FACTORS AFFECTING RUMEN MOTILITY AND RUMINATION IN DAIRY CATTLE

by

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INTRODUCTION

The dehydration of forages is an important industry in America. Practically all commercial formula feed manufacturers use some dehydrated forage in their mixes. Dehydration is of special importance in Kansas because of the large acreage of alfalfa, and the availability of an ample and cheap supply of natural gas as a source of heat. In production of dehydrated alfalfa for 1954 Kansas ranked second in the United States with 154,100 tons.[1]

Dehydrated alfalfa is a valuable feed for cattle because of its high protein and carotene content. Carotene content of dehydrated alfalfa is much higher than in the sun-cured alfalfa. In some instances there are the added advantages of savings on cost of shipping and handling.

Generally, dehydrated forages are finely ground. This is done to facilitate processing, and in mixing with other feeds. The finely ground product is easier to handle, and requires less storage space.

It was observed, first by Forbes et al. (1926) and later by Kick et al. (1937), that the use of ground roughage for cattle caused impairment of rumination. A reduction in rumination was observed by Powell (1938, 1939) and Voelker (1949) when the roughage ration consisted of dehydrated alfalfa pellets.

This study was undertaken to obtain further fundamental information on how rumination, rumen motility, and other physiological behaviors of cows are affected by the feeding of finely ground roughages.

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[1] Alfalfa Meal Production, U.S.D.A. Agr. Marketing Service, Grain Division, Kansas City, Missouri, April, 1955.

REVIEW OF LITERATURE

Rumination, according to Schalk and Amadon (1928), "- is the result of a highly complex, reflex mechanism dependent upon proper stimuli, the nature and quantity of the food, and quite definite moisture requirements."

Theories were postulated but there was not much known concerning rumination and regurgitation until the experimental work of Colin, Flourens, Chauveau, and Toussaint in the middle 19th century, as cited by Schalk and Amadon (1928). Chauveau theorized that regurgitation was brought about by a special aspiratory act of the thorax with a closed glottis which forced the rumen material into the cardia. Later, Chauveau and Toussaint proved this to be true, by the use of fistulated animals. This was contradictory to the belief that rumen contractions forced the bolus into the mouth.

These findings were overlooked in America until 1921, when Chauveau's theory of regurgitation was incorporated in Smith's (1921) "Manual of Veterinary Physiology."

Results of work by Bergman and Dukes (1926), and Schalk and Amadon (1928) on the physiology of rumination, with rumen fistulated animals, supported Chauveau's theory of regurgitation.

Time Spent in Rumination

Dairy cows have been reported to spend from 5 1/2 to 8 1/2 hours per 24-hour period in ruminating (Bergman and Dukes, 1925; Fuller, 1928; Schalk and Amadon, 1928; Hancock, 1950). Bergman and Dukes (1925) observed a Guernsey cow and a Jersey cow for a 24-hour period and found that the rumination time was 6 hours and 42 minutes, and 8 hours and 22 minutes, respectively. The number of ruminating periods, 15 and 20 respectively, were evenly distributed throughout

the 24-hour period. Similar results were obtained by Schalk and Amadon (1928) who observed nine animals for 60 consecutive hours, and found the total ruminating time averaged 6.89 hours per 24-hour period. Fuller (1928) observed 22 animals and found they had an average rumination time of 8 hours and 17 minutes in 24 hours with a range of 5 hours and 44 minutes to 10 hours. An average ruminating time of 5 hours and 24 minutes per 24 hours was reported by Hancock (1950) in studies with identical twin cows. The total time ruminating was divided into 13.3 average periods of 24.5 minutes each.

Bergman and Dukes (1926) reported that the cows favored the lying position for ruminating. A Guernsey cow which they observed spent 59.5 percent of a 24-hour period in the lying position, and 91 percent of the total ruminating time was in this position. Similarly, they found that a Jersey cow spent 63.3 percent of a 24-hour period in lying position, and 81.7 percent of the total ruminating time was in this position. In general accordance with this work is that of Schalk and Amadon (1928), who observed four animals that ruminated an average of 66 times in the standing position, and 75 times in the lying position during 60 consecutive hours.

An even distribution of time spent standing and lying was reported for stabled cattle by Fuller (1928). No difference in standing and lying time could be ascribed to stage of lactation, or to breeds.

Importance of Roughage in the Diet of Ruminants

The need for roughage in the diet of the ruminant has been well established (Davenport, 1897; McCandlish, 1923; Huffman, 1928; Mead and Goss, 1936). Attempts by Davenport (1897), McCandlish (1923), and Huffman (1928) to raise calves without roughage failed. Growth was subnormal in all cases, and death occurred near the seventh month unless roughage was placed in the diet.

It might be postulated that the failure in early experiments to raise calves without roughage was due to vitamin deficiencies since Mead and Regan (1931), and Mead and Goss (1935, 1936) were moderately successful in raising calves without roughage. However, Mead and Goss (1936) later reported that four of the original 14 heifers had died of bloat. Though some of the heifers had been raised on the roughage-free diet to three years and eight months of age, bloat was a constant problem, and feed intake had to be limited. Herman (1936) and Wise et al. (1939) reported success in raising calves on rations devoid of roughage, when the ration was supplemented with minerals and vitamins known to be essential.

When roughage is omitted from the diet of ruminants, there is a complete cessation of rumination (Beach, 1907; Mead and Goss, 1935; Ritzman and Benedict, 1938; Davenport, 1897). The earliest reports of a cessation of rumination due to a lack of roughage was made by Miller in 1874, as cited by Beach (1907). He maintained cows during the winter dry periods (about 8 weeks) on ground corn meal. The cows remained in good health and condition, with no inordinate desire for food. Ritzman and Benedict (1938) reported complete cessation of rumination three days following the omission of roughage from the diet.

Kick et al. (1937) observed among steers maintained on a ration devoid of roughage that rumination was slow and listless, and seemed to be initiated by an inherent impulse rather than from any desire or need.

The Effect of Ground and Chopped Roughage on Ruminants

Dairymen long have been interested in the place of chopped and ground roughage as a feedstuff for their cattle. Most authorities report a slight advantage to ground or chopped roughage for cattle. This advantage is due largely to greater consumption of the stemmy material, resulting in less wastage

(Ingham and Meade, 1929; Reed and Burnett, 1926; Gramlich, 1919; Potter and Withycombe, 1920; Moore and Cowsert, 1926).

In recent years, dehydrated and pelleted roughages have become widely used by feed manufacturers, and to some extent by livestock feeders. Dehydration is the process in which the moisture content of a green cut crop is reduced by subjecting it to a blast of hot air for a short period of time. Dehydrated roughage is frequently pelleted to facilitate handling and to eliminate dust (Schrenk et al., 1953). Usually following dehydration the forage is finely ground to facilitate storage.

The value of dehydrated alfalfa in dairy cattle rations has been demonstrated at several stations (Bartley et al., 1951; Knott and Hodgson, 1934; Newlander, 1933; Camburn, 1953; Blosser et al., 1952; Warren et al., 1954; Snell, 1934; Eaton et al., 1951, 1952; Gardner and Akers, 1954).

It has been shown in many experiments that: there is a greater retention of carotene in dehydrated roughage than in sun-cured (Huffman, 1939; Eaton et al., 1951, 1952; Haige and Aitkenhead, 1931; Kane et al., 1937; Bechdel et al., 1940); and that the availability of nutrients in dehydrated roughages were equal to or slightly better than those of sun-cured roughages (Newlander et al., 1938; Bartlett et al., 1938; Hart et al., 1932; Bechdel et al., 1940).

It was first noted by Forbes et al. (1925), and later by Kick et al. (1937) that rumination was suppressed in cows that received finely ground roughage. Powell (1938, 1939) observed the same conditions in cows fed finely ground pelleted roughage. These results were substantiated by several other authorities (Cole and Mead, 1943; Swanson and Ragsdale, 1947; Voelker, 1949; Swanson and Herman, 1952; Porter et al., 1953).

Forty percent reduction in rumination time was reported by Kick et al. (1937) when steers were fed ground hay, while coarse cutting or chopping had no

effect upon rumination time. Swanson and Ragsdale (1947) fed roughage which was chopped and ground into three different degrees of fineness and found that rumination was depressed according to the fineness of grinding. They obtained normal rumination with the coarse chopped hay, but not with the finely ground. Missouri workers postulated that rumination may not be essential to the proper digestion of roughage, provided the roughage is ground fine enough to not require mastication (Swanson and Ragsdale, 1947; Swanson and Herman, 1952). Bloat, as well as depraved appetites, were problems among cows fed ground alfalfa as the only source of roughage in California experiments (Cole and Mead, 1943).

Porter et al. (1953) reported results of two similar experiments, differing only in that pelleted roughage was used. No difference was noticed between groups fed pelleted and sun-cured hay in the first experiments, while in the second, severe anorexia and low roughage consumption were observed in the pellet-fed cows. They suggested that pellet firmness, which is a reflection of fineness of grinding, might have been a factor in the time spent in rumination when pellets were fed as the sole source of roughage.

