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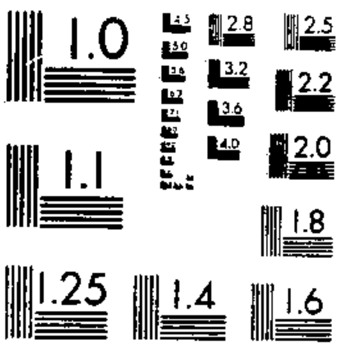

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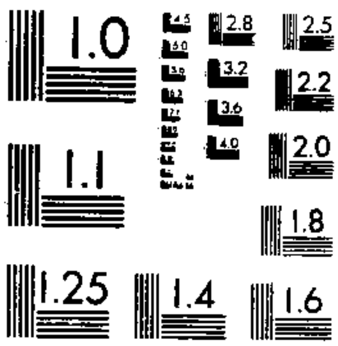

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Technical Bulletin No. 1314

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
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CONTENTS

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ERRATA

INFLUENCE OF TOTAL FEED AND PROTEIN INTAKE ON REPRODUCTIVE PERFORMANCE OF THE BEEF FEMALE THROUGH SECOND CALVING

Technical Bulletin No. 1314

Please make the following corrections on page 9, figure 1:

1. Change word "protein" at top of each chart to "energy."
2. Change "energy" in legend block to "protein."

February 1965

Influence of Total Feed and Protein Intake on Reproductive Performance in the Beef Female Through Second Calving [1]

By J. N. Wiltbank, *research physiologist (animal)*; J. Bond, *research animal husbandman*; and E. J. Warwick, *agricultural administrator*, in collaboration with R. E. Davis, *research chemist (biochemistry)*; A. C. Cook, *animal husbandman*;[2] W. L. Reynolds, *research physiologist (animal)*; and M. W. Hazen, *animal husbandman*,[2] *Animal Husbandry Research Division, Agricultural Research Service*.[3]

A major problem in the beef industry is poor reproductive performance. Reproductive performance of beef females is influenced by the quantity and quality of feed. More knowledge about the influence of nutrition on the reproductive performance of beef females could lead to more effective and more efficient supplementation of their diet. More effective supplementation could result in better reproductive performance through increasing calf crop and by concentrating calving of a herd in a shorter period of time. This bulletin reports the results of an experiment undertaken to study the effect of total feed intake (for convenience called "energy") and of protein on the reproductive performance of beef females.

REVIEW OF LITERATURE

Nutrition plays a significant role in the reproductive performance of farm animals. The literature on this subject has been reviewed by Asdell (*1*),[4] Reid (*51*, *52*), Blaxter (*6*), and Hafez (*25*). The review of literature in this bulletin, therefore, will deal mainly with the effect of nutrition on the reproductive performance of beef cows.

Calf crop varies from year to year (*2*, *10*, *11*, *29*, *33*, *36*, *46*, *47*, *61*) and from area to area (*19*, *27*). Differences in range condition and condition of the cow are two of the main factors reported to be responsible for variation in calf crop. Parr and Klemmedson (*47*) reported that on seven ranches where forage was scare the calf crop was 49 percent while on eight ranches where forage supply was normal, the calf crop was 80 percent.

Hilts (*28*) reported that cows turned out in good condition had a calf crop of 70 percent, whereas those turned out in poor condition had a calf crop of 52 percent. Walker and Lantow (*59*) observed that

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[1] The research performed at Jeanerette, La., was done in cooperation with the Louisiana Agricultural Experiment Station.

[2] Now retired.

[3] The authors gratefully acknowledge contributions from W. A. Curry and Banner L. Phillips, Animal Husbandry Research Division, ARS; Thomas Meredith, resigned; and T. M. DeRouen, Louisiana Agricultural Experiment Station.

[4] Italic numbers in parentheses refer to Literature Cited, p. 37.

the calf-crop percentage increased when cows had enough forage. Baker and Quesenberry (*2*) reported calf crops of 77 percent and 68 percent in years following a drought compared to an average of 85 percent in years following normal rainfall. Knox and Watkins (*33*) reported that 78 percent of cows gave birth to calves in the years following drought compared to 92 percent in years following average rainfall.

Marsh and others (*40*) in Montana reported that cows on heavily grazed pasture (23.1 acres per cow) weaned a calf crop of 70 percent; those on moderately grazed pasture (30.5 acres per cow), a calf crop of 89 percent; and those on lightly grazed pasture (38.8 acres per cow), a calf crop of 90 percent. The work of McIlvain (*42*) in Oklahoma shows that the average calf crop weaned from cows on heavily grazed range (12 acres per cow) was 83 percent; from cows on moderately grazed range (17 acres per cow), 90 percent; and from cows on lightly grazed range (22 acres per cow), 93 percent. Cows on heavily grazed range calved later than those on moderately grazed range.

Studies in Oklahoma (*48*) show that heifers and cows wintered on low levels of feed had approximately as many calves as those on moderate, high, or very high levels of feed. Adequate forage was available for all these animals in summer. The average calving date was later for animals that had wintered on the lower levels of feed than for those that had wintered on higher levels of feed.

Protein and energy supplements fed to cows do not always improve calf crop, as indicated by the work of Stanley (*54*). He fed cottonseed cake, white corn, yellow corn, and cottonseed cake plus cornmeal to groups of cows on range pasture, but the calf crop did not differ in the supplemented and control groups. On the other hand, Lantow and Snell (*35*) showed that cows fed cowpea hay and sorghum silage on pasture had a 100-percent calf crop compared with 20 percent for cows in the control pasture group. Similarly, Walker and Lantow (*59*) reported that the calf crop increased when cows were fed high roughage and concentrate.

Black and others (*3*) reported that the calf crops of cows fed cottonseed cake and of cows fed no cake did not differ. However, in years that the control cows were left on range and received no supplemental hay, the cows fed cake did have a better calf crop. Guilbert and Rochford (*24*) reported that cows supplemented with cottonseed cake and barley had a calf crop of 91 percent compared to 61 percent for cows receiving no supplement.

The work of Foster and others (*23*) shows that the calf crops of cows grazing on the southeastern coastal plains varied according to the level of winter supplement received. Cows that received 2 pounds of protein supplement per day had an average calf crop of 48 percent compared to 63 percent for those that had received 4 pounds of protein supplement per day and 68 percent for those that had received 6 pounds of protein supplement.

Joubert (*30*) in South Africa showed that puberty was hastened by feeding beef heifers supplementary feed during the winter. He also showed that the first post-partum estrus occurred 414 days after calving for cows that received no supplementary feed compared to 267 days for cows that received supplementary feed. The work of Morris (*43*) in Australia indicates that heifers fed bush hay plus 1 pound of crushed grain sorghum daily had greater ovarian activity than those fed bush hay alone. Workers in Africa (*21*) reported that supplementary feeding increased the calf crop.

The feeding of winter supplements did not increase the calf crop in New Mexico (*33*) in years of average rainfall. However, supplements fed cows during years of drought increased the calf crop from 78 percent to approximately 85 percent. Studies in New Mexico also showed that when bonemeal was available, ground maize was as valuable a supplement as was cottonseed meal alone or as cottonseed meal plus dehydrated alfalfa.

Work at Fort Reno, Okla. (*49*), showed that supplementation in excess of need may decrease the calf-crop percentage. Cows fed 1 pound of cottonseed meal daily on native range during winter months had a calf crop of 95 percent; those fed 2.5 pounds of cottonseed meal on native range had a calf crop of 87 percent; those fed 2.5 pounds cottonseed meal and 3 pounds of oats on native range had a calf crop of 87 percent.

Wagnon and others (*58*) reported that cows, each of which was supplemented with an average of 380 pounds of cottonseed meal and barley during months of forage scarcity, had a calf crop of 83 percent compared to 66 percent for cows not supplemented. In addition, the calf crop of the supplemented group was more uniform from year to year than that of the unsupplemented group.

Studies in Florida during the winter (*60*) showed a beneficial effect when cows were either provided with a protein supplement on grass pasture or were grazed on a clover-grass pasture. Cows on grass pasture had a calf crop of 75 percent compared to 100 percent for cows that had grazed on grass pasture plus a protein supplement, on clover-grass pasture, or on clover-grass pasture plus a protein supplement. The time required to conceive was also longer for cows grazing on the grass pastures.

Feeding supplements high in phosphorus has been shown to increase calf crop in certain geographic areas (*4*, *5*, *32*). Knox and Watkins (*33*) point out that the high content of phosphorus rather than the protein may be the reason that cottonseed meal is a better supplement than grain.

According to the foregoing results, the benefits of supplemental feed apparently depend on the quality and quantity of forage available at the time of supplementation and during the breeding period.

Some work has been done to measure the effect of protein and energy intake on the reproductive performance of beef females in the drylot. The work of Langford and others in North Dakota (*34*) shows that reproductive performance did not differ when cows were wintered on approximately 10 pounds per day per head of total digestible nutrients (TDN) or 8 pounds of TDN. Bond and others (*8*) have demonstrated that estrual cycles ceased in heifers fed low levels of energy and protein. Warnick (*60*) has shown that estrus and ovarian activity were delayed when heifers got an inadequate level of protein. Inadequate protein also caused estrus to be delayed in cows suckling calves. Zimmerman and others (*65*) reported that the interval between calving and the first estrus was lengthened when the intake of energy was at low levels for 140 days before calving. Christian and others (*12*) concluded that the addition of alfalfa hay to a diet of wheat straw shortened the interval between calving and first ovulation.

