PART I
GRAZING BEHAVIOR OF RANGE BEEF COWS

PART II
EFFECT OF DIFFERENT LEVELS OF SUPPLEMENTAL WINTER FEED
UPON THE PRODUCTION OF FALL-CALVING BEEF COWS

by

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PART I. GRAZING BEHAVIOR OF RANGE BEEF COWS

INTRODUCTION

Studies of the grazing behavior of an animal can help to explain its response to its environment, although feed intake probably provides the best single index of its reaction. A more complete and critical interpretation of production records would be possible through the use of both grazing behavior studies and feed-intake measurements. Hancock (1950) stated: "The almost total reliance on pasture, and the great variability of the sward due to seasons and human factors seem to justify all the effort which can be spared on investigations into the animals' reaction to the sward and other environmental conditions."

The investigations reported herein were undertaken to study the activities of beef cows on the range including determination of the amount of time spent in various activities such as grazing, ruminating, idling, standing, lying, walking, suckling calves, and sleeping. The effect of frequency of observation when estimating the time spent in the various activities over a 24-hour period was also studied.

REVIEW OF LITERATURE

Grazing Behavior

One of the early studies of the activities of livestock on the range was conducted by Cory (1927). His purpose was to obtain definite information on behavior of range livestock, their requirements, and their preferences for range forage. Cory stated: "Such information should be helpful in developing a system of grazing that approximates the very best utilization of the range vegetation." Continuous observations were made on individual cattle, sheep, and goats between the time of their "getting up" in the morning and their "bedding down" at night. The amount of time spent in various activities such as grazing, resting, ruminating, idling, traveling, and drinking was noted. However, no observations were made during the night on the assumption that once the animals laid down to rest in the evening they would continue resting until the next morning. Although many data were presented they have not been summarized here because of the omission of night-time observations.

Hodgson (1933) reported the results of a study relating to the relative value of continuous as compared with rotational grazing. Lactating dairy cows were used as the experimental animals, and the time devoted to various physical activities was recorded. The results showed that cows on rotational grazing treatment grazed a total of 28 minutes less during the day than those on continuous grazing, but the latter cows grazed more

frequently. It was assumed that the cows did very little grazing at night; consequently, no observations were made after dark.

During three summers, Doran (1943) studied the grazing habits and activities of range sheep. The time spent in feeding, traveling, resting, idling, ruminating, salting, nursing, drinking, and in other activities was recorded in minutes or fractions thereof. No observations were conducted between 7:30 p.m. and 5:00 a.m. Thus, the activities were only recorded over a 14.5 hour period.

Later behavior studies of cattle indicated that a certain amount of grazing did occur at night. For example, Fisher et al. (1954) reported that an average of 51 percent of the grazing time of lactating dairy cows was at night.

Hein (1935) reported the grazing time of beef steers on permanent pasture at Beltsville, Maryland. Data were collected over three 24-hour periods, observations being taken every 15 minutes during each period. Abundance of pasturage appeared to be the major factor in determining the total time spent grazing. Approximately 8.75 hours were spent grazing during a 24-hour period when the pastures furnished an abundance of forage. Grazing time increased to about 10 hours when the herbage was less plentiful. The animals did not graze at night except at twilight or in moonlight. They grazed more intensively between 5:00 p.m. and 8:00 p.m. and between 5:00 a.m. and 8:00 a.m. than at any other period during the 24 hours. Smith (1959), in grazing behavior studies with lactating cows, reported a morning and afternoon peak of intense grazing separated by a rest period and watering about midday. In general, there was one peak of night grazing.

Johnston-Wallace and Kennedy (1944) studied the grazing habits of beef cows, on pasture without supplemental feed, over continuous periods of 24 hours during the months of July, August, and September. Four trials were conducted, the observations being concentrated on one particular animal in each trial. During each 24-hour period the cows spent from 7 to 8 hours grazing. Of this time, approximately 5 hours were all that could be counted as time employed in gathering herbage, as some time was spent in walking short distances and in selecting the area to be grazed. On the average, 60 percent of the grazing time was spent during the day and 40 percent at night while the distances traveled were about two miles and one-half mile, respectively. Records were also made of frequency of defecation (12); frequency of urination (9); frequency of drinking (once only, usually in late afternoon); and frequency of suckling calf (3, for about 15 min. each at 8 hr. intervals).

A study of the grazing habits of beef cattle on mixed prairie pasture near Hays, Kansas was conducted by Moorefield and Hopkins (1951). The average total time spent grazing by a steer, heifer, and cow was 9 hours and 54 minutes, 10 hours and 21 minutes, and 10 hours and 25 minutes, respectively. Each animal traveled a distance of 2.5 to 3 miles per day and drank two or three times.

Peterson and Woolfolk (1955) studied the grazing habits of Hereford cows and calves on shortgrass range in Montana. The time spent on major activities and the sequence of activities during 24-hour periods in August and October were recorded. In August, cattle devoted 11 hours and 38 minutes to grazing. This was reduced slightly to 11 hours during mid-October. Day-time grazing increased in October relative to August.

Calves in this study grazed 2 or 3 hours less than their mothers and tended to rest longer each day. Corbett (1953) found that calves, from an early age, exhibited a cyclic pattern of behavior similar to that shown by mature cattle.

Dwyer (1960) conducted an intensive study of the behavior pattern of beef cows on Adam's Ranch located in northeastern Osage County, Oklahoma. This area has been described as being true prairie. Results showed cows to graze an average of 9.67 hours during a 24-hour period. Approximately 82 and 18 percent of the grazing occurred during the day and night, respectively. A total resting time (total time standing and lying) of 13.4 hours was recorded. The cattle ruminated 6.05 hours at night and 4.42 hours during the day. Six and one-half hours of rumination occurred while lying and 3.97 hours while standing. There were two periods of intense grazing; in the morning between 5:00 and 8:00 a.m., and in the evening between 5:00 and 8:00 p.m. The cows traveled an average distance of 3.76 miles per day. The time spent walking directly from one point to another was 25.8 minutes. This time did not include the time spent walking while grazing. An average of 12.2 defecations and 4.6 urinations were recorded for the cow-day (period from rising in the morning until bedding down in the evening). In this study, as the temperature increased, the total time spent grazing was reduced. The reduction in grazing time was during daylight hours of the hot days and the cows failed to compensate for time lost in grazing by increasing their night-time grazing. The calves generally nursed an average of four times during a 24-hour period, for a total of 43.8 minutes. Chambers (1959) reported four nursing periods for calves; three times during daylight hours and once about midnight.

Seath and Miller (1946) reported that during relatively warm weather, dairy cows spent considerably more time grazing during the night hours than during the day. Day-time grazing was 2.4 times greater on cool days than on warm days and 24-hour grazing time was more than 1 hour longer on cool days.

The grazing habits of grade Friesian cattle were studied by Payne et al. (1951). The study was conducted on the Fiji Islands located near the International Date line and less than 20° south of the Equator. Under these tropical conditions, total grazing time was reduced during the hot months, the cows grazing mainly at night (67 percent of the total grazing time). It was concluded that the grazing behavior of European-type cattle was radically different in the tropics from that in the temperate zone. Hancock (1953) concluded that the primary effect of high maximum temperatures was to cause dairy cows to spend less of their total grazing time between the a.m. and p.m. milkings.

Waite et al. (1951) reported the results of a study of the activities of two groups of dairy cows, six head each, for a total of 22 24-hour periods during the months of May through August. They concluded that temperature changes, under the conditions in southwestern Scotland, had only a limited effect upon the general pattern of grazing. Similar conclusions were reached by Harker et al. (1954) from studies at Entebbe in Uganda. The seasonal variation in average maximum and minimum temperatures was reported to be less than 10° F. However, he suggested, from three consecutive 24-hour periods of observation on the same 10 animals, that "Zebu cattle on a high level plateau near the equator have grazing habits which differ from those recorded for other cattle." Holder (1960), in

studies with lactating dairy cows, found that environmental temperatures up to 87° F. did not alter total grazing time from that recorded when temperature reached a maximum of only 70° F.

Tribe (1949) conducted numerous observations over continuous periods of 24 hours during 12 consecutive months in an attempt to determine seasonal influences upon the grazing habits of sheep. The animals spent an average of 9 hours and 25 minutes grazing per 24 hours. This figure remained constant throughout the year, although considerably more daytime grazing was done in winter than in summer. The sheep rested an average total of 12 hours and 55 minutes and walked an average of 2.6 miles per 24 hours. A total of 1 hour and 40 minutes was spent idling per 24 hours. Tribe assumed, in this study, that data collected for various activities of one sheep reflected the actions of the five sheep used.

Wardrop (1953) conducted a study with commercial dairy cows where the times spent grazing, ruminating, drinking, and resting were observed. The average time spent grazing was 7 hours and approximately 6.25 hours were spent ruminating. An average of 42 percent of the grazing took place during the day and 58 percent at night. The grazing time appeared to be correlated with the length and dampness of the herbage and the milk yield. Time spent ruminating appeared to be associated with a low moisture content and a high proportion of fiber in the herbage being consumed.

Atkenson et al. (1942) observed that dairy heifers grazed an average of 7 hours, or 29 percent of a 24-hour period. The animals spent an average of 4 hours, or 17 percent of the time, walking or standing without grazing and 13 hours, or 54 percent of the 24-hour period, lying

down. Forty percent of the daytime was occupied in grazing, 25 percent in walking and standing, and 35 percent lying down; during the nighttime these were 16, 4, and 80 percent, respectively.

The above authors, in another part of the study, noted the comparative time spent in grazing on six different pastures during the daytime. On good pasture the cows spent 5.6 hours grazing. On fair pasture the cows spent 6.5 hours grazing and on poor pasture 7.3 hours. Consequently, 31 percent more time was spent in grazing on poor pasture than on good pasture. The classification of pasture in this trial was related mainly to the length and density of the sward. Four primary grazing periods were noted during the day with two less pronounced periods during the night.

Harker et al. (1961) summarized results from 26 days of observation on five paddocks representing three different pasture types. Data were collected over a period of nearly 5 years. Large differences were noted among days on the same pasture and among pastures both for the individual animal and for the herd. However, there were a number of features common to all the records. The animals started grazing each morning after 6:00 a.m. and ceased grazing each evening between 7:00 and 8:00 p.m. Most of the rumination occurred between 7:00 p.m. and 7:00 a.m. The authors thought that part of the large variation could have been caused by individual behavior and changes in climatic conditions. However, it was concluded that the primary source of variation was the difference between quantity and quality of herbage on different pastures.

Hancock (1950) reported the conclusions drawn from four years' work during which nearly 2,000 cow-days of grazing were recorded. Monozygotic

dairy cattle twins were used in all trials. He found the time spent grazing and the subsequent time required for rumination were interdependent and under certain conditions mutually restrictive. To enable this relationship to be depicted, the use of the ratio of ruminating time to grazing time (rt/gt ratio) was suggested. The two most important factors affecting this ratio were the quantity and quality of the forage. Other modifying factors affecting grazing behavior were divided into: (1) Metabolic, diurnal, and seasonal rhythms; (2) weather; (3) individual idiosyncrasies; (4) environment-inheritance interactions; and (5) "herd law" or "bunting order."

In confirmation of his previous study, Hancock (1954) reported that the most important external factors affecting the grazing and ruminating time of dairy cows were the quality and quantity of the forage. An increase in both grazing and ruminating time, in general, was noted for adverse pasture conditions. Grazing time was increased when the forage was scarce or of a mixed quality. Ruminating time was increased when the quality of grass was poor. The increased grazing time on mixed quality pasture was attributed to selective grazing. However, the ruminating time was also increased when the animals were grazing a mixed quality forage. Feed requirement for milk production was listed as the most important internal factor determining variation in the length of grazing time.

Hancock (1954) also found a very distinct relationship between dry matter intake and the average rumination time. Grass of high fiber content required much longer rumination time per pound of dry matter than grass of low fiber content. From these studies, Hancock concluded that

results of observations based on a few animals may not be generally valid. In fact, he stated that the outstanding feature of grazing behavior was its variability due to internal and external conditions as applied to the animals. He also concluded that observations from a greater number of animals reduced the variability and seemed to be necessary for a more complete picture because of the great individual variation.

McCullough et al. (1954) undertook a study with dairy cows to determine the various factors affecting the time spent grazing, ruminating and the rt/gt ratio. The total time spent grazing and ruminating appeared to be chiefly affected by the quality and quantity of the forage. Observations showed both inadequate forage and highly selective grazing to lengthen the total time spent grazing. In order to avoid confusion, these workers suggested that the above two factors could be best separated by the differences in ruminating time. Basis for this explanation was that an abundant supply of mixed forage may lengthen grazing time but it also increases the time spent ruminating since it apparently allows adequate intake of forage. Insufficient forage apparently increases grazing time, but the resulting ruminating time is short, due to the small quantity consumed. It was noted that, in general, increasing percentages of digestibility were accompanied by longer grazing times and shorter ruminating times.

Lofgreen et al. (1957) studied changes in grazing behavior of sheep and cattle associated with abundant compared to scant forage when grazing either a pure stand of alfalfa or a trefoil-orchard grass combination. The size of the fields to be grazed were arranged so that the forage would be well utilized by the end of 6 days. During this period, 24-hour

observations were made on the 2nd and 5th days. Both steers and sheep spent significantly more time grazing alfalfa pasture on the 5th day in the field than on the second. Ruminating time increased for the steers on the 5th day but remained rather constant for the sheep. It was suggested that the ratio of ruminating time to grazing time was affected by the TDN content of the forage and that a highly digestible diet required less rumination. On trefoil-orchard grass the same length of time was spent grazing on the 2nd and 5th days in the field. The difference in behavior pattern on the two types of forage seemed to be related to ability of the animal to graze selectively.

Meyer et al. (1957), in a companion study with the previous trial, studied the differences in the abilities of cattle and sheep to select forage. Differences between these species were apparent when given alfalfa forage. The sheep selected and consumed from the alfalfa pasture a forage higher in total digestible nutrients. Sheep also made more gain per unit of total digestible nutrients consumed. With the trefoil-orchard grass, however, differences between sheep and cattle in selecting ability were not so apparent. Selective grazing was not as great with a low dense forage (trefoil-orchard grass) as with a tall, less dense forage (alfalfa). Results indicated that caution should be exercised in the use of data from one species to predict the grazing response of some other species on pasture or rangeland conducive to selective grazing.

Continuous vs. Intermittent Observations

The method of continuous observation, even though the most accurate, is laborious. It provides a large quantity of data on individual animals.

By lengthening the time interval between observations, a larger number of animals could be observed with less labor per animal.

Harker et al. (1954) observed the error introduced by increasing the interval between observations of grazing habits. He presented evidence of close agreement between observations made at 4-minute intervals and continuous observations. The error introduced was inversely proportional to the time spent in each habit. Thus, the error associated with the major cattle activities such as grazing, standing, standing ruminating, and lying was small. Hughes and Reid (1951) concluded that observing activities at 4-minute intervals yielded satisfactory results. Also, Tayler (1953) used 4-minute interval observations in reporting the grazing activity of bullocks.

Sheppard et al. (1957) reported observations of grazing habits recorded at 30-minute intervals during periods of heaviest grazing and at 1-hour intervals during the remaining "daylight" hours. Observations were not made at night. The calculations were based on percentages of all animals in a given behavior, on the assumption that the animals observed in a given behavior continued in that behavior until the next observation. Lofgreen et al. (1957) recorded observations at approximately 20-minute intervals during daylight and about 30-minute intervals at night for grazing animals (cattle and sheep) and for animals fed soilage.

Hull et al. (1960) compared 15-, 30- and 60-minute observation intervals with continuous observation. The study involved the behavior pattern of four steers over a 24-hour period in 0.40 acre of irrigated pasture. They concluded that the major activities such as grazing, ruminating, or idling could be adequately predicted using 15- and 30-minute

observation intervals. For the minor activities, apparently continuous or 15-minute observations were needed to determine the behavior pattern. The authors also reported considerable individual variation in animal behavior patterns and recommended the use of several animals in animal behavior studies. They concluded, "In this study four animals per treatment were adequate to obtain reliable estimates of animal behavior."

The present study was undertaken to obtain additional data on the behavior of relatively large numbers of range beef cattle grazing in native grass pastures, and to determine the time interval between observations required for reliable results.

MATERIALS AND METHODS

Grazing behavior studies were conducted with Hereford cattle grazing native grass pasture at the Lake Carl Blackwell experimental range area located approximately 15 miles northwest of Stillwater, Oklahoma. Five 24-hour periods of continuous observations were conducted with a total of 49 cows. The number of cows per observation period varied from 7 to 11. In three of the five studies, the cows were suckling calves.

