24.9	0.14	0.04	0.07	0.008	0.150	1.19	14.2
March 1940	53.0	47.0	0.85	27.8	0.15	0.05	0.08	0.009	0.395	1.33	15.9
April 1940	23.0	77.0	1.40	45.5	0.25	0.07	0.13	0.015	0.285	2.18	26.0
May 1940	26.2	73.8	1.33	43.7	0.24	0.07	0.12	0.015	0.195	2.09	24.9

Table 21. Analyses of alfalfa hay used in calculating nutrient intake

	Moist. %	Dry Matter	D.P. %	T.D.N. %	Ca %	P %	Mg %	Fe %	Carotene (wet) mgms/100 gms.	Crude Fat %	Crude Fiber %
December 1938	———	———	———	———	———	———	———	———	———	———	———
January 1939	5.88	94.12	10.66	52.61	1.079	0.255	0.193	0.0312	1.54	1.33	33.22
February 1939	5.88	94.12	10.66	52.61	1.079	0.255	0.193	0.0312	1.54	1.49	33.37
March 1939	6.70	93.30	10.28	51.49	1.070	0.253	0.192	0.0309	1.54	1.49	33.37
April 1939	7.51	92.49	9.90	50.37	1.06	0.25	0.19	0.0306	1.54	1.64	33.52
May 1939	9.01	90.99	9.74	49.57	1.043	0.246	0.187	0.0301	1.60	1.61	32.99
June 1939	9.01	90.99	9.74	49.57	1.043	0.246	0.187	0.0301	1.60	1.61	32.99
July 1939	9.01	90.99	9.74	49.57	1.043	0.246	0.187	0.0301	1.60	1.61	32.99
August 1939	10.5	89.5	9.58	48.76	1.026	0.242	0.184	0.0296	1.65	1.58	32.45
Sept. 1939	9.01	90.99	10.10	49.91	1.233	0.226	0.187	0.0301	1.33	1.60	31.66
October 1939	7.52	92.48	10.62	51.05	1.44	0.21	0.19	0.0306	1.0	1.61	30.87
November 1939	10.00	90.0	10.4	48.9	1.12	0.25	0.17	0.0298	1.37	1.54	32.11
December 1939	7.5	92.5	10.70	50.20	1.15	0.25	0.17	0.031	0.998	1.58	32.46
January 1940	11.5	88.5	10.22	48.10	1.10	0.24	0.16	0.030	0.803	1.51	31.55
February 1940	12.5	87.5	10.25	47.6	1.22	0.22	0.17	0.028	1.32	1.49	31.0
March 1940	9.0	91.0	10.67	49.5	1.27	0.23	0.18	0.030	2.06	1.54	32.3
April 1940	9.0	91.0	10.67	49.5	1.27	0.23	0.18	0.030	1.39	1.54	32.3
May 1940	8.75	91.25	10.70	49.7	1.27	0.23	0.18	0.030	0.728	1.54	32.4

Table 22. Analyses of Atlas silage used in calculating nutrient intake

		Moist. %	Dry Matter	D.P. %	T.D.N. %	Ca %	P %	Mg %	Fe %	Carotene (wet) mgms/100 gms.	Crude Fat %	Crude Fiber %
December	1938	79.0	21.0	1.15	12.15	0.076	0.039	0.067	0.0059	0.226	0.49	5.82
January	1939	78.0	22.0	1.21	12.76	0.080	0.041	0.070	0.0062	0.763	0.52	6.12
February	1939	76.0	24.0	1.32	13.91	0.087	0.045	0.076	0.0068	0.986	0.57	6.67
March	1939	76.0	24.0	1.32	13.91	0.087	0.045	0.076	0.0068	0.986	0.57	6.67
April	1939	74.0	26.0	1.43	15.05	0.094	0.049	0.083	0.0073	1.209	0.61	7.21
May	1939	74.0	26.0	1.46	15.36	0.098	0.050	0.085	0.0075	1.345	0.62	7.36
June	1939	73.0	27.0	1.49	15.66	0.098	0.051	0.086	0.0076	1.480	0.63	7.51
July	1939	71.0	29.0	1.59	16.77	0.105	0.054	0.092	0.0082	0.275	0.68	8.04
August	1939	70.0	30.0	1.65	17.38	0.109	0.056	0.096	0.0085	0.433	0.70	8.33
Sept.	1939	71.0	29.0	1.58	16.65	0.105	0.054	0.092	0.0082	0.528	0.67	7.88
October	1939	72.5	27.5	1.51	15.91	0.100	0.052	0.088	0.0078	0.623	0.64	7.63
November	1939	71.0	29.0	1.60	16.34	0.109	0.059	0.06	0.008	1.90	0.74	8.11
December	1939	68.5	31.5	1.74	17.76	0.118	0.064	0.06	0.009	0.709	0.81	8.81
January	1940	75.0	25.0	1.38	14.13	0.094	0.051	0.05	0.007	2.230	0.64	7.01
February	1940	78.0	22.0	1.14	12.50	0.08	0.05	0.06	0.006	0.688	0.49	7.45
March	1940	72.5	27.5	1.43	15.60	0.10	0.06	0.07	0.008	0.991	0.61	9.30
April	1940	78.0	22.0	1.14	12.50	0.08	0.05	0.06	0.006	0.352	0.49	7.45
May	1940	75.0	25.0	1.30	14.20	0.09	0.05	0.07	0.007	0.207	0.56	8.46