Experiments with dairy heifers and bulls show that the onset of puberty can be delayed by underfeeding. Westmacott (*62*) reported that more heifers calved at 2 years of age when reared on a high level of feed during the first two winters of their life than when reared on a moderate level of feed in both winters or during either of the winters. Reid (*52*) reported that the average age at puberty was 616 days, 337 days, and 279 days for three groups of Holstein heifers fed 65 percent, 100 percent, and 140 percent, respectively, of Morrison's standard of total digestible nutrients. Average body weight at puberty for the three groups was 634 pounds, 583 pounds, and 631 pounds, respectively. Reports from the State of Missouri (*16*), and from England (*13*) and Sweden (*26*) also show that a low plane of nutrition delays puberty in dairy heifers. None of these workers has reported conception rate to be influenced by level of feeding.

Bulls reared on low levels of TDN tend to reach puberty later (*9*, *14*, *22*) than those fed at higher levels. They also tend to produce less semen until they reach maturity.

The old adage that fatness causes sterility has long been accepted. Marshall and Peel (*41*) found fatty deposits in and around the ovarian bursas of sterile heifers and cows and believed the deposits were the cause of sterility. Quinlan (*50*) reported that the ovaries of fat heifers were smaller than usual. Recent studies (*48*, *57*) do not show that fatness has any effect on conception rate. These same studies, however, indicate that fat heifers do have more difficulty at first calving than cows given lower levels of feed.

The literature reviewed in the foregoing paragraphs shows that nutrition can affect the reproductive performance of the beef cow. When forage is scarce, the calf crop can be increased by feeding a protein or an energy supplement. The levels of energy and protein necessary for satisfactory reproduction, however, have not been established. Studies in this area of animal nutrition could lead to better and more efficient supplementation of the diet of beef cows under range and pasture conditions.

EXPERIMENTAL PROCEDURE

The overall plan of the experiment reported in this bulletin was (a) to observe the reproductive performance through the first calving and subsequent post-parturition period of beef females started as weanling heifers and fed rations that differed widely in protein and energy levels, and (b) to observe the reproductive performance through the second calving and post-parturition period of the same females after all had been changed to a single ration.

To determine whether breed and climatic conditions would affect results, the experiment was replicated at two locations—the Agricultural Research Center, Beltsville, Md., and the Iberia Livestock Experiment Station, Jeanerette, La.

Fifty-four grade Angus heifer calves of unknown exact age and ancestry and weighing initially an average of 392 pounds were used in the experiment at Beltsville. The Jeanerette heifers were of mixed breeding, averaged 406 pounds initially, and were likewise of unknown exact age and ancestry (appendix table 15).

At each location, heifers were allotted at random by weights and breeds into nine treatment groups of six animals each. Each group was fed a ration of a specified level of energy and of protein. Experimental work was started in November 1956 at Beltsville and in January 1957 at Jeanerette. In this report, experimental animals are called heifers until they calve the second time.

Groups of experimental animals were fed three levels of total feed. The heifers on high-level rations were fed ad libitum. Heifers on medium-level rations were fed approximately 66 percent of the feed consumed by those on high-level rations at the same body weight. Those on low-level rations were fed enough to maintain body weight. The amount of feed had to be adjusted from time to time to accomplish these objectives.

Within each total-feed (energy) level, protein was fed at three levels—high, medium, and low. At the high-protein level, heifers were fed approximately 0.23 pound of digestible protein per hundred pounds of body weight; at the medium-level, approximately 0.15 pound per hundred of body weight; and at the low-level, approximately 0.06 pound per hundred of body weight.

Heifers at Beltsville on the low and medium levels of energy were fed individually once each day, and those on the high levels of energy were fed in groups of two. All heifers at Jeanerette were group fed. Those on medium- and low-energy rations were fed once a day; those on high-energy rations had feed available at all times.

Rations at Beltsville were mixed, ground, and made into pellets five-eighths of an inch in diameter. Rations at Jeanerette were fed as ground, mixed feed. Water, salt, and bonemeal were available to heifers of all groups (tables 1 and 2).

TABLE 1.—*Composition of experimental rations fed heifers at Beltsville*

[All rations had the following materials added—1 percent salt, 1 percent steamed bonemeal, and 1,875 I.U. of vitamin A per pound of ration]

Ration level	Ingredients					Crude protein content
	Timothy hay	Corn and cob meal	Molasses	Cotton-seed meal	Starch	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
High energy:						
High protein	25	50	10	15	0	13.2
Medium protein	25	61	10	4	0	9.2
Low protein	25	25	20	0	30	4.1
Medium energy:						
High protein	25	32.5	10	32.5	0	19
Medium protein	25	50	10	15	0	13.2
Low protein	25	50	10	0	15	6
Low energy:						
High protein	25	2.5	10	62.5	0	28.1
Medium protein	25	32.5	10	32.5	0	19
Low protein	25	61	10	4	0	9.2

Table 2.—*Composition of experimental rations fed heifers at Jeanerette*

[All rations had the following materials added—1 percent salt, 1 percent steamed bonemeal, and 1,875 I.U. of vitamin A per pound of ration]

Ration level	Ingredients: Grass hay	Snapped corn	Shelled corn	Cottonseed meal	Molasses	Starch	Crude protein
Rations Fed First 9 Months of Experiment							
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
High energy:							
High protein	10.0	65.0	-------	15.0	10	0	12.6
Medium protein	15.0	82.5	-------	2.5	10	0	8.1
Low protein	17.5	32.5	-------	0.0	20	30	4.2
Medium energy:							
High protein	15.0	42.5	-------	32.5	10	0	18.4
Medium protein	10.0	65.0	-------	15.0	10	0	12.6
Low protein	7.5	67.5	-------	0.0	10	15	6.0
Low energy:							
High protein	25.0	2.5	-------	62.5	10	0	28.8
Medium protein	15.0	42.5	-------	32.5	10	0	18.4
Low protein	15.0	82.5	-------	2.5	10	0	8.1
Rations Fed Remainder of Experiment							
High energy:							
High protein	30.0	--------	45.0	15.0	10	0	12.6
Medium protein	30.0	--------	57.5	2.5	10	0	7.9
Low protein	27.5	--------	22.5	0.0	20	30	3.9
Medium energy:							
High protein	27.5	--------	30.0	32.5	10	0	19.3
Medium protein	30.0	--------	45.0	15.0	10	0	12.6
Low protein	30.0	--------	45.0	0.0	10	15	5.7
Low energy:							
High protein	25.0	--------	2.5	62.5	10	0	30.0
Medium protein	27.5	--------	30.0	32.5	10	0	19.3
Low protein	30.0	--------	57.5	2.5	10	0	7.9

As the experiment progressed, it proved impossible to get animals on the high-energy, low-protein and on the medium-energy, low-protein rations to consume the desired amounts of feed. This result and that reported in other work (*7*) make it appear that protein deficiency causes low voluntary intake of feed.

Heifers that did not attain puberty or that ceased to have estrual cycles before becoming pregnant were removed from the original rations. These heifers were then given the ration containing the next higher level of energy or of protein. During the period of increased feed, heifers taken off the low-energy rations had their feed increased to 1.89 pounds of feed per hundred pounds of body weight. This amount of feed was approximately 66 percent of the feed consumed by the animals fed ad libitum. Heifers were maintained on the new ration until they reached puberty; were bred and diagnosed pregnant. They were then returned to their original ration.

The first ration change at Beltsville occurred 391 days after the experiment was started; that at Jeanerette, 371 days after the experiment was started. At these times approximately one-half of the heifers in each group that had not shown estrus or that had ceased to cycle were changed to a higher ration. The other half of the heifers in these groups were changed to higher rations after all the heifers changed initially had shown estrus.

During pregnancy, heifers on low-level rations were fed slightly more feed to compensate for the increase in weight due to pregnancy.

Except for the previously mentioned changes of rations, all heifers were kept on their original rations for 180 days after their first calf was born or until they were 90 days pregnant with their second calf, depending on which date occurred first. Beginning at this time, heifers were fed ad libitum on a ration consisting of 94 percent timothy hay and 6 percent cottonseed meal, salt, bonemeal, and vitamin A. This ration was designed to improve the condition of the heifers on low levels of feed and to reduce fatness in the extremely fat heifers. Heifers were fed this ration during the remainder of the second pregnancy, through calving, and through the post-partum period until the time they were diagnosed as pregnant with their third calf. When diagnosed pregnant, they were removed from the experiment.

Checks for estrus were made twice daily through use of vasectomized bulls. Heifers at Beltsville were turned into an exercise lot for the estrus check; those at Jeanerette were checked in their feedlots. Heifers were not bred during the first 8 months of the experiment. After this period, an attempt was made to breed each heifer at every estrual period. Breeding was done either naturally or through artificial insemination.

To determine estrual period lengths, heifers were checked at 2-hour intervals during one 3-week period at Beltsville. This check was made in May and June 1957, before any of the heifers had been bred. To determine time of ovulation, the ovaries were examined rectally at 2-hour intervals, starting at the end of the estrual period.