In the first study, large numerals were painted with aluminum paint on both sides of each cow. These large numbers permitted long range identification of individuals. In subsequent observations, different colored paints or a combination thereof were used to identify each individual. In addition to a stripe or stripes of different colored paint across the back, each cow was painted across the forehead and the pinbone region. This facilitated the identification of individuals from any angle of observation. In studies with lactating cows, the calves were marked like their mothers. Small reflective glass beads were "dusted" on the wet paint as an aid to identification during night-time observations. The original study began on August 18, 1959, at 10:00 a.m. and terminated 24 hours later. All later studies started at 5:30 a.m. and continued for 24 consecutive hours.

Two different groups of cows were used in these five studies. One group consisted of 10 spring-calving cows which were observed on August 25, 1959, and again on September 25, 1959. On the morning of September 26,

1959, three cows wandered from the group. Consequently, data were collected over the second 24-hour period only on the seven remaining animals.

The other group of cows consisted of fall-calving cows which had been born in the spring of 1956. These cows were observed for three continuous 24-hour periods: August 18, 1959; September 11, 1959; and July 2, 1960. During the last period, cows were suckling their second calf. Of the 11 cows used in the first two periods, only seven were observed on July 2, 1960.

The two studies with spring-calving cows were made in one pasture, and the three studies with fall-calving cows in a second pasture. Each pasture was approximately 110 acres. The range condition class of the pasture used in the study with the spring-calving cows was "Excellent". The basal ground cover was 11.9 percent and the pasture contained 85 percent of climax grasses. The vegetation consisted largely of tall grasses with big bluestem (Andropogon gerardi), 9.0 percent; little bluestem (Andropogon scorparius), 63.9 percent, switchgrass (Panicum virgatum), 1.5 percent; and Indiangrass (Sorghastrum nutans), 5.2 percent. There was 8.3 percent sideoats grama (Bouteloua curtipendula) and 3.8 percent buffalo grass (Buchloe dactyloides). All other species were present in amounts less than 2.3 percent. The pasture for the fall-calving cows had approximately the same characteristics.

Observations were made by at least three persons. Usually two persons observed the animals, generally with the aid of field glasses, while the third person recorded the information. During daylight hours continuous observations were recorded. Since 1 to 3 minutes were required to observe all animals during hours of darkness the various activities were recorded usually only once or twice every 5 minutes during these

hours. Observers were generally at a distance of 60-80 and 40-50 yards from the cattle during the daytime and nighttime, respectively. The time activities included grazing, standing ruminating, standing idle, lying ruminating, lying idle, walking, suckling calves, and sleeping. The total time spent at the mineral box was recorded separately; however, it was included in the standing idle category.

The following nomenclature was used in this study:

1. Grazing time - included time spent actually grazing plus short periods of walking while selecting suitable areas to be grazed.
2. Rumination time - included the time spent (either standing or lying) in regurgitation, mastication, swallowing of ruminal ingesta, and the short time intervals between boluses.
3. Idling time - includes the time spent (either standing or lying) neither grazing, ruminating nor walking.
4. Walking - included the time spent walking while not grazing.

Aerial photographs of the pastures were used to trace routes of the cattle. The daily distance traveled by the cows was determined from the traced routes.

A pickup truck, which the cattle were accustomed to, was used to follow the cattle in the pasture. Movement of the truck near the herd produced very little disturbance.

At night, it was usually necessary for the observers to employ a handlamp or spotlight to determine particular activities such as rumination and sleeping. Disturbance resulting from the use of lights appeared

to be negligible. Other workers have reported that the use of lights resulted in practically no disturbance (Dwyer, 1960; Lofgreen et al., 1957; Peterson and Woolfolk, 1955).

The results of the continuous observations were compared with those obtained at 15-, 30- and 60-minute intervals. Observations at these three time intervals were obtained from the continuous observation data at the end of each 15-, 30- and 60-minute interval over the 24-hour periods.

RESULTS AND DISCUSSION

Average Activities Over a 24-Hour Period

The average activities of the five groups of cows were quite similar and followed a general pattern. The cows usually arose in the morning just as the sky became bright and objects were clearly discernible by shadows. After arising, the cows stood ruminating or idling for about 5 minutes and then started an intense grazing period. In studies with lactating cows, the calves generally nursed during these early morning hours.

Early morning grazing was followed by a period in which the activities were primarily ruminating and idling. Cattle usually continued in these activities until a period of intense grazing began in the afternoon. In general, the calves nursed a second time during the afternoon or evening. Grazing usually ceased by about 8:30 p.m. and the cows soon started ruminating. Rumination was mostly at night while the cow was in a lying position, although occasionally a cow would stand up and within a few minutes lie down again. There were brief intermittent periods of idling between 8:30 p.m. and midnight. In general, a relatively short period of grazing occurred near midnight. Also the calves usually nursed at this time. Subsequently, cattle were observed to "bed down" in one large group until daybreak. Rumination was the predominant activity between the night grazing period and daybreak. Some idling time was also

recorded during this period. Sometimes, cows would lay their heads back against their sides, this particular activity being recorded as sleeping time.

In Table I, a summary is presented of the major activities of all cows (49) under continuous observation. The standard error of the mean is also presented in order to give an indication of the variability that prevailed within and between these studies.

TABLE I

AVERAGE ACTIVITIES OF BEEF COWS UNDER CONTINUOUS OBSERVATION ON THE RANGE, SUMMARY OF FIVE STUDIES

		Ruminating		Idling	
	Grazing	Standing	Lying	Standing	Lying
Minutes	600 ± 8.6[1]	171 ± 11.4	368 ± 13.0	156 ± 8.0	118 ± 7.0
Percentage of 24 Hours	41.7	11.9	25.6	10.8	8.2

[1]Standard error of the mean.

The average total of 10 hours grazing per 24 hours agrees with results obtained in other studies with beef cattle (Dwyer, 1960; Peterson and Woolfolk, 1955; Moorfield and Hopkins, 1951). Nearly all of the total time spent grazing occurred during the three main grazing periods previously discussed.

Apparently, the animals preferred to ruminate in a lying position rather than a standing (25.6 vs. 11.9 percent), whereas they preferred idling in the standing position (10.8 vs. 8.2 percent). Average total time spent in standing and lying positions amounted to 22.7 and 33.8 percent of the 24-hour period, respectively. Dwyer (1960) reported that beef

cows spent an average of 25.2 percent of the time standing and 30.6 percent of the time lying during a 24-hour period.

General Activities of Cows

Grazing Time

A summary of the average grazing time recorded in each of the five studies is presented in Table II. Average temperature and percentage of total grazing time are presented for both day and night. Average temperatures in daytime and nighttime, based on sunrise and sunset, were obtained by averaging hourly temperatures. Similarly, the percentage of total time spent grazing in either day or night was based upon the time of sunrise and sunset.

The average grazing time varied from 536 to 673 minutes. In the three trials when the average daytime temperature was relatively high, the total time spent grazing was noticeably less than in the two trials when the temperature was lower. Similar results were reported by Dwyer (1960) who found that cattle grazed 2.05 hours less on a hot day (above 85°F.) than on a cool day (below 80° F.). Also Seath and Miller (1956) concluded that maximum day temperatures of 85° F. and over had the effect of reducing the time spent grazing.

Seath and Miller (1956) reported that when day temperatures became too hot for comfort, cattle spent appreciable time grazing at night. Studies conducted on August 18, 1959, and August 25, 1959, tend to substantiate this report. Conversely, 71.3 percent of the total grazing time was recorded on the hottest day of the five studies.

Figure 1 summarizes the relative times spent in grazing and ruminating during each 24-hour period (continuous observation). Three peaks of

TABLE II

GRAZING ACTIVITIES OF BEEF COWS ON THE RANGE

Date of study	July 2, 1960	August 18, 1959	August 25, 1959	September 11, 1959	September 25, 1959
Number of animals	10	11	10	11	7
Average temperature, ^{o} F.					
Daytime	90.4	85.4	89.6	69.6	72.4
Nighttime	81.7	73.9	81.3	56.9	74.3
Average total grazing time, minutes[1]	536 $\pm$ 11.2[2]	586 $\pm$ 10.8	576 $\pm$ 7.5	673 $\pm$ 10.3	634 $\pm$ 20.9
Daytime grazing, percent[3]	71.3	65.7	49.5	71.1	75.1
Nighttime grazing, percent[3]	28.7	34.3	50.5	28.9	24.9

[1] In a 24-hour period.

[2] Standard error of the mean.

[3] Percentages of total grazing time.

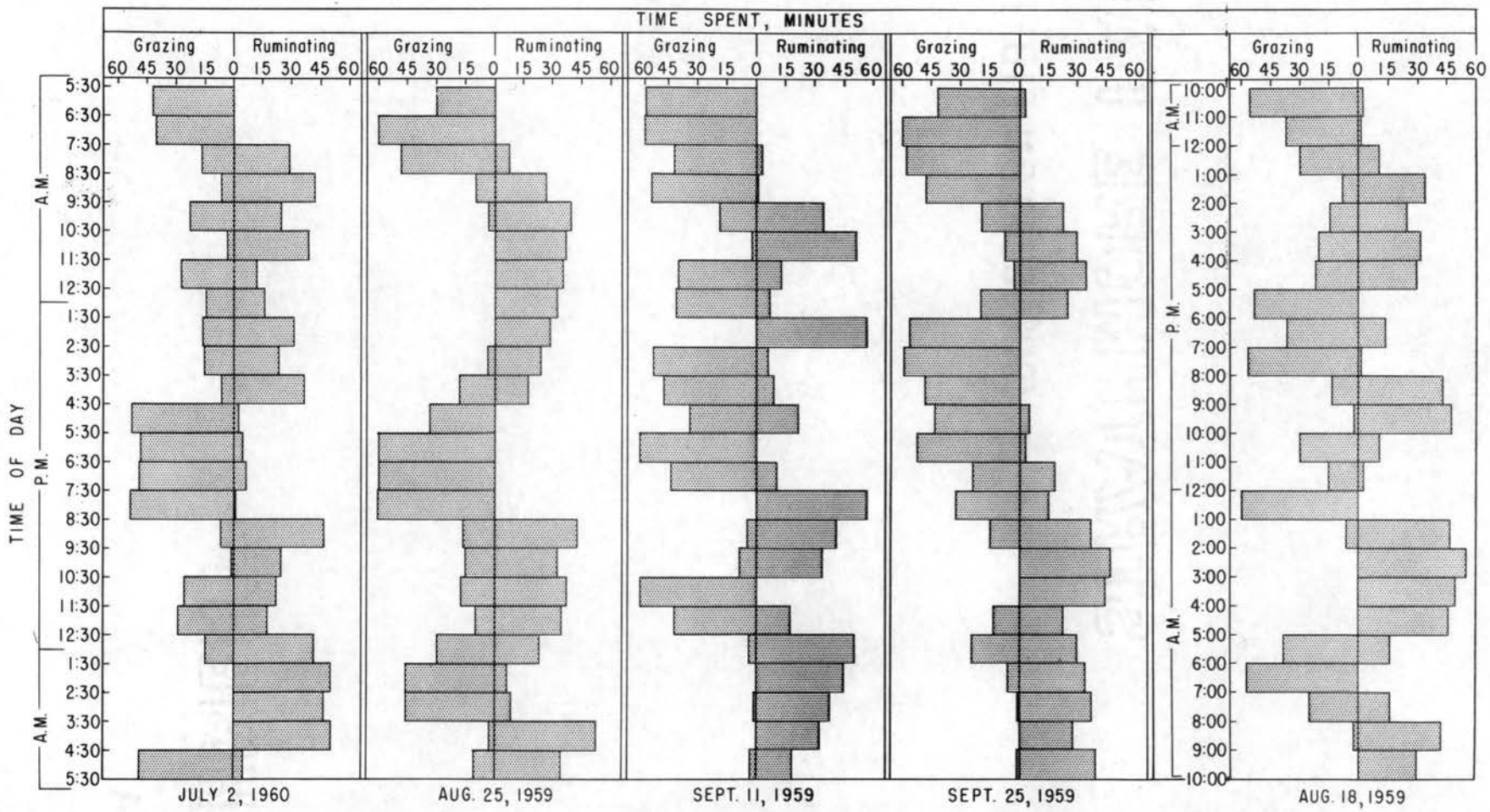

Figure 1. Grazing and Ruminating Times of Range Beef Cows Observed Continuously (24 Hours) in Five Studies . . . . .

grazing usually occurred and the time and height of the peaks was apparently related to temperature.

Greater total grazing time between 12:00 and 5:00 p.m. is apparent on September 11, 1959, and September 25, 1959, relative to the other three studies. Thus, on cooler days the afternoon grazing periods were earlier; however, intense afternoon grazing appeared to extend further into the evening on warmer days. It would also be noted that daybreak occurred earlier and morning grazing began earlier on July 2, 1960, and August 18, 1959, than in the September studies. In relation to the time of daybreak, initiation of the morning grazing periods was similar in all studies. The fact that 71.3 percent of the total grazing on July 2, 1960, occurred during the day appears to be attributable to longer hours of daylight and scattered grazing throughout the day.

A decrease in temperature may not be the only reason cattle grazed more total time during a 24-hour period. Other factors, such as a decrease in the quantity and quality of the forage have been listed as important variables by previous workers. Quantity of forage was assumed to be adequate in all studies, but, quality of the pasture may have been related to the increased grazing time. Hancock (1950) and McCullough (1954) reported that pastures of mixed quality, (i.e., herbage of varying fiber content or pastures which had previously been grazed unevenly) resulted in greater grazing time than when the pastures were of good quality (i.e., herbage of uniformly low fiber content).

Ruminating Time

In all trials the cows ruminated more at night than during the day. The total daytime rumination was greater on hot days than on cool days

(Table III). As Figure 1 indicates, afternoon grazing time was usually less on hot days.

It is well established that the nutritive value of native forage decreases with an increase in maturity. This is particularly apparent in a decrease in protein content and an increase in fiber content. Since an increase in fiber content has been reported to increase ruminating time (Hancock, 1950), ruminating time would probably be expected to increase along with grazing time in late summer and early fall. However, the average total minutes spent ruminating were as follows: July 2, 1960, 576; August 18, 1959, 552; August 25, 1959, 522; September 11, 1959, 544; and September 25, 1959, 479. Since grazing time increased and ruminating time generally decreased, possibly the animals became more selective in their grazing as the quality of the forage decreased. Hancock (1950) noticed that under conditions of mixed quality pasture, cows became very selective in their grazing and consequently the grazing time was lengthened. Despite this selectivity, however, he reported that the ingested material was of a type that caused long ruminating times.

Idling Time

Table IV summarizes the average idling time of cows in each of the studies. The time devoted to standing and lying idling varied considerably between studies. The standing idling time was longer than the lying idling time on July 2, August 18, and August 25, whereas the opposite was true on September 11, and September 25.

Temperature appeared to be a factor in determining whether idling was longer in the standing or lying position. During cool temperatures,

TABLE III

RUMINATION BY BEEF COWS ON THE RANGE

	Average temperature, °F.		Average total ruminating time, minutes[1]		Percent of total ruminating time	
	Daytime	Nighttime	Standing	Lying	Daytime	Nighttime
July 2, 1960	90.4	81.7	133 ± 18.4[2]	443 ± 21.3	47.5	52.5
August 18, 1959	85.4	73.9	188 ± 14.5	364 ± 15.8	42.6	57.4
August 25, 1959	89.6	81.3	280 ± 17.6	242 ± 13.9	48.3	51.7
September 11, 1959	69.6	56.9	131 ± 13.4	413 ± 19.1	37.6	62.4
September 25, 1959	72.4	74.3	106 ± 23.0	373 ± 26.6	25.3	74.7

[1] In a 24-hour period.

[2] Standard error of the mean.

the animals preferred to spend most of their idling time in a lying position. The opposite was noted for warm days.

TABLE IV

IDLING TIME OF BEEF COWS ON THE RANGE

	Average total idling time, minutes[1]	
	Standing	Lying
July 2, 1960	192 ± 10.8[2]	110 ± 8.0
August 18, 1959	170 ± 11.1	85 ± 9.7
August 25, 1959	204 ± 10.0	104 ± 16.0
September 11, 1959	81 ± 7.9	133 ± 13.3
September 25, 1959	134 ± 13.2	178 ± 17.9

[1] In a 24-hour period.

[2] Standard error of the mean.

The average total idling times were: 302, 255, 308, 214, and 312 minutes on July 2, August 18, August 25, September 11, and September 25, respectively. Consequently, total time spent idling failed to follow a definite trend in relation to temperature. The percentage of time spent idling in each 24-hour period was: 21.0, 17.7, 21.4, 14.9, and 21.7 for July 2, August 18, August 25, September 11, and September 25, respectively.