Table 23. Analyses of grain mix fed to cows in Lot 1 used in calculating nutrient intake

	Moist %	Dry Matter	D.P. %	T.D.N. %	Ca %	P %	Mg %	Fe %	Carotene (wet) mgms/100 gms.	Crude Fat %	Crude Fiber %
December 1938	11.37	88.63	6.49	73.39	0.030	0.299	0.207	0.0051	———	3.03	1.21
January 1939	11.37	88.63	6.49	73.39	0.030	0.299	0.207	0.0051	———	3.03	1.21
February 1939	10.69	89.31	6.54	73.94	0.030	0.301	0.209	0.0052	———	3.06	1.22
March 1939	10.69	89.31	6.54	73.94	0.030	0.301	0.209	0.0052	———	3.06	1.22
April 1939	10.69	89.31	6.54	73.94	0.030	0.301	0.209	0.0052	———	3.06	1.22
May 1939	10.69	89.31	6.54	73.94	0.030	0.301	0.209	0.0052	———	3.06	1.22
June 1939	10.69	89.31	6.54	73.94	0.030	0.301	0.209	0.0052	———	3.06	1.22
July 1939	10.69	89.31	6.54	73.94	0.030	0.301	0.209	0.0052	———	3.06	1.22
August 1939	10.69	89.31	6.54	73.94	0.050	0.301	0.209	0.0052	———	3.06	1.22
Sept. 1939	10.69	89.31	6.54	73.94	0.030	0.301	0.209	0.0052	———	3.06	1.22
October 1939	10.0	90.0	6.59	74.49	0.030	0.303	0.21	0.0053	0.036	3.08	1.23
November 1939	11.0	89.0	6.20	72.70	0.03	0.30	0.16	0.0052	0.036	2.95	1.50
December 1939	11.0	89.0	6.20	72.70	0.03	0.30	0.16	0.0052	0.036	2.95	1.50
January 1940	13.0	87.0	6.06	71.09	0.03	0.29	0.15	0.0051	———	2.88	1.47
February 1940	12.0	88.0	6.48	72.31	0.02	0.34	0.15	0.005	———	3.68	1.46
March 1940	11.0	89.0	6.59	73.49	0.02	0.35	0.16	0.005	———	3.74	1.48
April 1940	14.0	86.0	6.34	70.17	0.02	0.33	0.14	0.005	———	3.60	1.42
May 1940	14.0	86.0	6.34	70.17	0.02	0.33	0.14	0.005	———	3.60	1.42

Table 24. Analyses of grain mix fed to cows in Lot 2 used in calculating nutrient intake

