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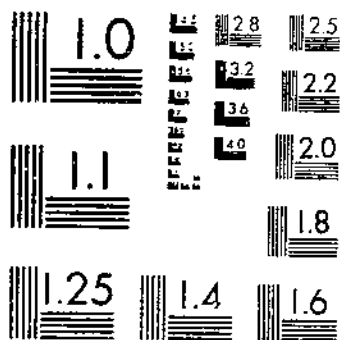
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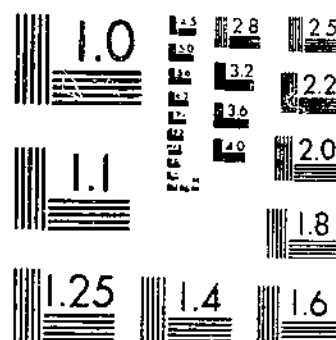
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USE OF AERIAL PHOTOGRAPHY IN THE STUDY OF MILK AND BUTTERFAT PRODUCTION BY DAIRY COWS ON FOUR DIFFERENT PLANES
GRAVES, R. R., ET AL.

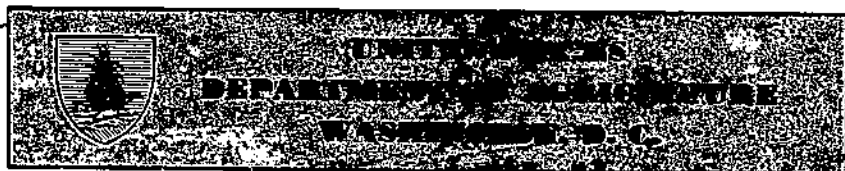
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Milk and Butterfat Production by Dairy Cows on Four Different Planes of Feeding¹

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United States Department of Agriculture, Bureau of Dairy Industry, in cooperation with the Utah Agricultural Experiment Station

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INTRODUCTION

Pasture grasses and other roughage crops as a rule produce nutrients for livestock rations at less cost than the grain crops. It is important, therefore, to know the extent to which home-grown roughage crops may be used instead of the more costly grain crops in feeding dairy cows for the most economical production.

This bulletin presents the results of a feeding experiment with dairy cows at the Utah Agricultural Experiment Station, covering the period 1928 to 1935. The object of the experiment was to obtain data on the quantity of milk and butterfat produced by dairy cows when kept under good average herd conditions, milked twice daily, and fed throughout the lactation period on a ration containing home-grown roughages and either a moderate or limited amount of grain, or on a ration of home-grown roughages only, with or without corn silage. Also, data were to be obtained on the effect of the rations on the health and reproductive activities of the cows.

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This experiment, which involved the comparison of four different rations, or so-called planes of feeding, was somewhat similar to an experiment¹ conducted by the Bureau of Dairy Industry at its Huntley, Mont., field station, in which cows were fed on three planes of feeding. The rations used in the two experiments were different in many respects, however, those used in the present experiment being more comparable to dairy-feeding practices in Utah. Also there were a number of differences in the methods of handling the cows during the experimental period, which accounts for certain differences in the results of the two experiments.

EXPERIMENTAL PROCEDURE

Twelve registered and grade Holstein-Friesian cows were used in this experiment, each cow being fed throughout one complete lactation period on each of the following four rations, or so-called planes of feeding: Full-grain ration; ration 1 (alfalfa hay and pasture); ration 2 (alfalfa hay, pasture, and ground barley); and ration 3 (alfalfa hay, pasture, and corn silage).

The quantity of milk and butterfat produced on rations 1, 2, and 3 was compared with the quantity produced on the full-grain ration.

RATIONS FED

The full-grain ration consisted of alfalfa hay, corn silage, pasture in season, and a grain mixture made up of barley, 2 parts; oats, 1 part; and wheat bran, 1 part. The cows were fed the grain mixture at the rate of 1 pound a day for each pound of butterfat produced per week. Grain feeding was discontinued when butterfat production dropped below 20 pounds per month. The quantity of grain fed on the above basis varied somewhat with the individual cows, ranging from 1 pound of grain for each 3.73 pounds of milk produced to 1 pound for each 5.62 pounds of milk produced, the average for the 12 cows being 1 pound of grain for each 4.33 pounds of milk produced.

Ration 1 consisted of alfalfa hay alone, or pasturage alone when good pasture was available. Some hay was fed during the pasture season, however, when pastures became short.

Ration 2 consisted of alfalfa hay and pasture, with the addition of ground barley grain. The barley was fed at about the same rate both summer and winter. The rate of barley feeding varied somewhat with the individual cows and ranged from 1 pound for each 5.57 pounds of milk produced to 1 pound for each 6.50 pounds of milk produced, the average for the 12 cows being 1 pound of barley for each 6.03 pounds of milk produced.

Ration 3 consisted of alfalfa hay and pasture, with the addition of corn silage. Both the hay and corn silage were fed largely during the winter months, although a small percentage was fed during the pasture season when the pastures were short.

With the exception of the wheat bran, all feeds were grown on the Utah station farms. All the crops, including pasturage, were grown under irrigation. The barley was the Trebi variety, with a weight of 50 pounds to the bushel or slightly above. The oats were Swedish Select.

¹ MOSELEY, T. W.; STUART, DUNCAN; and GRAVES, R. R. DAIRY WORK AT THE HUNTLEY FIELD STATION, HUNTLEY, MONT., 1918-1927. U. S. Dept. Agr. Tech. Bull. 1:1, 48 pp., illus. 1929.

The alfalfa hay fed was principally of the first and third cutting, with a very small amount of second cutting. On an average, it is believed, the hay would grade U. S. No. 1, though no hay was actually graded. At times the different cuttings would be slightly under this grade, mostly because of color. At other times, the hay, especially the third cutting, would probably grade No. 1 Extra Leafy or Extra Green, or both. The cows were given all the alfalfa hay they would clean up, with but little waste. The amount of hay refused was only 2.89 percent of the amount offered in the full-grain ration, 1.71 percent of the amount offered in ration 1, 2.08 percent in ration 2, and 3.26 percent in ration 3.

The corn from which the silage was made was the Improved Leaming variety. It was well cared and was cut when a majority of the ears were well denting and the stalks and leaves were still of a good green color. The quality of the corn silage was very good. Representative samples of corn ears pulled from stalks at silo-filling time, allowed to become air dry and then husked and shelled, indicated an average yield per acre of 45 bushels of corn that would grade No. 2 to No. 3.

The pasture herbage consisted chiefly of Kentucky bluegrass and white clover, grading down to sedges and rushes in the lower areas. Five pastures were grazed in rotation. The cows were kept on each pasture from 5 to 7 days, depending on the amount of forage available. There was plenty of water available each year for irrigating the pastures, even in 1931 when the general water supply was limited, and the pastures were irrigated every 10 to 14 days throughout the pasture season.

With the exception of the one analysis made on third-cutting alfalfa, no analyses were made of these feeds. Table 1, however, shows the average analyses given by Morrison¹ for the class of feeds considered to be most representative of the feeds used in this experiment.

TABLE 1.—Average dry-matter, protein, and total-digestible-nutrient content of feeds of the kind used in this feeding experiment¹

Feed	Dry matter	Digestible protein	Total digestible nutrients
	Percent	Percent	Percent
Alfalfa hay, leafy (25- to 28-percent fiber)	90.4	12.0	51.1
Corn silage, dent (well matured) ²	28.3	1.3	18.7
Barley, common ³	90.4	9.3	78.7
Oats ³	91.1	8.4	71.5
Wheat bran ³	90.6	13.1	70.2

¹ From Feeds and Feeding, Ed. 20. 1936.

² All analyses.

³ Not including that grown in the Pacific Coast States.

MANAGEMENT OF THE COWS

The cows were milked twice daily by machine throughout each lactation period. During the winter months they were housed in a stanchion barn and for a part of each day, in good weather, they were allowed to run in an open lot that was well protected from the wind. During the winter months, and also during the pasture season,

¹ MORRISON, F. B. FEEDS AND FEEDING. A HANDBOOK FOR THE STUDENT AND STOCKMAN. Ed. 20, unabridged, 1,950 pp., illus. Ithaca, N. Y. 1936.

they received all their feed in individual mangers while they were stanchioned. All feeds, except pasturage, were weighed as fed and the refused feed was weighed back. The cows had access to water in drinking cups in the barn and in a large watering trough in the barnyard, and to running spring water in the pastures.

Since these 12 cows were also being used in a breeding experiment, in which they had been fed the full-grain ration during their first lactation period to determine their inherent producing capacity, production records on the full-grain ration were already available for use in this four planes of feeding experiment. Subsequently, each cow was placed on each of the 3 other rations, at the beginning of a dry period preceding calving.

ORDER OF LACTATION ON THE DIFFERENT RATIONS

The order in which each of the 12 cows made her lactation records on the 4 different rations is shown in table 2.

TABLE 2.—Order in which each of the 12 cows made her lactation records on the 4 rations

Cow No.	Ration during indicated lactation record			
	First	Second	Third	Fourth
E-25 ¹	Full-grain ration.....	Ration 1.....	Ration 3.....	Ration 2.....
F-34.....	do.....	do.....	Ration 2.....	Ration 3.....
E-38.....	do.....	do.....	Ration 3.....	Ration 2.....
E-40.....	do.....	do.....	Ration 2.....	Ration 3.....
E-41.....	do.....	Ration 3.....	Ration 1.....	Ration 2.....
E-42 ¹	do.....	Ration 2.....	Ration 3.....	Ration 1.....
E-43.....	do.....	Ration 3.....	Ration 1.....	Ration 2.....
E-44.....	do.....	do.....	do.....	Do.....
E-45.....	do.....	do.....	do.....	Do.....
E-46.....	do.....	do.....	do.....	Do.....
A-42.....	do.....	Ration 1.....	Ration 2.....	Ration 3.....
W-20 ¹	do.....	do.....	do.....	Do.....

¹ 1 nonexperimental lactation intervened between the full-grain ration and ration 1.

¹ 1 nonexperimental lactation intervened between the full-grain ration and ration 2.

In every instance, the lactation on the full-grain ration preceded the lactations by the same cow on the other rations. Of the lactations on ration 1, six followed a lactation on the full-grain ration and six followed a lactation on ration 3. Of the lactations on ration 2, one followed a lactation on the full-grain ration, nine followed a lactation on ration 1, and two followed a lactation on ration 3. Of the lactations on ration 3, five followed a lactation on the full-grain ration, two followed a lactation on ration 1, and five followed a lactation on ration 2.

AGE OF COWS ON EACH RATION

Table 3 shows the average age of the cows, at the time of calving, prior to starting the lactation period on the different rations.

TABLE 3.—Age of each cow at the time she calved to start her lactation on each ration

Cow No.	Full-grain ration			Ration 1			Ration 2			Ration 3		
	Yr.	Mo.	Days	Yr.	Mo.	Days	Yr.	Mo.	Days	Yr.	Mo.	Days
E-25.....	2	3	29	5	7	18	8	4	17	6	11	29
E-34.....	2	2	26	4	7	11	5	9	1	6	11	26
E-38.....	3	3	9	4	2	25	6	11	12	5	10	1
E-40.....	2	9	22	3	9	9	5	1	10	6	2	8
E-41.....	3	2	7	6	5	12	7	8	9	4	1	13
E-42.....	2	7	17	7	1	9	4	11	7	5	11	28
E-43.....	2	5	0	4	9	16	5	9	23	3	9	10
E-44.....	2	6	2	4	7	28	6	9	12	3	7	21
E-45.....	2	7	1	5	3	18	6	9	17	4	1	11
E-46.....	2	4	21	4	9	12	5	9	24	3	7	4
A-42.....	6	8	22	7	8	24	8	10	12	10	0	0
W-201.....	4	2	27	5	5	12	6	5	24	7	7	5
Average.....	3	1	10	5	3	15	6	6	12	5	8	25

On the full-grain ration, 10 of the cows were heifers with their first calf, 8 were under 3 years old, 2 were between 3 and 4 years, 1 was between 4 and 5 years, and 1 was over 6 years old. On ration 1, 1 cow was between 3 and 4 years old, 5 were between 4 and 5 years, 4 were between 5 and 6 years, and 2 were over 7 years. On ration 2, 1 cow was between 4 and 5 years old, 5 were between 5 and 6 years, 3 were between 6 and 7 years, 1 was between 7 and 8 years, and 2 were over 8 years old. On ration 3, 3 cows were between 3 and 4 years old, 2 were between 4 and 5 years, 2 were between 5 and 6 years, 3 were between 6 and 7 years, 1 was between 7 and 8 years, and 1 was 10 years old.

DATES OF CALVING

The dates of calving to start the lactation on each of the four rations (table 4) ranged from March 15, 1928, to June 19, 1935.