Voelker (1949) reported reduced rumination time for dairy cows fed dehydrated atlas sorgo pellets as the sole source of roughage. While it was noted, in all previous reports, that rumination was suppressed only when the roughage ration was limited to finely ground roughage, or when small amounts of roughage were fed, Hope et al. (1950) reported that rumination was suppressed in cows when 30 or 45 percent of the concentrate mixture was replaced by dehydrated grass, even though the cows were fed three pounds of hay crop silage per 100 pounds of body weight and alfalfa hay ad libitum.

Rumen Motility

The activities inside the fermentation vat, as the rumen is often called, have long been the subject of study and contemplation. The principal means of obtaining information concerning rumen movements has been by the use of fistulated animals. Due to the extensive development of the rumen and its close proximity to the abdominal wall, it is a relatively simple operation to establish a rumen fistula.

Fistulated animals were first used by Colin in 1875 to observe rumen motility and regurgitation, as cited by Schalk and Amadon (1928). Bergman and Dukes (1926) observed rumen activity by means of fistulated steers. Schalk and Amadon (1928) made their classic studies of rumen motility by palpation and by placing balloons attached to pneumatic kymograph recording systems at various locations in the rumens of fistulated cattle.

Normal rumen motility as described by Schalk and Amadon (1928), and by Dukes (1955) originates in the reticulum by two rapid contractions of the walls of that cavity, the second immediately following the first. As a result of these contractions, liquid material is thrown into the rumen. Before the completion of the second reticular contraction, however, the anterior pillar of the rumen begins to contract, forming a barrier to the second reticular outflow. The wave of rumen contraction begun at the anterior pillar, proceeds posterially involving the entire dorsal part of the rumen, and, as these structures relax, the ventral sac goes into contraction. This forces ingesta forward and upward into the anterior dorsal region of the rumen. Following the primary wave, just mentioned, is a secondary wave similar to the primary, but which involves only the rumen.

Schalk and Amadon (1928) noted that the rate of motility in the rumen varied

during rumination, resting, and feeding. During feeding, rumen motility was the most rapid, while slowest during rumination.

Magee (1932), however, while studying rumen motility, by use of X-ray, using barium sulfate and calcium sulfate pills as tracers, found that rumen movements were most rapid and extensive during rumination.

The rumen motility cycle normally occurs once each minute or minute and a half (Schalk and Amadon, 1928; Magee, 1932; McAnnally and Phillipson, 1944), with the two contractions totalling 25-40 seconds and the remainder of the time in rest.

According to McAnally and Phillipson (1944), reticulum contractions of five seconds are followed immediately by the rumen contraction of about 15 seconds. The second contraction of the rumen follows the first by a few seconds, and it also lasts approximately 15 seconds. A rest period of 25 to 30 seconds then usually prevails.

Irregularities noted in the rumen cycle have been found to be due to irregularities in the length of pause between the two rumen contractions, and in the period of rest following the complete rumen cycle (McAnally and Phillipson, 1944). Schalk and Amadon (1928) noted an occasional extra wave of contraction, involving only the muscularis of the rumen, which was inaugurated by the anterior pillar of the rumen.

In order to study rumen motility in intact animals, Dougherty and Crumb (1949) devised a piston pneumatic apparatus for recording rumen reticular movements. Rumen movements were conveyed by air pressure through rubber tubing from a plunger held against the flank to a tambour and recorder. The results obtained compared favorably with tracings recorded from cows with permanent rumen fistulas. Respiration did not affect the tracings to any great degree.

A ruminometer to compare the relative force of rumen contractions was

reported by Coryainova (1949). Pressure against a disc applied to the deepest part of the paralumba fossa region was transferred to a pointer which registered the pressure in grams.

EXPERIMENTAL PROCEDURE

For simplicity, the following terms will be used to describe the roughage rations fed:

Term	Abbreviated in tables as:	Roughage or combination of roughage used:
Pellets	P	Entire roughage furnished by finely ground dehydrated alfalfa, pelleted.
Sun-cured pellets	SCP	Entire roughage supplied by finely ground sun-cured alfalfa hay, pelleted.
Hay and pellets	H - P	75 percent of roughage consisted of finely ground dehydrated alfalfa, pelleted, 25 percent as chopped alfalfa hay.
Hay	H	Entire roughage supplied by chopped alfalfa hay.
Pellets and silage	P - S	Sorgo silage, 2 lb./100 lb. body weight remainder of roughage furnished by finely ground dehydrated alfalfa, pelleted.
Hay and silage	H - S	Sorgo silage, 2 lb./100 lb. body weight, and alfalfa hay, ad libitum.
Pellets, silage, and hay	P-S-AH	Pellets furnished at the rate of 0.5 lb./100 lb. body weight, sorgo silage, 2 lb./100 lb. body weight, and chopped alfalfa hay, ad libitum.
Silage and alfalfa hay	S - AH	Sorgo silage 2 lb./100 lb. body weight and chopped alfalfa hay, ad libitum.

The experiment was divided into two phases as follows:

Phase I. Observations of physiological activities of dairy cows fed various types and forms of roughage. The following data were recorded:

1. Rumination time.
2. Time standing and lying.
3. Number of drinks and total water consumption.
4. Number of defecations and percent moisture in feces.
5. Number of urinations.
6. Pulse.
7. Respiration.
8. Temperature.

Phase II. The effect of various types and forms of roughage on rumen motility as measured by:

1. Rumen palpation per rectum.
2. Kymograph tracings of rumen motility obtained by the use of the Dougherty-Crumb pneumatic piston.

Phase I. Observations of Physiological Activities

Experimental animals used in this study were lactating cows of the Ayrshire, Guernsey, Holstein, and Jersey breeds which were being used in experiments to determine the feeding value of finely ground dehydrated roughage for dairy cows. Descriptions of these cows and of their experimental treatment are listed in Appendix, Table 17. One 24-hour and three 12-hour observations were made each week on 18 selected cows being fed varying amounts of finely ground roughage. These 18 cows were alloted into three groups of six. Each group was assigned at random to one of the following rations:

1. Concentrate mixture and dehydrated alfalfa pellets (Pellets).
2. Concentrate mixture and chopped alfalfa hay (Hay).
3. Concentrate mixture plus roughage of the following proportions: Dehydrated alfalfa, 75 percent; alfalfa hay, 25 percent (Hay-pellets).

The detailed experimental design was as follows:

Group No.	Dates of experimental periods				
	11/15/49-1/10/50 Ration fed	1/10-2/22/50 Ration fed	2/22-3/29/50 Ration fed	3/29-5/7/50 Ration fed	
I	P	H	SCP	P	H-S
II	H	P	S-P	HS[1]	H-S
III	HP	HP	HP	P[2]	H-S

It will be noted that in the period beginning February 22, 1950, sun-cured pellets were fed to cows in group I, and silage and pellets were fed to cows in group II, and that in the period beginning on March 23, hay and silage were fed as roughage to cows in group II.

In addition, one 24-hour and two 12-hour observations were made on a group of six cows which were selected from experimental groups which received either hay and silage or hay and silage plus 0.5 pound of dehydrated alfalfa pellets per 100 pounds body weight as the roughage.

These six cows were observed for several 24-hour periods, after the termination of the experiment, while they were on the standard Kansas State College dairy roughage ration of alfalfa hay and sorgo silage.

Twelve cows on the standard ration (hay and silage) were observed for varied numbers of observational periods as a control group to obtain data on

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[1] Period began 3-23.

[2] Period began 3-7.

normal physiological activities.

In the experimental rations where roughage was limited, it was fed at the rate of 2.5 pounds per 100 pounds of body weight. Roughages fed in accordance with experimental rations were: good quality, second cutting alfalfa, equivalent to U.S. No. 2 grade; commercially dehydrated alfalfa pellets, containing approximately 17 percent protein; and sorgo silage fed at the rate of 2 pounds per 100 pounds body weight. Rations were adjusted at the end of each 30-day period on the basis of body weight and average daily milk production of that period. The roughage rations were supplemented with sufficient concentrate to provide 110 percent of Morrison's (1947) standards for total digestible nutrients.

The concentrate mixture for all cows was as follows:

400 pounds ground corn
100 pounds ground oats
100 pounds wheat bran
100 pounds soybean oil meal
7 pounds salt
7 pounds bonemeal

Records. Six cows were observed during each observation period for either 12 or 24 consecutive hours, in which actual clock time was recorded for ruminating periods, time standing and lying, drinking, urinating, and defecating.

Water meters were placed on the water lines to the drinking cups of 10 pellet-fed cows and one control cow and the water consumption was recorded daily.

Pulse and respiration rates were determined and rectal temperatures were taken of individual cows prior to the evening feeding for each observation period.

Samples of feces were taken for moisture determination from representative cows of the various roughage treatment groups at semi-weekly intervals for approximately four weeks. Weighed samples were dried at 100° C. for 24 hours and moisture determined by loss of weight.

Management. The 24 cows fed the experimental rations were housed in the east side of the Kansas State College Dairy Barn. They were fed twice daily, the concentrate being fed first, followed by the roughage ration. All feed was weighed and any refused was weighed back. White pine shavings were used for bedding. Cows were kept in conventional stanchion-stalls. Water cups were provided for all animals. Mangers were divided with metal dividers and boards to prevent any exchange of feed between cows, and to minimize wastage of rations.

In fair weather, the cows were allowed access to a dry exercise lot two hours daily.

The control cows were managed under normal herd treatment. All observations on these cows were made on those days that they remained in the barn. On these days, hay was before them at all times.