	Moist %	Dry Matter	D.P. %	T.D.N. %	Ca %	P %	Mg %	Fe %	Carotene (wet) mgms/100 gms.	Crude Fat %	Crude Fiber %
December 1938	10.07	89.93	16.33	68.62	0.55	0.92	0.368	0.0089	------	4.87	6.01
January 1939	10.07	89.93	16.33	68.62	0.55	0.92	0.368	0.0089	------	4.87	6.01
February 1939	9.79	90.21	16.38	68.83	0.55	0.93	0.369	0.0090	------	4.09	6.03
March 1939	9.79	90.21	16.38	68.83	0.55	0.93	0.369	0.0090	------	4.09	6.03
April 1939	9.79	90.21	16.38	68.83	0.55	0.93	0.369	0.0090	------	4.09	6.03
May 1939	9.79	90.21	16.38	68.83	0.55	0.93	0.369	0.0090	------	4.09	6.03
June 1939	9.79	90.21	16.38	68.83	0.55	0.93	0.369	0.0090	------	4.09	6.03
July 1939	9.79	90.21	16.38	68.83	0.55	0.93	0.369	0.0090	------	4.09	6.03
August 1939	9.79	90.21	16.38	68.83	0.55	0.93	0.369	0.0090	------	4.09	6.03
Sept. 1939	9.79	90.21	16.38	68.83	0.55	0.93	0.369	0.0090	------	4.09	6.03
October 1939	9.5	90.50	16.43	69.03	0.55	0.95	0.37	0.0090	0.039	4.90	6.05
November 1939	8.5	91.5	15.54	68.87	0.56	0.94	0.36	0.009	0.04	4.72	4.54
December 1939	7.5	92.5	15.72	69.60	0.57	0.95	0.36	0.009	0.04	4.78	4.59
January 1940	11.0	89.0	15.12	66.04	0.54	0.91	0.36	0.009	0.00	4.59	4.42
February 1940	11.0	89.0	15.12	66.04	0.54	0.91	0.35	0.009	------	4.59	4.42
March 1940	10.5	89.5	15.13	36.07	0.54	0.91	0.35	0.009	------	4.59	4.42
April 1940	11.0	89.0	15.12	66.04	0.54	0.91	0.35	0.009	------	4.59	4.42
May 1940	11.0	89.0	15.12	66.04	0.54	0.91	0.35	0.009	------	4.59	4.42

Table 25. Analyses of grain mix fed to cows in Lot 3 used in calculating nutrient intake

		Moist. %	Dry Matter	D.P. %	T.D.N. %	Ca %	P %	Mg %	Fe %	Carotene (wet) mgms/100 gms.	Crude Fat %	Crude Fiber %
December	1938	10.96	89.04	10.22	69.93	0.39	0.86	0.39	0.0100	———	4.0	4.99
January	1939	10.96	89.04	10.22	69.93	0.39	0.86	0.39	0.0100	———	4.0	4.99
February	1939	11.00	89.00	10.22	69.93	0.39	0.86	0.39	0.0100	———	4.0	4.99
March	1939	11.00	89.00	10.22	69.93	0.39	0.86	0.39	0.0100	———	4.0	4.99
April	1939	11.00	89.00	10.22	69.93	0.39	0.86	0.39	0.0100	———	4.0	4.99
May	1939	11.00	89.00	10.22	69.93	0.39	0.86	0.39	0.0100	———	4.0	4.99
June	1939	11.00	89.00	10.22	69.93	0.39	0.86	0.39	0.0100	———	4.0	4.99
July	1939	11.00	89.00	10.22	69.93	0.39	0.86	0.39	0.0100	———	4.0	4.99
August	1939	11.00	89.00	10.22	69.93	0.39	0.86	0.39	0.0100	———	4.0	4.99
Sept.	1939	11.00	89.00	10.22	69.93	0.39	0.86	0.39	0.0100	———	4.0	4.99
October	1939	11.00	89.00	10.22	69.93	0.39	0.86	0.39	0.0100	0.024	4.0	4.99
November	1939	11.00	89.00	10.12	69.01	0.39	0.86	0.31	0.010	0.024	3.59	4.48
December	1939	10.5	89.5	10.12	69.01	0.39	0.86	0.31	0.010	0.024	3.59	4.48
January	1940	11.00	89.00	10.12	69.01	0.39	0.86	0.31	0.010	———	3.59	4.48
February	1940	12.00	88.00	10.10	69.1	0.28	0.84	0.34	0.010	———	4.24	4.74
March	1940	12.00	88.00	10.10	69.1	0.28	0.84	0.34	0.010	———	4.24	4.74
April	1940	11.0	89.00	10.22	69.9	0.29	0.25	0.35	0.010	———	4.29	4.79
May	1940	11.0	89.00	10.22	69.9	0.29	0.85	0.35	0.010	———	4.29	4.79