Suckling Time

As mentioned previously, cows were suckling calves in three of the studies. The calves observed with their dams on July 2, 1960, were approximately 8 months of age whereas those calves observed on August 25, 1959, and September 25, 1959, were about 6 and 7 months of age, respectively. In the latter two studies the time spent inside the creep-feeder,

which supplied supplemental feed for the calves, was recorded for individual animals. This information is presented in Table V along with the number of nursing periods and total time spent nursing in each 24-hour period.

TABLE V

OBSERVATIONS ON CALVES WITH THEIR DAMS ON THE RANGE[1]

Date of study	Number of nursing periods	Total time spent nursing minutes	Time in creep-feeder minutes
July 2, 1960	2.4 ± .5[2]	18.1 ± 4.6	
August 25, 1959	3.2 ± .4	23.7 ± 2.8	17.9 ± 7.0
September 25, 1959	3.6 ± .4	27.3 ± 4.9	46.3 ± 13.5

[1]In a 24-hour period.

[2]Standard error of the mean.

The calves usually nursed three times in a 24-hour period as follows: (1) about daybreak, (2) afternoon or evening, and (3) around midnight. There were exceptions to these nursing periods as indicated by the above mean nursing times for the three studies. On September 25, several of the calves nursed about noon. The average total time spent nursing varied from 18.1 to 27.3 minutes on July 2, and September 25, respectively.

Only 5 of the 10 calves observed on August 25, and 5 of the 7 calves observed on September 25, were recorded in the creep-feeder. This, together with considerable individual variation in time spent at the creep-feeder, accounts for the relatively large standard errors of the mean. In many instances a calf in the creep-feeder ate little or no feed. No

observations were made of the amount of creep-feed eaten or the time spent by each calf eating creep-feed.

Distance Traveled

The time recorded in minutes for walking includes only the actual time spent by the animals in walking directly from one place to another and did not include the time devoted to travel which accompanied grazing. Therefore, the average time spent walking is not necessarily related to the average distance traversed over a 24-hour period. Table VI summarizes the average distance traveled and the average time recorded for walking in each of the five 24-hour periods. The average distance traveled ranged from 2.00 on September 11, to 3.73 miles on August 18. The over-all average was 2.59 miles.

Most of the distance traveled was related to four definite places; water, shade, mineral box, and bedding grounds. Generally the cattle preferred to travel in a group which, occasionally, was dispersed over a large area.

Grazing and Ruminating Rate

The length of time an animal spends in grazing is obviously only one of the factors which determine its feed intake. Other factors, such as the number of bites taken per unit of time and the size of each bite are of great importance and, for a full description of grazing activity, should be included. Practically no information is available on the quantity of food consumed per bite but the grazing rate (bites per minute) can be ascertained simply by counting, since each bite is distinctly visible. Information obtained in these studies relative to grazing rate and rate of mastication during the rumination process appears in Table VII.

TABLE VI

DISTANCE TRAVELED AND TIME SPENT WALKING BY BEEF COWS ON THE RANGE

Date of study	July 2, 1960	August 18, 1959	August 25, 1959	September 11, 1959	September 25, 1959
Average distance traveled, miles[1]					
Day	1.92	2.81	2.26	1.64	1.52
Night	.23	.92	.65	.36	.65
Total	2.15	3.73	2.91	2.00	2.17
Time spent walking, minutes[2]	26.0 ± 2.8[3]	47.0 ± 2.3	34.0 ± 1.1	9.0 ± 1.9	15.0 ± 3.7

[1]Aerial photographs of the pastures were used to trace routes of the cattle. The daily distance traveled by the cows was determined from traced routes.

[2]Includes only the actual time spent by the animals in walking directly from one place to another and does not include the time devoted to travel accompanying grazing.

[3]Standard error of the mean.

A total of 37 individual 1-minute counts were made in an attempt to determine the grazing rate. An average of 65.7 bites per minute was obtained. Most of these counts were made during the early part of two intense grazing periods on August 25. Hancock (1950) reported that more bites were taken per minute at the beginning of a grazing period than at the end. In a trial with two sets of identical twins, in which bites were counted over a 24-hour period, he found that the rate was 60-70 and 40-50 bites per minute at the beginning and at the end of each grazing cycle, respectively. Ruminating rate did not appear to be influenced by cyclic changes and it was concluded that a small number of counts should be adequate to establish characteristic rates. However, Hancock (1954) indicated that both ruminating and grazing rates were inherited characteristics. In 10 sets of twins, the fastest ruminating rate was 68.5 chews per minute and the slowest was 43, while the average difference within sets was only 3.5.

TABLE VII

AVERAGE GRAZING AND RUMINATING RATES OF BEEF COWS ON THE RANGE

Grazing	Ruminating		
Bites/minute	Chews/minute	Seconds/bolus	Chews/bolus
65.7 ± 1.41[1]	65 ± 1.02	56.3 ± 2.16	49.2 ± 4.37

[1]Standard error of the mean.

In 26 counts of ruminating the frequency of chewing varied between 56 and 76 chews per minute; the number of seconds per bolus and the chews per bolus were 56.3 and 49.2, respectively. Dwyer (1960) reported 44.4

as the mean number of seconds per bolus and 49.3 as the average number of mastications required for each bolus.

Miscellaneous Activities

Table VIII summarizes various activities which were recorded in these studies. The time spent sleeping was recorded in only three studies, one in July and two in September. Practically all of the time spent sleeping by cattle was recorded between the night and early morning grazing periods. They very seldom slept during daytime.

Dwyer (1960) reported that water drinking increased with daily temperature increases. In the present studies, the large day to day variation tended to obscure any such relationship.

Considerable variation in number of defecations and urinations was noted between animals on the same day as well as between days. The average number of defecations in a 24-hour period ranged from 2.1 on August 25, to 8.0 on August 18. Average number of urinations ranged from 1.5 on July 2, to 5.0 on August 18. No particular cyclic pattern appeared to be associated with these metabolic activities. Cattle usually defecated and urinated soon after arising in the morning and generally defecated after an extended period of lying down.

Continuous vs. Intermittent Observations

Table IX summarizes the results using the four different observation intervals in each of the five studies. Activities compared at different intervals of observation included grazing, walking, standing ruminating, lying ruminating, standing idle, and lying idle.

TABLE VIII

MISCELLANEOUS ACTIVITIES OF BEEF COWS ON THE RANGE[1]

Date of study	July 2, 1960	August 18, 1959	August 25, 1959	September 11, 1959	September 25, 1959
Time spent sleeping, minutes	30.6 ± 5.2[2]			26.6 ± 4.0	27.0 ± 6.0
Number of drinks of water	2.0		2.0	1.4	
Number of defecations	7.8 ± .5	8.0 ± 1.2	2.1 ± .5	6.4 ± 1.0	3.6 ± .5
Number of urinations	1.5 ± .4	5.0 ± 1.1	1.5 ± .3	2.4 ± .5	1.6 ± .3

[1] In a 24-hour period.

[2] Standard error of the mean.

TABLE IX

ACTIVITIES OF RANGE BEEF COWS AS DETERMINED AT DIFFERENT TIME INTERVALS[1]

Minutes ?

Interval of time	Grazing	Walking	Ruminating		Idling	
			Standing	Lying	Standing	Lying
			July 2, 1960 (10 head)			
Continuous	536 ± 11.2[2]	26 ± 2.8	133 ± 18.4	443 ± 21.3	192 ± 10.8	110 ± 8.0
15 minutes	523 ± 14.2	21 ± 4.6	134 ± 20.2	452 ± 19.6	207 ± 13.9	103 ± 9.6
30 minutes	482 ± 19.2	21 ± 6.4	147 ± 23.0	453 ± 15.1	225 ± 14.3	111 ± 17.9
60 minutes	456 ± 38.2	24 ± 9.8	162 ± 28.4	396 ± 33.7	270 ± 22.5	132 ± 34.4
			August 18, 1959 (11 head)			
Continuous	586 ± 10.8	47 ± 2.3	188 ± 14.5	364 ± 15.8	170 ± 11.1	85 ± 9.7
15 minutes	573 ± 11.4	19 ± 2.9	187 ± 14.4	361 ± 14.5	207 ± 14.3	93 ± 10.9
30 minutes	619 ± 10.9	3 ± 2.7	177 ± 18.3	368 ± 15.7	175 ± 12.7	98 ± 12.8
60 minutes	638 ± 21.8	6 ± 5.4	169 ± 26.6	382 ± 14.6	169 ± 24.0	76 ± 20.0
			August 25, 1959 (10 head)			
Continuous	576 ± 7.5	34 ± 1.1	280 ± 17.6	242 ± 13.9	204 ± 10.0	104 ± 16.0
15 minutes	582 ± 9.7	28 ± 4.7	300 ± 11.6	228 ± 17.7	195 ± 17.5	107 ± 15.9
30 minutes	612 ± 13.6	33 ± 3.0	297 ± 17.0	228 ± 22.0	168 ± 16.8	102 ± 16.2
60 minutes	660 ± 17.9	0	258 ± 28.4	246 ± 24.4	168 ± 23.3	108 ± 19.6

TABLE IX (Continued)

Interval of time	Grazing	Walking	Ruminating		Idling	
			Standing	Lying	Standing	Lying
			September 11, 1959 (11 head)			
Continuous	673 ± 10.3	9 ± 1.9	131 ± 13.4	413 ± 19.1	81 ± 7.9	133 ± 13.3
15 minutes	686 ± 11.3	1 ± 1.4	120 ± 12.0	420 ± 19.4	87 ± 8.8	126 ± 14.9
30 minutes	693 ± 12.4	3 ± 2.7	120 ± 12.1	403 ± 19.6	90 ± 14.0	131 ± 16.3
60 minutes	671 ± 22.6	0	153 ± 18.7	393 ± 23.4	76 ± 16.4	147 ± 20.4
			September 25, 1959 (7 head)			
Continuous	634 ± 20.9	15 ± 3.7	106 ± 23.0	373 ± 26.6	134 ± 13.2	178 ± 17.9
15 minutes	647 ± 21.8	13 ± 6.9	105 ± 22.7	367 ± 23.1	124 ± 10.7	184 ± 18.7
30 minutes	651 ± 26.0	9 ± 5.6	99 ± 25.1	377 ± 26.9	116 ± 7.8	188 ± 23.4
60 minutes	634 ± 34.3	17 ± 11.1	60 ± 26.2	343 ± 40.8	129 ± 24.3	257 ± 28.4
			Average (Weighted) Activities of Five Dates of Observation			
Continuous	600 ± 8.6	27 ± 2.3	171 ± 11.4	368 ± 13.0	156 ± 8.0	118 ± 7.0
15 minutes	601 ± 10.1	16 ± 2.2	173 ± 12.2	366 ± 13.8	166 ± 9.3	118 ± 7.3
30 minutes	611 ± 12.3	14 ± 2.5	171 ± 12.8	366 ± 13.8	156 ± 9.2	122 ± 8.4
60 minutes	612 ± 16.4	9 ± 3.0	166 ± 13.9	354 ± 14.1	163 ± 11.2	136 ± 13.3

[1]Results are expressed in minutes and calculated for a 24-hour period.

[2]Standard error of the mean.

From a check of the standard error of the mean for the various activities recorded under continuous observation, it is apparent that grazing time was the least variable within any individual study. This would probably be expected since the other major activities are dependent mostly upon grazing. For instance, the standing idle and lying idle times were much more variable within studies than grazing times.

In most studies, the variation tended to increase as the time interval between observations increased. As would be expected, the activities with the least amount of time associated with them were usually the most vulnerable. A good example would be walking. The time associated with this activity was greatly altered in two of the studies (August 18, and September 11) when the observation intervals were 15 minutes instead of continuous. The standard error of the mean for average walking time was usually markedly increased when the observation interval was 15 minutes instead of continuous. When the interval of observation was increased to 60 minutes, no time whatsoever was recorded for walking on August 25, 1959, and September 11, 1959. It is concluded from these results that, for a reliable estimate of the minor activities, the observation interval must be less than 15 minutes.

The standard error of the mean was almost always larger for all activities in all studies at the 60-minute interval of observation as compared with continuous observation. This was true even though the mean minutes associated with the particular activity did not noticeably change. Illustrative of this would be a comparison of the different intervals of observation for grazing on September 11, 1959. The average numbers of minutes recorded for grazing time were 673, 686, 693, and 671 for continuous,

15-, 30- and 60-minute intervals of observation, respectively. However, the standard error of the mean was more than doubled from continuous to 60-minute intervals of observation. Usually, the largest increase in the variation occurred when the interval of observation was increased from 30 to 60 minutes. This was evident in the previous illustration (12.4 at the 30-minute interval vs. 22.6 at the 60-minute interval).

In general, for the major activities (grazing and ruminating), the variation and the mean were not altered greatly up to but not including 60-minute intervals of observation. This is depicted graphically in Figures 2-6 where grazing time and ruminating time over each 24-hour period are compared at the different intervals of observation. The greatest alteration of grazing and ruminating patterns generally appeared between the 30- and 60-minute intervals of observation. For example, in Figure 2, the ruminating and grazing patterns appeared to be altered considerably when the interval of observation was increased from 30- to 60-minutes. No time was recorded for either activity between 6:30 and 7:30 a.m. at the 60-minute interval of observation even though an average of 24 minutes was noted for grazing time at the 30-minute interval of observation. Similarly, in Figure 6, the total time between 7:30 and 8:30 p.m. devoted to grazing and ruminating at 30-minute intervals of observation was approximately 30 minutes. Yet, at the 60-minute interval of observation, none of the cows was observed grazing or ruminating.

In Figure 3, the change in the grazing and ruminating patterns is noticeable at the 30-minute interval of observation, but the greatest change is apparent when the interval of observation was increased from 30 to 60 minutes. Also, in Figures 4 and 5, the longer the interval of

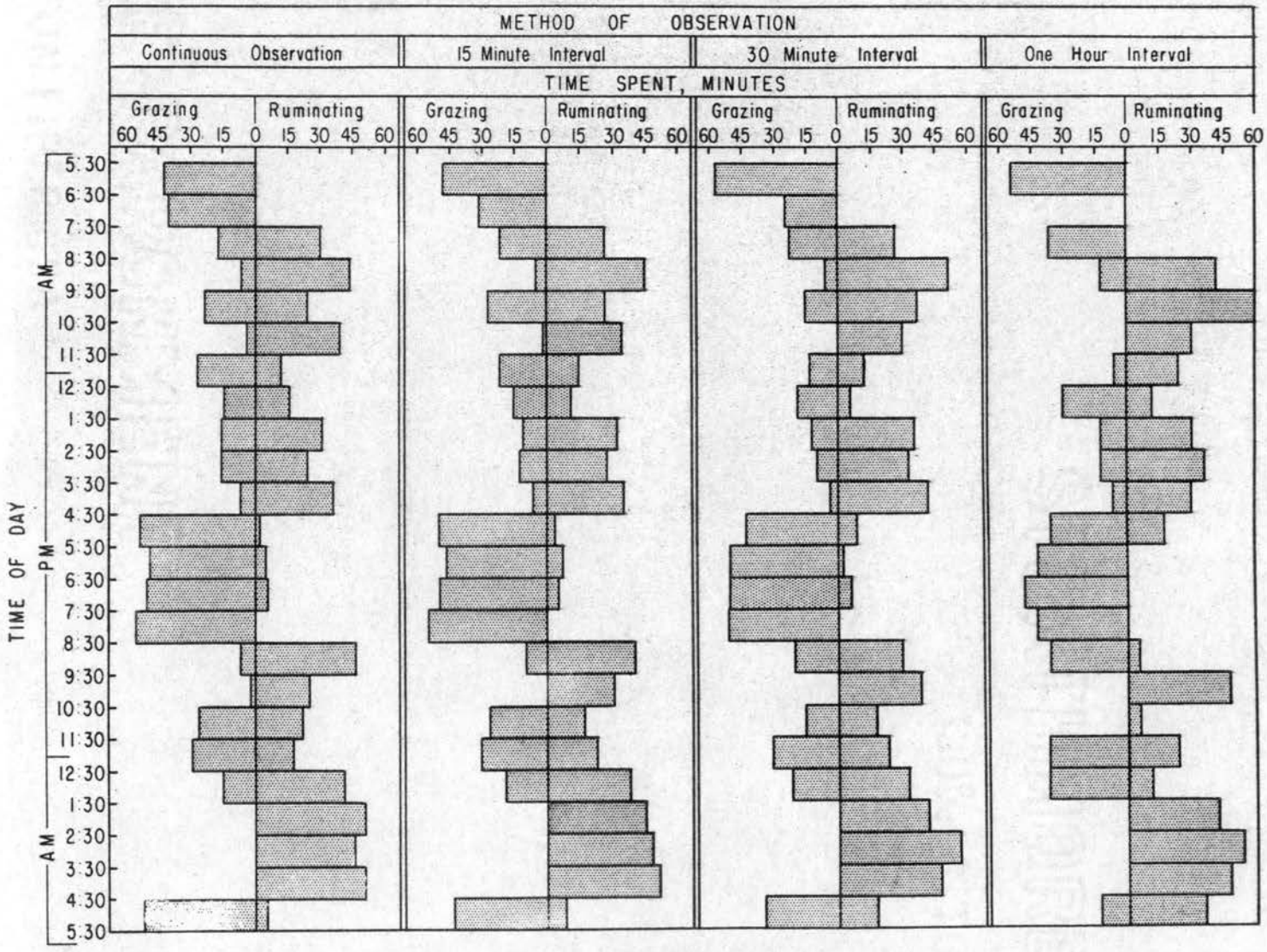

Figure 2. Grazing and Ruminating Times of Range Beef Cows When Observed Continuously and at 15-, 30- and 60-Minute Intervals, July 2, 1960