At Beltsville, the reproductive organs of heifers were examined rectally on the following schedule: (1) Weekly until puberty was reached; (2) 15 to 21 days after calving and weekly thereafter until the heifers showed estrus and involution of the uterus was complete; (3) 7 to 13 days after estrus to check for ovulation; and (4) 35 to 41 days after breeding for pregnancy diagnosis. At Jeanerette, the reproductive organs were rectally examined by manual palpation at irregular intervals throughout the year.

Most calves were creep fed from the time they were 75 days old. Exceptions to this at Beltsville were calves suckling cows on high-energy, high-protein and on high-energy, medium-protein ration levels. Cows on these ration levels were fed ad libitum, and their calves had access to their dam's feed. Creep feed was provided at ages earlier than 75 days to calves in which death seemed inevitable because their milk supply was inadequate. Except as noted, all calves were creep fed in a separate pen. Calves were removed from their dam's pen and allowed access to creep for at least 3 to 4 hours each day.

Estimates of milk production were obtained once a week by separating calves from their dams for approximately 12 hours. After this period of separation, calves were weighed, allowed to suckle their dams for approximately 20 to 30 minutes, and were reweighed as soon as possible after nursing.

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Heart rates were determined in all heifers after they had been on experimental rations for about a year. Heart rate was determined by placing the hand in the rectum and taking the pulse from the femoral artery.

At Beltsville, wither-height and body-length measurements were taken three times during the experiment. Each recorded measurement was an average of three independent measurements by the same person.

Heifers were scored for condition after approximately 8 months on experimental rations. Condition scores ranged from 1 (very thin) to 14 (very fat).

EXPERIMENTAL RESULTS AND DISCUSSION

Prepuberal and Puberal Periods of Heifers

Heifers gained weight according to planned energy intakes except for those on the high-energy, low-protein and the medium-energy, low-protein rations (fig. 1). Heifers on these rations consumed less feed and gained more slowly than those in groups where protein was fed at the high or medium levels (table 3). The total feed and the calculated amounts of energy and of digestible protein consumed by heifers on each ration level are also shown in table 3. Reports of digestion trials at Beltsville by Elam and others (*18*) indicate that the digestibility of these rations may have been lower than was calculated.

Differences in reproductive performance of heifers were related mostly to differences in occurrence of estrus (table 4). All heifers fed the high- or medium-energy rations and adequate protein showed estrus. In contrast, most heifers fed low-energy rations did not show estrus. Nearly all heifers that showed estrus on low-energy rations stopped cycling before breeding started. Not all heifers fed high-energy, low-protein rations nor those fed medium-energy, low-protein rations showed estrus. Heifers that showed estrus in these groups appeared to have a higher intake of feed than those that did not show estrus. Condition scores at breeding time (shown in table 3) tended to be slightly higher in the low-protein groups for heifers that were cycling than for those that were not cycling.

The ovaries in heifers that did not cycle showed very little evidence of activity. They were small and had a few follicles 8 to 10 millimeters in diameter. Heifers that showed estrus and then ceased cycling had usually ovulated at each estrus. The corpus luteum then regressed, and the ovaries became inactive.

Reasoning from work done in other species, it seems probable that ovarian inactivity of heifers fed low energy levels resulted from a decreased supply of gonadotrophic hormone rather than ovarian insensitivity. Ovaries of undernourished rats are responsive to gonadotrophic hormones (*20, 39, 44, 55*). Injection of gonadotrophic hormone into young undernourished bulls reversed the effects caused by undernourishment on semen composition (*35*). Thus, low levels of energy appear to result in reduced production and/or release of gonadotrophic hormones. Change in ovarian sensitivity to gonadotrophic hormones could also be a cause.

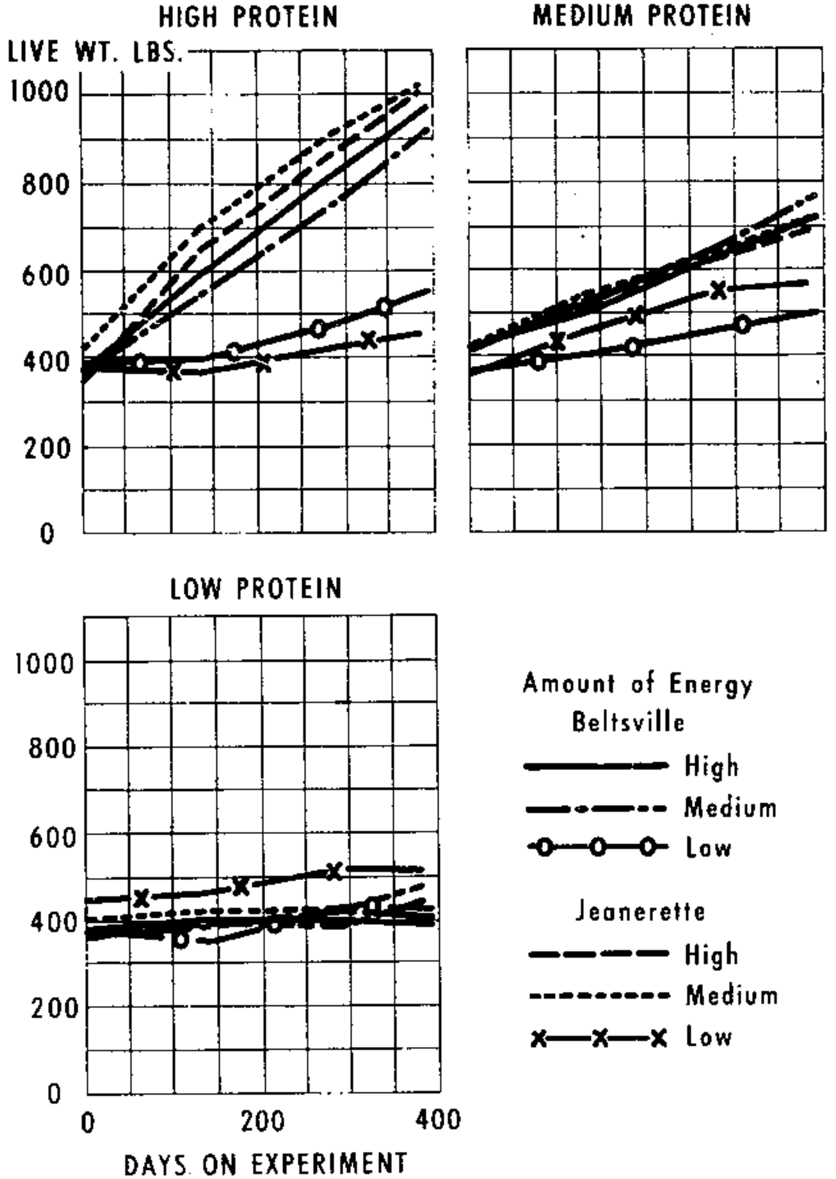

FIGURE 1.—Average weight changes in heifers on original rations during the prepuberal and puberal periods.

The interval from start of experiment to puberty and the weight of heifers at puberty are also shown in table 4. The variation in time from start of experiment to puberty and weight at puberty was large within each experimental group. At Beltsville, there was a trend for heifers fed rations at the higher energy and protein levels to show estrus after shorter periods than those fed rations at the

TABLE 3.—*Feed consumed and the growth rate of heifers during prepuberal and puberal periods, when all heifers were on original rations*

AT BELTSVILLE FOR 391 DAYS OF EXPERIMENT

Ration level	Average daily consumption by heifers of—			Average weight of heifers at—		Average daily gain	Average condition score of heifers at time breeding commenced [1]
	Total feed	Digestible energy (calculated)	Digestible protein (calculated)	Start of experiment	End of period		
	Pounds	*Therms*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	
High energy:							
High protein	16. 1	20. 88	1. 34	385	971	1. 5	12. 5
Medium protein	15. 1	19. 68	. 79	389	916	1. 4	10. 0
Low protein	9. 2	12. 45	. 20	397	547	. 38	3. 0
Medium energy:							
High protein	9. 2	11. 85	1. 20	415	716	. 77	6. 0
Medium protein	9. 7	12. 59	. 80	414	769	. 91	8. 5
Low protein	7. 2	9. 71	. 25	387	499	. 29	2. 5
Low energy:							
High protein	5. 1	6. 49	1. 09	378	393	. 04	1. 5
Medium protein	5. 0	6. 45	. 66	379	408	. 07	1. 8
Low protein	5. 0	6. 53	. 26	385	415	. 08	1. 9

At Jeanerette for 371 Days of Experiment

High energy:							
High protein	19.0	24.82	1.63	395	1000	1.6	11.2
Medium protein	21.0	28.03	1.11	429	1022	1.6	12.0
Low protein	9.5	12.81	.23	388	488	.16	1.9
Medium energy:							
High protein	10.1	13.01	1.34	407	692	.77	5.4
Medium protein	9.9	13.01	.85	423	712	.78	5.9
Low protein	9.8	13.41	.37	384	558	.47	4.8
Low energy:							
High protein	5.1	6.41	1.09	383	425	.11	2.7
Medium protein	5.5	7.21	.73	404	470	.18	2.5
Low protein	6.6	8.81	.35	445	512	.18	3.6

[1] On a scale of 1 (very thin) to 14 (very fat).