Phase II. Rumen Motility

This phase of the study was conducted concurrently with Phase I. The 18 cows used to study the effect of varying amounts of finely ground roughage on milk production were used in this phase of the experiment. Details of feeding and management of these cows was as described in Phase I. Internal palpation of the rumen of selected cows in the various roughage groups were made with the assistance of Dr. M. J. Twiehaus, Department of Pathology, Kansas State College. Palpations were made just prior to and during a reversal of periods for the roughage groups.

Kymograph tracings were made of the rumen contractions of the 18 cows fed

various types and forms of roughage by use of the Dougherty-Crumb (1948) pneumatic piston. Tracings were also obtained just prior to, and 2; 6; and 24 hours following a change in roughage from pellets to hay.

EXPERIMENTAL RESULTS AND DISCUSSION

The presentation and discussion of experimental results will be divided as follows:

1. Observation of physiological activities.
2. Rumen motility.

Phase I - Observations

Ruminating Time. Summaries of all 12-hour and 24-hour observations made on ruminating activities according to types and forms of roughages fed are presented in Tables 1 and 2, respectively. Individual cow observations are listed in Tables 16 and 17 of the Appendix.

The time spent in rumination varied markedly between cows fed finely ground and "normal" roughages. There was a very definite reduction in rumination time for all animals fed a high level of finely ground roughage. It should be noted that cows on normal roughage diets ruminated 380 to 474 minutes per 24 hours as compared with 95 to 102 minutes for cows fed finely ground roughage as their entire roughage supply (Table 2).

This difference in rumination time between roughage groups is also manifested in the difference in percent of time spent ruminating (Tables 1 and 2). There was a pronounced reduction in rumination when pellets were fed as the sole source of roughage. The cows receiving pellets as their only source of roughage ruminated an average of only 6 percent of the time observed, whereas the cows fed chopped hay ruminated an average of 27 percent of the time. This is a highly

Table 1. Summary of time spent ruminating for cows on 12-hour observation periods for various experimental rations.

Roughage ration[1]	Total cows	No. of obser. periods	Total time obser. min.	Ruminating time: No. of periods	Total min.	% of time spent ruminating	Av. no. of periods/ 24 hrs.	Av. time per period min.	Range in rumination periods min.	Standing %	Lying %	Total time Standing %	Total time Lying %
H-P	6	39	28,080	166	2852	10.2	8.5	17.2	2-56	63.6	36.4	73.0	27.0
P	17	46	33,120	122	2048	6.2	5.3	16.8	0-49	59.8	40.2	69.4	30.6
H	12	29	20,880	200	4764	22.8	13.8	23.8	4-83	57.7	42.3	66.0	34.0
P-S	4	10	7,200	39	938	13.0	7.8	24.1	5-55	49.4	50.6	74.0	26.0
SCP	6	21	15,120	32	466	3.1	3.0	14.6	0-46	26.0	74.0	63.0	37.0
P-S-AH	6	6	4,320	41	1275	29.5	13.7	31.1	2-57	67.5	32.5	72.4	27.6
S-AH	6	6	4,320	48	1289	29.8	16.0	26.9	4-54	56.7	43.3	65.8	34.2
H-S	19	72	51,840	501	14,760	28.5	13.9	29.5	2-92	49.3	50.7	66.9	33.1

[1] H-P 75% dehydrated alfalfa pellets, 25% alfalfa hay.
P Dehydrated alfalfa pellets.
H Chopped alfalfa hay.
P-S Sorgo silage (2 lb./100 lb. body weight) and dehydrated alfalfa pellets.
SCP Sun-cured alfalfa pellets.
P-S-AH Sorgo silage (2 lb./100 lb. body weight) dehydrated alfalfa pellets (½ lb./100 lb. body weight) and chopped alfalfa hay (ad. lib.).
S-AH Sorgo silage (2 lb./100 lb. body weight) and chopped alfalfa hay (ad. lib.).
H-S Sorgo silage (2 lb./100 lb. body weight) and alfalfa hay (ad. lib.).

Table 2. Summary of time spent ruminating for cows on 24-hour observation periods for various experimental rations.

Rough-age ration[1]	Total cows	No. of obser-lods	Total time obser. min.	Ruminating time: No. of periods	Total min.	Av. time/ 24 hrs.	% of time spent rumi-nating	Av. no. of per-iods/ 24 hrs.	Av. time per period min.	Range in rumi-nating periods: min.	Total time Stand-ing %	Total time Lying %	Stand-ing %	Lying %
H-P	6	14	20,160	133	2488	177.7	12.3	9.5	18.7	1-47	53.4	46.6	59.0	41.0
P	14	15	21,600	88	1427	95.1	6.6	5.9	16.2	3-54	34.5	65.5	58.0	42.0
H	11	16	23,040	235	6205	387.8	26.9	14.7	26.4	4-81	46.4	53.6	57.0	43.0
P-S	3	3	4,320	31	829	276.3	19.2	10.3	26.7	2-56	43.1	56.9	56.8	43.2
SCP	5	7	10,080	38	712	101.7	7.1	5.4	18.7	2-57	32.4	77.6	54.0	46.0
P-S-AH	3	3	4,320	41	1380	460.0	31.9	13.7	33.7	9-65	34.1	65.9	48.9	51.1
S-AH	3	3	4,320	50	1423	474.3	32.9	16.7	28.5	4-61	43.3	56.7	52.2	47.8
H-S	4	5	7,220	61	1904	380.8	26.4	12.2	31.2	6-80	33.7	66.3	48.8	51.2

[1] H-P 75% dehydrated alfalfa pellets, 25% alfalfa hay.
P Dehydrated alfalfa pellets.
H Chopped alfalfa hay.
P-S Sorgo silage (2 lb./100 lb. body weight) and dehydrated alfalfa pellets.
SCP Sun-cured alfalfa pellets.
P-S-AH Sorgo silage (2 lb./100 lb. body weight) dehydrated alfalfa pellets (½ lb./100 lb. body weight) and chopped alfalfa hay (ad. lib.).
S-AH Sorgo silage (2 lb./100 lb. body weight) and chopped alfalfa hay (ad. lib.).
H-S Sorgo silage (2 lb./100 lb. body weight) and alfalfa hay (ad. lib.).

significant difference ($P < .01$).

A difference was noted in the percent of time spent ruminating for the same roughage treatment groups during 12-hour and 24-hour periods. The average percent of time spent in rumination for all groups of 20 percent during 24-hour periods as compared to 18 percent for the 12-hour periods was significant ($.01 < P < .05$).

This difference in time is thought to be largely due to the difference in surrounding conditions rather than any physiological dissimilarity of the animals. The majority of 12-hour observations were taken during the day when there was a constant flow of activity to annoy the cows, while at night there was very little to disturb them. It is regretable that there was not an equal number of day and night observations in the 12-hour periods.

Though there was a significant difference between the percentage of time spent ruminating while observed for 12 hours as compared to 24-hour periods, the cows responded similarly to the same roughage ration ($P > .05$) (Table 11 in the Appendix).

In order to determine whether the difference in rumination time between cows fed pellets and those fed normal roughage was due to the dehydration process or to the fineness of grinding, ruminating time was compared between cows fed dehydrated alfalfa pellets and sun-cured alfalfa pellets.

The cows fed dehydrated alfalfa pellets ruminated an average of 95 minutes per 24-hours or 6.6 percent of the time while those fed sun-cured alfalfa hay pellets ruminated an average of 102 minutes or 7.1 percent (Table 1). It is evident from the results (Table 10 of the Appendix) that there were no significant differences in ruminating time between cows fed dehydrated alfalfa pellets and those fed sun-cured hay pellets ($P > .05$). Thus, the difference in ruminating time between pellet-fed and normal-fed cows is due to the fineness of grinding

Table 3. Ruminating activity of breeds during 12-hour observation periods, as summarized by types and forms of roughages fed.

Breed	Number of cows	Observations		Ruminating periods		Range in rumination periods	Ruminating time			Total time	
		No.	min.	Total no.	Average time per period min.	min.	Total min.	Periods %	Standing %	Lying %	Standing %	Lying %
Dehydrated alfalfa pellets												
Ayrshire	5	15	10,800	43	14.7	0-34	633	5.9	62	38	77	23
Guernsey	4	8	5,760	21	14.6	0-32	307	5.3	41	59	54	46
Holstein	6	18	12,960	50	20.1	0-49	1005	7.8	61	39	68	32
Jersey	2	5	3,600	8	12.9	0-27	103	2.9	89	11	78	22
75% dehydrated alfalfa pellets, 25% alfalfa hay												
Ayrshire	2	14	10,080	63	17.1	3-55	1080	10.7	59	41	76	24
Guernsey	1	6	4,320	30	20.1	2-42	604	14.0	39	61	59	41
Holstein	2	13	9,360	53	15.8	4-31	840	9.0	77	23	70	30
Jersey	1	6	4,320	20	16.4	6-34	328	7.6	92	8	86	14
Chopped alfalfa hay												
Ayrshire	4	12	8,640	81	19.4	2-50	1575	18.2	54	46	71	29
Guernsey	3	7	5,040	49	24.6	6-68	1206	23.9	47	53	58	42
Holstein	4	8	5,760	57	27.6	4-83	1573	27.3	71	29	68	32
Jersey	1	2	1,440	13	31.5	2-67	410	28.5	51	49	61	39
Sun-cured alfalfa pellets												
Ayrshire	2	6	4,320	6	12.2	0-25	73	1.7	0	100	70	30
Guernsey	2	10	7,200	19	12.5	0-27	238	3.3	27	73	57	43
Holstein	2	5	3,600	7	22.1	7-46	155	4.3	37	63	66	34
Jersey	-	-	-	-	-	-	-	-	-	-	-	-

Table 3 (concl.).