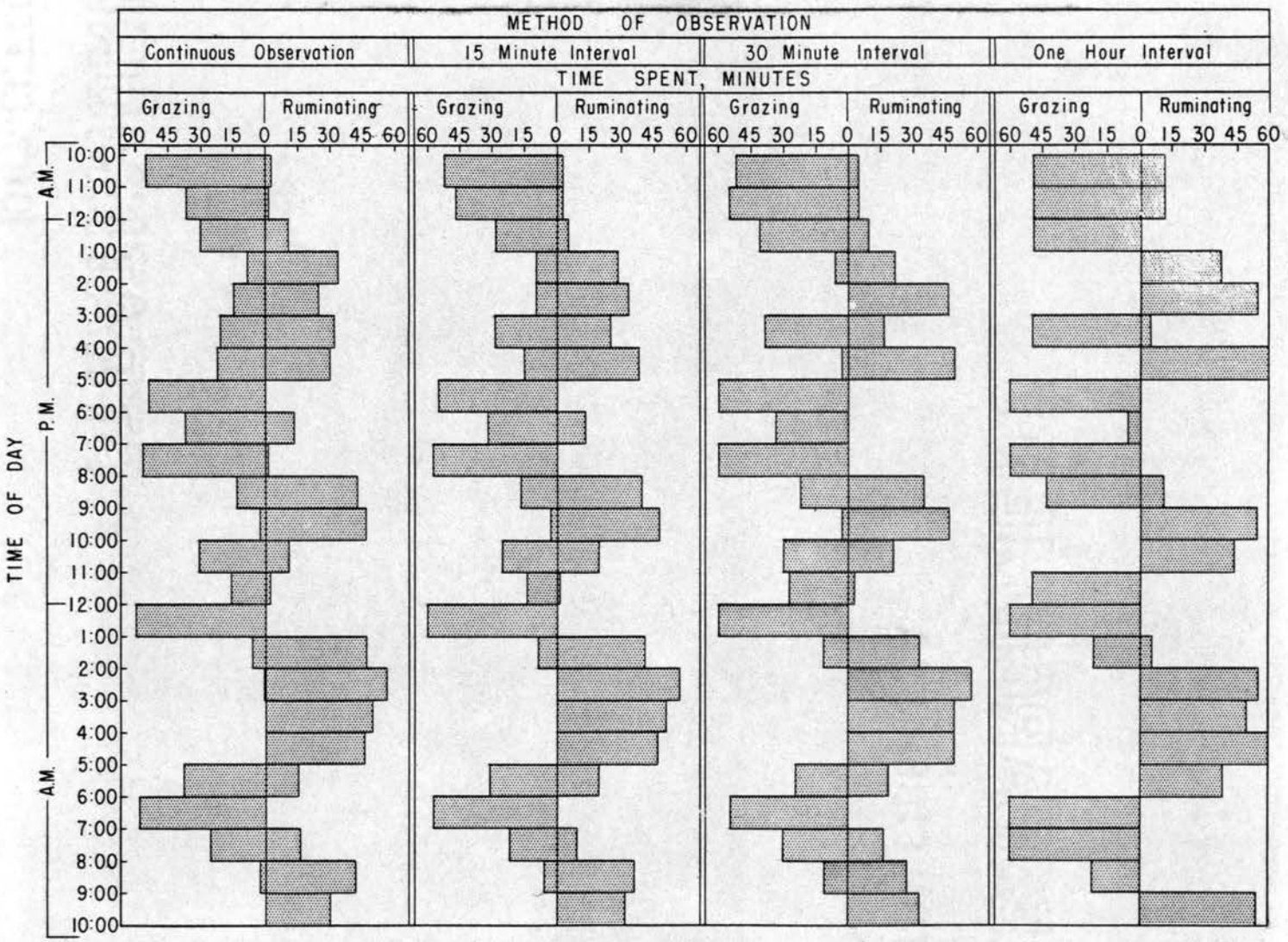

Figure 3. Grazing and Ruminating Times of Range Beef Cows When Observed Continuously and at 15-, 30- and 60-Minute Intervals, August 18, 1959

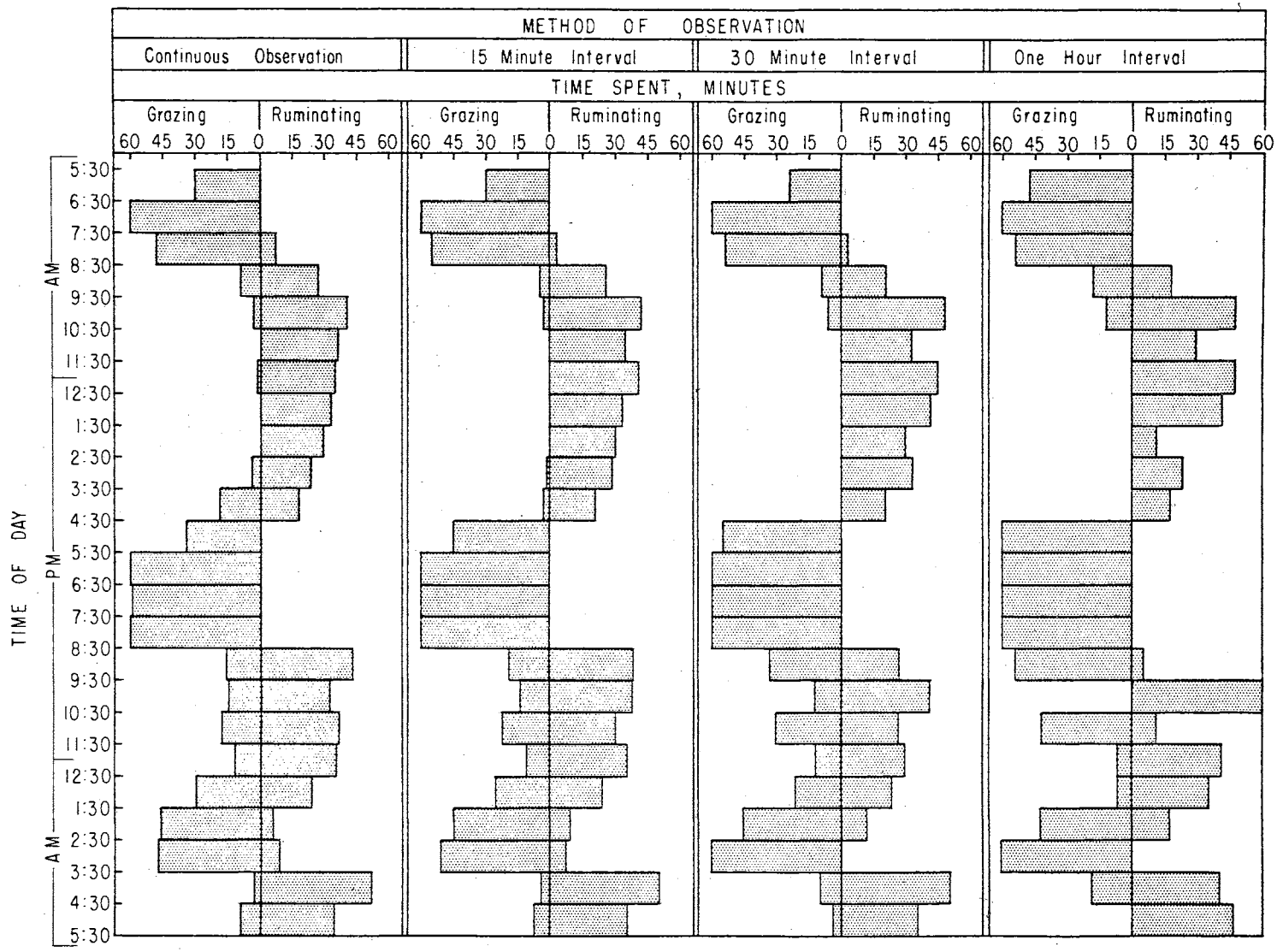

Figure 4. Grazing and Ruminating Times of Range Beef Cows When Observed Continuously and at 15-, 30- and 60-Minute Intervals, August 25, 1959

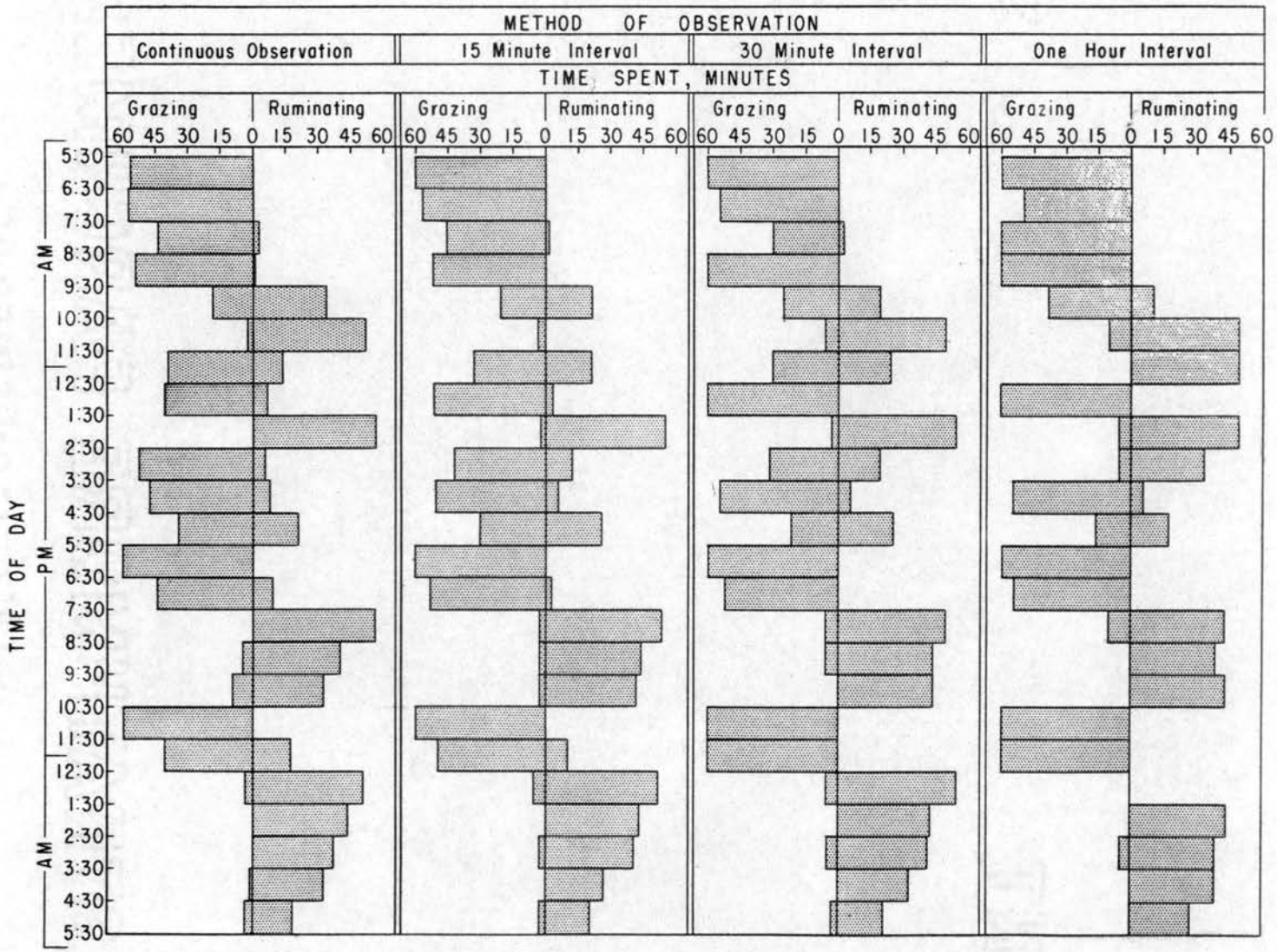

Figure 5. Grazing and Ruminating Times of Range Beef Cows When Observed Continuously and at 15-, 30- and 60-Minute Intervals, September 11, 1959

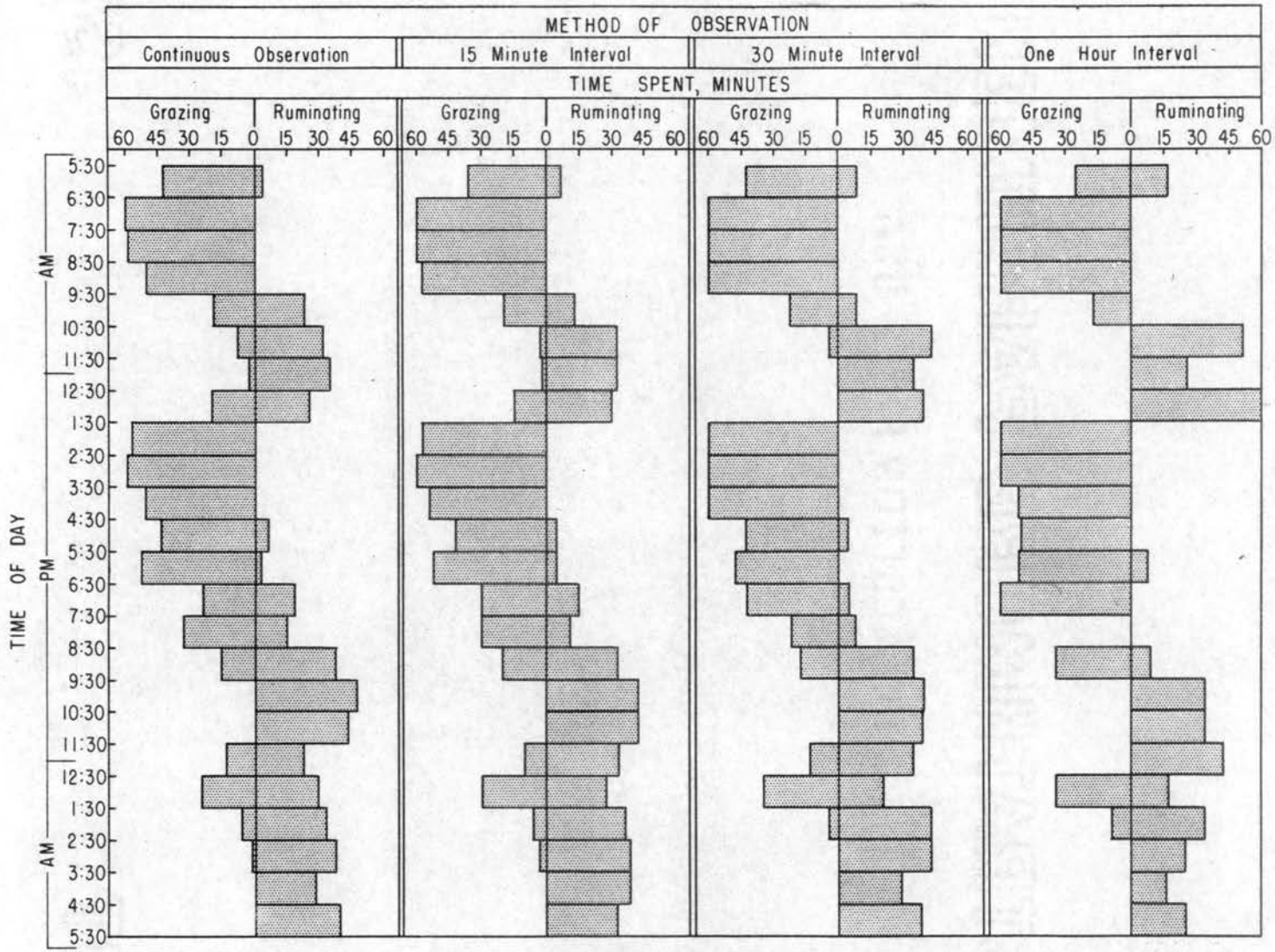

Figure 6. Grazing and Ruminating Times of Range Beef Cows When Observed Continuously and at 15-, 30- and 60-Minute Intervals, September 25, 1959

time between observations, the greater the alteration of the 24-hour grazing and ruminating patterns. However, this change is more noticeable in Figures 2 and 3 than in Figures 4 and 5.