TABLE 4.—*Puberty and conception data for heifers that reached puberty on original ration levels*

AT BELTSVILLE

Ration level	Heifers observed	Heifers that showed estrus	Heifers that ceased cycling before breeding	Interval from start of experiment to puberty		Weight of heifers at puberty		Heifers fed original rations and bred that—	
				Average	Range	Average	Range	Conceived	Conceived on first service
	Number	*Number*	*Number*	*Days*	*Days*	*Pounds*	*Pounds*	*Number*	*Number*
High energy:									
High protein	6	6	0	101	30–172	541	372–733	6	2
Medium protein	6	6	0	83	21–178	506	403–673	5	1
Low protein	6	4	1	167	41–234	466	387–570	3	0
Medium energy:									
High protein	6	6	0	149	104–214	519	462–579	6	1
Medium protein	6	6	0	125	19–193	508	462–539	6	3
Low protein	6	5	2	198	122–268	442	365–510	3	0
Low energy:									
High protein	4	2	2	220	203–238	404	356–453	0	----------
Medium protein	6	5	3	175	124–215	407	372–455	2	1
Low protein	6	2	0	150	127–172	400	363–438	2	1

At Jeanerette

High energy:									
High protein	6	6	0	160	21–470	657	368–1,065	6	6
Medium protein	6	6	0	123	40–218	666	530– 821	6	3
Low protein	6	2	1	58	32–84	358	310– 406	1	0
Medium energy:									
High protein	6	6	0	107	66–143	493	449– 577	5	2
Medium protein	6	6	0	242	37–468	596	468– 705	[1] 5	3
Low protein	6	3	0	32	14–58	412	346– 914	3	1
Low energy:									
High protein	5	1	1	100	----------	475	----------	0	----------
Medium protein	5	2	1	62	49–76	464	337– 592	1	1
Low protein	6	2	1	70	20–121	466	406– 525	1	0

[1] One heifer became crippled and died. She was never bred.

lower levels. At Jeanerette, heifers fed rations that were inadequate in energy or in protein either showed estrus shortly after they were started on the experiment or did not show estrus on the original rations. Marked differences in ability to conceive were not observed between groups of heifers on different rations. The data on conception may not be reliable because (1) the numbers of animals were extremely small, and (2) there were difficulties with semen quality at Beltsville.

All anestrus heifers raised to higher levels of feed showed estrus, whereas none of the anestrus heifers left on the original rations showed estrus (table 5). Anestrus in heifers, therefore, appeared to have been caused by an inadequate supply of energy or of protein. The interval from ration change to estrus appeared to depend somewhat on weight gain, although here again there were large variations. Rations inadequate in energy and in protein delayed estrus indefinitely in most heifers. Even when adequate energy and protein were available, the heifers gained from 57 to 329 pounds before their ovaries became functional and they started regular estrus cycles. This observation agrees with that in an earlier experiment conducted by the authors (*8*).

A low level of protein in the diet appeared to reduce the voluntary intake of feed and thus to have the effect of lowering the energy level of feed consumed. Bond and others (*7*) reported that a low intake of protein limited the intake of total feed. They also showed that a minimum amount of protein must be available to insure that cattle consume an adequate amount of total feed.

It is impossible to determine from the results of this experiment if the low level of protein in the diet directly inhibits the reproductive process or if the effect of the low level on the reproductive process is indirect through the reduced intake of total feed.

Neither length of the estrous period nor time of ovulation were affected by ration fed (table 6). The average length of 45 estrous periods was 21.1 hours. Time from end of estrus to ovulation averaged 9.2 hours. The estrous period was somewhat longer than the 14 hours given by Willett as the average estrual length for dairy cows (*63*). Time from end of estrus to ovulation was shorter than the 13.5 to 15.5 hours given by Willett for dairy cattle (*63*) and the 14.3 given by Nalbandov and Casida (*45*) for beef cows. However, it was comparable to the 9.5 hours reported by Marion and others (*38*), where sterile copulation was permitted.

Large variations in heart rates were found in heifers fed the different levels of energy and protein at each location. Heart rates were faster in animals on the higher levels of energy after a 24-hour fast and 1 to 2 hours after they had been fed ($P < .01$) (table 7). The level of protein also influenced the heart rate significantly at Jeanerette ($P < .01$). At Beltsville, there was a significant interaction between the levels of energy and of protein ($P < .05$). This interaction was mainly the result of the slow heart rate in heifers fed on a high-energy, low-protein ration when compared to that in heifers on other high-energy rations. Heart rate was faster in heifers shortly after they had been fed than in heifers after they had been on a 24-hour fast ($P < .01$). These differences in the heart rate agree with the results obtained by other workers (*26*, *53*, *56*), who have shown that the heart rate was faster in animals on high levels of feed.

First Calving

A large number of calves born to heifers on the high-energy, high-protein ration or on the high-energy, medium-protein ration died either at birth or shortly thereafter (table 8). Many of the calves born to heifers on these high-energy rations were presented backwards or in some other abnormal position. Some of the calves that died early were born alive but breathed only once or twice after birth. Birth weights of calves born to heifers on high-energy rations were not excessive, and the gestation period averaged about the same length as that of heifers on medium-energy levels of feed. Thus, the birth-weight of calves and length of gestation periods did not seem to be related to calving difficulty (table 8). Instead, calving difficulty appeared to be related to condition of the heifers. Totusek (*57*) and Pinney and others (*48*) have also reported that fat heifers had a high incidence of calving difficulty.

Birth weights of calves born to heifers on low-energy rations were considerably lower than those of calves born to heifers on high- or medium-energy rations that included adequate protein (table 8). Calves born to heifers on the high-energy, low-protein ration and medium-energy, low-protein were also lighter at birth than those born to heifers on high- or medium-energy rations that included adequate protein.

Calves born to heifers fed the various levels of rations weighed the following percentage of the dams' weights. At Beltsville, calves from heifers on high-energy rations, 5.8; medium-energy, 7.4; low-energy, 8.5. At Jeanerette, calves from heifers on high-energy rations, 5.4 percent; medium-energy, 6.7; and low-energy, 6.6.

Heifers fed low-level rations at Jeanerette had a considerably higher daily intake of energy than those on similar rations at Beltsville. This resulted in higher gains and in higher body weights for the heifers at Jeanerette (table 9). The higher daily intake of energy by heifers at Jeanerette may explain the lower percentage of calves' weight to dams' weight in the medium and low levels of feeding at this station. The work of Eckles and Sweet (*17*), Joubert (*30*, *31*), and Reid (*52*) show similar results for the effect of nutrition on the birth weight of calves.

The length of the gestation period did not appear to be affected by the ration except possibly in heifers on high-energy, low-protein feed at Jeanerette.

Most heifers were gaining weight before they had their first calf, but the magnitude of the gain was variable. Weight losses at calving varied considerably for heifers fed the different levels of energy and protein (table 9). At Jeanerette, the losses ranged from an average of 66 pounds for heifers on the low-energy, high-protein ration to 102 pounds for those on the high-energy, high-protein ration. At Beltsville, the losses ranged from an average of 59 pounds for heifers on the low-energy, low-protein ration to 103 pounds for those on the medium-energy, low-protein ration. Plans were to allow heifers on the low-energy rations to gain enough weight while pregnant to compensate for the expected loss in weight at calving, so that body weights after calving would be equal to those before conception. However, the gains in weight during pregnancy were actually more than the losses at calving, especially at Jeanerette.

737-667 O-65-3

Table 5.—*Reproductive performance of heifers after their rations were changed to higher levels of energy or protein*

At Beltsville

Original ration level	Next higher ration level	Number of heifers	Interval from ration change to estrus[1]		Gain in weight from ration change to estrus		Average weight at estrus	Average daily gain from ration change to estrus	Heifers bred that—	
			Average	Range	Average	Range			Conceived	Conceived on first service
			Days	*Days*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Number*	*Number*
High energy:	High energy:									
Low protein	Medium protein.	3	102	73–165	170	57–329	568	1.67	3	1
Medium energy:	Medium energy:									
Low protein	Medium protein.	3	156	142–162	116	104–129	625	.74	3	2
Low energy:										
High protein	High protein	4	256	204–371	192	139–217	600	.75	4	0
Medium protein	Medium protein.	4	183	146–247	139	111–185	583	.76	4	2
Low protein	Low protein	4	214	146–262	130	67–197	618	.61	4	3

At Jeanerette

High energy: Low protein	High energy: Medium protein.	5	55	10– 98	148	30–215	608	2.69	4	2
Medium energy: Low protein	Medium energy: Medium protein.	3	277	181–469	148	65–255	728	.53	3	2
Low energy: High protein	High protein	5	136	33–208	143	0–320	582	1.05	5	2
Medium protein	Medium protein.	4	106	87–183	170	180–275	597	1.60	4	1
Low protein	Low protein	5	166	73–180	154	105–140	692	.93	5	3

[1] All heifers showed estrus.

Table 6.—*Average length of estrous period and time to ovulation [1] of heifers on stated ration levels at Beltsville*

Ration level	Heifers observed	Length of estrous period		Time from end of estrus to ovulation	
		Average	Range	Average	Range
	Number	*Hours*	*Hours*	*Hours*	*Hours*
High energy:					
High protein	6	21	8–40	10	6–14
Medium protein	6	23.3	20–28	6.4	0–12
Low protein	2	24	20–28	8	2–14
Medium energy:					
High protein	6	23.3	20–26	6.8	0–12
Medium protein	6	20	12–28	9	4–14
Low protein	2	19	6–32	(2)	----------
Low energy:					
High protein	2	21	20–22	(2)	----------
Medium protein	5	19.2	12–30	12.5	8–18
Low protein	2	22	20–24	8	0–16

[1] During a 3-week period, May–June, 1957.
[2] Observations were not taken on ovulation.