Breed	Number of cows	Observations No.	Observations min.	Ruminating periods Total no.	Ruminating periods Average time per period min.	Range in rumination periods min.	Ruminating time Total min.	Ruminating time Periods %	Ruminating time Standing %	Ruminating time Lying %	Total time Standing %	Total time Lying %
Sorgo silage, dehydrated alfalfa pellets												
Ayrshire	1	1	720	5	18.2	14-22	91	12.6	100	0	91	9
Guernsey	-	-	-	-	-	-	-	-	-	-	-	-
Holsetin	2	6	4,320	26	26.8	6-55	699	16.2	49	51	70	30
Jersey	1	3	2,160	8	18.5	5-28	148	6.9	22	78	77	23
Sorgo silage, chopped alfalfa hay												
Ayrshire	1	2	1,440	15	26.2	5-45	392	27.3	62	38	78	22
Guernsey	-	-	-	-	-	-	-	-	-	-	-	-
Holstein	2	4	2,880	33	27.1	4-54	896	31.1	65	35	65	35
Jersey	-	-	-	-	-	-	-	-	-	-	-	-
Sorgo silage, alfalfa hay												
Ayrshire	6	13	9,360	77	26.7	7-55	2056	22.0	58	42	74	26
Guernsey	3	10	7,200	66	30.0	6-89	1978	27.5	36	64	62	38
Holstein	9	47	33,840	345	29.6	2-92	10226	30.2	48	52	65	35
Jersey	1	2	1,440	13	38.5	16-89	500	34.7	60	40	58	42
Dehydrated alfalfa pellets (0.5 lb./100 lb. body weight), sorgo silage, chopped alfalfa hay												
Ayrshire	-	-	-	-	-	-	-	-	-	-	-	-
Guernsey	-	-	-	-	-	-	-	-	-	-	-	-
Holstein	3	6	4,320	44	29.0	2-57	1275	29.5	64	36	71	29
Jersey	-	-	-	-	-	-	-	-	-	-	-	-

and not due to the dehydration process.

Because the effects of each of the various rations were not measured on the same cows, the observations for each ration were averaged for each type of observational period. Comparisons of the coefficient of variation of the different rations indicated that the variances might not be homogeneous, or that the differences within some groups might be greater than in others (Table 11, Appendix). The variances were tested by Bartlett's test (Snedecor, 1947) for homogeneity of variance and it was found that the 12-hour, 24-hour, and combined observations were homogeneous ($P > .05$). Thus, the variations within a group were no greater than variations within the other groups. Since homogeneity was established, the groups were combined into three levels of pellet feeding and a normal feeding group for statistical comparison (Table 4).

Cows receiving 15 to 20 percent of their roughage in the form of pellets ruminated on the average 460 minutes per 24-hours which was equal to the time spent in rumination for cows on normal roughage treatments (380-474 minutes). However, when finely ground roughage comprised 70-75 percent of the roughage intake, rumination time was significantly decreased to average only 178 minutes on hay and pellets and 276 minutes on silage and pellets ($P < .01$).

A roughage ration of pellets alone decreased rumination time to an average of only 95 to 100 minutes per 24-hours which was a significant reduction in rumination time from the 75 percent pellet ration ($P < .01$). Several cows fed pellets only were observed for 12 consecutive hours with no evidence of rumination.

The small but insignificant difference between ruminating time of cows receiving a normal ration and those receiving 20 percent of their roughage as pellets, together with the highly significant difference between the ruminating time of cows in these groups and those receiving 75 percent and 100 percent pellets in their ration would strongly suggest that after a certain point is

Table 4. Analysis of general effect of various roughages on rumination time.

Type of roughage ration	Average rumination time	Number of observations	Total
A) Normal basic ration			
1) Sorgo silage and alfalfa hay	28.2	22	620.3
2) Chopped alfalfa hay	25.3	23	582.1
3) Sorgo silage and chopped alfalfa hay	30.4	10	304.3
		55	1506.7
B) Low level pellet ration			
4) Pellets, sorgo silage, and chopped alfalfa hay	30.0	9	270.3
C) High level pellet ration			
5) Pellets and sorgo silage	15.5	7	108.4
6) Pellets (75%), alfalfa hay (25%)	11.8	12	141.6
		19	250.0
D) All-pellet ration			
7) Dehydrated alfalfa pellets	6.3	31	194.5
8) Sun-cured alfalfa pellets	5.5	11	60.0
		42	254.4

Table 4-b. Combined analysis of variance.

Source of variation	Degrees of freedom	Sums of squares	Mean squares	F
Treatments	7	12,534.2	1,790.6	61.5**
Residual	117	3,405.7	29.1	
Total	124	15,939.9	---	---

Treatment comparisons (non-orthogonal)	d.f.	F[1]
a. Pellets (75%) alfalfa hay (25%) vs. sorgo silage and alfalfa hay (5 vs. 1)	1	71.73**
b. Pellets, sorgo silage, and chopped alfalfa hay vs. sorgo silage and alfalfa hay (4 vs. 1)	1	0.06 NS
c. Basic ration vs. low level pellet ration (A vs. B)	1	0.26 NS
d. Basic ration vs. high level pellet ration (A vs. D)	1	98.26**
e. Basic ration vs. all pellet ration (A vs. D)	1	372.27**
f. Low level pellet vs. high level pellet ration (B vs. C)	1	59.61**
g. High level pellet vs. all pellet ration (C vs. D)	1	20.78**

[1] Approximate only.

reached, rumination time is decreased proportional to the amount of finely ground roughage in the ration.

A difference was noted between the number of ruminating periods observed per 24-hours for the various roughage treatment groups. Cows receiving the finely ground roughages had decidedly less number of ruminating periods, and these periods were of less average duration, than cows receiving normal rations (Tables 1 and 2). This observation is in disagreement with that of Kick et al. (1937) who reported reduced minutes per ruminating period but no reduction in the number of periods for steers receiving finely ground roughages.

The range in time within the ruminating periods for cows in the roughage groups should be noted. Though some cows did not ruminate at all during a 12-hour period while fed pellets; other cows receiving the same ration had ruminating time within one period as much as 57 minutes, even though cows were rather listless as to rumination while on the pellets.

Time Standing and Lying. The division of time between standing and lying was fairly uniform between the various roughage groups (Table 1). The percent of time spent in these activities, when all groups and observations are included, gives a slightly biased figure. In Tables 1 and 2, it will be noted there was a definite higher average percentage of time spent in lying (44 percent) during the 24-hour observations as compared with 32 percent during the 12-hour observations. The majority of the 12-hour observations were made during the daytime and some of the difference in time standing and lying can be attributed to normal barn activities. During the daytime, the routine work of the barn and the stir which is constantly present may have been a reason for the difference in time spent lying in the different length periods. However, Atkeson et al. (1942), Ainslie (1950), and Hancock (1950) have reported similar diurnal patterns in lying and standing time of cows on pasture. Individual cow differences from day to day

existed but they could not be attributed to treatment, weather conditions, or breed.

Time Spent in Ruminating while Lying and Standing. Cows observed in this experiment had a definite preference to ruminate in the lying position. During the 24-hour observation, cows spent 43 percent of the total time lying but they spent 57 percent of their ruminating time in that position. When cows were observed for only 12 hours, they spent only 32 percent of the time lying but 46 percent of their total rumination was in that position.

The sun-cured pellet group favored the lying position for its ruminating activity to a greater extent than the other groups during both the 12- and 24-hour observation periods. Cows fed the sun-cured pellets ruminated on the average, 78 percent and 74 percent, respectively, of their total time in rumination while lying down. It is believed that this preference was due to the relatively small amount of ruminating time evidenced in this group. Since this same effect was not apparent in the other pellet-fed cows, the preference for the lying position for ruminating by this group is believed to be due to chance differences.