These studies indicate that the accuracy desired by the experimenter will tend to dictate the most desirable observation time interval. It appears that reasonably accurate estimates of the major activities can be obtained up through 30-minute intervals of observation. As mentioned previously, the primary objective of increasing the interval of observation is to allow more animals to be observed with less labor per animal. The need for a greater number of animals has been emphasized in previous studies because of relatively large individual variation. However, these studies also tend to indicate that the variation introduced by the interval of observation may possibly lead to erroneous conclusions. These data indicate that appreciable variation may be introduced into all activities at 60-minute intervals of observation, while for the minor activities, such as walking, the variation introduced by 15-minute intervals of observation may be large.

SUMMARY

Five 24-hour grazing behavior studies (continuous observation) were conducted with grade Hereford cattle grazing native grass pastures at the Lake Blackwell experimental range area. The number of individual cows observed per study varied from 7 to 11 and, in three of the studies, the cows were suckling calves.

In general, three primary periods of grazing were recorded: (1) Soon after the cattle arose in the morning (around daybreak), (2) sometime during the afternoon and/or evening, and (3) around midnight. Time between these grazing periods was devoted primarily to ruminating and idling, a greater percentage of the total ruminating time being at night. The calves were observed to nurse about three times during a 24-hour period for an average total of 23 minutes.

In a 24-hour period, cattle spent 600, 539, and 274 minutes or about 42, 37, and 19 percent of their time grazing, ruminating, and idling, respectively. Temperature changes and quality of forage appeared to alter the total time spent grazing and the behavior patterns. Apparently, the cattle preferred to ruminate in a lying position rather than standing (25.6 vs. 11.9 percent). Idling was mostly in the standing position compared to the lying position (10.8 vs. 8.2 percent). A total of 56.5 percent of the 24-hour period was spent ruminating and idling. Of this time 22.7 and 33.8 percent of the time was spent in the standing and lying

position, respectively. In 24 hours the cattle traveled an average of 2.59 miles; they defecated 5.6 times and urinated 2.4 times.

Continuous observations in all five studies were compared with observations at 15-, 30- and 60-minute intervals. There was considerable variation in major activities (grazing and ruminating) between dates of observations, but, in general, reasonably accurate estimates of these two activities on a given date were obtained from observations at 15- and 30-minute intervals. Estimates of major activities obtained from observations at 60-minute intervals were not reliable. Observations even at 15-minute intervals did not appear to be adequate for reliable estimates of such minor activities as walking, sleeping, nursing calves, defecation, urination, and drinking.

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PART II. EFFECT OF DIFFERENT LEVELS OF SUPPLEMENTAL WINTER FEED UPON THE PRODUCTION OF FALL-CALVING BEEF COWS

INTRODUCTION

In the management of range beef cattle in the Southwest the production of fall calves presents feeding problems different from those encountered with spring calves. This is particularly true if cows are allowed to graze the native grass pastures yearlong because much pasture grass, although adequate for maintenance and growth of cattle during the spring and early summer months, steadily declines in nutritive value in late summer and fall. In a spring-calving herd, the cows produce their calves only a short time before green grass of high nutritive value is available. By contrast, in a fall-calving herd the cows produce and suckle calves during the fall and winter when the nutritive value of the forage is low and the nutritive requirements of the cow are high.

Since cost of supplemental winter feed is a large percentage of the total cost of producing a calf, the practical cow-calf producer needs to know the optimum level of supplemental winter feeding. Of primary concern in determining the optimum level of supplemental feed are production measures such as winter weight loss, thriftiness, milk production, rebreeding rate of cows, percentage calf crop, and weaning weight and quality of calves.

Although practically all of the nutrient intake of calves during the first few months of their life is supplied by milk from their dams, few attempts have been made to measure the quantity of milk produced by beef cows and practically no data are available on the estimated milk production

of fall-calving range beef cows. Also, relatively few studies of level of wintering have been conducted with fall-calving cows grazing native grass pastures yearlong. Consequently, a study was undertaken at the Oklahoma Agricultural Experiment Station in the fall of 1954 to provide information on winter feeding levels for fall-calving cows. In the original study, Furr (1959) found that high levels of supplemental winter feed resulted in a slightly larger percentage calf crop and heavier calves at weaning than low levels of feeding.

The trials reported herein were initiated to study further the effects of different levels of winter supplement upon the growth and production of young beef cattle.

REVIEW OF LITERATURE

Literature relating to the effects of plane of nutrition on the performance of beef cows has been reviewed by Thomas (1952), Shroder (1954), Miller (1958), Zimmerman (1958), and Furr (1959). Only additional literature related to this subject is reviewed here.

Level of Wintering

Furr (1959) reported results obtained in a 4-year study with fall-calving, mature, Hereford cows grazing in native grass pastures. Cows were divided into four lots and for four consecutive winters were fed the following amounts of supplemental feed, and their calves were fed as follows:

Lot 1 - 1.5 pounds of pelleted cottonseed meal; calves not creep-fed.

Lot 2 - 1.5 pounds of pelleted cottonseed meal; calves creep-fed.

Lot 3 - 2.5 pounds of pelleted cottonseed meal and 3 pounds of grain; calves not creep-fed.

Lot 4 - 2.5 pounds of pelleted cottonseed meal and 3 pounds of grain; calves creep-fed.

Lots 1 and 2 represented low levels of wintering and Lots 3 and 4 represented high levels. The 4-year average winter weight loss of the cows was 36 pounds less for those fed on the high level. The average winter weight loss was largest for cows whose calves were creep-fed, the difference being 30 pounds in favor of not creep-feeding. The average

age- and sex-corrected weaning weights for the 4 years were 469, 556, 516, and 568 pounds for the calves in Lots 1, 2, 3, and 4, respectively. Consequently, the high level of winter feeding increased weaning weights an average of 30 pounds relative to the low level, and creep-feeding increased weaning weights an average of 87 and 52 pounds for the low and high levels of wintering, respectively. The calf crop was 85 percent on the low level and 90 percent on the high level of wintering. Neither the high level of wintering nor creep-feeding was profitable when prices prevailing during the experiments were considered.

In another level of wintering study, Miller (1958) reported results of feeding different kinds and quantities of protein supplement to 100 grade Hereford females for four consecutive winters while grazing native grass pasture. On November 2, 1953, the weanling heifer calves were divided into five lots and were fed the following protein supplements for the first two winters: Lot 1, 1 pound of 40 percent protein pelleted cottonseed meal; Lot 2, 2 pounds of the supplement fed in Lot 1; Lot 3, 2 pounds of 20 percent protein combination pellet; Lot 4, 2 pounds of 20 percent protein pellet (cottonseed meal and corn); and Lot 5, 2 pounds of 40 percent protein pellet in which 50 percent of the nitrogen was from urea. During the next two winters, when the cows were suckling calves, the quantity of supplemental feed was increased to 1.5 pounds per head daily for Lot 1 and 3 pounds per head daily for the other lots. The combination pellet contained several feed ingredients (corn, cottonseed meal, linseed meal, soybean oil meal, dehydrated alfalfa meal, molasses, and minerals).

During the first two winters very minor differences in the average gains of heifers were noted and no statistically significant differences

were found among treatments or between years. However, during the last two winters while suckling calves, cows fed 3 pounds per head daily of pelleted cottonseed meal lost less weight during the winter and produced heavier calves than the other four lots. Average birth weights in all lots were similar but weaning weights were heaviest for calves in Lot 2 and lighest for calves in Lot 1. At weaning, the calves averaged 361, 420, 404, 381, and 404 pounds in Lots 1, 2, 3, 4, and 5, respectively.

Pinney et al. (1960) reported results of an 11-year study on the effect of different levels of wintering upon the performance of spring-calving beef cows grazing native grass pasture yearlong. Percentage calf crop and longevity tended to favor the low level of supplemental winter feed (1 pound of cottonseed meal per head daily) relative to the high level (2.5 pounds of cottonseed meal plus 3 pounds of oats per head daily). After corrections for sex and age at weaning, the calves in the low level lot weighed more than those in the high level lot.

Zimmerman (1960) reported results obtained in five trials designed to study the effect of various levels of winter supplement on the growth, development and the reproductive performance of spring-calving beef heifers. A total of 249 weanling Hereford heifers were used in these trials. The low level of wintering resulted in delayed calving, reduced birth and weaning weights, and a decreased percentage calf crop. The high level of wintering resulted in earlier calving and slightly increased weaning weights compared to the medium level of wintering. Both birth weights and percent calf crop weaned were nearly equal for the medium and high level lots. A very high level of wintering did not increase weaning weights and decreased the percentage calf crop. Concerning these studies, Pinney et al.

(1961) stated: "A medium to high level appears to be the most desirable in terms of growth and development of the female and size of her calf at weaning. Of these two, the medium level which allows the beef heifer to gain approximately 0.5 pound per head daily the first winter as a weaner calf, and lose less than 10 percent of her body weight each subsequent winter has seemed most desirable and profitable in previous trials due to the advantage in calf crop percentage, weaning weights, and development of the female."

Milk Production

One of the earlier studies pertaining to the yield of milk by beef cows was reported by Cole and Johanson (1933). Lifetime milk production records were obtained on seven purebred Aberdeen Angus cows milked twice daily and stall-fed. On the average, cows produced 3,100 pounds of milk per lactation, but there was a considerable range in milk yield (1,027 to 6,746 pounds in the first lactation). Maximum milk production within lactations was reached about 4 weeks post partum.

Black and Knapp (1936) found that weight gain from birth to weaning was highly correlated with pounds of milk received during that period. However, no milk production records were presented. In a report based on the same data, Knapp and Black (1941) indicated that of feeds consumed by calves prior to weaning, the quantity of milk had the greatest effect on rate of gain, followed in order by grain and hay. The correlation coefficient between daily gain of calves prior to weaning and quantity of milk consumed was 0.517 which was highly significant ($P < .01$).

Anthony et al. (1959) reported a procedure for the direct measurement of milk secretion and composition. The cow was separated from her

calf, injected intra-muscularly with oxytocin and subsequently milked dry with a milking machine and hand stripping. After the cow was separated from her calf for 12 hours, the milking procedure was repeated and production was reported on a 12-hour, FCM basis.

Results of three separate studies using the above technique were reported by Anthony et al. (1961). In the first study, milk production was little affected when beef cows and their calves were winter-fed either (1) coastal Bermuda grass hay plus 2 pounds of cottonseed meal, or (2) small grain-clover grazing plus hay and CSM as needed to supplement the grazing. Calves gained an average of 1.16 and 1.50 pounds per head daily in groups 1 and 2, respectively.

During the subsequent winter, cows grazing a vetch-clover-rye sward established on coastal Bermuda grass sod produced 5.58 pounds and 4.96 pounds of milk (12-hour FCM) on February 16 and April 26, respectively. Cows which received coastal hay plus 2 pounds of cottonseed meal per head daily produced 4.54 and 4.25 pounds on February 16 and April 26, respectively. Calves with cows on pasture gained 1.92 pounds per day while the calves of the coastal Bermuda grass hay-cottonseed meal fed cows gained 1.30 pounds per head daily.

In the third study, significantly less milk was produced by cows wintered on poor quality grass hay than by those fed a superior diet. The components of the superior diet were not reported. When the cows were turned to excellent spring pasture, a greater increase in milk production was noted for the poorly-fed cows.

A study was conducted by Howes et al. (1958) with 12 Hereford and 12 Brahman heifers where heifers of each breed were randomly allotted into

two groups and fed 100 and 50 percent of the N.R.C. recommended protein allowances. Quantity of milk produced was determined at time of parturition and at subsequent 28-day intervals, on 2 successive days, by the suckling and hand milking technique. Level of protein significantly affected milk production. Correlations for the first 4 months of lactation between calf weight gain and quantity of milk produced by the dam were .67, .83, .50, and .45, respectively. Brahman cows produced significantly more milk and their calves gained more during the first 112 days post parturition than Hereford cows. Average daily calf gains over the first 112 days for the Brahman groups were 1.74 and 1.23 pounds, while those for the Herefords were 1.32 and 0.97 pounds, for the 100 percent and 50 percent groups, respectively.

Lampkin and Lampkin (1960) conducted a study on some of the factors which influence the growth of suckling calves from birth to weaning, with particular reference to the milk which they obtained from their dams. The amount of milk produced by Zebu cows over 36-week lactations was determined each week by the differences in weight of their calves before and after nursing. In this 3-year study, neither the cows nor their calves received feed as a supplement to grass, except under serious drought conditions when a little hay was fed. Mean estimated yield for the 164 cows over the 36-week lactation was 2,486 pounds. When the 36 weeks were divided into three 12-week periods, 40, 35, and 25 percent of the milk was produced in the first, second, and third period, respectively. A peak daily average of 13.1 pounds was recorded during the 7th week of lactation. Eighteen cows were dry at weaning time, although the average production was still 6.6 pounds per head daily in the last week. The average total

yield was 3,189 pounds, the lowest lactation totaling 1,011 pounds and the highest 4,200 pounds. Male calves gained an average of 9.66 pounds per week and females gained 8.71 pounds. Average weaning weights were 408 and 370 pounds for the males and females, respectively.

Drewry et al. (1959) reported milk production of 48 Angus cows grazing pasture during the spring calving seasons of 1957 (27 cows) and 1958 (21 cows). The quantity of milk produced by each cow was estimated for one day in the first, third, and sixth month of lactation by differences in calf weights taken immediately before and after nursing. The estimated milk required to produce a pound of gain (combination of both years' data) was 12.5, 10.8, and 6.3 in the first, third, and sixth month of lactation, respectively. Correlations between total gain from birth and estimated daily milk production for the first, third, and sixth month were -0.15, 0.35, and 0.48, respectively.

One of the most extensive studies relating to the milk production of beef cows suckling calves was reported by Gifford (1953). A total of 77 milk and butterfat records were obtained with 28 Hereford cows, 14 lactation records with 7 Aberdeen Angus cows, and 9 lactation records with 5 Shorthorn cows. The daily quantity of milk produced was determined once each month over an 8-month lactation period by milking one-half of the udder for 2 consecutive days and combining the 2 records. In these studies, the cows were kept on pasture 9 to 10 months, and during the remainder of the year they were fed silage, prairie hay, and 1.5 pounds of cottonseed cake. The cows which calved during the winter months were fed an additional 2-4 pounds of grain.

The average quantity of milk produced was calculated to be 1,498 pounds with an average butterfat test of 3.08 percent. An average of 8.5,

9.5, and 14.6 pounds of milk was produced during the 1st month after calving by the Herefords, Angus, and Shorthorns, respectively.

The range in the average daily gain of Hereford calves was 1.1 to 1.6 pounds from birth to weaning even though the average daily milk production of their dams ranged from 8.5 pounds during the 1st month to 4.1 pounds during the 8th month. The average daily milk production of the Hereford cows during each of the 8 months following parturition was 8.52, 7.67, 7.26, 6.07, 5.25, 4.79, 4.80, and 4.14 pounds per head daily. Correlation coefficients between daily milk production of Hereford dams and monthly gains in calves within months were .60, .71, .52, .35, .19, .24, .39, and .57 for the 1st to the 8th month, respectively. Milk production was lowest for cows between 2 and 3 years of age and generally increased to a maximum at about 6 years of age.

In his two reports, Gifford (1949, 1953) presented evidence which indicated that the maximum milk production normally attained during the first 6 weeks of lactation may be affected by the capacity of the young calves to consume milk.

Dawson et al. (1960) has summarized the results obtained in an earlier study conducted at Beltsville. This study included the production of 30 Shorthorn cows from 1931 to 1935 in which 14 cows had single lactations and the others had from two to five lactations. Milk production was estimated by weight differences in the calves before and after nursing on 1 day each week. For a lactation period of 252 days, the average quantity of milk produced was 4,444 pounds with a standard deviation of 871 pounds. An average of 4,168 pounds of milk per cow (standard deviation within years of 743 pounds) was noted for the 2 years when the calves were weaned at

245 days of age. On the average, peak milk production was reached at the end of the 2nd month post partum. The highest individual milk production in this month was 22.7 pounds per head daily. At weaning time, the cows were producing an average of 13.6 pounds of milk per day with a range of 6.0 to 24 pounds. Results showed age of cows and years to have marked effects upon milk production.