TABLE 4.—Date each cow calved to start her lactation period on each ration

Cow No.	Date of calving to start lactation on—			
	Full-grain ration	Ration 1	Ration 2	Ration 3
E-25.....	Mar. 15, 1928	July 4, 1931	Apr. 4, 1934	Nov. 16, 1932
E-34.....	Feb. 16, 1929	June 6, 1931	Aug. 21, 1932	Nov. 16, 1933
E-38.....	June 21, 1930	June 7, 1931	Feb. 14, 1934	Jan. 13, 1933
E-40.....	June 30, 1930	June 17, 1931	Oct. 18, 1932	Nov. 16, 1933
E-41.....	Dec. 17, 1930	Mar. 22, 1933	June 19, 1935	Jan. 12, 1932
E-42.....	June 6, 1930	Nov. 15, 1934	Sept. 28, 1932	Oct. 17, 1933
E-43.....	Aug. 15, 1930	Dec. 31, 1932	Jan. 12, 1934	Dec. 25, 1931
E-44.....	Sept. 27, 1930	Nov. 23, 1932	Jan. 6, 1934	Nov. 16, 1931
E-45.....	Oct. 27, 1930	July 13, 1933	Jan. 13, 1935	May 6, 1932
E-46.....	do.....	Mar. 18, 1933	Mar. 30, 1934	Jan. 10, 1932
A-42.....	Oct. 15, 1930	Oct. 17, 1931	Dec. 6, 1932	Jan. 25, 1934
W-201.....	Feb. 25, 1930	May 8, 1931	May 21, 1932	June 3, 1933

There was some variation in the seasonal distribution of the calving dates on each ration. On the full-grain ration, 4 cows calved during the pasture season and 8 during the winter period between September 27 and March 15. On ration 1, 6 cows calved during the pasture season and 6 between October 17 and March 22. On ration 2, 3 cows calved during the pasture season and 9 between September 26

and April 4. On ration 3, 2 cows calved during the pasture season and 10 between October 17 and January 25.

MILK AND BUTTERFAT PRODUCTION RECORDS

ACTUAL RECORDS OF PRODUCTION

A number of factors, other than the rations, caused one or more of the four lactation periods for some of the cows to be shorter than the 365-day lactation period originally planned. For this reason, the four lactation records of each cow were adjusted to an equal period of time (table 5). This period was usually the length of the cow's shortest lactation on any one of the rations. However, a longer period was used in several instances where the ration appeared to be the cause of the shortness of the lactation and there was no other known reason for a limited lactation, such as advanced pregnancy. The adjusted lactation period for the different cows ranged from 291 to 365 days, with an average of 331.4 days for all cows.

Production per cow per day averaged 31.2 pounds of milk and 1.051 pounds of butterfat on the full-grain ration; 25.9 pounds of milk and 0.825 pound of butterfat on ration 1; 33.1 pounds of milk and 1.039 pounds of butterfat on ration 2; 27.2 pounds of milk and 0.870 pound of butterfat on ration 3.

It is to be expected that the percentage of butterfat will decline somewhat with advance in age, but not to the extent shown in this experiment.

In the three planes of feeding experiment conducted by the Bureau at its Huntley, Mont., field experiment station,⁵ the 10 cows had an average butterfat test of 3.45 on the full-grain ration, 3.59 on the limited-grain ration, and 3.49 on a roughage ration similar to ration 3. In that experiment the production records on the full-grain ration were also made at the most immature age.

In another experiment conducted by the Bureau,⁶ in which 15 cows were fed through 24 lactation periods on alfalfa hay alone, the average percentage of butterfat was 3.51; and when the 15 cows were on a full-grain ration, at a younger age, the average percentage was 3.35.

Why the trend in butterfat percentage should have been downward on the roughage and limited-grain rations in the present experiment, when the reverse was true in the two previous experiments, is not known.

⁵ See footnote 3, p. 2.

⁶ GRAVES, R. R., DAWSON, J. R., KOPLAND, D. V., WATT, A. L., and VAN HORN A. G. FEEDING DAIRY COWS ON ALFALFA HAY ALONE. U. S. Dept. Agr. Tech. Bul. 610, 47 pp. illus. 1938.

TABLE 5.—*Milk and butterfat production (actual basis) for each cow, on the 4 rations*

Cow No.	Lactation period ¹	Full-grain ration			Ration 1			Ration 2			Ration 3		
		Milk	Butterfat		Milk	Butterfat		Milk	Butterfat		Milk	Butterfat	
	Days	Pounds	Per-cent	Pounds	Pounds	Per-cent	Pounds	Pounds	Per-cent	Pounds	Pounds	Per-cent	Pounds
E-25.....	365	9,127.1	3.57	326.37	8,535.6	3.33	284.50	8,488.1	3.21	272.63	8,281.4	3.35	277.24
E-34.....	365	10,402.1	3.28	340.98	9,787.1	3.13	305.89	12,378.6	3.09	382.64	8,788.5	2.92	256.76
E-38.....	321	8,919.5	3.50	317.40	8,647.5	3.53	109.36	8,500.1	3.22	273.72	6,558.2	3.40	222.72
E-40.....	312	10,520.3	3.13	329.09	8,420.7	3.23	271.69	10,691.4	3.11	332.96	9,093.6	2.97	297.35
E-41.....	342	12,210.5	3.42	417.36	10,511.3	3.20	330.00	12,342.6	3.19	393.26	11,803.7	3.28	357.44
E-42.....	338	12,929.7	3.33	430.61	10,107.4	2.93	296.33	12,362.9	3.29	406.91	10,312.9	3.14	324.18
E-43.....	323	10,532.5	3.44	362.32	7,990.4	3.31	264.52	10,466.0	3.10	324.18	9,085.5	3.43	312.02
E-44.....	291	7,061.5	3.60	254.33	7,934.1	3.32	263.05	9,407.9	3.29	309.73	6,793.6	3.48	236.75
E-45.....	353	11,490.4	3.21	369.95	7,977.4	2.93	233.43	10,453.6	2.89	302.69	8,266.0	2.87	237.44
E-46.....	333	11,550.6	3.41	392.50	8,279.6	3.01	249.65	10,992.9	2.88	315.44	10,043.8	3.30	331.89
A-42.....	315	9,639.4	3.47	334.80	8,242.6	3.42	282.10	11,345.3	3.39	385.07	8,007.8	3.14	251.74
W-201.....	319	9,803.9	3.10	303.97	9,424.0	3.14	295.54	14,148.9	3.05	451.01	10,418.5	3.13	325.94
Average.....	331.4	10,349.0	3.37	348.31	8,571.5	3.19	273.50	10,904.9	3.14	344.19	9,029.5	3.19	288.46

¹ The 4 lactation-period records for each cow have been adjusted to the same number of days. (See opposite page.)

TABLE 6.—Milk and butterfat production (calculated to mature-age equivalent) for each cow on each ration

Cow No.	Full-grain ration			Ration 1			Ration 2			Ration 3		
	Age-correction factor	Milk	Butter-fat	Age-correction factor	Milk	Butter-fat	Age-correction factor	Milk	Butter-fat	Age-correction factor	Milk	Butter-fat
		<i>Pounds</i>	<i>Pounds</i>		<i>Pounds</i>	<i>Pounds</i>		<i>Pounds</i>	<i>Pounds</i>		<i>Pounds</i>	<i>Pounds</i>
E-25.....	1.35	12,321.6	440.00	1.02	8,706.3	290.19	1.00	8,488.1	272.63	1.00	8,281.4	277.24
E-34.....	1.30	14,146.9	463.73	1.06	10,374.3	324.24	1.01	12,502.4	386.47	1.00	8,788.6	256.76
E-38.....	1.18	10,525.0	374.53	1.09	6,155.8	217.30	1.00	8,500.1	273.72	1.01	6,523.8	224.95
E-40.....	1.26	13,255.6	414.65	1.12	9,431.2	304.29	1.04	11,119.1	346.28	1.00	9,993.6	297.35
E-41.....	1.19	14,530.5	496.66	1.03	10,826.6	346.08	1.00	12,342.6	393.26	1.09	12,866.0	422.31
E-42.....	1.28	16,550.0	551.18	1.00	10,107.4	296.33	1.05	12,981.0	427.26	1.01	10,416.0	327.42
E-43.....	1.31	13,797.6	474.64	1.05	8,389.9	277.75	1.01	10,550.5	327.42	1.12	10,175.8	349.46
E-44.....	1.29	9,109.3	328.09	1.06	8,410.1	278.83	1.01	9,502.0	312.83	1.14	7,744.7	269.90
E-45.....	1.28	14,707.7	473.54	1.03	8,216.7	240.43	1.00	10,453.6	302.69	1.09	9,009.9	258.81
E-46.....	1.33	15,362.3	522.03	1.05	8,693.6	262.13	1.01	11,102.8	318.59	1.14	11,449.3	378.35
A-42.....	1.00	9,639.4	334.80	1.00	8,242.6	282.10	1.00	11,345.3	385.07	1.00	8,007.8	251.74
W-201.....	1.09	10,686.3	331.33	1.03	9,706.7	304.41	1.00	14,148.9	431.01	1.00	10,418.5	325.94
Average.....	1.25	12,866.0	433.82	1.05	8,038.4	285.34	1.01	11,086.4	348.10	1.05	9,481.3	303.35
Relative average production on the 4 rations..percent.....	-----	100	100	-----	69.37	65.77	-----	86.03	80.24	-----	73.58	69.93

AGE-CORRECTED RECORDS OF PRODUCTION

Table 6 shows the production record of each cow for each ration, calculated to a mature-age equivalent, and the age-correction factors that were used.

The average (mature-age equivalent) production of the 12 cows was the highest on the full-grain ration. The average daily production per cow was 38.9 pounds of milk and 1.309 pounds of butterfat on the full-grain ration; 27.1 pounds of milk and 0.861 pound of butterfat on ration 1; 33.5 pounds of milk and 1.050 pounds of butterfat on ration 2; and 28.6 pounds of milk and 0.915 pound of butterfat on ration 3.

RELATIVE INDIVIDUAL PRODUCTION ON THE FOUR RATIONS

There was considerable range in the level of production of the individual cows on each ration (table 6). Some of this difference is no doubt due to differences in their inherited ability to produce. On the full-grain ration the five highest butterfat-producing cows averaged 503.6 pounds of butterfat (mature basis) and the five lowest butterfat-producing cows averaged 356.6 pounds. The average yield of butterfat of the five low cows was 70.8 percent of that of the five high cows. On ration 1 the five high cows averaged 315.1 pounds of butterfat; and the five low cows averaged 255.0 pounds, or 81.0 percent as much as the high cows. On ration 2 the five high cows averaged 404.6 pounds of butterfat; and the five low cows averaged 296.1 pounds, or 73.2 percent as much as the high cows. On ration 3 the five high cows averaged 360.7 pounds of butterfat; and the five low cows averaged 252.4 pounds, or 70.0 percent as much as the high cows.

It was expected that cows with the inherent ability for high production would not be able to produce as nearly up to their capacity when they were on roughage alone as when they were on the full-grain ration; and that, for this reason, there would be less difference between the low producers and the high producers when they were on the roughage rations. This proved to be the case when these cows were on ration 1, but when they were on the other three rations the ratio of the yield by the five low cows to the yield by the five high cows was almost the same.

In a period of 4 years or more, many factors other than the ration may affect the level of production of a cow. A cow may not be in the physical condition to produce up to her capacity in one lactation; yet by the time she begins the next lactation, the causes for her poor condition may have been removed and, as a result, her production level may increase greatly. In this experiment cow W-201 probably represents a case of this kind. On the full-grain ration she was next to the lowest butterfat producer; but on ration 1 she was the third highest producer, on ration 2 she was the highest producer, and on ration 3 she was the fifth highest producer. Perhaps an explanation of her poor production on the full-grain ration is to be found in the reproduction data (table 13). These data show that she was dry only 24 days prior to starting on the full-grain ration and that she dropped a bull calf weighing 110 pounds.

Some of the cows were very consistent in their relative production level throughout the four lactations. Cows E-41 and E-42 appear among the five highest-producing cows on each of the four rations, while cows E-38 and E-44 appear among the five lowest-producing cows on each of the four rations. On the other hand, cow E-45, the fifth highest producer on the full-grain ration, ranks eleventh in production on ration 1, tenth on ration 2, and ninth on ration 3.

If some cows are able to produce up to 360 pounds of butterfat on roughage alone, as did the five high cows on ration 3, it would seem that cows whose inherent ability is below 360 pounds, as shown by their lower production when on a full-grain ration, should be able to produce up to their inherent capacity when on a ration composed entirely of roughage. This does not appear to be the case, however. The five lowest producers on the full-grain ration, with an average yield of 356.6 pounds of butterfat, had an average yield of only 277.4 pounds on ration 1 and 274.0 pounds on ration 3. Their yields on these two roughage rations were approximately 77 percent of their yields on the full-grain ration. This is a higher percentage than the average for all 12 cows, but not as high as was to be expected if these five low cows actually produced up to the limit of their inherent ability when they were on the full-grain ration.

At least one reason why these five cows were the lowest producers on the full-grain ration is that they became pregnant in a relatively short time after starting the lactation—95 days on the average as compared to 183 days for the five highest-producing cows. Also, prior to starting the lactation on the full-grain ration, four of these low-producing cows dropped calves that were very large, averaging 109 pounds in weight, and the fifth cow had difficulty in calving. Four of the five highest-producing cows, on the other hand, dropped calves averaging only 99.5 pounds.

The five high cows on the full-grain ration, with an average yield of 503.6 pounds of butterfat, averaged approximately 284 pounds on ration 1, or only 56.4 percent as much as on full grain, and 347 pounds on ration 3, or about 69 percent as much as on full grain. The yields on the two roughage rations do not seem consistent, relative to the yield on full grain, and there are probably other factors that affected the results. All these cows had been accustomed to a ration of alfalfa hay and corn silage in addition to grain, which may account in part, at least, for their better showing on the roughage ration that included corn silage.

In the present experiment, the relation of the yield on roughage alone (rations 1 and 3) to the yield on the full-grain ration was very similar to that obtained in the three-planes-of-feeding experiment at Huntley, Mont., and also at the other stations of the Bureau where similar experiments were conducted. The relation of the yield on ration 2, however (barley was fed at the rate of 1 pound to 6.03 pounds of milk produced), to that on the full-grain ration was considerably lower in this experiment than the relation of the yield on the limited-grain ration to that on the full-grain ration in the Huntley experiment. In the latter experiment, however, the cows received a grain mixture instead of only one kind of grain and they also received corn silage in the roughage part of the ration instead of being restricted to alfalfa hay or pasturage.