Table 7.—*Average heart rate in heifers that had been on stated ration levels for about 1 year*

Ration level	At Beltsville		At Jeanerette
	Following a 24-hour fast	1 to 2 hours after feeding	1 to 2 hours after feeding
	Beats in 15 sec.	*Beats in 15 sec.*	*Beats in 15 sec.*
High energy:			
High protein	19.5	26.5	29.2
Medium protein	19.2	27	28.8
Low protein	15.7	24.3	22.2
Medium energy:			
High protein	15.2	21	23.8
Medium protein	16.5	24.5	25.8
Low protein	18.5	21.3	21.8
Low energy:			
High protein	14	21	20.3
Medium protein	14.3	19.3	22.6
Low protein	14	19.5	17.3

Feed intake after calving was higher in all groups than it was during the puberal and prepuberal period. The cows receiving medium-energy rations received more feed because of adjustments according to their live weight gain and to feed consumed by ad libitum heifers. Low-energy heifers received more feed because they had greater body weight to maintain. Intake of cows in the high-energy, low-protein groups was less than for cows in other high-energy groups. Also intake in the medium-energy, low-protein group at Beltsville was lower than planned. However, even in these two groups, intake was much higher than in the prepuberal period.

Weight changes after calving differed between groups of heifers on the various levels of experimental feeding. Substantial gains in weight after calving were shown by heifers fed the high-energy, high-protein ration at both stations and by heifers fed the high-energy, medium-protein ration at Jeanerette. Heifers on other ration levels showed either a loss in weight after calving or little or no change in weight (table 9). Most heifers receiving low-energy rations were extremely thin (fig. 2).

Differences in reproductive performance of heifers receiving different rations were mainly the result of heifers not showing estrus after calving (table 10). All heifers in high-energy and medium-energy groups showed estrus before 180 days after calving except two at Jeanerette (one in the high-energy, medium-protein group and one in the medium-energy, medium-protein group) and two at Beltsville in the medium-energy, low-protein group. Most heifers in the low energy groups failed to show estrus after calving on original rations.

The interval from calving to first estrus was somewhat increased in heifers showing estrus on the medium-energy, low-protein ration and in a few heifers that showed estrus on low-energy rations. The data in table 10 indicate that post-partum estrus does not occur unless heifers get enough energy, regardless of the amount of protein in the ration. There also appears to be some delay of post-partum estrus in heifers on the medium-energy, low-protein ration. These results agree with those of Joubert (*30*). They do not agree with those of Witt and others (*64*), who reported that very few cows on a low-protein ration conceived. However, results in the latter study also appeared to be confounded with intake of energy. All heifers that had been on low levels of energy or of protein showed estrus and conceived after their feed was changed to the hay ration (table 11). However, the days from ration change to estrus and the weight gains from ration change to estrus were variable.

Calves suckling cows receiving either a low-energy or low-protein ration grew less rapidly than calves suckling cows receiving other rations (table 12). The one exception to this was cows receiving the medium-energy, low-protein ration at Jeanerette. At Jeanerette, calves of cows receiving the high levels of energy and high or medium levels of protein grew faster than calves from heifers receiving the medium levels of energy. This was not the case at Beltsville.

Growth of calves tended to follow the same pattern as milk production of their dams. Little or no decrease in milk production was noted as lactation progressed in heifers on rations adequate in energy and protein.

Creep feeding improved the gains of the calves from cows on low-protein or low-energy rations. Adequate levels of both energy and protein appear necessary for adequate milk production and for promotion of calf growth.

TABLE 8.—*Survival, weight, and gestation period of first calves born to heifers on stated ration levels*

AT BELTSVILLE

Ration level	Heifers calving	Still-births	Calves living— When born	Calves living— 24 hours after birth	Calves living— 2 weeks after birth	Calves living— At weaning time	Average birth weight of calves	Calves' birth weight in relation to dams' body weight	Average gestation period
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Pounds*	*Percent*	*Days*
High energy:									
High protein	5	1	4	3	1	1	54. 5	5. 1	277
Medium protein	5	1	4	2	2	2	62. 4	6. 3	275
Low protein	6	0	4	4	3	3	46. 5	5. 9	277
Medium energy:									
High protein	6	0	6	6	6	6	59. 6	7. 2	272
Medium protein	6	1	5	5	5	5	56. 1	6. 8	274
Low protein	6	1	5	5	5	4	53. 5	8. 1	282
Low energy:									
High protein	4	[1] 1	3	3	3	3	43. 5	8. 3	280
Medium protein	5	0	5	5	5	5	40. 6	8. 3	274
Low protein	6	[2] 2	4	4	4	4	41. 6	8. 8	273

AT JEANERETTE

High energy:									
High protein	6	2	4	3	3	2	66. 0	6. 0	281
Medium protein	6	0	6	4	4	4	59. 0	4. 9	280
Low protein	5	0	5	5	5	4	49. 0	5. 2	269
Medium energy:									
High protein	5	0	5	5	5	5	62. 0	7. 3	280
Medium protein	5	0	5	5	5	5	67. 0	7. 1	285
Low protein	6	1	5	5	5	4	59. 0	5. 6	281
Low energy:									
High protein	4	0	4	4	4	4	53. 0	7. 3	288
Medium protein	5	0	5	5	5	5	45. 0	6. 5	278
Low protein	6	0	6	6	6	6	47. 0	5. 9	282

[1] Calf was born premature by about 2 months.
[2] Calves were born premature by about 3 months.

Table 9.—*Weight changes and feed consumption of heifers before and after first calving*

At Beltsville

Ration level	Average heifer weight before calving			Average heifer weight after calving				Average daily feed consumed by heifers for 90 days after calving		
	60 days	30 days	1 to 7 days	1 to 7 days	30 days	60 days	90 days	Total feed intake	Digestible energy	Digestible protein
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Therms*	*Pounds*
High energy:										
High protein	1,114	1,139	1,151	1,060	1,072	1,080	1,114	21. 4	27. 8	1. 78
Medium protein	1,011	1,046	1,089	996	988	984	997	20. 3	26. 4	1. 07
Low protein	816	867	873	794	783	784	789	17. 4	23. 6	. 39
Medium energy:										
High protein	866	896	926	830	790	767	769	13. 6	17. 5	1. 78
Medium protein	865	896	891	825	795	776	772	14. 9	19. 4	1. 24
Low protein	717	735	760	657	619	603	595	10. 4	14. 0	. 36
Low energy:										
High protein	606	579	625	526	518	531	568	6. 8	8. 7	1. 46
Medium protein	557	570	569	488	469	482	480	7. 5	9. 6	. 98
Low protein	538	532	533	474	450	447	456	6. 8	8. 9	. 36

AT JEANERETTE

High energy:										
High protein	1,172	1,174	1,192	1,090	1,095	1,136	1,162	26. 6	34. 8	2. 34
Medium protein	1,251	1,280	1,295	1,194	1,199	1,203	1,222	24. 6	32. 8	1. 30
Low protein	986	1,016	1,025	940	894	867	831	16. 1	21. 8	. 40
Medium energy:										
High protein	858	889	921	853	827	801	809	15. 4	20. 0	2. 06
Medium protein	999	1,019	1,058	942	946	953	969	17. 2	22. 4	1. 51
Low protein	908	935	970	881	855	828	819	16. 4	22. 4	. 64
Low energy:										
High protein	796	772	796	730	708	654	656	10. 6	13. 6	2. 27
Medium protein	762	728	787	693	640	613	618	10. 7	13. 8	1. 43
Low protein	848	862	878	799	761	723	720	10. 4	13. 8	. 57

Table 10.—*Reproductive performance of heifers on original rations after their first calf*

At Beltsville

Ration level	Heifers observed	Heifers showing estrus [1]	Average interval, calving to first estrus	Heifers showing estrus within—			Heifers bred that—	
				60 days after calving	90 days after calving	120 days after calving	Conceived	Conceived on first service
	Number	*Number*	*Days*	*Number*	*Number*	*Number*	*Number*	*Number*
High energy:								
High protein	5	5	57	4	4	4	5	2
Medium protein	4	4	80	0	3	4	4	2
Low protein	6	6	72	2	4	5	6	3
Medium energy:								
High protein	6	6	81	3	3	5	6	4
Medium protein	6	6	58	2	6	6	6	4
Low protein	6	4	61	3	3	4	4	0
Low energy:								
High protein	4	0	----------	0	0	0	0	0
Medium protein	5	0	----------	0	0	0	0	0
Low protein	6	1	112	0	0	1	1	0

AT JEANERETTE

High energy:								
High protein	5	5	45	4	5	5	5	2
Medium protein	6	5	35	5	5	5	5	0
Low protein	4	4	58	1	2	4	4	3
Medium energy:								
High protein	5	5	41	4	5	5	5	1
Medium protein	5	4	81	3	4	4	4	2
Low protein	6	6	95	2	3	3	6	2
Low energy:								
High protein	4	0	----------	0	0	0	0	----------
Medium protein	5	1	163	0	0	0	1	1
Low protein	6	3	122	1	1	1	3	3

[1] In less than 180 days after calving.