Dawson et al. (1960) also reported results obtained in a study at Manhattan, Kansas (1915-1918) with 24 highly selected Shorthorn cows. The cows were selected on their ability to produce beef calves of exceptional merit. A total of 42 lactation records of 365 days or less was obtained by the hand milking method over the 4-year period. Over-all averages of 4,862 pounds of milk and 192 pounds of butterfat per head were obtained in this study. In this article, the authors stated: "It is believed that the nursing method used at Beltsville has an advantage over milking beef cows by hand or with a machine in that it takes advantage of any ability of the calf to encourage the cow to give milk."

Holland (1961) reported that estimates of milk production by the calf weight-change method were almost 3 pounds greater than the estimates by hand milking. He stated: "A trend in this direction was expected because the cows could not be completely stripped by the hand milking method."

TRIAL I

Experimental Procedure

The two lots of 4-year-old grade Hereford cows used in this study had been wintered at different levels of supplemental feed the previous two seasons. They were fed different levels of supplemental winter feed as heifers calving in the fall of 1958 when they were 2.5 years of age and again during the winter of 1958-59 as 3.5-year-olds. In both years neither group of cows produced calves of desirable weaning weight, although the high level of feed increased calf weights. These same cows were continued on test for another season (1959-60) so that accumulative effects of the different levels of supplemental winter feed could be observed. Both lots were allowed to graze the native grass (Bluestem and associated grasses) pastures yearlong. The stocking rate was about eight acres of pasture per cow. Supplemental feeding was started October 13, 1959, and discontinued April 22, 1960 (192 days). The low-level cows were fed 2.5 pounds of pelleted cottonseed meal per head daily and the high-level cows were fed 6.58 pounds of pellets consisting of 40 percent cottonseed meal and 60 percent ground milo. Daily consumption per head in the high-level group was 2.63 pounds of cottonseed meal and 3.95 pounds of ground milo.

Hereford bulls were placed with the cows on January 8, 1959 and the first calves were born in mid-October.

A total of seven 24-hour milk production records were obtained with all cows. The technique used in estimating milk yield was similar to

that reported by Howes et al. (1958), Drewry et al. (1959), and Dawson et al. (1960). This procedure included weighing the calf immediately before and after nursing and any increase in weight was recorded as the quantity of milk produced by the cow. Samples were not obtained; therefore, no corrections for the fat content of the milk were made.

Milk production records over 24-hour periods were obtained on January 30, March 11, April 14, May 20, June 25, July 9, and July 22. The calves were in the pastures with their dams except on the days when milk production was being estimated. In the latter case, the cows and calves were driven into the corral, separated, and placed in separate pens at about noon. Approximately 5 hours later the calves were allowed to suckle their dams. This preliminary separation and subsequent nursing period was to insure that all cows would apparently be nursed dry at the start of the 24-hour period to be used for estimating milk production. After the pre-test suckling period on January 20 and March 11, the calves were weighed before and after nursing (to the nearest 0.1 pound) at 8-hour intervals. Approximately 45 minutes were required to obtain records on each lot of cows. The three successive 8-hour estimates were combined for the estimate of milk yield over the 24-hour period. On the five subsequent days of milk production estimates, the calves were weighed before and after nursing (after the pre-test period) at approximately 12-hour intervals. When separated, the cows were placed in small native grass pastures and the calves were kept in small pens at the corral where hay and water was available.

The data were analyzed according to procedures outlined by Snedecor (1956).

Results and Discussion

A summary of the level of wintering data is given in Table I. The data include only those cows which weaned calves in each of the three successive years of the trial. Originally there were 17 cows in each lot, but in the third test only 25 cows were included in the summary data.

The cows in Lot 1 lost an average of 306 pounds, or 28 percent of their body weight, while those in Lot 2 lost 279 pounds, or 25 percent. The calves in Lot 2 were born an average of 3 days earlier and weighed 3 pounds more than those in Lot 1. Average spring weights were significantly ($P < .05$) heavier in Lot 2 but both lots of calves were relatively light; 201 and 233 pounds for those in Lots 1 and 2, respectively. This average difference of 32 pounds in favor of Lot 2 decreased to 9 pounds by weaning in July (388 vs. 397 pounds).

The lower portion of Table I is a cost summary which includes application of the experimental results using prevailing feed and cattle prices. Both lots of calves were weaned and sold as good-choice feeders in July at the Oklahoma City Stockyards. The steers sold for an average of $27 per 100 pounds and the heifers sold for $25. The cost of the increased feed for Lot 2 was greater than the increased value of the calves. Selling value minus feed cost was $11.66 in favor of the low level ($55.38 vs. $43.72).

Table II is a summary of the milk production data obtained during the 1959-60 season. This summary includes all the cows in the test which raised calves in 1959-60 (33 head) rather than just those cows which had raised calves in three successive years.

The first milk production estimate was obtained on January 30, about 80 days following the average calving date for the two lots. At

TABLE I

RESPONSE OF FOUR-YEAR-OLD BEEF COWS TO LEVELS OF SUPPLEMENTAL WINTER FEEDING, 1959-60

Lot number	1	2
Level of supplemental feed	Low[1]	High[2]
Number of cows raising calves[3]	12	13
Average weight per cow (lb.)		
Initial 10-13-59	1089	1116
Spring 4-22-60	783	837
Weaning 7-22-60	984	1003
Fall 10-7-60	1037	1070
Winter gain (192 days)	-306	-279
Gain to weaning	-105	-113
Yearly gain	-52	-46
Average weight per calf (lb.)		
Birth[4]	73	76
Spring[5]	201	233
Weaning[6]	388	397
Average birth date of calves, Nov.	10	7
Supplemental feed per cow (lb.)[7]		
Cottonseed meal	480	503
Ground milo		699
Total feed cost per cow ($)[8]	40.12	54.12
Selling value ($)		
Per 100 lb.		
Steers	27.00	27.00
Heifers	25.00	25.00
Per head[9]	95.50	97.84
Selling value minus feed cost ($)	55.38	43.72

[1]Fed 2.5 lb. pelleted cottonseed meal per head daily.

[2]Fed same as Lot 1 until October 28, at which time the daily feed was increased to 6.58 lb. of pellets consisting of 40 percent cottonseed meal and 60 percent milo. Daily consumption was 2.63 lb. of cottonseed meal and 3.95 lb. milo.

[3]There were 13 and 16 cows in Lots 1 and 2, respectively, in the experiment in 1958-59. One cow was open in Lot 1. In Lot 2, 1 cow was open, 1 cow failed to calve and 1 calf was born dead.

[4]Corrected for sex by the addition of 3 lb. to the birth weight of each heifer.

[5]Corrected for sex by the addition of 18 lb. to the weight of each heifer after a 170-day age correction by interpolation.

[6]Corrected for sex by the addition of 43 lb. to the weight of each heifer after a 260-day age correction by interpolation.

[7]192 days of feeding which started 10-13-59.

[8]Includes pasture cost and prices of feeds at the time tests were conducted.

[9]Based on an equal number of steers and heifers in each lot using the age and sex corrected weaning weights as the steer selling weight and this weight minus 43 lb. (sex correction factor) as the average weight of heifers.

TABLE II

ESTIMATES OF MILK PRODUCTION OF FOUR-YEAR-OLD BEEF COWS WINTERED AT TWO LEVELS OF SUPPLEMENTAL FEED, 1960

Lot number Level of supplemental feed	1 Low	2 High
Number of cows raising calves	17	16
Pounds of milk produced in 24 hours		
January 30	6.01 ± .71[1]	6.82 ± .43
March 11	3.09 ± .35	5.10 ± .36
April 14	5.32 ± .64	7.02 ± .40
May 20	7.69 ± .66	7.60 ± .65
June 25	7.27 ± .60	6.92 ± .59
July 9	6.58 ± .57	5.50 ± .72
July 22	5.62 ± .53	5.78 ± .69

[1]Standard error of the mean.

this time, an average of 6.01 pounds of milk per cow was recorded for Lot 1 and 6.82 pounds for Lot 2. The yield decreased noticeably on March 11 when an average of 3.09 and 5.10 pounds was obtained in Lots 1 and 2, respectively. Very severe weather prevailed for several days, including March 11, and may have affected milk yield. When grass of high nutritive value became available in the spring, both lots of cows increased in milk

yields. This was particularly noticeable for the low-level cows which produced a larger quantity of milk in May, June, and July than the high-level cows. Similar results were reported by Anthony et al. (1961). When average milk yields are plotted (Figure 1), the curves fail to follow the gradual decline as reported by Gifford (1953) for Hereford cows. It would appear that the lactation curve of the fall-calving cow is different from the curve of the spring-calving cow. Correlation coefficients between the average daily gain of the calves and the average milk yields of their dams appear in Table III.

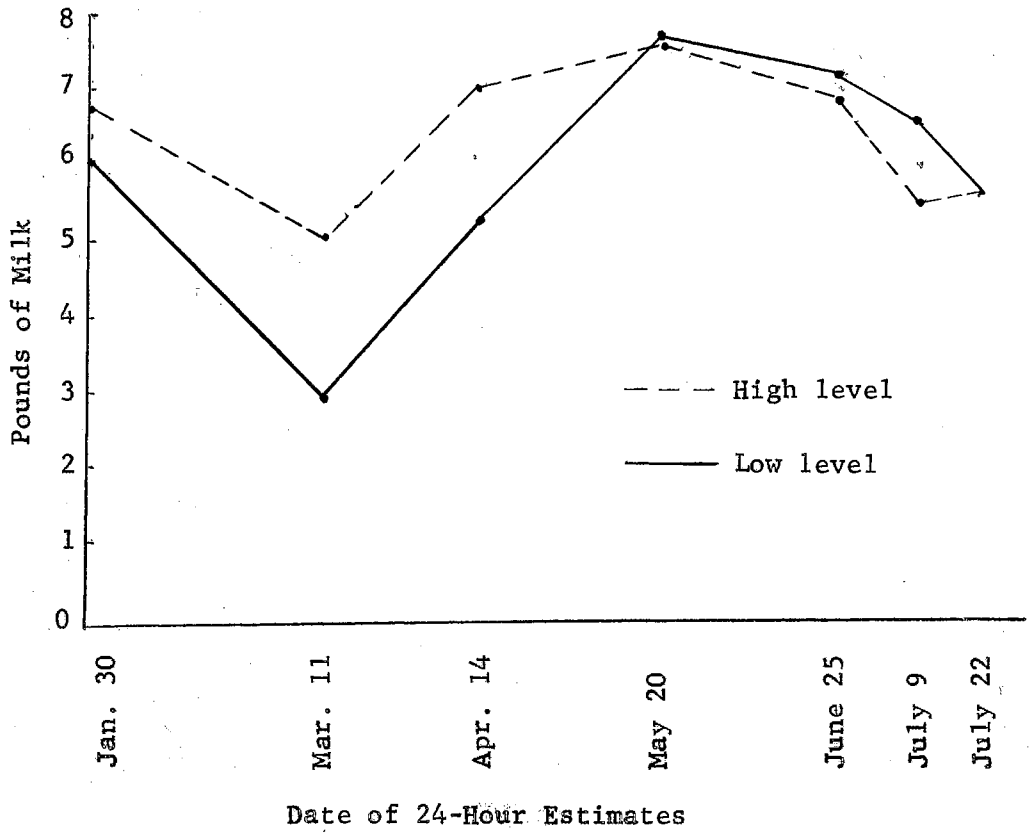

Figure 1. Milk Production of Four-Year-Old Hereford Cows Wintered at Different Levels of Supplemental Feed, 1960

TABLE III

AVERAGE DAILY GAINS OF CALVES AND MILK YIELD OF COWS, AND THEIR CORRELATION, 1960

Period	Lot 1			Lot 2		
	Average daily gain	Average milk yield	Correlation coefficient	Average daily gain	Average milk yield	Correlation coefficient
January 30 to March 11	.42 ± .05[1]	4.50 ± .49	.84[2]	.64 ± .06	5.97 ± .34	.41[3]
March 11 to April 14	.32 ± .04	4.20 ± .46	.38	.55 ± .04	6.60 ± .31	.65
April 14 to May 20	1.61 ± .05	6.52 ± .61	.80	1.61 ± .06	7.35 ± .47	.73
May 20 to June 25	1.95 ± .06	7.46 ± .59	.59	2.10 ± .08	7.28 ± .57	.13
June 25 to July 9	1.77 ± .09	6.89 ± .55	.45	2.10 ± .10	6.21 ± .64	.17
July 9 to July 22	1.62 ± .11	6.10 ± .48	.30	.92 ± .11	5.63 ± .56	.36
Over-all	1.16 ± .04	5.92 ± .48	.81	1.26 ± .05	6.40 ± .39	.85

[1] Standard error of the mean.

[2] In Lot 1, correlation coefficients of .575 and above are highly significant ($P < .01$); and .456 to .575 significant ($P < .05$).

[3] In Lot 2, correlation coefficients of .590 and above are highly significant ($P < .01$); and .468 to .590 significant ($P < .05$).

Average milk yield was obtained from two successive records. For example, milk production records were obtained on January 30 and March 11. The average daily calf gain over this 41-day period was correlated with the average of the two milk yield estimates.

The individual correlations for the different periods vary considerably within and between lots and fail to follow the correlation trends presented by Gifford (1953) and Howes (1958). However, the correlations were usually larger during the earlier periods and became smaller for the periods just prior to weaning. For example in Lot 1, the correlation coefficients were .84, .38, .80, .59, .45, and .30 for the first, second, third, fourth, fifth, and sixth periods, respectively. It is recognized that considerable age differences existed within lots and that this could influence the correlation values.

Over-all lot correlation coefficients were .81 and .85 for Lots 1 and 2, respectively. When the coefficients of determination (r^2) are calculated, about 66 and 72 percent of the differences in average daily gain of the calves can be accounted for by differences in milk yield of their dams.

In a test with mature cows calving in the fall, Furr (1959) reported that production did not appear to be greatly affected by body weight losses of 25 to 30 percent. However, results with 4-year-old cows, and with the same cows as 2-year-olds and 3-year-olds, indicate that production of younger cows may be reduced unless the winter weight losses are considerably reduced. Both groups of cows receiving the low and high level of supplemental feed failed to produce calves with desirable weaning weights.

TRIAL II

Experimental Procedure

A second test was initiated in the fall of 1958 to study the effect of 20 and 30 percent body weight losses upon the production of fall-calving heifers. A summary of the results for the 1958-59 seasons was reported in Oklahoma Agricultural Experiment Station Miscellaneous Publication MP-57:117. A continuation of this test was completed during the 1959-60 season and the results are reported as Trial II of this thesis.

The 3.5-year-old grade Hereford cows were weighed and divided into their respective lots on October 8, 1959. During the wintering season of 1959-60, the cows were suckling their second calf. All three lots of cows had access to the native grass pastures. Cows in Lots 1 and 2 (low level) were fed an average of 2.5 pounds of cottonseed meal pellets per head daily. The cows in Lot 3 (high level) were fed 6.25 pounds of a pelleted mixture consisting of 40 percent cottonseed meal and 60 percent ground milo. Thus, each cow in Lot 3 was fed an average of 2.5 pounds of cottonseed meal and 3.75 pounds of ground milo daily. Pellets were fed in bunks every other day in amounts to furnish the above pounds per head daily. The calves in Lot 1 were offered creep-feed starting December 31, 1959. Milk production records were obtained on all three lots of cows by the procedure described in Trial I .

Results and Discussion

Table IV is a summary of the level of wintering data collected in 1959-60. Average birth weights of the calves in the three lots were nearly equal. This is in agreement with the results of Pinney et al. (1960) and Miller (1958) who found that different levels of wintering had little effect upon the birth weights of either spring or fall calves. Average birth dates of the calves were considerably different; the calves in Lot 3 were 19 days younger than those in Lot 2 and 29 days younger than those in Lot 1. Much of these differences in average calving date was apparently due to sterility in one of the bulls. The bulls were rotated among the lots at 2-week intervals during the breeding season, therefore the presence of the sterile bull was responsible for at least a portion of the later average calving date in both Lots 2 and 3. Spring and weaning weights have been corrected for both sex and age.