PERSISTENCY OF MILK YIELD ON EACH RATION

Table 7 shows the average daily milk yield (actual basis) by calendar months throughout the lactation periods on the different rations. The average daily yield for each month of lactation is also expressed as a percentage of the average daily yield for the month of maximum production.

On the full-grain ration the cows reached their maximum milk yield during the second month of lactation, on the average. Four cows reached their maximum yield in the first month, five in the second month, and three in the third month. The four that reached their maximum milk yield in the first month averaged 415 pounds of butterfat (mature basis) for the lactation and produced 46.9 percent as much milk in the tenth month as in the first; the five that reached their maximum in the second month averaged 418 pounds of butterfat for the lactation and produced 64.2 percent as much milk in the tenth as in the second month; and the three that reached their maximum in the third month averaged 485 pounds of butterfat for the lactation and produced 69.6 percent as much milk in the tenth month as in the third. On the average these 12 cows produced 59.7 percent as much milk in the tenth month as they did in their month of maximum yield. Two of the cows (A-42 and E-44) that declined very rapidly in the late months of their lactation periods were on pasture in the late months of lactation and had conceived 83 and 100 days, respectively, after calving.

On ration 1, all but 2 of the 12 cows reached their maximum yield in the first month of lactation, and those 2 (E-41 and E-43) reached their maximum during the second month. On this ration, the cows received no feed but pasturage during the pasture season, unless the pasture became quite short. Then the pasture was supplemented with alfalfa hay. This resulted in more rapid declines in yield during the pasture season than was the case when the cows were on the full-grain ration and on ration 2, when the pastures were supplemented with grain throughout the pasture season. It is often difficult to judge just when pastures reach the stage of scarcity or of maturity in which they must be supplemented with other feeds in order to prevent a decline in milk yield by grazing cows. Had the cows on ration 1 had access to alfalfa hay throughout the pasture season they would undoubtedly have made a much more favorable showing.

There were seven cows that were on pasture 3 months or more during the first 6 months of the lactation period on ration 1. In the sixth month these cows produced an average of 60.6 percent as much as they did in the month of their maximum yield. The five cows that were on pasture not more than 2 months during the first 6 months of the lactation were producing an average of 67.5 percent as much in the sixth month as in the month of maximum yield and three of the five were producing in excess of 70 percent as much. There were four cows that had no more than 1 month of pasturage from the fourth to the tenth month of the lactation, inclusive. On the average these cows declined from 74.7 percent of their maximum monthly yield in the fourth month to 48.4 percent in the tenth month. The other eight cows, that had more than 1 month pasturage in this period, declined on the average from 75.7 percent of their maximum monthly yield in the fourth month to 22.7 percent in the tenth month.

TABLE 7.—Average daily milk yield per cow, by months, and the relation of each monthly average to the maximum monthly average¹
ON THE FULL-GRAIN RATION

Cow No., and items of comparison	Data for indicated month in lactation											
	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh	Twelfth
E-25:												
Average daily yield.....pounds..	28.1	28.9	29.8	28.4	27.6	26.3	25.0	24.0	21.8	20.2	18.3	17.4
Relation to maximum daily yield.....percent..	94.3	97.0	100.0	95.3	92.6	84.9	83.9	80.5	73.2	67.4	63.1	58.4
E-34:												
Average daily yield.....pounds..	34.1	32.8	34.9	34.3	31.9	32.7	30.1	30.0	29.0	23.1	14.4	5.8
Relation to maximum daily yield.....percent..	97.7	94.0	100.0	98.3	91.4	93.7	86.2	86.0	83.1	66.2	41.3	16.6
E-38:												
Average daily yield.....pounds..	28.1	34.7	32.2	29.3	28.3	28.2	28.4	26.8	24.2	22.3	14.2	-----
Relation to maximum daily yield.....percent..	81.0	100.0	92.8	84.4	81.6	81.3	81.8	77.2	69.7	64.3	40.9	-----
E-40:												
Average daily yield.....pounds..	37.7	38.6	35.4	35.8	32.7	35.2	36.0	35.2	32.0	26.2	-----	-----
Relation to maximum daily yield.....percent..	97.9	100.0	91.9	93.0	84.9	91.4	93.5	91.4	83.1	68.1	-----	-----
E-41:												
Average daily yield.....pounds..	40.4	45.1	43.1	41.1	39.9	37.7	36.8	32.7	28.4	25.0	25.1	-----
Relation to maximum daily yield.....percent..	89.6	100.0	95.6	91.1	88.5	83.6	81.6	72.5	63.0	55.4	55.7	-----
E-42:												
Average daily yield.....pounds..	39.7	42.9	45.1	41.4	39.8	38.3	37.0	36.1	36.7	34.0	32.8	-----
Relation to maximum daily yield.....percent..	88.0	95.1	100.0	91.8	88.2	84.9	82.0	80.0	81.4	75.4	72.7	-----
E-43:												
Average daily yield.....pounds..	35.9	34.9	35.1	32.7	32.8	31.1	31.1	30.9	31.3	30.1	28.6	-----
Relation to maximum daily yield.....percent..	100.0	97.2	97.8	91.1	91.4	86.6	86.6	86.1	87.2	83.8	79.7	-----
E-44:												
Average daily yield.....pounds..	31.4	30.8	27.9	24.6	23.9	23.0	22.4	22.3	19.3	11.9	-----	-----
Relation to maximum daily yield.....percent..	100.0	98.1	88.9	78.3	76.1	73.2	71.3	71.0	61.5	37.9	-----	-----
E-45:												
Average daily yield.....pounds..	32.6	37.0	35.5	35.1	33.9	32.6	33.8	33.0	32.7	28.6	27.8	26.3
Relation to maximum daily yield.....percent..	88.1	100.0	95.9	94.9	91.6	88.1	91.4	89.2	88.4	77.3	75.1	71.1
E-46:												
Average daily yield.....pounds..	45.5	45.2	41.3	39.0	34.2	33.0	33.2	32.2	29.4	27.6	25.7	-----
Relation to maximum daily yield.....percent..	100.0	99.3	90.8	83.5	76.3	72.5	73.0	70.8	64.6	60.7	56.5	-----
A-42:												
Average daily yield.....pounds..	49.6	46.6	40.8	36.3	33.4	31.1	28.6	21.0	10.1	2.6	-----	-----
Relation to maximum daily yield.....percent..	100.0	94.0	82.3	73.2	67.3	62.7	57.7	42.3	20.4	5.2	-----	-----
W-201:												
Average daily yield.....pounds..	39.8	40.4	39.8	31.8	30.6	28.7	27.1	26.9	24.4	22.6	20.9	-----
Relation to maximum daily yield.....percent..	98.5	100.0	98.5	78.7	75.7	71.0	67.1	66.6	60.4	55.9	51.7	-----
Average.....pounds..	36.9	38.2	36.7	34.1	32.4	31.4	30.8	29.3	26.6	22.8	-----	-----
.....percent..	98.6	100.0	96.1	89.3	84.8	82.2	80.6	76.7	69.6	59.7	-----	-----

ON RATION 1

E-25:													
Average daily yield.....	pounds	37.5	37.1	34.1	29.7	25.8	20.7	19.5	17.7	17.1	16.3	16.0	14.8
Relation to maximum daily yield.....	percent	100.0	98.9	90.9	79.2	68.3	55.2	52.0	47.2	45.6	43.5	42.7	39.6
E-34:													
Average daily yield.....	pounds	48.0	48.2	40.2	36.0	33.8	31.5	20.7	19.9	19.4	18.5	13.0	6.3
Relation to maximum daily yield.....	percent	100.0	98.6	82.2	73.6	69.1	64.4	42.3	40.7	39.7	37.8	26.0	10.8
E-38:													
Average daily yield.....	pounds	30.9	27.4	22.9	20.9	19.3	18.7	13.5	12.4	11.1	11.1	11.3	-----
Relation to maximum daily yield.....	percent	100.0	88.7	74.1	67.6	62.5	60.5	43.7	40.1	35.9	35.9	36.6	-----
E-40:													
Average daily yield.....	pounds	34.8	30.1	21.7	27.3	29.8	22.8	23.9	24.3	26.0	26.6	-----	-----
Relation to maximum daily yield.....	percent	100.0	86.6	62.4	78.4	85.6	65.5	68.7	69.8	74.7	76.4	-----	-----
E-41:													
Average daily yield.....	pounds	38.5	41.0	39.4	35.3	31.2	27.2	34.5	29.6	23.2	18.7	16.1	-----
Relation to maximum daily yield.....	percent	93.9	100.0	96.1	88.0	78.1	68.3	84.1	72.2	58.6	45.6	39.3	-----
E-42:													
Average daily yield.....	pounds	40.3	36.4	35.0	31.7	29.2	30.1	29.2	27.9	25.6	20.6	17.5	-----
Relation to maximum daily yield.....	percent	100.0	90.3	86.8	78.7	72.5	74.7	72.5	69.2	63.5	51.0	43.4	-----
E-43:													
Average daily yield.....	pounds	35.8	37.0	34.5	31.2	31.1	32.2	29.5	24.1	11.1	0	-----	-----
Relation to maximum daily yield.....	percent	96.8	100.0	93.2	84.3	84.1	87.0	79.7	65.1	30.0	0	-----	-----
E-44:													
Average daily yield.....	pounds	39.6	36.1	33.6	30.2	26.8	28.0	27.1	21.8	11.1	0	-----	-----
Relation to maximum daily yield.....	percent	100.0	91.2	84.8	76.3	67.7	70.7	68.4	55.1	28.0	0	-----	-----
E-45:													
Average daily yield.....	pounds	40.4	34.0	32.8	28.5	22.8	18.8	17.0	15.9	15.9	15.9	7.6	-----
Relation to maximum daily yield.....	percent	100.0	84.2	81.2	70.5	56.4	46.5	42.1	39.4	34.4	34.4	18.8	-----
E-46:													
Average daily yield.....	pounds	43.9	39.4	37.3	32.7	28.0	21.6	19.4	16.2	11.0	6.1	2.1	-----
Relation to maximum daily yield.....	percent	100.0	89.7	85.0	74.5	63.8	49.2	44.2	36.9	25.1	13.9	4.8	-----
A-42:													
Average daily yield.....	pounds	45.2	28.6	29.6	27.0	27.7	26.6	26.2	21.2	15.5	6.9	-----	-----
Relation to maximum daily yield.....	percent	100.0	63.3	65.5	59.7	61.3	58.8	58.0	46.9	34.3	15.3	-----	-----
W-201:													
Average daily yield.....	pounds	49.7	49.1	42.6	36.8	33.4	31.4	30.5	21.6	16.6	10.2	4.7	-----
Relation to maximum daily yield.....	percent	100.0	98.8	85.7	74.0	67.2	63.2	61.4	43.5	33.4	20.5	9.5	-----
Average.....	pounds	40.5	37.0	33.6	30.6	28.2	25.8	24.3	21.1	16.8	12.4	-----	-----
	percent	100.0	91.4	83.0	75.6	69.6	63.7	60.0	52.1	41.5	30.6	-----	-----

¹ Figures in italics are for months when cows were in pasture. (Pasture season extended from May 1 to Oct. 1.)

TABLE 7.—Average daily milk yield per cow, by months, and the relation of each monthly average to the maximum monthly average—Contd.
ON RATION 2

Cow No., and items of comparison	Data for indicated month in lactation											
	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh	Twelfth
E-25:												
Average daily yield.....pounds..	40.4	38.4	34.7	32.0	28.9	27.4	22.6	18.5	16.0	12.7	9.9	6.4
Relation to maximum daily yield.....percent..	100.0	95.0	85.9	79.2	71.5	67.8	55.9	45.8	39.6	31.4	24.5	15.8
E-34:												
Average daily yield.....pounds..	49.3	40.9	40.2	40.5	35.3	34.3	32.7	30.3	29.0	27.3	18.7	5.8
Relation to maximum daily yield.....percent..	98.8	100.0	92.6	81.2	70.7	68.7	65.5	60.7	58.1	54.7	33.5	11.6
E-38:												
Average daily yield.....pounds..	41.6	35.2	32.9	29.0	25.1	22.3	21.3	19.3	18.3	16.1	-----	-----
Relation to maximum daily yield.....percent..	100.0	84.6	79.1	69.7	60.3	53.9	51.2	46.4	44.0	38.7	-----	-----
E-40:												
Average daily yield.....pounds..	52.8	44.5	39.3	39.3	30.5	33.2	32.0	28.4	23.7	15.0	-----	-----
Relation to maximum daily yield.....percent..	100.0	84.3	74.4	74.4	57.8	62.9	60.6	53.8	44.9	28.4	-----	-----
E-41:												
Average daily yield.....pounds..	56.8	48.7	43.8	42.0	39.0	36.2	30.5	25.7	22.5	21.5	22.6	-----
Relation to maximum daily yield.....percent..	100.0	85.7	77.1	73.9	68.7	63.7	53.7	45.2	39.6	37.9	39.7	-----
E-42:												
Average daily yield.....pounds..	46.4	44.8	41.1	39.9	38.2	38.3	35.2	36.1	34.7	27.9	20.2	-----
Relation to maximum daily yield.....percent..	100.0	96.6	88.6	86.0	82.3	82.5	75.6	77.8	74.8	60.1	43.5	-----
E-43:												
Average daily yield.....pounds..	41.4	44.8	44.8	42.1	38.9	34.2	32.7	29.7	25.9	20.7	9.2	-----
Relation to maximum daily yield.....percent..	92.0	100.0	100.0	94.0	88.8	78.0	73.0	66.3	67.8	46.2	20.5	-----
E-44:												
Average daily yield.....pounds..	51.8	50.1	41.2	37.1	33.5	27.4	25.0	23.3	20.7	18.7	-----	-----
Relation to maximum daily yield.....percent..	100.0	96.7	79.5	71.6	64.7	52.9	48.3	45.0	40.0	36.1	-----	-----
E-45:												
Average daily yield.....pounds..	47.3	45.9	43.2	40.9	39.3	34.1	27.3	16.9	12.1	8.9	7.0	-----
Relation to maximum daily yield.....percent..	100.0	97.0	91.3	86.5	83.1	72.1	57.7	35.7	23.6	18.8	14.8	-----
E-46:												
Average daily yield.....pounds..	65.7	53.0	44.5	39.3	36.8	31.6	27.5	22.9	17.8	14.2	12.3	-----
Relation to maximum daily yield.....percent..	100.0	80.7	67.7	59.8	56.0	48.1	41.9	34.9	27.1	21.6	18.7	-----
A-42:												
Average daily yield.....pounds..	50.9	48.9	47.8	44.6	38.5	40.2	40.8	33.9	22.9	14.3	-----	-----
Relation to maximum daily yield.....percent..	100.0	96.1	93.9	87.6	75.6	79.0	80.2	66.9	45.0	28.9	-----	-----
W-201:												
Average daily yield.....pounds..	58.8	54.3	50.7	48.3	47.5	44.2	38.4	34.6	35.2	31.8	29.5	-----
Relation to maximum daily yield.....percent..	100.0	92.3	86.2	82.1	80.8	75.2	65.3	58.8	59.9	54.1	50.2	-----
Average.....pounds..	50.3	46.5	42.5	39.6	36.0	33.6	30.5	20.6	23.2	19.1	-----	-----
.....percent..	100.0	92.4	84.5	78.7	71.6	66.8	60.6	52.9	46.1	38.0	-----	-----