Distribution of Ruminating Time. It is interesting to note in the distribution of rumination time for the 24-hour observations as shown in Fig. 1, that definite periods of rumination can be detected irregardless of type of roughage ration fed. This is in disagreement with Bergman and Dukes (1925) and Kick et al. (1937), who reported even distribution of ruminating periods but it must be recognized that the cows herein reported were not fed in the usual manner. Grain and roughage were fed at approximately 5:30 night and morning, but as a general rule, the mangers were licked clean within a short time after feeding, even though the cows were given 110 percent of their nutrient needs. Thus, the time spent in eating was less than by cows on a normal feeding regimen. It might be conjectured that these evident cycles of rumination might be due to the

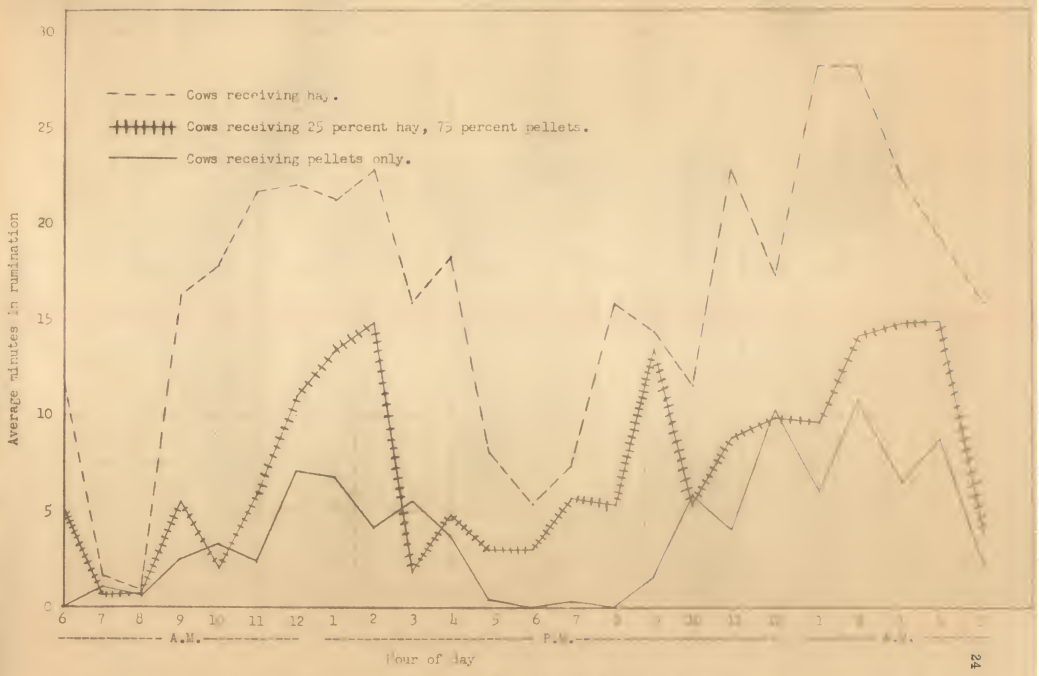

Fig. 1. The effect of various types of roughage on distribution of rumination time.

type of feeding plan, and that the cows might have had their ruminating periods more equally distributed had they been fed under normal conditions where hay or pasture is available to the cattle at all times.

Drinking Activity. Data on the average number of drinks taken by the cows while under constant supervision are presented in Table 5. Variations are evident among both cows and groups for the average number of drinks in 24 hours, but since the greatest variation occurred between averages of the groups of the high-pellet groups (5.9 drinks for cows fed pellets, and 9.1 for those fed hay and pellets), it is believed that this difference was caused by individual cow differences rather than the type of roughage fed. There were no consistent differences between breeds in numbers of drinks within the different roughage groups (Appendix, Table 13). Since there were wide differences between cows, even within breeds, any average difference between breeds is of doubtful significance.

Because of a delay in shipment of water meters, there was no means of measuring the amount of water actually drunk during these observation periods. Upon arrival, the water meters were placed on the water lines to the individual drinking cups of 11 of the experimental cows. Since it was believed that the most useful information would be gained from water consumption data of cows fed pellets, the meters were used for 10 pellet-fed cows. The remaining meter was used to obtain water intake data from one Guernsey cow receiving hay and silage. Data on average water consumption are listed in Table 6 and Appendix, Table 15.

The 10 cows fed alfalfa pellets as the sole source of roughage consumed an average of 12.6 gallons, or 105 pounds, per day. Water consumption per 100 pounds of body weight averaged 1.1 gallons, or 9.1 pounds. By comparison, the one Guernsey cow being fed hay and silage as roughage consumed an average of 10.4 gallons, or 87 pounds, and 1.2 gallons, or 10.1 pounds per 100 pounds of body weight.

Table 5. The effect of forms and types of roughage on certain physiological activities of dairy cows.

Ration	Number of observations	Av. number/24 hours			Number of observations	Av. number/minute		Av. body temperature
		Drinks	Urinations	Defecations		Pulse	Respiration	° F.
H-P	14	9.1	7.4	13.0	34	65.9	27.2	101.5
P	15	5.9	7.9	10.7	49	69.2	28.9	101.5
H	16	7.9	8.1	12.1	24	67.1	32.6	101.5
P-S	6	8.0	7.7	12.7	13	70.6	29.1	101.5
SCP	7	7.0	6.0	14.4	28	73.9	29.5	101.8
H-S	4	5.8	5.0	10.3	19	75.4	30.8	101.8

Table 6. Summary of average daily water consumption of cows fed dehydrated alfalfa pellets.

Cow number	Breed	Body weight	Average consumption per day for 5-week period		Average consumption per 100 lb. body weight		Average consumption for weeks ending 5-5-50		5-12-50	
			Gal.	Lbs.	Gal.	Lbs.	Gal.	Lbs.	Gal.	Lbs.
267A	Ayrshire	998	13.5	112.5	1.35	11.3	10.8	90.0	13.9	115.9
248A	Ayrshire	1019	10.2	85.0	1.00	8.3	11.3	94.2	12.4	103.4
255A	Ayrshire	1206	11.5	96.9	0.95	7.9	11.3	94.2	14.6	121.7
482A	Guernsey	905	11.7	97.5	1.29	10.7	13.0	108.4	11.4	95.0
474A	Guernsey	879	9.2	76.7	1.04	8.7	8.4	70.0	--	--
153A	Holstein	1273	16.0	133.4	1.26	10.5	17.7	147.5	14.6	121.7
163A	Holstein	1339	17.5	145.9	1.31	10.9	17.3	144.2	17.9	149.2
145A	Holstein	1257	16.6	138.4	1.32	11.0	19.0	158.4	18.2	151.7
111A	Holstein	1601	11.9	99.2	0.74	6.2	11.6	96.7	13.9	115.9
395A	Jersey	962	8.2	68.4	0.85	7.1	8.9	74.2	10.3	85.9
Average					1.11	9.26				
482A[1]	Guernsey	856	10.4	86.7	1.21	10.1	9.0	75.0	8.1	67.5

[1] Fed hay and silage.

Comparison was made also between the water consumption of the cows during their last week on alfalfa pellets, and the same cows the following week when they were fed hay and silage as roughage. During the last week on pellets, the average water consumption was 109 pounds, while the following week, when fed hay and silage, the average consumption was 106, or only 3 percent more.

Urination. Cows in the various roughage groups correspond rather closely in average number urinations for 24 hours (Table 5). In Table 13 in the Appendix, a comparison is made of urinations by rations and breeds of cows. There were no consistent differences in number of urinations between breeds of cows, or between groups of cows when fed different types of roughage.

Defecation. The number of defecations per 24 hours are given in Table 5, and the number of defecations classified according to breed, are listed in Table 13 in the Appendix. Eleven defecations per day are considered normal by Mead and Goss (1935), while Dukes (1955) lists a range of 10 to 24 defecations per 24 hours. All group averages for number of defecations per day were within the normal range. This is in disagreement with Mead and Goss (1935) who reported a 50 percent reduction in defecations when cows were fed finely ground roughage.

The Ayrshires reported herein had the least number of defecations of any of the breed averages for all the different roughage treatments. The average number of defecations for Ayrshires when fed pellets was considerably below normal, and when being fed hay, or being fed silage and hay, the Ayrshires were slightly below normal. This breed difference can not be satisfactorily explained from the data obtained in this study. Samples of feces were collected twice weekly for a one-month period, and analyzed for moisture content. The 15 cows used represented the different roughage treatments being fed at that time. The average percent moisture in the feces for the various groups is given in Table 7, and moisture contents of feces of individual cows are given in Appendix Table 14.

Table 7. Percentage of moisture in feces of experimental cows.

Roughage group	Number of cows	Number of samples	Range in percent of moisture	Average percent of moisture content
Pellets	4	14	75.90 to 82.41	78.98
Hay and pellets	5	5	78.23 to 82.59	80.70
Silage and pellets	4	6	78.30 to 82.92	80.67
Sun-cured pellets	5	19	76.21 to 81.45	80.06
Hay and silage	1	3	82.71 to 83.47	83.10

The average moisture content (79 to 81 percent) of the feces of the cows fed varying amounts of pellets was slightly lower than that of the one check cow (83 percent). The moisture in the feces of the control cow was similar to the normal of 83 percent reported by Dukes (1955) and the range from 83 - 87 percent reported by Ritzman and Benedict (1938).

Pulse. Pulse rates were taken each observation period for those cows observed. All pulse rates were taken at approximately 4:30 p.m., and the rates reported are the average of two separate counts. The pulse was taken by pressing the fingers against the posterior tibial artery on the medial surface of the tibial region 8-10 inches above the hock joint, as described by Fuller (1928).

The average pulse rates for the four breeds as compared to results reported by other stations are given as follows:

	Alfredson and Sykes (1942)		Fuller (1928)			Present study		
	No. cows	Pulse/ min.	No. cows	No. of obser.	Pulse/ min.	No. cows	No. of obser.	Pulse/ min.
Ayrshire	13	76.4	8	332	69.6	6	56	68.9
Guernsey	22	72.7	7	317	59.8	4	43	72.8
Holstein	20	71.5	15	687	68.6	6	59	65.9
Jersey	23	65.9	9	356	62.7	2	17	67.2

It can be seen readily that the average pulse rates by breeds were similar to those reported by Alfredson and Sykes (1942) and Fuller (1928), even though the cows in this study were under experimental feeding conditions. Differences between roughage groups were not so great as breed differences within groups (Table 5 and Appendix Table 13).