During the wintering period (197 days), the cows lost an average of 287, 301, and 252 pounds in Lots 1, 2, and 3, respectively. Body weight loss for the three respective lots was 26, 29, and 25 percent. Since the cows were suckling calves during most of the winter feeding period, any effect of the two levels of supplemental feed on calf weights should be apparent in the weights of the calves in mid-April when supplemental feeding was stopped. At that time, the average calf weights were 45 pounds more in Lot 3 (high level) than in Lot 2. At weaning, this difference had increased to 61 pounds. When an analysis of variance was conducted, the differences in both the spring and weaning weights between Lots 2 and 3 were statistically significant ($P < .01$). Miller (1958) reported that the weaning weights of calves whose dams were fed 3 pounds of 40 percent

TABLE IV

RESPONSE OF THREE-YEAR-OLD BEEF COWS TO LEVELS OF SUPPLEMENTAL WINTER FEEDING, 1959-60

Lot number	1	2	3
Level of supplemental feed	Low[1] (Creep-fed)	Low[2]	High[3]
Number of cows raising calves[4]	11	10	14
Average weight per cow (lb.)			
Initial 10-8-59	1088	1040	1019
Spring 4-22-60	801	739	767
Weaning 7-22-60	1052	992	1021
Fall 10-7-60	1083	1062	1058
Winter gain (197 days)	-287	-301	-252
Gain to weaning	-36	-48	2
Yearly gain	-5	22	39
Average weight per calf (lb.)			
Birth[5]	72	71	73
Spring[6]	230	168	213
Weaning[7]	416	331	392
Average dirth date of calves[8]	Oct. 19	Oct. 29	Nov. 17
Supplemental feed per animal (lb.)[9]			
Cow			
Cottonseed meal	493	493	493
Ground milo			578
Calf (creep-feed)	1042		
Total feed cost per head ($)[10]			
Cow	40.53	40.53	51.51
Calf	26.05		
Total	66.58	40.53	51.51
Selling value ($)			
Per 100 lb.			
Steers	27.00	27.00	27.00
Heifers	25.00	25.00	25.00
Per head[11]	102.78	80.68	96.54
Selling value minus feed cost ($)	36.20	40.15	45.03

[1]Fed 2.5 lb. pelleted cottonseed meal per head daily. Creep-feeding of calves was started December 31.

[2]Cows fed same as those in Lot 1.

[3]Cows fed same as those in Lots 1 and 2 until November 20, at which time the daily feed was increased to 6.25 lb. of pellets consisting of 40 percent cottonseed meal and 60 percent ground milo.

[4]There were 16, 15, and 15 cows in Lots 1, 2, and 3, respectively, in the experiment in 1958-59. In Lots 1, 2, and 3, respectively, 3, 2, and 1 cows were found to be open upon pregnancy examination 7-6-59 and were therefore removed from the experiment. In addition, 1, 2, and 1 cows failed to calve in Lots 1, 2, and 3, respectively. One calf was born dead in Lot 1 and 1 calf died in Lot 2.

[5]Corrected for sex by the addition of 3 lb. to the birth weight of each heifer.

[6]Corrected for sex by the addition of 18 lb. to the weight of each heifer after a 170-day age correction.

[7]Corrected for sex by the addition of 43 lb. to the weight of each heifer after a 260-day age correction by interpolation.

[8]The bulls were rotated among the pastures at 2-week intervals during the calving season. One of the bulls was found to be sterile and this is probably responsible for a major portion of the differences in average calving date.

[9]197 days of feeding which started 10-8-59.

[10]Includes pasture cost and prices of feeds at time tests were conducted.

[11]Based on an equal number of steers and heifers in each lot using the age and sex corrected weaning weights as the steer selling weight and this weight minus 43 lb. (sex correction factor) as the average weight of heifers.

protein supplement per head daily were 59 pounds more than the weaning weights of calves whose dams were fed 1.5 pounds of the same supplement.

Creep-feeding markedly affected the average spring and weaning calf weights. The weight differences in favor of creep-feeding calves were 62 and 85 pounds in the spring and at weaning, respectively. Also creep-feeding and the low level of feeding of cows (Lot 1) resulted in calves which weighed 24 pounds more at weaning than calves from cows on the high level of feeding and not creep-fed (Lot 3). An average of 1,042 pounds of creep-feed was consumed per calf in Lot 1.

Interpretation of the experimental data in terms of practical production can be made by using the data in the lower portion of Table IV. All calves were weaned in July and sold as feeders at the Oklahoma City stockyards. The steers sold for $27 per 100 pounds and the heifers for $25. Average weaning weights were 416, 331, and 392 pounds for Lots 1, 2, and 3, respectively. When the prices of feeds and cattle prevailing

at the time of the test were used, the selling value per calf minus the feed costs was $4.88 ($45.03 - $40.15) more for the high-level cattle than the low-level cattle. Creep-feeding was not profitable.

Results of milk production estimates are reported in Table V. The first estimate was made with nine calves from Lot 3 on December 11, 1959. In subsequent estimates, all cows nursing calves in each of the three lots were used.

When all cows nursing calves within each lot were included, the average birth dates were October 21, November 5, and November 17, for Lots 1, 2, and 3, respectively. Since the cows calved about 1 month earlier in Lot 1 than Lot 3, it might be expected that on a given date, the cows in Lot 3 would produce a greater quantity of milk due to stage of lactation.

The low-level cows (Lots 1 and 2) yielded a very small quantity of milk on March 14. As mentioned in Trial I, weather conditions may have influenced this low production. Even though the production for these low-level cows was extremely low, they made a remarkable recovery by May 10 and at that time they were producing almost as much milk as the high-level cows (Lot 3). The milk production curves are shown in Figure 2. The greater increase in milk production in the spring by the low-level cows compared to the high-level cows agrees with the results obtained in Trial I with 4-year-old beef cows. Milk production estimates of all cows in both Trials I and II appear to be relatively low. It should be noted that the estimates were not obtained for about the first 3 months of lactation. Gifford (1953) reported that the average daily milk production of Hereford cows during each of the 8 months following

TABLE V

ESTIMATES OF MILK PRODUCTION OF THREE-YEAR-OLD BEEF COWS WINTERED AT TWO LEVELS OF SUPPLEMENTAL FEED, 1959-60

Lot number Level of feeding	1 Low	2 Low	3 High
Number of cows raising calves	12	12	15
Pounds of milk produced in 24 hours			
December 11			9.12 ± 1.23
February 2	3.72 ± .43[1]	3.84 ± .39	5.13 ± .24
March 14	2.60 ± .52	2.48 ± .49	5.80 ± .32
April 9	3.67 ± .31	2.89 ± .50	6.01 ± .32
May 10	6.24 ± .98	6.49 ± .68	6.99 ± .47
June 24	4.28 ± .82	5.32 ± .72	4.67 ± .51
July 23	2.38 ± .56	4.21 ± .72	3.93 ± .46

[1]Standard error of the mean.

parturition was 8.52, 7.67, 7.26, 6.07, 5.25, 4.79, 4.80, and 4.14 pounds per head daily. Cows of several different ages were included. He also reported that milk production was lowest for cows between 2 and 3 years of age.

Table VI is a summary of the average daily gains of calves, average milk production of cows, and the correlation coefficients between average daily gain and average milk production for the 172-day period, February 2, to July 23, 1960.

The correlation coefficient between average daily calf gains and average milk yields in Lot 1 might be expected to be relatively low since

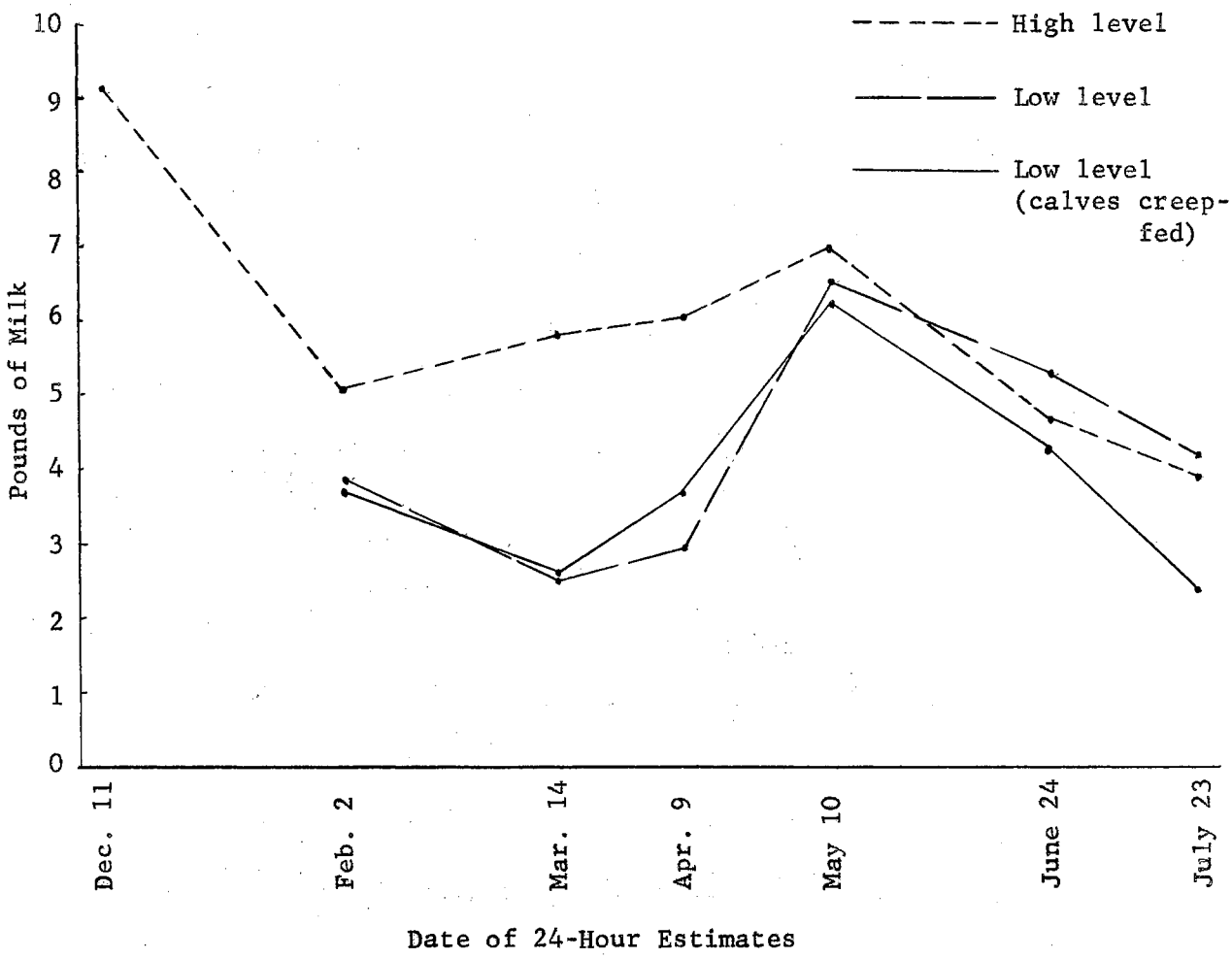

Figure 2. Milk Production of Three-Year-Old Hereford Cows Wintered at Different Levels of Supplemental Feed, 1959-60

these calves were creep-fed but the negative correlation (-.31) obtained in Lot 2 is difficult to explain. None of the over-all correlations obtained for these three lots were significant at the .05 level of probability. Knowledge of the total lactation period might be beneficial in explaining these results. Some of the oldest calves in Lot 2 gained comparable to the lot average for the 172-day period even though they received considerably less milk than the lot average. Other calves made relatively poor gains when receiving relatively large quantities of milk.

TABLE VI

AVERAGE DAILY GAINS OF CALVES AND MILK YIELD OF COWS, AND THEIR CORRELATIONS, 1959-60

Lot number Level of supplemental feed	1 Low[1]	2 Low	3 High
Average daily gain (lb.)	1.65 ± .07[2]	1.06 ± .02	1.27 ± .04
Average milk yield (lb.)	3.81 ± .44	4.21 ± .22	5.42 ± .30
Correlation coefficient	.15	-.31	.53

[1]Calves in this lot were creep-fed.

[2]Standard error of the mean.

However, all average daily calf gains were noticeably low in late winter in this low-level lot. An average 260-day age and sex corrected weaning weight of 331 pounds was considered unsatisfactory.

TRIAL III

The cows used in both Trials I and II had not been wintered at different levels of supplemental feed prior to calving in the fall at 2.5 years of age. Trial III was a study of the effect of level of supplemental winter feed for three successive winters upon the performance of cows producing their first calf in the fall when 2.5 years old.

Experimental Procedure

Seventy-two weanling, grade Hereford heifers were divided into two groups of 36 each on November 5, 1958. Both groups were wintered in small traps with prairie hay fed as the roughage. One group was fed on a low level of wintering which was estimated to permit body weight maintenance. The supplemental winter feed was about 0.9 pound of cottonseed meal per head daily from 11-5-58 to 3-14-59 (129 days). The other group (high level) was wintered to gain approximately 1 pound per head daily. The winter feed for this group was about 6 pounds of pellets, consisting of 25 percent cottonseed meal and 75 percent milo, per head daily from 11-5-58 to 5-1-59 (177 days).

During the second winter feeding season (1959-60), the heifers were continued on their respective levels of supplemental feed; however, one-half of the heifers on each feeding level was fed prairie hay in a trap and one-half was allowed to graze the native grass. In addition to prairie hay in the traps, the low-level heifers were fed 1.11 pounds

pelleted cottonseed meal per head daily and the high-level heifers were fed 6.94 pounds of pellets consisting of 35 percent cottonseed meal and 65 percent ground milo. The low and high level heifers on the range received the same daily quantities of supplemental winter feed as the low and high level heifers in the traps, respectively.

In the fall of 1960, the same heifers were continued in the test. They were weighed and divided into their respective lots on October 13. The low level of supplemental feed for heifers on the range was 2.78 pounds of cottonseed meal pellets per head daily and the high level of supplemental feed was 7.35 pounds of a pellet containing 35 percent cottonseed meal and 65 percent ground milo. The supplemental feed for the cows fed hay in the trap was 1.39 pounds of cottonseed meal for the low level and a milo-salt-cottonseed meal mixture self-fed for the high level. Salt was used at varying concentrations in order to regulate the daily consumption to about 5 pounds of milo and 2 pounds of cottonseed meal. The average consumption was 4.85 pounds of milo, 1.76 pounds of cottonseed meal and 1.78 pounds of salt. Supplemental feeding was started on October 17, 1959 and discontinued on April 19, 1960 (184 days).

Milk production estimates were obtained on December 2, December 31, February 11, March 11, April 20, May 30, June 23, and July 18. The procedure followed in estimating milk yields was the same as that described in Trial I. Weights were recorded for the calves before and after nursing at about three successive 8-hour intervals on December 2. The calves were heavier and older when subsequent milk production estimates were obtained; therefore, the interval between estimates was increased to 12 hours. The 8- or 12-hour estimates were combined in calculating the 24-hour milk production.

Results and Discussion

A summary of the results obtained with these cows as weanling heifers (1959) and as yearlings (1959-60) is given in Table VII.

During 1958-59, the winter gains were -2 and 125 pounds for Lots 1 and 2, respectively. As was expected, heifers which gained the most during the winter gained the least during the subsequent summer grazing season. The 127-pound difference in gain in April was reduced to 65 pounds in October.

During the second winter feeding season (1959-60), the heifers in the trap fed on the low level (Lot 1) gained almost as much as those fed on the high level (Lot 2). At the end of the supplemental feeding period in mid-April the difference in winter gain was 23 pounds (43 vs. 66 pounds) in favor of the high level.

Apparently, the small difference in winter gain can be attributed to the differences in hay consumption. The average daily hay consumption was 18.9 pounds in Lot 1 and 10.8 pounds in Lot 2. The estimated total digestible nutrient (TDN) intakes were 9.04 and 10.01 pounds for Lots 1 and 2, respectively. Summer gains were noticeably in favor of the heifers fed the low level (289 vs. 246 pounds).

Of the yearlings grazing the native grass pastures, the winter gains were -60 and 19 pounds for the heifers fed on low (Lot 3) and high (Lot 4) levels, respectively. Subsequent summer gains were 80 pounds greater for the low-level heifers than for the high-level heifers.

Fifty of the 71 cows in the test raised a calf during the 1960-61 season (see footnote, Table VIII). Only data from these 50 cows are included in the summary shown in Table VIII.

TABLE VII

GAINS OF HEIFERS AS WEANLING CALVES AND AS YEARLINGS FED DIFFERENT LEVELS OF SUPPLEMENTAL WINTER FEED, 1958-59 AND 1959-60

Weanling Heifers (1958-59)

Lot number	1	2
Level of supplemental feed	Low[1]	High[2]
Number of heifers per lot[3]	36	35[1]
Gains, lb.		
Winter	-2	125
Summer	208	146
Yearly	206	271

Yearling Heifers (1959-60)

Location	Trap		Range	
Lot number	1	2	3	4
Level of supplemental feed	Low[4]	High[5]	Low[4]	High[5]
Number of heifers per lot	18	18	18	17
Gains, lb.				
Winter	43	66	-60	19
Summer	246	182	294	214
Yearly	289	248	234	233

[1]Fed 1 lb. of pelleted cottonseed meal from 11-5-58 to 2-13-59 at which time the daily feed was reduced to 0.5 lb. per head. Feeding was discontinued on 3-14-59.

[2]Fed an average of approximately 6 lb. of pellets, consisting of 25 percent cottonseed meal and 75 percent milo, daily from 11-5-58 to 5-1-59.