ON RATION 3

E-25:													
Average daily yield.....	pounds.....	34.0	30.2	20.9	25.1	22.8	<i>22.8</i>	<i>21.9</i>	<i>21.4</i>	<i>17.7</i>	<i>15.6</i>	13.8	12.0
Relation to maximum daily yield.....	percent.....	100.0	88.8	79.1	73.8	67.1	<i>67.1</i>	<i>64.4</i>	<i>62.9</i>	<i>58.1</i>	<i>45.9</i>	40.6	35.3
E-34:													
Average daily yield.....	pounds.....	42.4	35.2	31.0	29.4	27.2	<i>29.6</i>	<i>24.5</i>	<i>19.5</i>	<i>12.5</i>	<i>10.5</i>	10.0	4.8
Relation to maximum daily yield.....	percent.....	100.0	84.0	74.0	70.2	64.9	<i>70.8</i>	<i>58.5</i>	<i>46.5</i>	<i>29.8</i>	<i>25.1</i>	23.6	11.3
E-38:													
Average daily yield.....	pounds.....	33.7	30.5	26.8	<i>25.6</i>	<i>25.1</i>	<i>21.9</i>	<i>18.2</i>	<i>15.3</i>	6.6	0	-----	-----
Relation to maximum daily yield.....	percent.....	100.0	90.5	79.5	<i>76.0</i>	<i>74.5</i>	<i>65.0</i>	<i>54.0</i>	<i>39.5</i>	19.6	0	-----	-----
E-40:													
Average daily yield.....	pounds.....	46.3	40.3	36.3	35.3	33.2	<i>35.0</i>	<i>30.2</i>	<i>24.4</i>	<i>16.3</i>	<i>12.5</i>	-----	-----
Relation to maximum daily yield.....	percent.....	100.0	87.0	78.4	74.1	78.2	<i>76.6</i>	<i>65.2</i>	<i>52.7</i>	<i>35.2</i>	<i>27.0</i>	-----	-----
E-41:													
Average daily yield.....	pounds.....	42.3	36.9	39.5	<i>42.1</i>	<i>40.6</i>	<i>35.2</i>	<i>29.6</i>	<i>27.5</i>	23.3	20.0	22.6	-----
Relation to maximum daily yield.....	percent.....	100.0	87.2	93.4	<i>99.5</i>	<i>96.0</i>	<i>85.2</i>	<i>70.0</i>	<i>65.0</i>	66.9	68.6	53.4	-----
E-42:													
Average daily yield.....	pounds.....	42.8	39.4	36.4	34.4	32.6	30.1	<i>30.8</i>	<i>27.0</i>	<i>22.4</i>	<i>17.9</i>	<i>15.8</i>	-----
Relation to maximum daily yield.....	percent.....	100.0	92.1	85.0	80.4	76.2	70.3	<i>72.0</i>	<i>63.1</i>	<i>62.3</i>	<i>41.8</i>	<i>32.2</i>	-----
E-43:													
Average daily yield.....	pounds.....	36.1	35.2	33.3	33.4	<i>34.0</i>	<i>31.6</i>	<i>28.7</i>	<i>25.8</i>	<i>20.2</i>	14.5	9.5	-----
Relation to maximum daily yield.....	percent.....	100.0	97.6	92.2	92.5	<i>94.2</i>	<i>87.5</i>	<i>79.5</i>	<i>65.9</i>	<i>56.0</i>	40.2	20.3	-----
E-44:													
Average daily yield.....	pounds.....	37.6	31.0	26.5	25.1	25.0	<i>25.1</i>	<i>22.0</i>	<i>15.6</i>	<i>5.1</i>	0	-----	-----
Relation to maximum daily yield.....	percent.....	100.0	82.4	70.5	66.8	66.5	<i>66.8</i>	<i>58.5</i>	<i>38.2</i>	<i>15.0</i>	0	-----	-----
E-45:													
Average daily yield.....	pounds.....	<i>37.8</i>	<i>40.9</i>	<i>38.1</i>	<i>32.6</i>	<i>28.1</i>	24.7	20.9	16.4	14.3	13.3	11.3	7.3
Relation to maximum daily yield.....	percent.....	<i>92.4</i>	<i>100.0</i>	<i>85.2</i>	<i>79.7</i>	<i>68.7</i>	60.4	51.1	40.1	35.0	32.5	27.6	17.8
E-46:													
Average daily yield.....	pounds.....	42.6	39.3	34.9	33.1	<i>36.7</i>	<i>34.4</i>	<i>31.0</i>	<i>26.9</i>	<i>24.4</i>	21.8	18.2	-----
Relation to maximum daily yield.....	percent.....	100.0	92.3	81.9	77.7	<i>85.0</i>	<i>80.8</i>	<i>72.8</i>	<i>63.1</i>	<i>57.5</i>	51.2	42.7	-----
A-42:													
Average daily yield.....	pounds.....	42.3	35.9	33.4	<i>37.4</i>	<i>34.3</i>	<i>28.0</i>	<i>21.5</i>	<i>16.1</i>	10.3	2.1	-----	-----
Relation to maximum daily yield.....	percent.....	100.0	84.9	79.0	<i>88.4</i>	<i>81.1</i>	<i>66.2</i>	<i>50.4</i>	<i>38.1</i>	24.3	5.0	-----	-----
W-201:													
Average daily yield.....	pounds.....	<i>46.2</i>	<i>42.4</i>	<i>40.3</i>	<i>35.5</i>	36.5	33.7	31.0	27.3	24.3	23.0	19.0	-----
Relation to maximum daily yield.....	percent.....	<i>100.0</i>	<i>91.8</i>	<i>87.2</i>	<i>72.5</i>	79.0	72.9	67.1	59.1	52.6	49.8	41.1	-----
Average.....	pounds.....	40.3	36.4	33.6	32.3	31.6	29.3	25.8	21.4	16.9	13.4	-----	-----
	percent.....	100.0	90.3	83.4	80.1	78.4	72.7	64.0	53.1	41.9	33.2	-----	-----

¹ Figures in italics are for months when cows were on pasture. (Pasture season extended from May 1 to Oct. 1.)

On ration 2, all but 2 of the 12 cows reached their maximum yield in the first month of lactation, and those 2 reached their maximum in the second month.

On ration 3, 1 cow reached her maximum yield in the second month of the lactation period and the other 11 in the first month.

There was not as great a difference in the average daily milk yield between the individual cows, when they were on the full-grain ration and on rations 1 and 3, as there normally would have been if all the cows had been mature when they were on these rations or if the yields had been calculated to a mature-age basis. The ages of the cows when starting their lactations on the various rations are shown in table 3. While the daily milk yields shown in table 7 are hardly comparable, the percentages of maximum yield (as a measure of the persistency on the different rations) are probably more accurate than they would be if based on yields that had been calculated to maturity.

In the third month of lactation, the average daily yield (expressed as a percentage of the maximum monthly yield) was 96.1 percent for the full-grain ration, 83.0 percent for ration 1, 84.5 percent for ration 2, and 83.4 percent for ration 3. The percentages for the third month and for the preceding months are very uniform for rations 1, 2, and 3. In the sixth month of lactation the percentages were as follows, in the order given above, 82.2, 63.7, 66.8, and 72.7. At this point in the lactation period the cows were holding up better on ration 3 than on either ration 2 or ration 1. In the tenth month of lactation the percentages were 59.7, 30.6, 38.0, and 33.2. During the ninth and tenth months the cows declined more rapidly on rations 1 and 3 than they did on ration 2, and, of course, on the full-grain ration they showed a much slower rate of decline than when they were on any of the other three rations. In view of the marked superiority of the full-grain ration in maintaining the persistency of the cows it is rather surprising that there was not a greater difference in their persistency on ration 2 (in which barley grain was fed) and on rations 1 and 3, in which no grain was fed.

The cows had some advantage in maintaining persistency on the full-grain ration because they were younger at the time they were fed this ration, most of them being in their first lactation period, but they also were at some disadvantage in that 3 of the 12 were due to freshen again within 2 months after completing 10 months of lactation. On ration 1, 3 of the 12 cows were due to freshen in from 2 to 2½ months after completing 10 months of lactation; only 1 cow on ration 2 was due to freshen 2 to 2½ months after completing 10 months of lactation, and 4 cows on ration 3 were due to freshen in from 2 to 2½ months. In many, though not all cases, these cows that were due to freshen early were less persistent than the other cows, particularly 1 cow on the full-grain ration, all 3 cows on ration 1, and 2 cows on ration 3.

Pasturing the cows was an important factor in causing a more rapid decline in the yield on the all-roughage rations. The reason was brought out in discussing ration 1 (p. 15). A comparison of the declines in milk yield on each ration by all cows that were on pasture 5 consecutive months shows the following facts: On the full-grain ration the average daily yield by 7 cows (expressed as a percentage

of the highest monthly yield) was 86.6 percent for the first month on pasture and 61.7 percent for the fifth month on pasture, or a decline of 24.9 points; on ration 2, the average daily yield for 8 cows was 79.0 percent for the first month on pasture and 41.2 percent for the fifth month, or a decline of 37.8 points; on ration 1, the average daily yield for 7 cows for the first month on pasture was 82.4 percent and for the fifth month 37.8 percent, or a decline of 44.6 points, and for 11 cows on ration 3 the average for the first month was 80.69 percent and for the fifth month 41.34 percent, a decline of 39.35 points. Thus the decline while the cows were on pasture was least on the full-grain ration and greatest on ration 1.

WEIGHTS OF COWS ON DIFFERENT RATIONS

The weight data for the cows when they were on rations 1, 2, and 3 are given in table 8. The before-calving and after-calving weights were not obtained when the cows were on the full-grain ration; the weight data for that ration are therefore not entirely comparable with the other rations and for that reason are omitted. The data in table 8 include the weights of the cows immediately before and soon after calving, weights by months throughout the lactation periods, the net gain or loss in weight, and the average weight for the lactation period. A fractional month longer than 15 days, or the first whole calendar month, is used as the first month of the lactation period. Table 8 also shows the months during the lactation period when the cows were on pasture.

The cows were fed ground barley during the dry period preceding their start on ration 2. During the dry period preceding their start on rations 1 and 3, however, they received no grain. This probably accounts for their heavier after-calving weight when they started on ration 2.

The average weights, and gains and losses in weight, of these 12 cows during their lactation periods on rations 1, 2, and 3 were remarkably uniform. During the first month of lactation the cows lost an average of 104, 105, and 105 pounds on rations 1, 2, and 3, respectively; during the second month they lost an average of 17, 14, and 15 pounds, respectively; and during the third month they gained an average of 6 pounds on ration 1, lost an average of 4 pounds on ration 2, and gained an average of 2 pounds on ration 3. Up to and including the tenth month, they had made an average net gain of 10 pounds on ration 1, an average loss of 19 pounds on ration 2, and an average gain of 34 pounds on ration 3. They were making somewhat greater gains from the sixth to the tenth months inclusive, on ration 3 (the ration that contained corn silage) than on the other two.

At the end of the tenth month the average weight of the cows on the three rations was 137 pounds less than the precalving weight. They had gained 44 pounds during the tenth month, however, and could be expected to gain faster when they were dry and more advanced in pregnancy. Since they still had an average of 4 months before calving again there seems little question but that they regained their precalving weights on the respective rations.