Table 11.—*Reproductive performance on the hay ration of heifers that had not shown estrus on original rations for 180 days after giving birth to their first calves*

Ration level	Heifers observed	Interval from ration change to estrus		Weight gain of heifers from ration change to estrus		Heifers bred that—	
		Average	Range	Average	Range	Conceived	Conceived on first service
At Beltsville							
	Number	*Days*	*Days*	*Pounds*	*Pounds*	*Number*	*Number*
Medium energy:							
Low protein	2	120	96–143	218	183–253	2	2
Low energy:							
High protein	4	166	139–213	337	307–376	4	2
Medium protein	5	112	20–178	229	125–344	5	3
Low protein	5	102	14–180	180	91–267	5	4
At Jeanerette							
High energy:							
Medium protein	[1] 1	228	----------	−120	----------	0	0
Medium energy:							
Medium protein	1	5	----------	−10	----------	1	1
Low energy:							
High protein	4	81	28–178	129	10–200	4	3
Medium protein	4	56	16–121	112	10–200	4	3
Low protein	3	38	13– 87	105	65–160	3	1

[1] This heifer had large luteinized cysts in the ovaries when slaughtered.

TABLE 12.—*Growth of first calves and milk production of their dams*

AT BELTSVILLE

Ration level	Weight gain of calves			Average 12-hour milk production of dams	
	First 60 days of life		First 150 days of life	First 60 days after birth of calves	First 150 days after birth of calves
	Total	Daily average	Daily average		
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
High energy:					
High protein	104	1.7	2	8.2	8.6
Medium protein	92	1.5	1.7	7.3	7.6
Low protein	57	1	1.1	6.2	5.1
Medium energy:					
High protein	89	1.5	1.7	7.5	7.0
Medium protein	98	1.6	1.7	8.4	7.9
Low protein	48	.8	1.1	6.5	4.9
Low energy:					
High protein	38	.6	1.1	3.4	2.4
Medium protein	42	.7	1.2	4.3	3.9
Low protein	39	.6	1	4.6	3.6

AT JEANERETTE

Ration level	Total	Daily average	Daily average	First 60 days after birth of calves	First 150 days after birth of calves
High energy:					
High protein	140	2.3	2.2		
Medium protein	125	2.1	1.8		
Low protein	78	1.3	1.6		
Medium energy:					
High protein	79	1.3	1.5		
Medium protein	99	1.6	1.6		
Low protein	86	1.4	1.5		
Low energy:					
High protein	50	.8	1.2		
Medium protein	59	1	1.1		
Low protein	65	1.1	1.4		

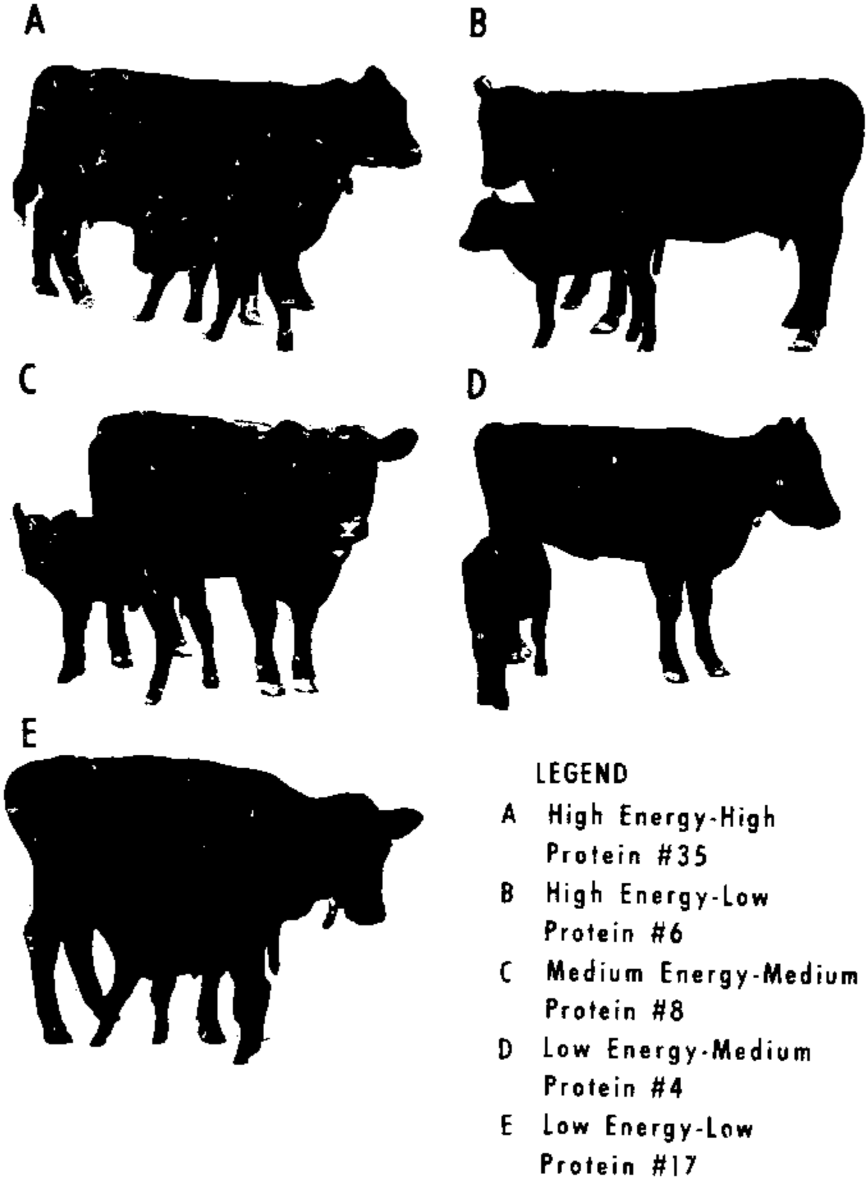

FIGURE 2.—A comparison of the condition of representative heifers fed the various levels of energy and protein. The first calves of these heifers are also shown.

Second Calving

Differences in body weight between groups tended to disappear after cows were put on the hay ration before their second calving (fig. 3). At the time they went on a hay ration, some groups of heifers at Beltsville differed in weight by more than 700 pounds. At Jeanerette, the greatest difference between groups was approximately 650 pounds. Heifers on medium or low levels of energy and low levels of protein gained weight steadily from the time they were fed hay until their second calf was born (appendix tables 16 and 17).

After second calving, the weight losses of cows formerly on high-energy, high-protein or on high-energy, medium-protein rations tended to be greater than those of cows formerly on other ration levels. The weight gains of cows before calving and weight losses after calving tended to minimize the large difference in body weights between groups on the various ration levels. Eighty-four days after calving, the largest difference in weight between groups of cows on various rations at Beltsville was 170 pounds; at Jeanerette, about 270 pounds.

The occurrence of estrus in cows following second calving did not appear to be affected markedly by previous rations (table 13). Estrus was delayed somewhat in two groups of cows previously fed low-energy rations at Jeanerette. However, this delay was not any longer than that in cows that were previously on the medium-energy, high-protein ration. Little or no delay in estrus was shown by these same groups of cows at Beltsville. It appears that the rations cows had been fed had little or no carryover effect on occurrence of estrus.

The data on conception are difficult to interpret because the number of animals was small and also because cows on the various rations were bred in different seasons of the year. However, the conception rate was very high at both locations for cows previously on low-energy feed.

Calves varied in size at birth, but there were no indications of a carryover from the effects of their dam's original rations. In addition, previous rations did not appear to influence the growth rate of calves for the first 60 days or 150 days after birth. Milk production between groups of cows varied less than during the first lactation and showed no effects of previous ration treatment (table 14).

Growth of Heifers

Body size was not affected permanently by rations fed. Wither heights and body lengths 3 months after the experiment was started differed but little between groups of heifers on the various rations (fig. 4). Body weights, however, differed by nearly 100 pounds between some groups of heifers.

Measurements on June 17, 1957, showed that body weights differed by large amounts in groups of heifers fed the various rations. Weights ranged from an average of 730 pounds for heifers on the high-energy, high-protein ration to 394 pounds for those on the low-energy, low-protein ration. The groups of heifers also differed as much as 11 centimeters in body length and as much as 8 centimeters in wither height. The differences in body weights and measurements disappeared after cows were placed on the hay ration. Differences in body weights and body sizes between groups were small when cows were removed from the experiment (appendix table 16).

TABLE 13.—*Reproductive performance of cows on hay ration following their second calving*

AT BELTSVILLE

Original ration level	Cows calving	Cows showing estrus—				Average interval between calving and first heat	Cows bred that—	
		60 days after calving	90 days after calving	120 days after calving	150 days after calving		Conceived	Conceived on first service
	Number	*Number*	*Number*	*Number*	*Number*	*Days*	*Number*	*Number*
High energy:								
High protein	5	3	5	5	5	81	5	1
Medium protein	4	2	3	4	4	66	4	2
Low protein	6	6	6	6	6	25	6	2
Medium energy:								
High protein	6	3	6	6	6	52	6	1
Medium protein	6	1	3	6	6	74	6	4
Low protein	6	6	6	6	6	37	6	4
Low energy:								
High protein	3	2	2	3	3	64	3	3
Medium protein	4	0	4	4	4	76	4	3
Low protein	6	4	6	6	6	48	[1] 4	[1] 4

AT JEANERETTE

High energy:								
High protein	5	2	3	4	5	75	5	3
Medium protein	5	4	5	5	5	40	4	2
Low protein	4	2	3	3	3	92	4	2
Medium energy:								
High protein	5	0	2	3	3	140	5	3
Medium protein	5	4	5	5	5	52	5	3
Low protein	5	1	3	4	4	86	5	4
Low energy:								
High protein	4	1	1	1	2	132	4	3
Medium protein	5	2	3	3	3	115	5	4
Low protein	4	1	4	4	4	68	4	3

[1] Two cows died after being bred but before pregnancy could be diagnosed.