Respiration. Respiration rates were observed and recorded for each observation period. Rates reported were the average of three visual observations, for one minute, of the flank of each cow. All respiration measurements were taken at approximately 4:30 p.m. There were only small differences in average respiration rates for the different roughage groups (Table 5). These rates are comparable to normal respiration rates as reported by Dukes (1955).

The effect of the type of roughage fed, and the breed of cow, on respiration rates is shown in Appendix Table 13. Respiration rates were quite similar for all breeds. These data are not in complete agreement with Fuller (1928) who reported relatively low respiration rates for Guernsey cows (18.6) and Jersey cows (21.7).

Rectal Temperature. Rectal temperatures were taken for individual cows at each observation period. All temperatures were taken and recorded at approximately 4:30 p.m. All temperatures were normal and no difference could be noted

between roughage groups or breeds of cows (Table 8 and Appendix Table 13).

Phase II. Rumen Motility

Palpations of the rumen, per rectum, were made to determine rumen tone and motility on cows fed various amounts of finely ground roughage. Data recorded for individual palpations are listed under Observations in the Appendix.

Rumen contractions of the cows while being fed alfalfa pellets as the exclusive source of roughage were characteristically weak and smooth, with none of the volcanic type of action which is found in cows fed normal hay rations. The number of contractions per minute varied considerably between cows within the pellet roughage group, but in all cases a lack of rumen tone was evident.

Cows whose rations consisted of hay and pellets had more rumen tone than did those on pellets alone, but rumen contractions were similar to those on pellets alone in that contractions were irregular, smooth, and weak.

When rumen palpations were made during a changeover in roughage rations (pellets to hay and silage) it was noticed that rumen movements became more regular within 24 to 36 hours after hay and silage feeding was begun, but that the normal volcanic action of the contractions were not evident for several days thereafter.

Due to a delay in obtaining the Dougherty-Crumb (1949) pneumatic piston apparatus, recordings of rumen movements could not be obtained until the latter part of the experiment. This apparatus consisted of a piston, connected by rubber tubing to a tambour which activated the pen arm of an electrically operated kymograph. When the apparatus was held in position at the region of the left paralumbar fossa, the pressure on the piston by rumen movements was recorded on the kymograph.

By use of this apparatus, kymograph tracings of rumen movements were obtained for cows being fed the various types of roughage. Tracings were selected which were typical of recordings obtained for cows when fed pellets as the exclusive source of roughage; and others at various intervals following a change to hay as the source of roughage. Comparison was also made of tracings obtained from other cows fed hay and silage (Plate I). A kymograph tracing of rumen motility obtained from a cow fed hay and silage shows the primary contractions (P) followed by the secondary contractions (S) in a rather uniform rhythmic pattern, with less interval between primary and secondary contractions than between the pairs of contractions (E, Plate I). The extra rumen contraction (ERC) which is evident between rumen cycles, usually occurs less frequently than is found in this tracing. In contrast, the typical recording taken of cows fed finely ground roughage shows no evidence of rumen contractions (A, Plate I).

In tracings B, C, and D (Plate I), typical recordings are shown of rumen motility at various periods of time following a change in roughage ration from pellets to hay.

Tabulation of the average length of time during contractions and length interval of time between contractions are given in Table 8. The percent of total time representing contraction time is noticeably greater for the cows on the silage and hay ration (47 percent) than for the pellet-fed cows (16 percent).

These results would seem to indicate that finely ground roughage impairs rumen motility by reduction in the frequency and degree of contractions, but the length of the individual contractions is not reduced to any appreciable degree.

EXPLANATION OF PLATE I

A. Rumen motility of a typical cow fed a roughage ration of pellets only.

B. Typical tracing of pellet-fed cow 2 hours post hay feeding.

C. Typical tracing of pellet-fed cow 24 hours post hay feeding.

D. Typical tracing of pellet-fed cow 10 days following a change to hay roughage.

E. Typical tracing of a cow fed hay and silage roughage.

PLATE I

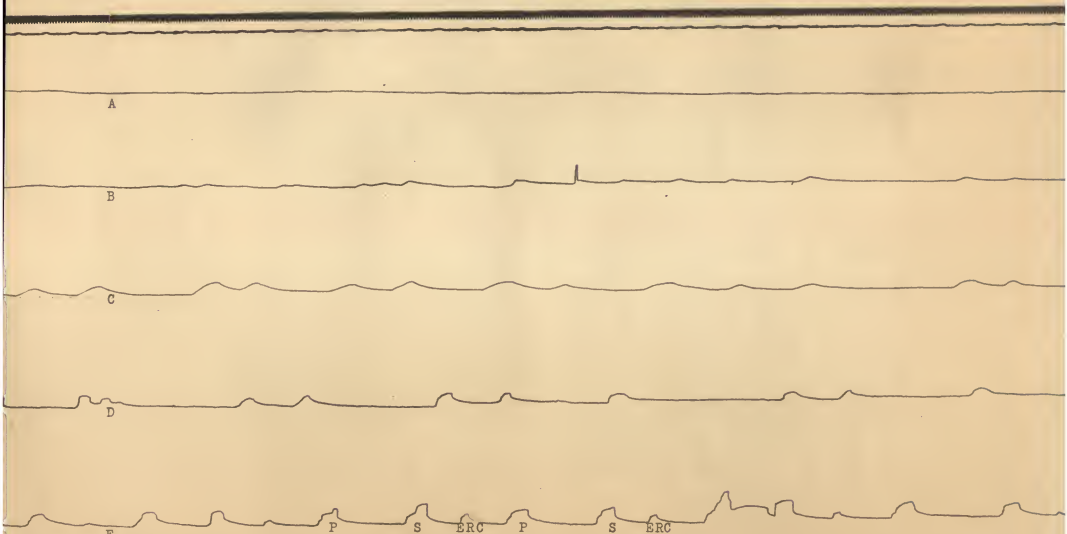

Table 8. The effect of physical form of roughage on rumen motility of dairy cows, as measured by kymograph tracings.[1]

		Experimental ration			Control ration
		Dehydrated alfalfa pellets	Transition from pellets to chopped hay[2]	Chopped alfalfa hay	Alfalfa hay Sorgo silage
Number of cows		8[3]	8[3]	8[3]	2
Number of observations		14	8	14	6
Av. length of primary rumen contraction	(sec.)	7.14[4]	7.25	8.79	11.00
Av. pause between primary and secondary contraction	(sec.)	29.57[4]	22.25	15.43	7.67
Av. length of secondary rumen contraction	(sec.)	7.57[4]	7.00	8.86	9.33
Av. pause following secondary rumen contraction	(sec.)	47.29[4]	44.75	30.14	15.33
Av. length of rumen contraction cycle	(sec.)	91.57	81.25	63.22	45.33
Time spent in rumen contraction	(%)	16.06	17.54	27.92	46.92
Extra rumen contraction following secondary rumen contraction	(no.)	4	2	8	5
Av. length of extra rumen contraction	(sec.)	5.50	4.00	9.25	8.80
Av. pause following extra contraction	(sec.)	117.25	32.00	30.50	28.80

[1] Measurements were made with the Dougherty-Crumb pneumatic piston.

[2] Measurements taken immediately after cows were fed chopped hay after being maintained on dehydrated alfalfa pellets from 30 to 45 days.

[3] The same eight cows on each ration.

[4] Averages are for four head only as the remaining four did not have any discernible movements whatsoever.

SUMMARY AND CONCLUSIONS

Thirty-six lactating dairy cows were observed for various 12-hour and 24-hour observation periods to determine the physiological responses to various types and forms of roughages. The results showed that rumination was markedly decreased when as much as 75 percent of the roughage ration consisted of finely ground roughage ($P < .01$), fed in pellet form. When this finely ground roughage comprised 20 percent of the roughage ration, no reduction in rumination time was evident ($P > .05$).

The reduction in ruminating time for cows fed dehydrated alfalfa pellets was due to the fineness of grind rather than to the dehydrating process, since sun-cured hay pellets retarded rumination equally as much.

Fifty-seven percent of the time while ruminating was while the cows were lying. However, the cows were lying only 44 percent of the total time. A cyclic distribution of rumination time occurred during the 24-hour day, but this may have been due to the feeding regimen.

Water consumption of cows fed dehydrated alfalfa pellets was no greater than a cow receiving a normal roughage ration, nor was there a material change in water consumption when the pellet-fed cows were changed to a hay ration. The moisture content of feces samples from cows fed pelleted rations was slightly below normal. No consistent differences were noted in pulse rates, respiration rates, or rectal temperatures of cows on the different roughage treatments.

In Phase II, rumen motility was studied in 18 lactating cows in various roughage treatment groups. A lack of tone of the rumina of pellet-fed cows was observed by rumen palpation. Weak, soft rumen contractions were noted in contrast to strong forceful movements of the hay-fed cows.

By use of the Doughtery-Crumb penumatic piston rumen motility of the pellet-fed cows was found to be slight if evidenced at all. The number of contractions were appreciably reduced in cows fed pellets as compared to cows fed hay and silage.