TABLE 8.—Average weight, and the gain or loss by each cow, during the lactation period on each ration ¹

ON RATION 1

Cow No.	Weight before calving	Weight after calving	Weight at end of indicated month of lactation												Gain (+) or loss (—) in weight at end of lactation	Average weight during the lactation period
			First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh	Twelfth		
E-25	Pounds 1,837	Pounds 1,641	1,555	1,508	1,491	1,547	1,552	1,530	1,490	1,512	1,513	1,540	1,579	1,637	-4	1,541
E-34	1,413	1,218	1,223	1,173	1,159	1,158	1,180	1,207	1,214	1,158	1,183	1,217	1,273	1,303	+85	1,190
E-38	1,540	1,403	1,352	1,339	1,377	1,451	1,358	1,404	1,393	1,406	1,422	1,427	1,430		+27	1,389
E-40	1,404	1,215	1,159	1,103	1,189	1,208	1,197	1,229	1,233	1,213	1,267	1,283			+33	1,198
E-41	1,325	1,463	1,289	1,357	1,355	1,498	1,317	1,550	1,335	1,373	1,450	1,459	1,497		+34	1,364
E-42	1,718	1,610	1,431	1,392	1,425	1,422	1,442	1,454	1,541	1,557	1,567	1,613	1,655		+45	1,494
E-43	1,564	1,452	1,385	1,372	1,373	1,277	1,505	1,336	1,382	1,416	1,477	1,518	1,549		+07	1,392
E-44	1,623	1,435	1,338	1,303	1,313	1,314	1,311	1,351	1,353	1,389	1,447	1,481			+46	1,316
E-45	1,457	1,342	1,266	1,225	1,241	1,163	1,216	1,212	1,133	1,194	1,219	1,277	1,304	1,335	-7	1,235
E-46	1,555	1,355	1,225	1,227	1,221	1,313	1,295	1,349	1,311	1,388	1,454	1,475	1,492		+137	1,326
A-42	1,648	1,498	1,242	1,283	1,230	1,255	1,252	1,283	1,339	1,383	1,454	1,476			-22	1,314
W-201	1,548	1,401	1,386	1,331	1,360	1,490	1,324	1,359	1,350	1,368	1,386	1,421	1,474		+73	
Average	1,570	1,422	1,318	1,301	1,307	1,309	1,312	1,340	1,314	1,366	1,401	1,432			+46	1,347

ON RATION 2

E-25	1,795	1,670	1,533	1,604	1,594	1,571	1,567	1,547	1,576	1,631	1,602	1,620	1,664	1,708	+38	1,602
E-34	1,512	1,342	1,213	1,260	1,270	1,230	1,203	1,200	1,213	1,250	1,260	1,422	1,473		+131	1,282
E-38	1,908	1,735	1,567	1,558	1,488	1,501	1,560	1,540	1,510	1,535	1,543	1,572			+163	1,552
E-40	1,303	1,414	1,378	1,317	1,306	1,313	1,287	1,301	1,274	1,331	1,348	1,448			-6	1,331
E-41	1,615	1,582	1,473	1,416	1,424	1,466	1,440	1,517	1,554	1,567	1,470	1,531	1,541		-41	1,492
E-42	1,623	1,510	1,470	1,450	1,491	1,487	1,480	1,480	1,502	1,532	1,552	1,604	1,651		+132	1,506
E-43	1,637	1,507	1,481	1,429	1,423	1,352	1,422	1,446	1,498	1,441	1,421	1,479	1,500		+53	1,423
E-44	1,640	1,523	1,373	1,360	1,347	1,356	1,401	1,415	1,490	1,404	1,421	1,421	1,440	1,510	+149	1,344
E-45	1,538	1,361	1,296	1,206	1,247	1,280	1,332	1,332	1,344	1,348	1,369	1,423	1,443		-14	1,348
E-46	1,580	1,447	1,240	1,310	1,332	1,321	1,339	1,350	1,380	1,402	1,376	1,375			-91	1,325
A-42	1,728	1,540	1,344	1,295	1,306	1,272	1,256	1,287	1,340	1,370	1,414	1,458			+107	1,428
W-201	1,573	1,414	1,397	1,405	1,405	1,428	1,426	1,407	1,441	1,418	1,482	1,510				
Average	1,648	1,507	1,402	1,388	1,384	1,391	1,394	1,407	1,422	1,434	1,439	1,488			+21	1,421

ON RATION 3

E-23	1,865	1,677	1,603	1,598	1,598	1,625	1,632	<i>1,605</i>	<i>1,604</i>	<i>1,614</i>	<i>1,667</i>	<i>1,669</i>	1,705	1,748	+71	1,635
E-34	1,587	1,369	1,268	1,181	1,188	1,181	1,120	<i>1,181</i>	<i>1,214</i>	<i>1,218</i>	<i>1,251</i>	<i>1,285</i>	1,401	1,440	+77	1,237
E-38	1,685	1,530	1,427	1,433	1,452	<i>1,445</i>	<i>1,464</i>	<i>1,615</i>	<i>1,644</i>	<i>1,657</i>	1,603	1,602	1,677	-----	+127	1,523
E-40	1,650	1,495	1,381	1,341	1,302	1,368	1,325	<i>1,334</i>	<i>1,509</i>	<i>1,377</i>	<i>1,406</i>	<i>1,446</i>	-----	-----	-49	1,336
E-41	1,503	1,405	1,251	1,264	1,255	<i>1,288</i>	<i>1,277</i>	<i>1,241</i>	<i>1,255</i>	1,260	1,308	1,356	1,397	-----	-8	1,280
E-42	1,679	1,580	1,464	1,448	1,448	1,447	1,453	1,411	<i>1,499</i>	<i>1,540</i>	<i>1,566</i>	<i>1,616</i>	<i>1,640</i>	-----	+80	1,495
E-43	1,533	1,409	1,345	1,325	1,322	1,308	<i>1,345</i>	<i>1,341</i>	<i>1,369</i>	<i>1,405</i>	<i>1,408</i>	1,497	1,527	-----	+118	1,368
E-44	1,593	1,427	1,325	1,315	1,342	1,341	1,353	<i>1,386</i>	<i>1,417</i>	<i>1,453</i>	<i>1,505</i>	<i>1,514</i>	-----	-----	+87	1,383
E-45	1,329	1,234	<i>1,159</i>	<i>1,186</i>	<i>1,169</i>	<i>1,164</i>	<i>1,166</i>	1,196	1,197	1,195	1,221	1,274	1,306	1,314	+80	1,205
E-46	1,435	1,240	1,143	1,100	1,133	1,116	<i>1,189</i>	<i>1,193</i>	<i>1,175</i>	<i>1,193</i>	<i>1,246</i>	1,299	1,360	-----	+120	1,195
A-42	1,680	1,478	1,251	1,241	1,212	<i>1,223</i>	<i>1,307</i>	<i>1,312</i>	<i>1,357</i>	<i>1,399</i>	1,463	1,609	-----	-----	+131	1,346
W-201	1,624	1,400	<i>1,398</i>	<i>1,375</i>	<i>1,358</i>	<i>1,352</i>	1,337	1,361	1,393	1,375	1,378	1,430	1,451	-----	+61	1,378
Average	1,585	1,437	1,332	1,317	1,319	1,329	1,331	1,340	1,359	1,381	1,418	1,471	-----	-----	+74	1,367

¹ Figures in italics are for months when cows were on pasture. (Pasture season extended from May 1 to Oct. 1.)

TABLE 9.—Total feed consumption per cow and the number of days of pasture with each ration

Cow No.	Full-grain ration					Ration 1		Ration 2				Ration 3		
	Alfalfa hay	Corn silage	Pasture	Grain mixture	1 pound of grain fed per milk yield of—	Alfalfa hay	Pasture	Alfalfa hay	Pasture	Ground barley	1 pound of grain fed per milk yield of—	Alfalfa hay	Corn silage	Pasture
	<i>Pounds</i>	<i>Pounds</i>	<i>Days</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Days</i>	<i>Pounds</i>	<i>Days</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Days</i>
E-25	5,469	4,185	150	2,284	4.00	5,252	150	3,619	173	1,237	6.86	3,373	11,870	146
E-31	6,179	0	143	2,417	4.30	7,965	147	7,974	144	2,037	6.08	2,876	9,825	173
E-38	5,203	6,416	97	2,155	4.14	7,774	107	4,905	173	1,226	6.93	4,673	10,245	146
E-10	4,922	5,528	89	2,406	4.37	8,693	98	8,445	110	1,920	5.57	4,804	8,860	161
E-11	3,759	6,285	138	2,062	4.12	7,891	146	7,075	127	2,241	5.51	5,626	8,727	153
E-12	5,275	5,046	112	2,996	4.32	7,575	148	9,057	112	2,092	5.91	5,111	10,361	156
E-13	4,764	5,893	103	2,533	4.16	6,675	146	5,099	173	1,813	5.77	4,922	8,665	153
E-14	3,721	5,926	70	1,839	3.84	6,412	123	3,859	173	1,592	5.91	3,556	7,342	130
E-15	3,015	5,902	138	2,705	4.25	6,007	154	6,307	148	1,607	6.51	5,120	8,417	148
E-16	3,621	4,993	138	2,815	4.10	6,604	140	5,567	173	1,727	6.37	5,032	7,001	153
A-12	5,293	6,375	113	1,802	5.35	9,335	123	6,444	146	2,031	5.59	3,290	7,950	173
W-201	4,007	0	153	1,746	5.62	6,304	136	7,788	133	2,280	6.18	4,296	9,358	126
Average	4,684	4,787	120.3	2,388	4.38	7,208	135.3	6,345	148.8	1,818	6.10	4,300	9,052	151.5

FEED CONSUMPTION

Table 9 shows the total consumption of the various feeds and the number of days of pasture per cow for each of the four rations.

Because of the fact that the cows on all of these rations were on pasture from 4 to 5 months of the year, and that they received only a limited amount of supplemental feed while on pasture (other than the grain fed in the full-grain ration and ration 2), a separate analysis of the requirements and consumption of digestible nutrients was made for the pasture season and for the nonpasture or winter season.

WINTER SEASON

Table 10 shows the quantity of nutrients required (for maintenance and production) and the quantity consumed by the 12 cows during the period when they were not on pasture, for rations 1, 2, and 3.

When they were on alfalfa hay alone (ration 1) the 12 cows had an average daily consumption of 34.8 pounds of hay. The average ranged from 23.1 pounds for E-25, the lightest consumer, to 45.8 pounds per day for A-42. The daily consumption of alfalfa hay in this experiment was not as great as in the experiment⁷ in which 15 cows that were fed on alfalfa hay alone throughout 24 lactation periods consumed an average of 39.3 pounds per day. One of the 15 cows averaged 47 pounds per day, and several averaged over 44 pounds, throughout the year.

One reason for the lower consumption of hay in the present experiment is that these cows were fed in such manner as to cause them to consume practically all the hay offered, less than 2 percent being refused. In the 15-cow experiment there was a refusal of 15 percent. In other words, the 15 cows were fed enough hay so they could refuse the less palatable parts. Whether this would account for the 13 percent greater consumption is questionable. The cows in the present experiment were not accustomed to a ration limited to alfalfa hay and this may have caused the somewhat lower consumption of hay. Assuming that the hay fed in this experiment contained 12 percent of moisture, the barley 10 percent, and the corn silage 70 percent, it is found that the cows on ration 1 consumed an average of 34.8 pounds of alfalfa hay per day that contained 30.6 pounds of dry matter; on ration 2 they consumed an average of 31.7 pounds of alfalfa hay and 5.5 pounds of barley per day that contained 32.85 pounds of dry matter; and on ration 3 they consumed an average of 22.8 pounds of alfalfa hay and 42.2 pounds of corn silage per day that contained 32.76 pounds dry matter. Thus it appears that the addition of either the grain or the corn silage to the ration of hay resulted in an increased dry-matter consumption of approximately 7 percent.

Consumption of total digestible nutrients failed to meet the requirements for maintenance and production by 1.19 percent when the cows were on ration 1, during the winter season, although 7 of the 12 gained in weight and the average net gain for the group was 3.4 pounds. Consumption failed to meet requirements by 3.5 per-

⁷ See footnote 6, p. 8.