[3]Originally there were 36 heifers in each of Lots 1 and 2. One calf died in mid-May in Lot 2 due to unknown causes.

[4]Both the heifers in the trap and those on the range were fed 1.11 lb. of pelleted cottonseed meal per head daily. In addition, the heifers in the trap received prairie hay. Supplemental feeding was started 10-23-59 and 11-10-59 for the heifers in the trap and those on the range, respectively.

[5]Heifers on the range fed 6.94 lb. of pellets consisting of 35 percent cottonseed meal and 65 percent ground milo. Those in the trap were fed the same plus prairie hay. Starting dates for winter feeding were the same as those listed above.

TABLE VIII

RESPONSE OF TWO-YEAR-OLD BEEF COWS TO LEVELS OF SUPPLEMENTAL WINTER FEEDING, 1960-61

Location	Trap		Range	
Lot number	1	2	3	4
Level of supplemental feed	Low[1]	High[2]	Low[3]	High[4]
Number of cows raising calves[5]	15	11	13	11
Average weight per cow (lb.)				
Initial 10-13-60	948	965	909	972
Spring 4-19-61	808	948	730	782
Weaning 7-18-61	927	1016	857	911
Winter gain	-140	-17	-179	-190
Gain to weaning	-21	51	-52	-61
Average weight per calf (lb.)				
Birth[6]	73	72	69	72
Spring[7]	193	210	165	171
Weaning[8]	357	371	337	343
Average birth date of calves, Nov.	18	17	18	12
Average winter feed consumption per cow (lb.)[9]				
Cottonseed meal	253	336	512	477
Ground milo	---	893	---	789
Salt[10]	---	323	---	---
Prairie hay[11]	3670	2766	---	---
Range	---	---	ad.lib.	ad.lib.
Total feed cost per cow ($)[12]	51.79	69.45	42.41	54.09
Selling value ($)				
Per 100 lb.				
Steers	29.50	29.50	29.50	29.50
Heifers	26.00	26.00	26.00	26.00
Per head[13]	93.48	97.36	87.93	89.59
Selling value minus feed cost ($)	41.69	27.91	45.52	35.50

[1]Fed 1.39 lb. of cottonseed meal per head daily in addition to prairie hay.

[2]Cows fed same as those in Lot 1 until October 27, at which time the cows started receiving a milo-salt-cottonseed meal mixture from a self-feeder. Over the entire wintering period, the average consumption was 4.85 lb. of milo, 1.76 lb. of cottonseed meal and 1.78 lb. of salt.

[3]Fed 2.78 lb. of cottonseed meal pellets per head daily.

[4]Cows fed same as those in Lot 3 until November 5, at which time the daily feed was increased to 7.35 lb. of pellets consisting of 35 percent cottonseed meal and 65 percent ground milo.

[5]There were 18, 18, 18, and 17 heifers in Lots 1, 2, 3, and 4, respectively, in the experiment in 1959-60. In Lot 1, 2 cows failed to calve and 1 calf was born dead. In Lot 2, 2 cows failed to calve, 3 calves were born dead and 2 calves died. In Lot 3, 4 cows failed to calve and 1 calf died. In Lot 4, 3 cows aborted, 2 cows failed to calve and 1 calf died.

[6]Corrected for sex by the addition of 3 lb. to the weight of each heifer.

[7]Corrected for sex by the addition of 18 lb. to the weight of each heifer after a 150-day age correction.

[8]Corrected for sex by the addition of 43 lb. to the weight of each heifer after a 240-day age correction.

[9]184 days of feeding which started 10-17-60.

[10]Pounds of salt consumed by the cows in Lot 2 from the milo-salt-cottonseed meal mixture. All lots had access to a mineral mixture of 2 parts salt and 1 part steamed bone meal.

[11]Total pounds of prairie hay consumed per cow. Average daily consumption was 19.9 lb. per head daily in Lot 1 and 15.0 lb. in Lot 2.

[12]Includes prices of feeds at the time tests were conducted.

[13]Based on an equal number of steers and heifers in each lot using the age and sex corrected weaning weights as the steer selling weight and this weight minus 43 lb. (sex correction factor) as the average weight of heifers.

In 1960-61, the cows fed the low level of supplement in the traps (Lot 1) consumed more hay than those fed the high level (Lot 2), average daily consumption being 19.9 pounds and 15.0 pounds, respectively. Total feed consumed was 21.3 and 21.6 pounds and estimated TDN intakes were 9.68 and 11.65 pounds, respectively. The difference of 1.97 pounds of TDN per head daily was reflected in the winter weight losses of -140 and -17 pounds for Lots 1 and 2, respectively.

When dry range grass was the forage available, the cows on the low level lost 179 pounds and those on the high level lost 190 pounds. It is probable that the TDN intakes of these two groups were nearly equal. Apparently the cows fed the lower quantity of supplemental feed consumed more dry range grass, although no estimates of consumption are available.

Difference in spring calf weights favored the higher levels of supplemental feed. The difference was 17 pounds for those fed prairie hay and 6 pounds for those on the range. Average weaning weights were 357 and 371 pounds for the low and high levels of feeding in the traps, and 337 and 343 pounds for the low and high levels on the range, respectively. Therefore, the high level of wintering only increased average weaning weights 14 pounds in the traps and 6 pounds on the range. The differences in calf weights at spring and again at weaning were not significantly different at the .05 level of probability.

Both the steers and heifers were weaned in July and sold as good-choice feeder calves at the Oklahoma City stockyards. The steers sold for an average of $29.50 per 100 pounds and the heifers for $26.00 with no differences among the lots. When 1960-61 feed costs were used, the total feed cost (including pasture) per cow was $51.79, $69.45, $42.41, and $54.09 for Lots 1, 2, 3, and 4, respectively. Since weaning weights were only slightly increased by the high level of wintering, this practice was not economical in the 1960-61 season.

A summary of the milk production data collected during 1960-61 is presented in Table IX. Only those cows which calved prior to December 2 (date of the first milk production estimate) were included in the data, although milk yields were obtained for all lactating cows within each of the four lots. A relatively large number of late calves in any one lot could obscure important relationships between treatment and milk yield.

With no exceptions, average milk yields of the four lots were the highest on December 2, approximately one month after the average calving date in each lot. The yields were 9.77, 9.18, 6.97, and 8.20 pounds for

Lots 1, 2, 3, and 4, respectively. Both of the lots in the traps continued to produce a larger quantity of milk during the entire wintering period than the lots on the range. Milk production curves are plotted for the cows in each of the four lots in Figure 3. The cows on the low level of feeding (Lot 1) in the traps produced a greater quantity of milk than those on the high level (Lot 2) for the first three milk production estimates. However, the former continued to decline in milk yield. On April 20 they were producing an average of 5.32 pounds per head daily, whereas the high-level cows were producing 7.62 pounds.

TABLE IX

ESTIMATES OF MILK PRODUCTION OF TWO-YEAR-OLD BEEF COWS WINTERED AT DIFFERENT LEVELS OF SUPPLEMENTAL FEED, 1960-61

Location	Trap		Range	
Lot number	1	2	3	4
Level of supplemental feed	Low	High	Low	High
Number per lot	10	9	10	8
Average calving dates	Nov. 6	Nov. 8	Nov. 2	Oct. 29
Pounds of milk produced in 24 hours				
December 2	9.77 ± .56[1]	9.18 ± .93	6.97 ± .71	8.20 ± .88
December 31	8.39 ± .69	7.07 ± .88	5.25 ± .61	6.48 ± .60
February 11	7.27 ± .66	7.18 ± .88	5.35 ± .61	7.15 ± .48
March 11	6.70 ± .61	7.18 ± .79	5.31 ± .46	5.32 ± .47
April 20	5.32 ± .57	7.62 ± .99	4.03 ± .51	5.18 ± .43
May 30	6.74 ± .63	6.01 ± .82	6.47 ± .71	7.68 ± .95
June 23	6.27 ± .45	5.47 ± .98	5.16 ± .59	7.22 ± .81
July 18	4.08 ± .37	5.36 ± .84	4.12 ± .69	5.12 ± .77

[1]Standard error of the mean.

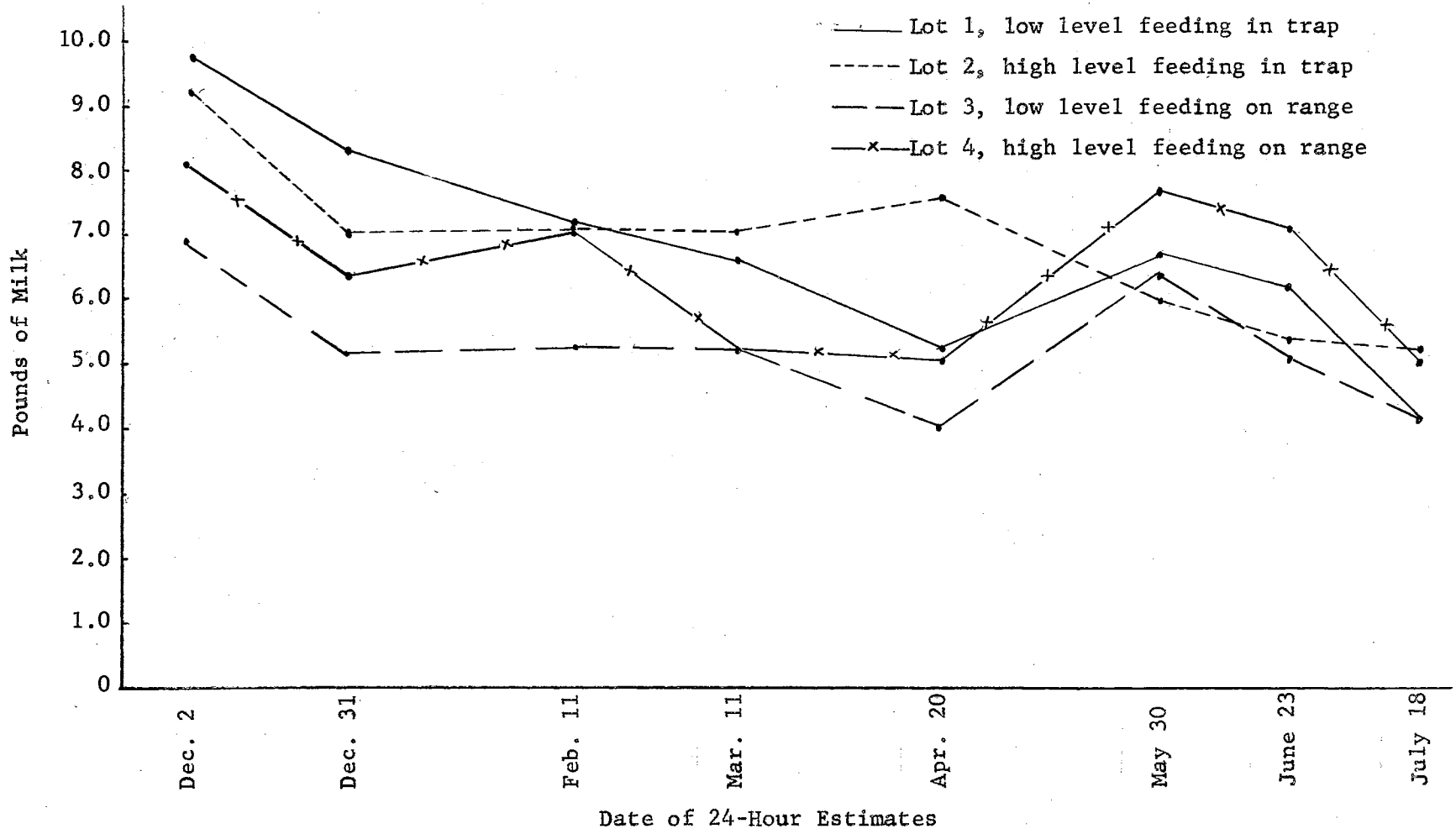

Figure 3. Milk Production of Two-Year-Old Hereford Cows Wintered at Different Levels of Supplemental Feed, 1960-61

Both the low level (Lot 3) and the high level (Lot 4) cows on the range usually declined in average milk yields from December 2 through April 20. Milk production in late winter by range cattle did not decrease as much in this trial as in either Trial I or II. Both groups of cattle on the range increased in milk production considerably from April 20 to May 30. This would be expected due to the appearance of grass of high nutritive value.

The high-level cows in the traps decreased in average milk production soon after supplemental feeding was discontinued, whereas the low-level cows in the traps increased (April 20 to May 30). Differences between the two lots in milk production were not statistically significant ($P < .05$). Neither were differences in milk production between the two lots of cows on the range. The average milk production estimates obtained in this study compare favorably with those reported for Hereford cows by Gifford (1953).

Correlations of over-all average daily calf gains with over-all average daily milk yield for individual cow-calf pairs appear in Table X.

TABLE X

AVERAGE DAILY GAINS OF CALVES AND MILK YIELD OF COWS, AND THEIR CORRELATIONS, 1960-61

Location	Trap		Range	
Lot number	1	2	3	4
Level of supplemental feed	Low	High	Low	High
Average daily gain (lb.)	1.16 ± .04[1]	1.27 ± .08	1.06 ± .07	1.18 ± .06
Average milk yield (lb.)	6.82 ± .40	6.88 ± .82	5.33 ± .45	6.54 ± .56
Correlation coefficient	.75	.91	.80	.80

[1]Standard error of the mean.

The over-all correlation coefficients were relatively high in all lots. When the coefficients of determination (r^2) were calculated, a large percentage of the differences in average daily calf gains was accounted for by the differences in the average milk production of their dams. These data indicate that average daily gain and weaning weight of calves may be good criteria in selecting beef cows for milk production.

SUMMARY

In three trials, fall-calving Hereford beef cows were fed on different levels of supplemental winter feed. The cows were either grazed in native grass pastures or confined in traps and fed prairie hay as the roughage during the winter. Milk production estimates were obtained on all cows in each of the three trials.

In Trial I, 4-year-old beef cows fed a pelleted mixture of 2.93 pounds of cottonseed meal and 3.95 pounds of ground milo per head daily lost 27 pounds less during the wintering period than cows fed 2.5 pounds of pelleted cottonseed meal, and weaned calves which were 9 pounds heavier. Average milk production declined in both lots in late winter and increased markedly when grass of high nutritive value became available in the spring. This spring increase in milk production was greater for the cows fed at the low level. Over the last 172 days of lactation, the low-level cows produced an average of 5.92 $\pm$ .48 pounds of milk per head daily and the high level cows 6.40 $\pm$ .39 pounds. The correlation coefficients between average daily gain of the calves and milk production of the cows for the 172-day period were .81 and .85 for the low and high level groups, respectively. These correlation coefficients were statistically significant ($P < .01$). Coefficients of determination (r^2) indicated that 66 and 72 percent of the differences in average daily gain of the calves could be accounted for by differences in milk yield of their dams.

In Trial II, three lots of 3-year-old beef cows, suckling their second calf, were wintered on native grass at two levels of supplemental winter feed. The calves in Lot 1 only were creep-fed. The low-level cows (Lots 1 and 2) lost 287 and 301 pounds, respectively, during the 197-day wintering period, whereas the high level cows (Lot 3) lost 252 pounds. The differencesin average calf weights at spring and weaning were 45 and 61 pounds, the differences being in favor of the high level of wintering ($P < .01$, Lot 2 vs. Lot 3). Average milk production, over the last 172 days of lactation, was $3.81 \pm .44$, $4.21 \pm .22$, and $5.42 \pm .53$ pounds per head daily for Lots 1, 2, and 3, respectively. The high level of wintering significantly ($P < .01$) increased milk production. The correlations between daily gain and milk yield were not statistically significant ($P < .05$).

In Trial III, two lots of 2-year-old beef cows were wintered at a low and high level of supplemental feed in small traps and fed prairie hay as the roughage. Two other lots of cows were wintered at a low and high level of supplemental feed on the range. During the 184-day wintering period, average weight loss of cows in traps was 133 pounds less for those fed on the high level than for those fed on the low level. However, the weight losses of the two groups on the range were about equal. The high level of wintering increased weaning weights 14 pounds in the traps and 6 pounds on the range.

Average milk yields of cows in traps and on the range were not significantly ($P < .05$) affected by the level of supplemental winter feed. Average milk yields for the 228-day period were $6.82 \pm .40$, $6.88 \pm .82$, $5.33 \pm .45$, and $6.54 \pm .56$ pounds for the low-level and high-level cows in the traps

and on the range, respectively. Correlations of daily gain with milk yield for the four groups in the above order were .75, .91, .80, and .80. All correlations were significant ($P < .01$). The coefficients of determination (r^2) in Trial III indicate that average daily gain and weaning weight of calves might be good criteria in selecting beef cows which produce the greatest quantity of milk.

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