On the basis of these investigations it may be stated that the feeding of finely ground roughages to dairy cows adversely affects rumination time and rumen motility.

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LITERATURE CITED

Ainslie, Harry R.
Grazing habits of dairy cattle as affected by weather and chemical composition of pasture. Unpublished M. S. Thesis; Kansas State College Library, Manhattan. 1950.

Alfredson, B. V., and J. F. Sykes.
Electrocardiograph studies in normal dairy cattle. J. Agr. Res. 65:61-87. 1942.

Atkeson, F. W., A. O. Shaw, and H. W. Cave.
Grazing habits of dairy cattle. J. Dairy Sci. 30:779-784. 1942.

Barr, H. T.
Artificial curing of forage crops. La. Agr. Expt. Sta. Bul. 261. 1935.

Bartlett, S., K. M. Henry, S. K. Kon, L. W. Osborne, S. Y. Thompson, and J. Tinsley. The effect of different methods of drying on the biological value and digestibility of the proteins and on the carotene content of grass. Biochem. J. 32:2024-2030. 1938.

Bartley, E. E., D. B. Parrish, F. C. Fountaine, and C. H. Whitnah.
Effects of supplementing dairy cow rations with dehydrated alfalfa. J. Dairy Sci. 34:509. 1951.

Beach, C. L.
The facility of digestion of foods a factor in feeding. Storrs Agr. Expt. Sta. 19th ann. report. Bul. 43:6-7. 1907.

Bechdel, S. I., A. W. Clyde, C. O. Cromer, and P. S. Williams.
Dehydrated and sun-cured hay. Penn. Agr. Expt. Sta. Bul. 396. 1940.

Bergman, H. D., and H. H. Dukes.
Observations on certain dirunal phases of rumination. J. Am. Vet. Med. Assoc. 67:364-366. 1925.

Bergman, H. D., and H. H. Dukes.
Regurgitation in rumination. J. Am. Vet. Med. Assoc. 69:600-612. 1926.

Blosser, T. H., F. R. Murdock, R. E. Lintott, R. E. Erb, and A. O. Shaw.
The use of dehydrated forages in dairy cattle rations. II. Comparative values of finely ground, chopped and pelleted dehydrated alfalfa as grain replacements for lactating cows. J. Dairy Sci. 35:515-523. 1952.

Camburn, O. M.
The feeding value of artificial dried young grass II. Vermont Agr. Expt. Sta. Bul. 359. 1933.

Cochrane, W. G., and Gertrude M. Cox.
Experimental designs. New York: John Wiley and Sons, Inc. p. 59. 1950.

Cole, H. H., and S. W. Mead.
A physical deficiency in the ration of ruminants. Science 98:543-544. 1943.

Davenport, E.
Results of an attempt to grow cattle without coarse feed. Ill. Agr. Expt. Sta. Bul. 46. 1897.

Dougherty, R. W., and Dana Crumb.
A new method for the graphic recording of rumen motility in the intact animal. Cornell Vet. 39:3-10. 1949.

Dukes, H. H.
The physiology of domestic animals. 8th ed. New York: Comstock Pub. Co. pp. 131, 211, 307-325, 372. 1955.

Eaton, H. D., C. A. Carpenter, R. J. Caverno, R. E. Johnson, F. I. Elliott, and L. A. Moore. A comparison of U.S. # 2 field cured field baled alfalfa hay with artificially dried and ground and pelleted alfalfa hays as a source of carotene and roughage for Holstein calves. J. Dairy Sci. 34:124-135. 1951.

Eaton, H. D., K. L. Dolge, R. D. Mochrie, J. E. Avampato, and L. A. Moore. Field cured and field baled alfalfa hay versus artificially dried and chopped and pelleted alfalfa hays as a source of carotene and roughage for Guernsey and Holstein calves. J. Dairy Sci. 35:98-105. 1952.

Forbes, E. B., J. A. Fries, and W. W. Braman.
Net energy values of alfalfa hay and alfalfa meal. J. Agr. Res. 31:987-995. 1925.

Fuller, J. M.
Some physical and physiological activities of dairy cows. New Hamp. Agr. Expt. Sta. Tech. Bul. 35. 1928.

Gardner, K. E., and W. F. Akers.
Calves prefer pelleted hay. Hoard's Dairyman 99:1063. 1954.

Goryainova, Z. S.
Apparatus for measuring the strength of rumen contractions. Veterinariya 26:24-26. 1949. Original not seen. Abstract in Am. Vet. Med. Ass'n. J. 115:63. 1949.

Gramlich, H. J.
Beef production. Neb. Agr. Expt. Sta. Bul. 174. 1919.

Haige, S. M., and W. Aitkenhead.
The effect of artificial drying upon the vitamin A content of alfalfa. J. Biol. Chem. 93:657-665. 1931.

Hancock, John.
Studies on monozygotic twins. IV. Uniformity trials: Grazing behavior. N. Z. J. Sci. Tech., A 32(4):22-59. 1950.

Hart, E. B., O. L. Kline, and G. C. Humphrey.
The effect of artificial drying on the availability of the nutrients of alfalfa hay. J. Agr. Res. 45:507-511. 1932.

Herman, H. A.
Growth and development of dairy calves on a milk diet. Mo. Agr. Expt. Sta. Res. Bul. 245. 1936.

Hope, E. B., R. E. Erb, T. H. Blosser, U. S. Ashworth, and A. O. Shaw.
The use of dehydrated forages in dairy cattle rations. I. Grain substitution with finely ground material. J. Dairy Sci. 33:306-314. 1950.

Huffman, C. F.
Hay is necessary in rations for dairy cattle. Mich. Agr. Expt. Sta. Q. Bul. 11-1. 1928.

Huffman, C. F.
Roughage quality and quantity in the dairy ration, a review. J. Dairy Sci. 22:905-915. 1939.

Ingham, L. W., and D. Meade.
Ground versus unground soybean hay for dairy cows. Md. Agr. Expt. Sta. Bul. 316. 1929.

Kane, E. A., M. G. Wiseman, and C. A. Cary.
The loss of carotene in hays and alfalfa meal during storage. J. Agr. Res. 55:837-847. 1937.

Kick, C. H., Paul Gerlaugh, A. F. Schalk, and E. A. Silver.
The effects of mechanical processing of feeds on the mastication and rumination of steers. J. Agr. Res. 55:587-597. 1937.

Knott, J. C., and R. E. Hodgson.
The feeding value of artificial dried pasture herbage for milk production. J. Dairy Sci. 17:409-416. 1934.

Magee, H. E.
Observations on digestion in the ruminant. J. Exp. Biology 9:409-426. 1932.

McAnnally, R. A., and A. T. Phillipson.
Digestion in the ruminant. Biol. Rev. 19:41-54. 1944.

McCandlish, Andrew C.
Studies in the growth and nutrition of dairy calves. V. Milk as the sole ration for calves. J. Dairy Sci. 6:54-66.

Mead, S. W., and Harold Goss.
Ruminant digestion without roughage. J. Dairy Sci. 18:163-170. 1935.

Mead, S. W., and Harold Goss.
Some results of eight years of investigation concerning the role of roughage in the diet of ruminants. J. Dairy Sci. 19:465-466. 1936.

Mead, S. W., and W. M. Regan.
Deficiencies in rations devoid of roughage for calves. I. The effect of the addition of cod liver oil and alfalfa ash. J. Dairy Sci. 14:283-293. 1931.

Moore, J. S., and W. C. Cowsert.
Soybeans for dairy cows. Miss. Agr. Expt. Sta. Bul. 235:10-11. 1926.

Morrison, F. B.
Feeds and Feeding, 21st ed. Ithaca, New York: Morrison Publishing Co. p. 1083-1164. 1948.

Newlander, J. A.
Feeding value of artificial dried young grass. Vermont Agr. Expt. Sta. Bul. 360. 1933.

Newlander, J. A., H. B. Ellenberger, O. M. Camburn, and C. H. Jones.
Digestibility of alfalfa, timothy, and soybeans as silages and as hays. Vermont Agr. Expt. Sta. Bul. 430. 1938.

Porter, G. H., R. E. Johnson, H. D. Eaton, F. I. Elliott, and L. A. Moore.
Relative value for milk production of field-cured and field-baled, artificially dried-chopped, artificially dried ground and artificially dried pelleted alfalfa when fed as the sole source of roughage to dairy cattle. J. Dairy Sci. 36:1140-1149. 1953.

Potter, E. L., and R. Withycombe.
Fattening steers. Oregon Agr. Expt. Sta. Bul. 174:1-23. 1920.

Powell, E. B.
One cause of fat variation in milk. Am. Soc. An. Prod. Proc. p. 40-47. 1938.

Powell, E. B.
Some relations of the roughage intake to the composition of milk. J. Dairy Sci. 22:453-454. 1939.

Reed, O. E., and J. E. Burnett.
Ground alfalfa for dairy cows. Mich. Agr. Expt. Sta. Q. Bul. 9:3-5. 1926.

Ritzman, E. G., and Francis G. Benedict.
Nutritional physiology of the adult ruminant. Carnegie Inst. Wash. Pub. 494:7-36. 1938.

Schalk, A. F., and R. S. Amadon.
Physiology of the ruminant stomach (Bovine). Study of the dynamic factors. N. Dak. Agr. Expt. Sta. Bul. 216. 1928.