TABLE 10.—Total digestible nutrients required and consumed on each ration during the period the cows were without pasture

RATION 1

Cow No.	Period with- out pas- ture	Production			Feed consumed			Average body weight	Net gain (+) or loss (-) in body weight	Total digestible nutrients					
		Milk	Butterfat	Alfalfa hay	Corn silage	Grain	Required for main- tenance and pro- duction			Total con- sumed	Excess (+) or deficiency (-)		Consumed		
													Per pound of butterfat	Per 100 pounds of milk	
	Days	Pounds	Per- cent	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Percent	Pounds	Pounds
E-25	218	4,631.3	3.10	146.43	5,029	0	0	1,523	+46	3,902.82	2,569.82	-1,423.00	-35.64	17.55	55.49
E-34	218	4,948.8	3.14	155.23	7,827	0	0	1,175	+115	3,474.29	3,897.40	+423.11	+12.18	25.11	78.75
E-38	215	3,002.4	3.48	100.57	7,598	0	0	1,399	+81	3,339.20	2,882.58	+543.38	+16.27	36.43	126.78
E-40	216	5,019.4	3.14	176.39	8,550	0	0	1,223	+157	3,734.40	4,360.05	+624.65	+16.99	24.77	77.75
E-41	196	5,519.0	3.29	181.80	7,312	0	0	1,391	-4	3,821.87	3,736.43	-85.44	-2.24	20.55	67.70
E-42	190	6,813.5	2.89	197.00	7,140	0	0	1,460	-119	4,132.02	3,648.54	-483.48	-11.70	18.52	53.55
E-43	177	4,418.7	3.33	147.22	6,343	0	0	1,405	-98	3,369.78	8,241.27	-123.51	-3.81	22.02	73.35
E-44	168	5,529.8	3.37	186.33	6,132	0	0	1,323	-115	3,495.51	3,133.45	-362.06	-10.36	16.82	56.66
E-45	196	4,217.4	2.96	124.75	5,286	0	0	1,202	+30	3,056.39	2,701.15	-355.24	-11.62	21.05	64.05
E-46	187	3,797.5	3.16	120.18	6,143	0	0	1,357	+26	3,170.52	3,139.07	-31.45	-0.99	23.12	82.66
A-42	192	6,099.6	3.43	209.30	9,027	0	0	1,271	-215	3,869.10	4,612.80	+743.70	+19.22	22.03	75.62
W-201	182	3,652.7	2.97	108.46	5,939	0	0	1,377	+137	3,016.17	3,034.83	+18.66	+0.62	27.98	83.08
Average	196.3	4,850.2	3.19	154.98	6,844	0	0	1,341	+3.4	3,539.34	3,497.20	-42.14	-1.19	22.57	71.97

RATION 2

E-25	192	2,881.0	3.45	90.51	3,164	0	239	1,628	+81	3,435.04	1,804.80	-1,630.17	-47.46	18.14	62.63
E-34	225	8,520.0	3.06	260.87	7,490	0	1,420	1,254	+50	4,689.81	4,040.53	-649.28	-15.54	18.97	58.09
E-38	148	3,049.3	3.31	130.57	4,090	0	518	1,563	-107	3,091.82	2,502.26	-589.56	-19.07	19.16	63.36
E-40	202	8,067.0	3.09	248.98	8,272	0	1,476	1,329	-164	4,522.08	5,388.60	+866.52	+19.16	21.64	66.80
E-41	221	6,707.4	3.15	213.04	6,647	0	1,245	1,501	+109	4,620.52	4,376.44	-244.08	-5.28	20.46	64.38
E-42	226	0,115.0	3.25	200.21	8,590	0	1,614	1,473	-4	5,410.56	5,817.61	+407.05	+7.52	19.04	63.62
E-43	150	4,045.0	3.23	157.38	4,430	0	812	1,471	-16	3,244.21	2,902.77	-341.44	-10.52	18.44	59.90
E-44	118	4,859.3	3.54	172.15	3,015	0	921	1,393	-129	2,888.54	2,265.50	-623.04	-21.57	13.16	46.62
E-45	205	5,798.5	2.98	172.86	5,909	0	915	1,352	+61	3,880.33	3,730.60	-149.73	-3.93	21.62	64.49
E-46	160	3,777.0	3.16	119.54	4,842	0	456	1,385	-20	2,921.50	2,856.74	-64.76	-2.22	23.60	75.64
A-42	169	7,153.0	3.40	240.37	6,087	0	1,322	1,280	-275	3,698.99	4,150.87	+451.88	+13.50	16.65	58.03
W-201	190	7,209.2	2.95	214.10	7,133	0	1,113	1,444	+62	4,216.95	4,520.89	+303.94	+7.21	21.12	62.19
Average	183.8	6,086.2	3.20	194.62	5,833	0	1,007	1,421	-36	3,910.03	3,772.98	-137.05	-3.50	19.39	61.99

RATION 3

E-25.....	219	5,440.0	3.42	186.40	3,270	10,402	0	1,635	+16	4,580.75	3,620.74	-060.01	-20.06	10.42	66.45
E-34.....	192	5,440.1	3.17	172.20	2,084	7,902	0	1,258	-106	4,445.42	3,360.10	-1,085.23	-24.41	10.61	61.77
E-38.....	175	3,175.0	3.86	122.61	4,521	8,794	0	1,517	-36	3,227.03	3,954.71	+726.78	+22.52	32.25	124.52
E-40.....	151	6,033.0	3.06	184.60	4,381	0,782	0	1,372	-155	3,433.96	3,606.92	+72.96	+2.12	19.00	58.12
E-41.....	189	6,445.3	3.38	217.57	5,290	7,590	0	1,298	-3	3,078.17	4,128.80	+150.63	+3.79	18.98	64.06
E-42.....	182	6,686.0	3.16	211.02	4,097	8,257	0	1,459	-135	4,116.32	3,944.23	-172.09	-4.18	18.69	58.99
E-43.....	170	4,845.9	3.44	166.53	4,558	7,415	0	1,372	+18	3,400.17	3,715.75	+315.58	+0.28	22.31	76.63
E-44.....	161	4,777.4	3.53	168.73	3,448	0,968	0	1,349	-74	3,290.24	3,064.95	-225.29	-0.85	18.16	64.16
E-45.....	212	3,287.4	3.04	99.98	4,883	7,340	0	1,232	+148	3,010.08	3,859.25	+849.17	+23.21	38.60	117.40
E-46.....	180	5,342.7	3.45	184.07	4,079	5,933	0	1,202	-10	3,418.53	3,600.44	+181.91	+2.40	19.02	65.52
A-42.....	142	3,321.3	3.39	112.71	2,950	0,104	0	1,377	-68	2,609.57	2,649.00	+40.33	+1.55	23.51	70.79
W-201.....	197	5,519.7	2.91	160.40	4,146	8,027	0	1,380	+102	3,688.97	3,619.66	-69.31	-1.88	22.67	65.58
Average.....	180.8	5,027.1	3.29	165.58	4,125	7,628	0	1,373	-25	3,600.01	3,577.13	-22.88	- .64	21.60	71.16

MILK AND BUTTERFAT PRODUCTION BY DAIRY COWS

cent when the cows were on ration 2, and 7 of the 12 lost weight, with an average net loss per cow of 36 pounds. Consumption failed to meet requirements by a very small margin, 0.64 percent, when the cows were on ration 3, and 8 of the 12 lost weight, with an average net loss of 25 pounds per cow. On ration 1, all of the nutrients were obtained from alfalfa hay during the winter season; on ration 2, 21 percent of the total digestible nutrients consumed were supplied by the barley and the remainder by the alfalfa hay; and on ration 3, 39.8 percent of the total digestible nutrients consumed came from the corn silage and the remainder from the alfalfa hay.

While the cows on the three rations failed by a small margin to consume enough total digestible nutrients to meet their requirements during the winter feeding period, they exceeded their requirements for digestible crude protein by a wide margin. The consumption of digestible crude protein exceeded the requirements by an average of 96.4 percent on ration 1, by 67.4 percent on ration 2, and by 41.3 percent on ration 3.

When the production figures for the winter season were reduced to a daily basis in order to correct for the differences in the length of the winter feeding period on the different rations, the alfalfa-fed cows (ration 1) produced 74.6 percent as much milk as the barley-fed cows (ration 2), and the silage-fed cows (ration 3) produced 86.6 percent as much as the barley-fed cows.

The data in table 10 indicate that the nutrients in ration 2 were used somewhat more efficiently than the nutrients in the other two rations, with ration 3 second in efficiency.

In the analysis of the data in table 10, the differences in the time of year or season the cows calved and started on the different rations have an effect on the results shown. In general, the ration on which the greatest number of cows freshened early in the winter season would have the greatest number of cows producing at their maximum rate during the period covered by these data and the cows on that ration would show greater average production and greater efficiency in the utilization of feed. They would likewise be more likely to lose weight and to show a deficit in the consumption of nutrients as compared to requirements. Six of the twelve cows freshened during the winter season to start on ration 1, 9 on ration 2, and 10 on ration 3. There were only 4 cows (E-42, E-43, E-44, and A-42) that were at all comparable in the season of freshening with respect to the winter season, and they are not as comparable as is to be desired. Their dates of freshening and starting on the different rations may be seen in table 4. The average length of time during the winter season that these 4 cows were on rations 1, 2, and 3 was 182, 166, and 164 days, respectively. The greater length of time these 4 cows were on ration 1 appears to make a separate comparison of the data inadvisable.

Cow E-25's record in these experiments is an unusual one. This cow was larger than any other cow in the group and yet on ration 1 she was the lightest consumer of roughage. She consumed an average of 23.1 pounds of hay per day, failing by a much larger margin than any other cow in the group to consume sufficient nutrients to meet requirements, but she gained 46 pounds in weight and was the ninth highest butterfat producer among the 12 cows. On ration 2, she was again the heaviest cow and the lightest consumer of nutrients,

failing by the widest margin to consume enough to meet requirements. But on ration 2 she was the lowest producer. On all three rations she was among the group that utilized the nutrients consumed most efficiently.

PASTURE SEASON

The number of days the cows were on pasture, their milk and butterfat production, feed consumption, and weights while on pasture, are given in table 11. Six of the cows freshened during the pasture season to start on ration 1, three to start on ration 2, and two to start on ration 3. The larger number of cows that freshened during the pasture season to start on ration 1 accounts for the shorter average period on pasture for that ration than for rations 2 and 3.

Daily production per cow averaged 27.5 pounds of milk containing 0.91 pound of butterfat for ration 1, 33.04 pounds of milk containing 1.01 pounds of butterfat for ration 2, and 26.6 pounds of milk containing 0.82 pound of butterfat for ration 3.

The figures for quantities of feed and the number of pasture days (table 11) include the period from calving to the start of the record, for the cows that calved during the pasture season. This period ranged from 4 to 7 days. The total given for pasture days in table 11 (column 8) is, therefore, longer in some cases than the figures given for length of period on pasture (column 2). On rations 1 and 3, the supplemental feed was fed during that part of the pasture season when the grass was short. On ration 2, alfalfa hay was likewise fed only when pasture was short, but the ground barley was fed throughout the pasture season according to the level at which the cow was producing. If spread out over the entire pasture season the supplemental feeds consumed would amount to 2.65 pounds of alfalfa hay per cow daily on ration 1, 3.44 pounds of alfalfa hay, and 5.45 pounds of ground barley on ration 2, and 1.75 pounds of alfalfa hay and 9.4 pounds of corn silage on ration 3. Thus on rations 2 and 3, the cows received supplemental feeds (in addition to the ground barley fed in ration 2) at a somewhat heavier rate than on ration 1.

On ration 1, 6 cows gained weight and 6 lost weight during the pasture season, with an average net gain of 42 pounds per cow. The cows that freshened during the pasture season were the ones that lost weight. On ration 2, 10 cows gained weight and 2 lost weight, with an average net gain of 57 pounds per cow for the season. On ration 3, 9 cows gained weight and 3 lost weight, with an average net gain of 99 pounds per cow for the season.

The nutritive requirements of the cows for maintenance and production, allowance being made for gain or loss in weight, were calculated on the basis of the Haecker feeding standard. From the total requirements for total digestible nutrients thus calculated, the total digestible nutrients contained in the supplementary feeds have been subtracted. The difference is assumed to be the quantity of total digestible nutrients obtained from pasture (table 11). The average daily requirement per cow was 20.43 pounds of total digestible nutrients on ration 1, 22.32 pounds on ration 2, and 20.92 pounds on ration 3. The quantity of nutrients in the supplementary feeds was

TABLE 11.—Total digestible nutrients required during the pasture season on each ration, the amount consumed in supplementary feeds, and the amount credited to the pasture

RATION 1

Cow No.	Period on pasture	Production			Supplementary feed				Average body weight	Net gain (+) or loss (—) in body weight	Total digestible nutrients					
		Milk	Butterfat	Alfalfa hay	Corn silage	Pasture ¹	Grain	Required for—				Consumed				
								Maintenance			Production	Gain (+) or loss (—) in weight	Total	In supplementary feeds	Credited to pasture	
	Days	Pounds	Percent	Pounds	Pounds	Pounds	Days	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
E-25	147	3,904.3	3.54	138.07	223	0	150	0	1,566	—50	1,886.41	1,229.85	—58.90	3,057.36	113.95	2,943.41
E-34	147	4,838.3	3.11	150.66	338	0	147	0	1,212	—30	1,450.37	1,403.11	—53.90	2,799.58	172.72	2,626.86
E-38	106	2,585.1	3.59	92.79	170	0	107	0	1,345	—54	1,183.16	822.06	—132.22	1,873.00	89.94	1,783.06
E-40	106	2,801.3	3.40	95.30	143	0	98	0	1,144	—110	915.69	800.00	—306.87	1,468.82	73.07	1,395.75
E-41	146	4,902.3	3.09	154.20	582	0	146	0	1,328	+38	1,536.56	1,442.77	+182.14	3,161.47	297.40	2,864.07
E-42	148	3,293.9	3.02	99.33	435	0	148	0	1,538	+164	1,803.93	938.76	+578.92	3,321.61	222.29	3,099.32
E-43	146	3,571.7	3.28	117.30	332	0	146	0	1,375	+195	1,590.95	1,071.51	+688.35	3,350.81	169.65	3,181.16
E-44	123	2,404.3	3.19	76.72	280	0	123	0	1,379	+161	1,312.05	709.27	+568.33	2,589.65	143.09	2,446.57
E-45	157	3,760.0	2.89	108.69	722	0	154	0	1,276	—37	1,638.19	1,018.96	—24.21	2,632.94	368.94	2,264.00
E-46	146	4,482.1	2.89	129.47	461	0	146	0	1,284	+111	1,485.65	1,214.65	+412.63	3,112.93	235.57	2,877.36
A-42	123	2,143.0	3.39	72.72	308	0	123	0	1,384	+193	1,349.09	657.90	+681.29	2,688.28	157.39	2,530.89
W-201	137	5,771.3	3.24	187.08	365	0	136	0	1,368	—64	1,528.64	1,708.30	—120.32	3,116.62	186.52	2,930.10
Average	143.5	3,712.3	3.19	118.53	364	0	135.3	0	1,350	+42	1,473.39	1,089.76	+201.27	2,764.42	185.88	2,578.54