TABLE 14.—*Growth of second calves and milk production of their dams on hay ration*

AT BELTSVILLE

Original ration level	Average birth weight of calves	Calves' birth weight in relation to dams' body weight	Calves stillborn	Average weight gained by calves from birth—		Average 12-hour milk production of dams	
				to 60 days	to 150 days	First 60 days after birth of calves	First 150 days after birth of calves
High energy:	*Pounds*	*Percent*	*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
High protein	57	4. 8	0	89	226	7. 8	8. 0
Medium protein	55	4. 9	0	81	228	7. 7	7. 6
Low protein	64	6. 8	1	100	291	7. 4	7. 1
Medium energy:							
High protein	61	6	0	106	264	7. 8	8. 1
Medium protein	56	5. 6	0	92	228	8. 4	9. 0
Low protein	66	7	1	98	290	7. 6	7. 2
Low energy:							
High protein	52	5. 1	0	100	275	7. 8	8. 6
Medium protein	62	6. 3	0	125	306	9. 7	9. 5
Low protein	57	6. 2	0	107	274	8. 0	7. 2

AT JEANERETTE

High energy:							
High protein	65	5. 9	0	83	258	4. 8	4. 2
Medium protein	67	6. 3	0	86	253	5. 7	5. 0
Low protein	58	6	0	71	196	3. 9	3. 4
Medium energy:							
High protein	51	5. 6	1	88	309	6. 5	5. 1
Medium protein	58	5. 7	0	67	215	4. 7	4. 1
Low protein	55	6. 3	0	64	191	5. 2	4. 9
Low energy:							
High protein	64	6. 6	1	72	162	5. 0	4. 2
Medium protein	61	6. 6	1	60	232	7. 2	6. 3
Low protein	52	5. 9	0	78	207	5. 3	4. 7

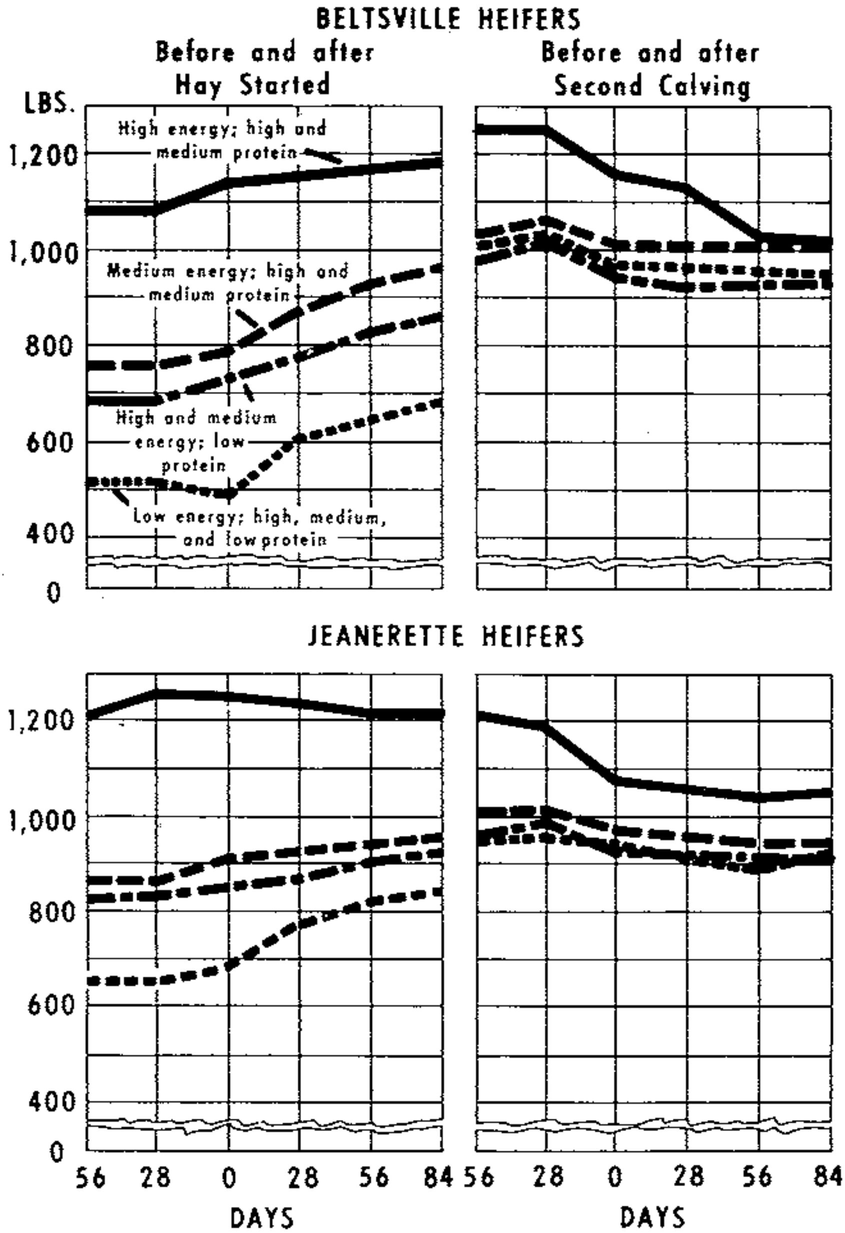

FIGURE 3.—Weight changes of heifers before and after hay ration started and before and after second calving.

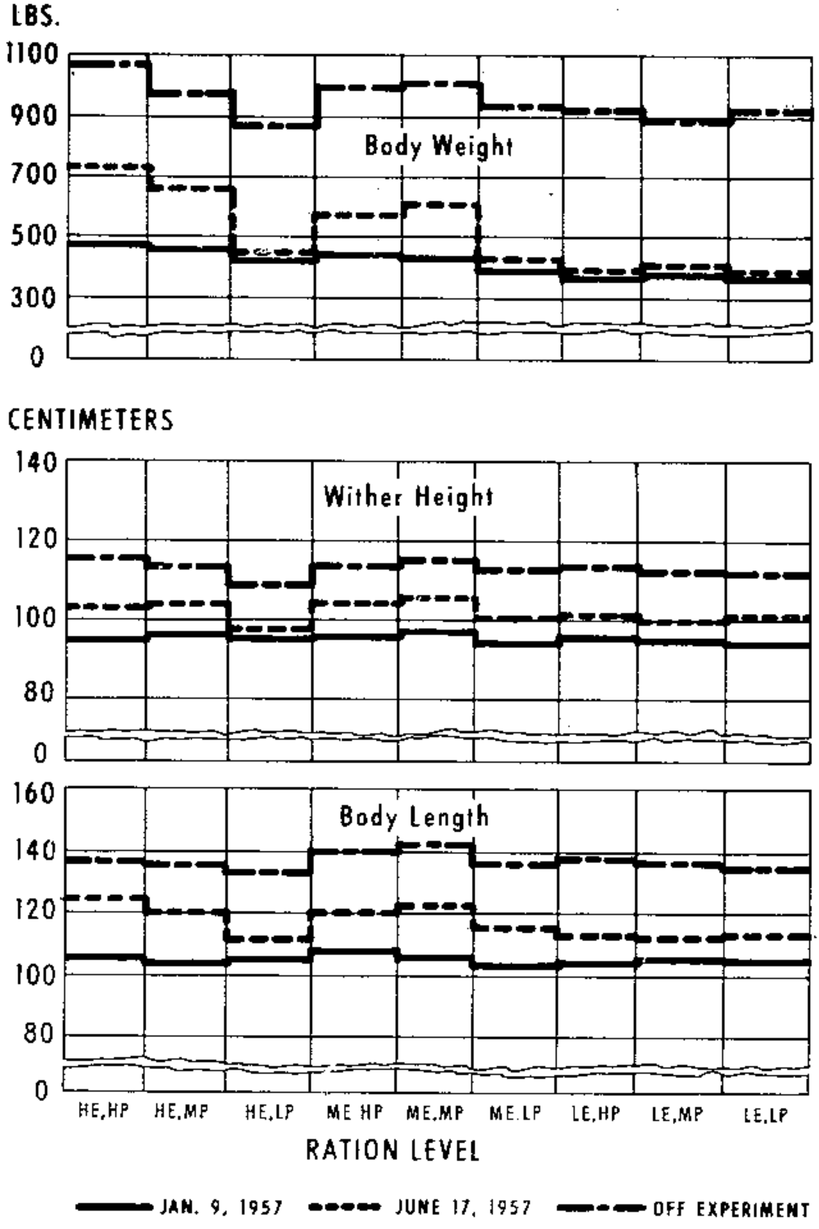

FIGURE 4.—Average body weights and body measurements of heifers fed various levels of rations at Beltsville.