RATION 2

E-25	173	5,606.2	3.09	173.12	455	0	173	998	1,573	—43	2,153.16	1,620.19	—52.59	3,720.76	1,017.94	2,702.82
E-34	140	3,858.6	3.16	121.77	475	0	144	617	1,323	+81	1,403.03	1,130.57	+391.53	2,985.13	728.31	2,256.82
E-38	173	4,550.8	3.15	143.15	806	0	173	708	1,542	+32	2,114.13	1,333.38	+360.47	3,604.47	989.07	2,615.40
E-40	110	2,624.4	3.20	83.98	173	0	110	444	1,330	+158	1,164.66	776.82	+570.54	2,512.02	437.83	2,074.19
E-41	121	5,545.2	3.23	179.32	428	0	127	996	1,476	—150	1,485.56	1,640.92	—396.70	2,735.78	1,002.56	1,733.22
E-42	112	3,247.0	3.41	110.70	158	0	112	478	1,574	+136	1,397.09	1,060.08	+469.16	2,860.33	456.93	2,403.40
E-43	173	5,000.1	2.98	166.80	669	0	173	1,001	1,409	+69	1,931.77	1,584.83	+281.07	3,798.57	1,129.65	2,668.92
E-44	173	4,548.0	3.02	137.58	844	0	173	671	1,401	+88	1,916.70	1,290.35	+322.64	3,535.69	959.36	2,576.33
E-45	148	4,655.1	2.79	129.83	398	0	148	692	1,333	—68	1,603.47	1,201.53	+317.04	3,142.04	747.98	2,394.06
E-46	173	7,215.9	2.71	195.90	725	0	173	1,241	1,312	+15	1,708.78	1,926.05	+140.16	3,865.58	1,347.15	2,518.43
A-42	146	4,192.3	3.24	135.70	357	0	146	709	1,367	+184	1,581.69	1,240.31	+649.52	3,480.52	740.41	2,740.11
W-201	129	6,879.7	3.15	216.91	655	0	133	1,176	1,406	+25	1,481.97	2,015.75	+109.05	3,606.77	1,260.32	2,346.55
Average	147.6	4,877.0	3.07	149.56	512	0	148.8	811	1,422	+57	1,671.00	1,403.53	+246.61	3,321.14	899.78	2,421.36

RATION 3

E-25-----	146	2,832.4	3.20	90.75	94	1,468	146	0	1,630	+55	1,886.00	838.39	+207.75	2,932.14	322.55	2,609.59
E-34-----	173	3,348.4	2.53	84.50	192	1,023	173	0	1,214	+183	1,694.43	857.19	+681.99	3,183.61	457.71	2,725.90
E-38-----	146	3,382.3	2.96	100.11	162	1,451	146	0	1,530	+163	1,770.29	953.81	+575.39	3,299.49	349.01	2,950.48
E-40-----	101	3,959.7	2.85	112.75	423	2,078	101	0	1,360	+106	1,735.28	1,088.92	+406.18	3,230.36	604.74	2,625.62
E-41-----	153	5,358.4	3.17	109.87	327	1,128	153	0	1,258	-5	1,525.36	1,575.37	+142.96	3,243.69	378.04	2,865.65
E-42-----	156	3,026.9	3.12	113.16	414	2,104	156	0	1,537	+215	1,900.19	1,055.43	+770.15	3,725.77	605.00	3,120.77
E-43-----	153	4,239.6	3.43	145.49	364	1,250	153	0	1,303	+100	1,652.68	1,310.04	+354.60	3,317.32	419.75	2,897.57
E-44-----	130	2,016.2	3.37	68.02	108	374	130	0	1,420	+161	1,469.14	614.94	+568.33	2,652.41	125.13	2,527.28
E-45-----	141	4,978.6	2.76	137.46	257	1,068	141	0	1,165	-68	1,368.42	1,344.22	-133.64	2,577.00	331.05	2,245.95
E-46-----	153	4,701.1	3.14	147.82	353	1,068	153	0	1,186	+130	1,438.06	1,372.72	+474.00	3,285.68	380.10	2,905.58
A-42-----	173	4,689.5	2.97	139.03	340	1,846	173	0	1,320	+199	1,809.75	1,321.59	+722.47	3,853.81	518.94	3,334.87
W-201-----	122	4,898.8	3.38	105.54	150	1,331	122	0	1,373	-51	1,371.01	1,503.93	-137.24	2,737.70	325.55	2,412.15
Average-----	150.6	4,002.4	3.07	122.88	265	1,424	151.5	0	1,360	+90	1,632.38	1,153.05	+384.49	3,169.92	401.47	2,768.45

¹ See text, p. 25

1.37 pounds for ration 1, 6.05 pounds for ration 2, and 2.65 pounds for ration 3. Thus the average daily quantity of digestible nutrients each cow obtained from pasture was 19.06, 16.27, and 18.27 pounds, respectively, for the three rations.

The proportion of the total feed requirement for the pasture season that was derived from pasturage was calculated at 93.3 percent for ration 1, 72.9 percent for ration 2, and 87.3 for ration 3. The proportion of the total feed requirement for the entire lactation period derived from pasture was 41.2, 34.1, and 41.0 percent, respectively, for rations 1, 2, and 3.

The daily consumption of nutrients from pasture was sufficient for maintenance and for the production of 27.2 pounds of milk and 0.865 pound of fat on ration 1; 17.4 pounds of milk and 0.534 pound of fat on ration 2; and 26.0 pounds of milk and 0.798 pound of fat on ration 3, if no allowances are made for gains or losses in weight.

Table 12 shows the average daily quantity (calculated) of total digestible nutrients obtained from pasture during each month of the pasture season for each of the three rations.

TABLE 12.—Average daily quantity of total digestible nutrients obtained from pasture (per cow) for each month of the pasture season

Ration fed	May	June	July	August	September
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Ration 1 ¹	20.56	20.83	20.97	18.60	16.37
Ration 2 ²	20.42	19.85	14.95	15.86	14.03
Ration 3 ³	22.53	21.26	17.86	16.38	12.59
Average.....	21.17	20.65	17.93	16.95	14.33

¹ 5 cows on pasture in 1931; 1 in 1932; 5 in 1933; and 1 in 1935.

² 5 cows on pasture in 1933; 5 in 1934; and 2 in 1935.

³ 5 cows on pasture in 1932; 4 in 1933; and 3 in 1934.

The smaller amount of nutrients the cows on ration 2 obtained from pasture, as shown in each of these monthly calculations, is no doubt due to the fact that cows receiving supplemental feeds do not work as hard to obtain the greatest possible quantity of nutrients as cows whose entire supply of nutrients must be obtained from pasturage. At the Huntley station⁴ the Bureau found that cows on pasture that received no supplemental feeds grazed an average of 9.16 hours per day (between 5 a. m. and 9 p. m.); cows that received alfalfa hay in addition to the pasture grazed 29 percent less time than the cows on pasture alone; those that received grain at the rate of 1 pound to each 6 pounds of milk produced, grazed 39 percent less time; and those that received grain at the rate of 1 pound to each 3 pounds of milk produced, grazed 42 percent less time.

⁴ See footnote 3, p. 2.

FACTORS AFFECTING PRODUCTION AND REPRODUCTION

Data bearing on reproduction, on sex and weight of calves, and on other factors that might affect milk and butterfat production on the different rations, such as the length of time the cows were dry prior to the lactation on a given ration, and the length of the period between freshening and subsequent conception, are brought together in table 13.

In order to show the effect of the preceding ration on some of the reproduction items, the data are given both for the calving just before the cow started on the ration and for the calving immediately following lactation, for each of the rations. In studying these data reference to table 2, which gives the order of succession of the four rations, will be helpful. In brief, it may be stated that the full-grain ration was the first in the order of occurrence for all cows. Six of the twelve records made on ration 1 each followed a record made on the full-grain ration, except that for one cow a nonexperimental lactation intervened between the record on full grain and the record on ration 1. The remaining six records made on ration 1 each followed a record made on ration 3. Eleven of the records made on ration 2 each followed a record made on rations 1 or 3 and the twelfth record followed a lactation not in this experiment that had been preceded by a lactation on full grain. Ten of the records made on ration 3 each followed a record made on the full-grain ration or ration 2, and the other two each followed a record on ration 1.

TABLE 13.—Breeding and calving data for the period preceding the experimental lactation on each ration, and for the period during the experimental lactation

FULL-GRAIN RATION

Cow No.	Period preceding the experimental lactation					Period during the experimental lactation period					
	Times bred	Length of gestation period	Length of dry period ¹	Calving condition	Sex ² and weight of calf	Time from calving to first heat period	Times bred	Time from calving to conception	Length of gestation period	Calving condition	Sex ² and weight of calf
	Number	Days	Days			Days	Number	Days	Days		
E-25.....	1	278	(⁰)	Normal.....	F 86	92	3	143	277	Normal.....	F 90
E-34.....	1		(⁰)	.....do.....	M 77	148	2	169	284	.....do.....	M 77
E-38.....	4	293	(⁰)	.....do.....	M 110	65	1	65	286	.....do.....	F 91
E-40.....	3	290	(⁰)	.....do.....	F 110	45	2	67	285	.....do.....	M 103
E-41.....	7	291	(⁰)	.....do.....	F 97	77	2	109	290	.....do.....	F 96
E-42.....	1	287	(⁰)	.....do.....	F 103	71	3	147	274	.....do.....	M 103
E-43.....	1	271	(⁰)	(⁰).....do.....	F 57	5	5	220	277	.....do.....	F 87
E-44.....	1	291	(⁰)	(⁰).....do.....	M 37	2	2	100	284	.....do.....	M 101
E-45.....	2	286	(⁰)	Normal.....	F 101	85	8	279	277	(⁰).....do.....	F 96
E-46.....	1	285	(⁰)	.....do.....	F 97	91	3	161	279	Normal.....	F 103
A-42.....	1	281	81	.....do.....	M 105	83	1	83	283	.....do.....	F 102
W-201.....	2	283	24	.....do.....	M 110	69	3	161	285	.....do.....	F 88
Average.....	2.08	285			90.6	76.7	2.9	142.0	281.8		94.8

RATION 1

E-25.....	3	277	215	Normal.....	F 90	33	2	222	279	Normal.....	M 109
E-34.....	2	284	66	.....do.....	M 77	79	1	149	292	.....do.....	M 120
E-38.....	1	280	30	.....do.....	F 91	55	7	276	290	(⁰).....do.....	F 90
E-40.....	2	285	40	.....do.....	M 103	15	5	197	292	Normal.....	M 103
E-41.....	3	282	54	.....do.....	F 85	79	2	103	284	.....do.....	F 85
E-42.....	1	281	48	.....do.....	M 112	57	1	130	282	.....do.....	F 84
E-43.....	1	278	45	.....do.....	F 81	33	1	99	278	.....do.....	M 90
E-44.....	1	285	52	.....do.....	M 102	34	1	124	285	.....do.....	M 88
E-45.....	2	280	73	.....do.....	F 100	107	5	261	279	(⁰).....do.....	M 105
E-46.....	1	289	55	.....do.....	F 85	43	1	104	281	Normal.....	F 83
A-42.....	1	283	48	.....do.....	F 102	36	1	120	286	.....do.....	F 88
W-201.....	3	285	54	.....do.....	F 88	30	1	94	283	.....do.....	M 100
Average.....	1.75	282.9	65.4		93.0	50.9	2.3	157.3	284.3		97.1

RATION 2

E-25.....	2	281	52	Normal.....	F	95	137	1	137	285	Normal.....	F	90
E-34.....	1	292	81	do.....	M	120	112	2	130	287	do.....	M	117
E-38.....	1	284	105	do.....	M	101	115	4	182	(¹)	do.....	M	103
E-40.....	5	292	36	do.....	M	103	105	1	105	288	Normal.....	M	80
E-41.....	1	281	39	do.....	F	92	28	2	183	282	do.....	F	90
E-42.....	1	282	56	do.....	F	84	105	1	105	281	do.....	F	89
E-43.....	1	278	93	do.....	M	90	104	1	164	276	do.....	(¹)	(¹)
E-44.....	1	285	114	do.....	M	98	135	2	100	271	do.....	F	86
E-45.....	5	279	180	(¹)	M	105	27	1	137	274	do.....	F	80
E-46.....	1	281	40	Normal.....	F	83	164	2	185	278	do.....	F	100
A-42.....	1	286	96	do.....	F	88	50	2	128	287	do.....	M	90
W-201.....	1	283	50	do.....	M	100	30	1	92	286	do.....	F	94.9
Average.....	1.7	283.7	70.3	-----	-----	96.5	98.2	1.7	142.8	281.4	-----	-----	-----

RATION 3

E-25.....	2	279	36	Normal.....	M	109	55	2	220	281	Normal.....	F	95
E-34.....	2	287	77	do.....	M	117	146	2	199	287	do.....	M	135
E-38.....	7	290	57	(¹)	F	90	63	1	108	284	do.....	M	101
E-40.....	1	288	50	Normal.....	M	103	26	1	121	279	do.....	F	80
E-41.....	2	290	51	do.....	F	96	17	3	162	282	do.....	F	85
E-42.....	1	281	44	do.....	F	89	116	1	116	281	do.....	M	112
E-43.....	5	277	43	do.....	F	87	42	1	95	278	do.....	F	81
E-44.....	2	284	89	do.....	M	101	42	1	87	285	do.....	M	102
E-45.....	8	277	48	(¹)	F	96	44	2	153	280	do.....	F	100
E-46.....	3	279	48	Normal.....	F	103	26	1	143	289	do.....	F	85
A-42.....	2	287	85	do.....	M	100	92	1	92	278	do.....	(¹)	(¹)
W-201.....	1	286	55	do.....	F	90	18	1	100	276	do.....	F	93
Average.....	3.0	283.7	50.9	-----	-----	98.4	57.3	1.4	132.2	281.7	-----	-----	97.2

¹ All dry periods longer than 90 days are calculated as 90 days in averages.

² F = female; M = male.

³ Heifer with no previous lactation.

⁴ Calf born dead.

⁵ Difficult calving, calf died.

⁶ Retained placenta.

⁷ No record, cow sold before calving.

⁸ Twin males, 85 and 76 pounds, respectively, not included in the average weight.

⁹ Mixed twins weighing 86 pounds each, not included in the average weight.

EFFECT OF THE RATION ON BREEDING EFFICIENCY

The 12 cows required an average of 2.08 services per conception prior to starting the lactation on full grain and 2.9 services per conception during the lactation on full grain. There were 3 cows that required 3 or more services for a conception prior to the lactation on full grain and 6 cows that required 3 or more services for a conception while they were on the full-grain ration. Ordinarily more services are required for the first conception than for subsequent conceptions.

The 12 cows required an average of 1.83 services for the conception prior to the start of the lactation on ration 1 and 2.3 services for the conception during the lactation on ration 1. There were 5 cows whose lactation on ration 1 followed a lactation on full grain. These 5 cows averaged 1.8 services for the conception prior to the lactation on ration 1 and 3.0 services for the conception during the lactation on ration 1; 2 of the 5 cows required 5 and 7 services, respectively, while on ration 1 and the other 3 each required 1 service per conception. There were 6 cows whose lactation on ration 1 followed a lactation on ration 3. These 6 cows required an average of 1.5 services for the conception to start on ration 1 and 1.83 services for the conception during the lactation on ration 1. Two of these 6 cows required more than 1 service for a conception for the calvings prior to and following the lactation on ration 1.

Eleven of the twelve cows were on rations 1 or 3 before making their records on ration 2. The 11 cows required an average of 1.82 services per conception for the calving prior to the lactation on ration 2 and 1.73 services per conception during the lactation on ration 2. However, only 3 cows required more than 1 service for the calving prior to the lactation on ration 2 and they required 2, 5, and 5 services, respectively; while there were 6 cows that required more than 1 service for a conception during the lactation on ration 2.

Ten of the records made on ration 3 followed a record made on either the full-grain ration or ration 2; the other 2 records each followed a record made on ration 1. The 10 cows (that made a record on full grain or ration 2 prior to the record on ration 3) required an average of 2.7 services per conception for the calving to start on ration 3, and 1.4 services per conception during the lactation on ration 3. Seven of the ten cows required more than 1 service per conception for the calvings prior to, and 3 of the 10 required more than 1 service per conception for the calvings following ration 3. Two cows (E-25 and E-38) made records on ration 1 just before making their records on ration 3. Cow E-25 required 2 services for the conception during the lactation on ration 1 and 2 services for the conception on ration 3. Cow E-38 required 7 services for the conception during the lactation on ration 1 and 1 service for the conception on ration 3.

On the whole, it appears that the cows were far more regular breeders when they were on the two roughage rations (rations 1 and 3) than when they were on the two rations in which grain was fed. There are so many other factors that may be responsible for irregularity in breeding efficiency, however, that it is not wise to draw too definite conclusions from such limited numbers and from experiments in which the rations were changed so often. In addition to disease or other abnormal conditions that may cause irregularity in breeding, there

is the question of the presence or absence of hereditary, or constitutional vigor of reproduction.

Some cows were relatively uncertain breeders on a number of the rations. Cow E-38 is an example. She required 4, 1, 7, 1, 4 services per conception, respectively, for her five calvings in this experiment (see table 2 for the order in which the different rations were fed). This was an average of 3.4 services per conception. Cow E-41 is another example with 7, 2, 3, 1, 2 services respectively, for five conceptions, or an average of 3.0. Cow E-45 with 2, 8, 2, 5, 1 services, respectively, for five conceptions, had an average of 3.6 services per conception. Some examples of good breeding records on all rations are: Cow A-42 with 1, 1, 1, 2, and 1 services for each conception, an average of 1.2; cow E-42 with 1, 3, 1, 1, 1, and 1 services for each conception with an average of 1.3; and cow E-44 with 1, 2, 1, 1, and 2 services for each respective conception, an average of 1.4. It can be stated definitely, however, that there is no evidence to indicate that rations 1 and 3 were in any way detrimental to breeding efficiency.

EFFECT OF EARLY CONCEPTION ON YIELD AND PERSISTENCY

Records were also kept of the time elapsing between calving and the first oestrus on the different rations. (See table 13.) The average time was 76.7 days for the full-grain ration, 98.2 days for ration 2, 50.9 days for ration 1, and 57.3 days for ration 3. It appears that the elapsed time was somewhat shorter when the cows were on the two rations that were composed entirely of roughage. The significance of this fact is not known. The average length of the gestation period when the cows were on the different rations was very uniform, ranging from 281.4 days for ration 2 to 284.3 days for ration 1.

It is generally thought that if a cow is bred soon after she freshens she is not likely to reach as high a level of milk flow, nor to be as persistent in milk yield, as when a long period elapses between freshening and the next conception. A. B. Chapman and L. E. Casida⁹ of Wisconsin have presented some data that indicate the sooner cows are bred following calving, the better they will produce for each day between the start of the lactation and the next calving. These results do not prove or disprove this theory since the data are not entirely comparable to those of Chapman and Casida, but they do have a bearing on the subject. A study of the data in table 13, which show the days elapsing between calving and the next conception on the different rations, and the data in table 7 which show the daily average milk yield by months of lactation and the percentage that the average daily milk yield for any given month is of the average daily yield for the month of maximum yield, appears to indicate that both yield and persistency of yield are markedly affected by the length of the period between calving and the subsequent conception. Three cows on the full-grain ration conceived in less than 90 days after they had calved—the average time being 71.7 days—and in the tenth month of lactation they were producing an average of 17 pounds of milk per day, which was an average of 45.9 percent of their maximum yield in any month. Four cows on this ration conceived between 90 and 150 days after calving—the average time being 125 days—and their average daily yield in the tenth month was 22.7 pounds,

⁹ Amer. Soc. Anim. Prod. Rec. Proc. Ann. Meeting 1935: 66-70.

or 59.0 percent of the maximum monthly yield. Five cows on this ration did not conceive until more than 150 days had elapsed from the date of calving—the average time being 198 days—and their average daily yield in the tenth month was 26.4 pounds, or 68.8 percent of the maximum monthly yield. These averages show a step up in yield, and in percentage of the maximum yield, for each additional division of time elapsing between calving and conception.

Studies were made of the yield and persistency of the different cows (on rations 1, 2, and 3) for similar time intervals between calvings and subsequent conceptions, that is, for intervals of less than 90 days, between 90 and 150 days, and more than 150 days following calving. On rations 1, 2, and 3 there were, with one exception, no conceptions in less than 90 days following calving, and that exception was 87 days. On ration 1, there were eight cows that conceived an average of 116 days following calving and their average yield in the tenth month was 10.1 pounds, or 23.4 percent as much as the highest monthly average. The other four cows on that ration conceived an average of 239 days after calving and their average yield in the tenth month was 16.9 pounds, or 47.5 percent as much as the highest monthly average. On ration 2, there were seven cows that conceived an average of 120 days following calving and their average daily yield in the tenth month was 19.7 pounds, or 39.5 percent of the highest monthly average. The other five cows on ration 2 conceived an average of 175 days following calving and their average daily yield in the tenth month was 18.2 pounds, or 36.1 percent of the highest monthly average. This is the only instance in which yield and persistency were greater for the cows having the shorter period between calving and conception. On ration 3, eight cows conceived an average of 108 days following calving and their average yield in the tenth month was 11.5 pounds, or 26.9 percent as much as in the highest month. The figures for the other four cows on this ration, that conceived an average of 181 days following calving, are 17.1 pounds and 43 percent.

The data show that the persistency of yield was somewhat more affected by early conception when the cows were on ration 1 than when they were on ration 3, but that it was depressed much more sharply when the cows were on the two roughage rations than when they were on the two grain rations.

The average weight of the calves born, as the result of conceptions during the lactations on the different rations, indicates that those conceived while their dams were on the two roughage rations were slightly heavier than those conceived while their dams were on the two rations that included grain, although the difference is not great. There were 15 female and 9 male calves born as a result of conceptions while the dams were on the two grain rations and 13 females and 12 males while the dams were on the roughage rations.

SUMMARY AND CONCLUSIONS

Twelve Holstein cows were each fed four different rations, each ration being fed for one complete lactation period. In one lactation period they were fed the so-called full-grain ration, that is, a grain mixture consisting of barley, 2 parts; oats, 1 part; and wheat bran, 1 part (at the average rate of 1 pound to each 4.33 pounds of milk

produced), pasture in season, and alfalfa hay and corn silage when they were not on pasture.

In another lactation period they were fed only alfalfa hay, and pasturage during the pasture season. This is ration 1.

In still another lactation period they were fed ground barley as the sole grain (at the rate of 1 pound to each 6.03 pounds of milk produced). In addition they were fed alfalfa hay, and pasturage during the pasture season. This is ration 2.

During a fourth lactation period they were fed alfalfa hay and corn silage, and pasturage during the pasture season. This is ration 3.

Compared to their production on the full-grain ration, the 12 cows produced 69.75 percent as much milk and 65.77 percent as much butterfat on ration 1, 86.03 percent as much milk and 80.24 percent as much butterfat on ration 2, and 73.57 percent as much milk and 69.93 percent as much butterfat on ration 3 (mature basis). The percentage of butterfat in the milk averaged considerably lower when the cows were on rations 1, 2, and 3 than when they were on the full-grain ration. The reverse was true in two other experiments conducted by the Bureau of Dairy Industry.

Only 4 of the 12 cows were consistent in their relative yield throughout the 4 lactation periods, 2 of these being among the 5 highest-producing cows, and 2 among the 5 lowest-producing cows on each of the 4 rations. Many things may happen in the course of four lactation periods to affect the relative yield other than the rations that are being weighed. Among the important things are abnormal calvings and differences in the length of time between freshening and conception, and in the length of the dry period.

On the full-grain ration, 4 of the 12 cows reached their maximum daily yield in the first month of lactation, 5 in the second month, and 3 in the third month. The total yield, and the persistency of yield, were greatest for those reaching their maximum yield in the third month and least for those reaching their maximum yield in the first month.

On ration 1, all but 2 of the 12 cows reached their maximum yield in the first month of lactation. The cows that were on pasture during the early months of their lactation period declined much more rapidly in milk flow than those that had little or no pasturage during the early months of lactation. The cows probably would have produced considerably more had they had access to alfalfa hay throughout the pasture season.

On ration 2, all but 2 of the 12 cows reached their maximum yield during the first month of lactation; and on ration 3 all but 1 reached the maximum in the first month.

In the sixth month of lactation, the average daily yield (expressed as a percentage of daily yield in the highest month) was 82.2 percent for the full-grain ration, 63.7 percent for ration 1, 66.8 percent for ration 2, and 72.7 for ration 3. In the tenth month, the relative percentages were 59.7, 30.6, 38.0, and 33.2, respectively, for the four rations.

The changes in weight during the first 3 months of the lactation period on rations 1, 2, and 3 were remarkably uniform. Up to and including the tenth month, the cows made an average net gain of 10 pounds on ration 1, an average loss of 19 pounds on ration 2, an average gain of 34 pounds on ration 3. Since, on the average, at the

end of the tenth month they were still 4 months away from the next calving, there is little question but that they regained the precalving weights for the different rations.

On ration 1 the cows consumed an average of 34.8 pounds of alfalfa hay per day during the part of the lactation that they were not on pasture. One cow ate only 23.1 pounds per day, but the heaviest consumer ate 45.8 pounds per day. The amount of hay consumed probably would have been increased had they been offered sufficient hay to permit a larger refusal of the least palatable parts of the hay. In this experiment the hay offered was so limited that the refusal was less than 2 percent.

During the winter feeding season, the cows consumed an average of 30.6 pounds of dry matter per day on ration 1; 32.85 pounds on ration 2; and 32.76 pounds on ration 3. On ration 1 they failed to consume sufficient nutrients to meet requirements by 1.19 percent, although they gained an average of 4 pounds per cow; on ration 2 they failed to consume sufficient nutrients to meet requirements by 3.6 percent, and the average loss in weight was 36 pounds; and on ration 3 they failed to meet requirements by 0.64 percent, and the average loss in weight was 25 pounds. During the winter feeding season, 21 percent of the total digestible nutrients for ration 2 came from the barley, and 39.8 percent of the nutrients for ration 3 came from the corn silage.

During the pasture season, the average amount of supplemental feeds fed to each cow on the different rations was: Ration 1, 2.65 pounds of alfalfa hay per day; ration 2, 3.44 pounds of alfalfa hay and 5.45 pounds of ground barley per day; and ration 3, 1.75 pounds of alfalfa hay and 9.4 pounds of corn silage per day. The amount of total digestible nutrients supplied by these supplementary feeds was 1.35 pounds per day for ration 1, 6.05 pounds per day for ration 2, and 2.65 pounds per day for ration 3. It is estimated that each cow obtained the following daily amounts of total digestible nutrients from pasture: Ration 1, 18.75 pounds; ration 2, 16.27 pounds; and ration 3, 18.27 pounds. During the pasture season, on ration 1 the cows obtained 93.3 percent of their nutrient requirements from the pasturage; on ration 2, 72.9 percent; and on ration 3, 87.3 percent. On ration 2, the cows were fed the ground barley throughout the pasture season, while on rations 1 and 3 they were fed supplemental feeds only when the grass was short.

There is some evidence to indicate that these cows were more regular breeders when they were on the rations in which no grain was fed.

The calves that were born as a result of conceptions that occurred while their dams were on the roughage rations were slightly heavier than those born as a result of conceptions occurring while the dams were on the rations that included grain.

END