Miscellaneous Results

Some heifers on the low-energy rations were observed eating feces and dirt, chewing or pulling the hair off other animals, and drinking urine. These heifers also consumed large amounts of bonemeal and salt. This depraved appetite disappeared after these heifers were fed the hay ration. Two heifers (one fed the low-energy, high-protein ration and the other the low-energy, low-protein ration) were inconsistent in their intake of the hay ration. They both died within a few weeks of the completion of the experiment. An autopsy on the heifer that had been fed the low-energy, high-protein ration revealed a number of hair balls in the rumen. The hair balls shown in figure 5 were removed by surgery from the rumen of the heifer that had been on the low-energy, low-protein ration. The total weight of these hair balls was 5,626 grams; the largest weighed 3,788 grams. The variation in feed intake and subsequent deaths of these animals are believed to have been caused indirectly by hair balls blocking the entrance of the rumen.

SUMMARY

An experiment was conducted to explore the effects of three levels of protein and three levels of energy on the reproductive performance of beef females. The experiment was conducted at Beltsville, Md., and Jeanerette, La. Most weanling heifers fed low levels of total feed (energy) did not reach puberty. Likewise, many heifers on low levels of protein did not reach puberty, but their total feed (energy) intake was also low. Thus, it is not known whether the effect of low protein on the reproductive processes was direct or indirect.

Heifers fed rations low in energy or in protein or in both came into estrus and conceived when a more adequate ration was provided. Heifers on high-energy rations became extremely fat and had trouble in calving. Death rates of their calves at or shortly after birth were excessive.

Heifers on high-energy rations had significantly faster heart rates than heifers on low-energy rations. Heart rate was lower at both locations on low-protein rations at all energy levels. This was statistically significant at Jeanerette but not at Beltsville. The heart rate was faster in heifers shortly after feeding than after a 24-hour fast.

Post-partum intervals to estrus and to ovulation were greatly lengthened by feeding low-energy rations. Most heifers on low-energy rations did not come into estrus during a 180-day period after calving. Calf growth and milk production of dams were less in groups of animals fed rations low in energy or in protein. Differences in body size tended to disappear when females were fed the same high-roughage ration. In addition, reproductive performance and milk production were similar in all groups of females during the second pregnancy, calving, lactation and post-partum interval when the same high-roughage ration was fed.

Data on conception are difficult to interpret because (1) the number of animals was small, (2) semen quality was uncertain at Beltsville, and (3) cows on the various rations were bred in different seasons. There are no wide differences in conception rate in heifers that showed estrus and ovulated. A noteworthy fact is that cows previously on

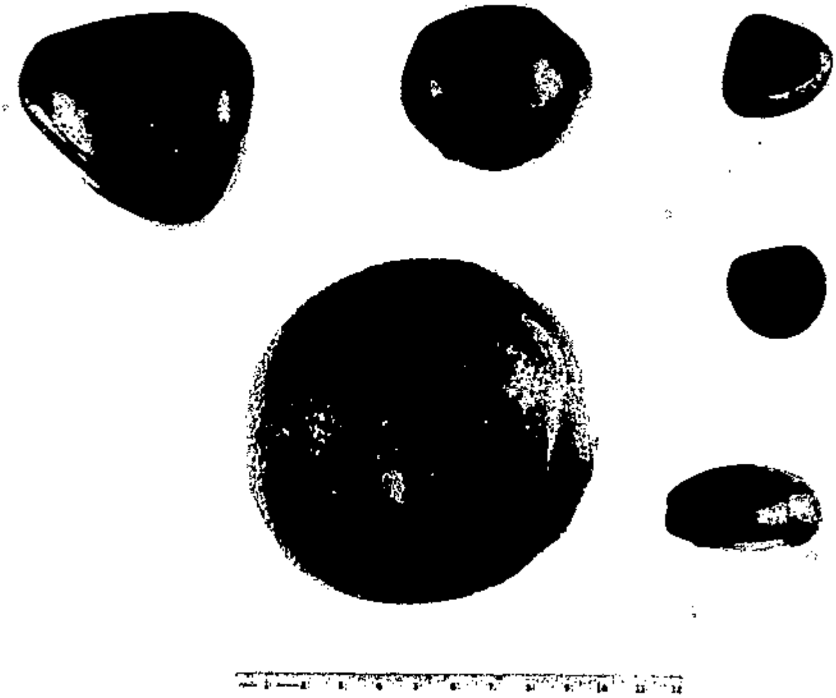

FIGURE 5.—Hair balls removed by surgery from the rumen of a heifer that had been on a low-energy, low-protein ration. Size of the balls in inches is shown by the scale.

low-energy rations had a very high conception rate at both locations when fed the high-roughage rations.

If the level of energy and protein allow the occurrence of estrus, there is no evidence that rations affect the duration of estrual periods, the regularity of the estrual cycle, or the length of the gestation period of beef females.

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APPENDIX

TABLE 15.—*Apparent breed or cross of heifers used in the replicate at Jeanerette, La.*

Ration level	Charbray	Brahman	Brahham cross	Hereford	Angus	Nondescript
High energy:						
High protein	1	1	1	1	1	1
Medium protein	1	2	2	1	0	0
Low protein	1	1	2	1	0	1
Medium energy:						
High protein	1	1	2	0	0	2
Medium protein	1	1	1	1	1	1
Low protein	1	1	2	1	1	0
Low energy:						
High protein	1	1	2	1	0	1
Medium protein	1	1	1	1	1	1
Low protein	1	1	2	0	1	1

TABLE 16.—*Weights of cows during the intervals on original rations and those during the first 84 days on a hay ration and feed consumed*

AT BELTSVILLE

Original ration level	Cows observed	Average body weights of cows at stated intervals before change to hay ration		Average body weights of cows on day changed to hay ration	Average body weights of cows at intervals after change to hay ration				Average daily feed consumed by cows—first 84 days after hay ration started
		84 days	56 days		7 days	28 days	56 days	84 days	
High energy:	*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
High protein	5	1, 136	1, 158	1, 207	1, 203	1, 216	1, 229	1, 251	19. 5
Medium protein	4	1, 037	1, 029	1, 039	1, 074	1, 076	1, 092	1, 126	20. 4
Low protein	6	785	788	813	827	837	873	907	17. 4
Medium energy:									
High protein	6	761	755	771	846	873	906	949	21. 3
Medium protein	6	780	783	808	871	894	927	958	19. 9
Low protein	6	590	599	612	644	702	757	810	19. 8
Low energy:									
High protein	4	524	531	506	595	638	682	720	21. 0
Medium protein	5	509	503	490	558	599	641	678	19. 6
Low protein	6	473	488	480	543	571	599	651	17. 9

At Jeanerette

High energy:									
High protein	5	1, 195	1, 230	1, 229	1, 217	1, 214	1, 190	1, 198	----------
Medium protein	6	1, 260	1, 278	1, 266	1, 258	1, 244	1, 223	1, 215	----------
Low protein	4	839	845	870	882	899	955	965	----------
Medium energy:									
High protein	5	771	779	825	835	844	861	857	----------
Medium protein	5	943	946	985	979	998	997	1, 014	----------
Low protein	6	793	792	815	831	832	854	859	----------
Low energy:									
High protein	4	644	635	648	720	770	791	819	----------
Medium protein	5	612	599	643	750	770	802	843	----------
Low protein	6	711	718	725	782	810	842	858	----------

TABLE 17.—*Weight gained and feed consumed by cows fed the hay ration at intervals before and after bearing second calf*

AT BELTSVILLE

Original ration level	Cows observed	Average body weight of cows at stated intervals before calving		Average body weights of cows at stated intervals after calving				Final weight of cows	Average daily consumption of hay ration by cows—	
		56 days	28 days	1–7 days	28 days	56 days	84 days		At calving time	84 days after calving
	Number	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
High energy:										
High protein	5	1, 302	1, 302	1, 200	1, 171	1, 119	1, 086	1, 087	28. 2	24. 0
Medium protein	4	1, 170	1, 174	1, 116	1, 075	1, 057	1, 009	998	32. 4	23. 9
Low protein	6	1, 003	1, 019	935	893	924	931	883	26. 3	23. 3
Medium energy:										
High protein	6	1, 032	1, 062	1, 020	1, 016	1, 021	1, 017	1, 000	27. 3	24. 5
Medium protein	6	1, 017	1, 061	1, 008	1, 000	994	993	1, 003	28. 0	24. 1
Low protein	6	972	1, 002	946	942	916	922	934	28. 1	25. 1
Low energy:										
High protein	4	1, 053	1, 070	1, 010	1, 015	1, 010	993	916	27. 3	24. 4
Medium protein	5	1, 002	1, 035	978	958	947	916	897	26. 4	24. 9
Low protein	6	963	982	914	915	930	921	924	27. 4	22. 4

At Jeanerette

High energy:									
High protein	5	1,229	1,224	1,095	1,051	1,045	1,062	----------	----------	----------
Medium protein	6	1,189	1,168	1,065	1,066	1,062	1,051	----------	----------	----------
Low protein	4	990	1,025	969	962	938	930	----------	----------	----------
Medium energy:									
High protein	5	953	947	911	883	875	866	----------	----------	----------
Medium protein	5	1,053	1,067	1,012	1,028	994	997	----------	----------	----------
Low protein	6	955	960	872	878	899	886	----------	----------	----------
Low energy:									
High protein	4	1,002	1,012	965	961	979	1,032	----------	----------	----------
Medium protein	5	966	980	921	940	928	918	----------	----------	----------
Low protein	6	955	939	886	849	770	791	----------	----------	----------

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