Schrenk, W. G., H. L. Mitchell, Ralph E. Silker, C. O. Grandfield, W. H. Honstead, and R. G. Taecker. Dehydrated alfalfa. Kan. Agr. Expt. Sta. Bul. 356. 1953.

Snedecar, G. W.
Statistical methods. 4th ed. Ames, Iowa: The Collegiate Press. 1947. p. 406.

Snell, M. G.
Machine dried soybean hay for fattening cattle. La. Agr. Expt. Sta. Bul. 257. 1934.

Smith, F.
A manual of veterinary physiology. 5th ed., London, Bailliere, Tindall and Cox. p. 200. 1921.

Swanson, E. W., and H. A. Herman.
The digestibility of coarsely ground and finely ground alfalfa for dairy heifers. J. Animal Sci. 11:688-692. 1952.

Swanson, E. W., and A. C. Ragsdale.
The digestibility of coarsely ground and finely ground alfalfa for dairy heifers. J. Dairy Sci. 30:570-571. 1947.

Voelker, Howard H.
Dehydrated atlas sorgo as a feed for dairy cattle. Unpublished M. S. Thesis. Kansas State College Library, Manhattan. p. 39-41. 1949.

Warren, F. S., R. E. Johnson, C. M. Dembiczak, H. D. Eaton, Geoffrey Bean, and L. A. Moore. Lactation response to artificial dehydrated and pelleted alfalfa added to a ration of timothy-grass mixed hay and grain. J. Dairy Sci. 37:523-530. 1954.

Wise, G. H., W. E. Peterson, and T. W. Gullickson.
Inadequacy of a whole milk ration for dairy calves as manifested in changes of blood composition and in other physiological disorders. J. Dairy Sci. 22:559-572. 1939.

APPENDIX

Table 9. Summary of all observations made on ruminating activities of dairy cows as affected by types and forms of roughage fed, and breeds of cows.

Breed	No. of cows	Observations no.[1]	Observations min.	Ruminating periods: Total no.	Ruminating periods: Average time per period min.	Ruminating periods: Range in ruminating periods min.	Ruminating time: Total for all periods min.	Ruminating time: Standing %	Ruminating time: Lying %	Total time: Standing %	Total time: Lying %
Dehydrated alfalfa pellets											
Ayrshire	5	18	15120	66	14.7	0-34	971	6.4	51.1	48.9	71.8	28.2
Guernsey	4	12	11520	43	15.9	0-32	682	5.9	32.0	68.0	52.8	47.2
Holstein	6	23	20160	82	19.1	0-54	1564	7.8	55.7	44.3	65.1	34.9
Jersey	2	8	7920	19	13.6	0-27	258	3.3	50.8	49.2	68.5	31.5
75% dehydrated alfalfa pellets, 25% alfalfa hay											
Ayrshire	2	17	14400	99	17.4	1-55	1725	12.0	54.0	46.0	72.8	87.2
Guernsey	1	10	10080	71	18.8	2-42	1335	13.2	33.3	66.7	55.9	44.1
Holstein	2	17	15120	89	18.0	4-47	1602	10.6	78.9	21.1	64.4	35.6
Jersey	1	9	8640	40	17.0	1-40	678	7.9	74.3	25.7	75.9	24.1
Chopped alfalfa hay											
Ayrshire	4	17	15840	156	21.4	2-81	3345	21.1	49.0	51.0	65.2	34.8
Guernsey	3	12	12240	127	24.7	3-80	3134	25.6	42.4	57.6	57.6	42.4
Holstein	4	13	12960	128	28.8	4-83	3687	28.5	61.3	38.7	60.8	39.2
Jersey	1	3	2880	24	33.5	2-67	803	27.9	49.8	50.2	60.4	39.6
Sun-cured alfalfa pellets											
Ayrshire	2	7	5760	12	16.7	0-39	200	3.5	7.5	92.5	66.5	33.5
Guernsey	2	14	12960	38	13.9	0-31	527	4.1	13.7	86.3	54.7	45.3
Holstein	2	7	6480	20	22.6	7-57	451	7.0	58.8	41.2	62.7	37.3
Jersey	-											

Table 9 (concl.).

Breed	No. of cows	Observations no.	Observations min.	Ruminating periods: Total no.	Ruminating periods: Average time per period min.	Range in ruminating periods min.	Ruminating time: Total for all periods min.	Ruminating time: Total for all periods %	Ruminating time: Standing %	Ruminating time: Lying %	Total time: Standing %	Total time: Lying %
Sorgo silage, dehydrated alfalfa pellets												
Ayrshire	1	1	720	5	18.2	14-22	91	12.6	100.0	0	91.4	8.6
Guernsey	-											
Holstein	2	7	7200	52	28.0	2-56	1456	20.2	45.9	54.1	63.7	36.3
Jersey	1	4	3600	13	16.9	5-30	220	6.1	27.7	72.3	70.2	29.8
Sorgo silage and chopped alfalfa hay[2]												
Ayrshire	1	3	2880	29	30.2	4-61	876	30.4	43.3	56.7	61.8	38.2
Guernsey	-											
Holstein	5	9	6930	81	28.1	4-58	2272	32.8	53.5	46.5	59.3	40.7
Jersey	-											
Dehydrated alfalfa pellets (0.5 lb./100 lb. body wt.) sorgo silage and chopped alfalfa hay[2]												
Ayrshire	1	1	390	3	29.0	23-40	87	22.3	72.4	27.6	85.6	14.4
Guernsey	-											
Holstein	5	11	9420	94	30.9	2-65	2903	30.8	51.5	48.5	61.1	38.9
Jersey	-											
Sorgo silage and alfalfa hay												
Ayrshire	6	19	14640	119	28.3	6-98	3362	23.0	54.0	46.0	69.9	40.1
Guernsey	3	13	10680	96	31.0	2-89	2973	28.0	33.5	66.5	58.6	41.4
Holstein	10	49	35880	365	29.6	2-92	10814	30.1	49.0	51.0	64.9	35.1
Jersey	1	2	1440	13	38.5	16-89	500	34.7	60.0	40.0	58.1	41.9

[1] Total of all 12-hour and 24-hour observation periods.

[2] This group includes several 6.5-hour and 10-hour observations.

Table 10. Analysis of general effects of various roughages on which paired observations are available.

ANALYSIS I

Cow		24-hour observational periods			12-hour observational periods		
Breed	Number	H	P	SCP	H	P	SCP
A	255	(2) 28.2	(1) 6.6	(1) 8.8	(3) 22.0	(4) 5.5	(4) 1.2
H	145	(1) 28.3	(1) 6.1	(1) 10.4	(3) 25.5	(4) 7.9	(4) 3.8
	163	(2) 32.1	(1) 13.8	(1) 10.1	(3) 28.7	(3) 10.3	(1) 6.4
G	470	(2) 25.9	(1) 4.7	(2) 4.1	(2) 24.2	(2) 3.2	(5) 3.1
	474	(2) 29.6	(1) 4.6	(2) 5.9	(2) 27.7	(2) 5.3	(5) 3.5

Source of variation	Degrees of freedom	Sums of squares	Mean squares	F
Periods	1	55.8	55.8	7.3*
Treatments	2	2,933.2	1,466.6	193.0**
H vs. P ≠ SCP	(1)	(2,927.4)	(2,927.4)	(385.1)**
P vs. SCP	(1)	(5.8)	(5.8)	(.76) NS
Interaction PxT	2	16.5	8.2	1.1 NS
Error	24	181.5	7.6	
Total	29	3,187.0		

ANALYSIS II

Cow		24-hour observational period		12-hour observational period	
Breed	Number	H	P	H	P
A	249	(1) 27.6	(1) 9.2	(3) 11.4	(3) 3.8
	255	(2) 28.2	(1) 6.6	(3) 22.0	(4) 5.5
H	145	(1) 28.3	(1) 6.1	(3) 25.5	(4) 7.9
	137	(1) 27.4	(1) 10.2	(1) 31.9	(2) 7.4
	125	(1) 26.9	(1) 7.2	(1) 22.9	(2) 2.9
	163	(2) 32.1	(1) 13.8	(3) 28.7	(3) 10.3
G	483	(1) 22.9	(1) 1.2	(3) 21.2	(1) 2.1
	470	(2) 25.9	(1) 4.7	(2) 24.2	(2) 3.2
	474	(2) 29.6	(1) 4.6	(2) 27.7	(2) 5.3
J	363	(1) 27.3	(2) 2.0	(2) 28.5	(2) 0.0

Source of variation	Degrees of freedom	Source of squares	Mean squares	F
Periods	1	87.5	87.5	5.6*
Treatments	1	4,075.2	4,075.2	262.9**
Interaction PxT	1	29.1	29.1	1.9 NS
Error	36	556.5	15.5	
Total	39	4,748.3		

Table 11. Analysis of effect of various rations on rumination time within periods.

Type of roughage ration	Rumination time* during 12-hour observational periods: Average rumination time %	s	C.V. %	No. of cows	Rumination time* during 24-hour observational periods: Average rumination time %	s	C.V. %	No. of cows
A) Normal basic rations								
1) Sorgo silage and alfalfa hay	27.4	6.4	23	19	27.1	3.7	11	3
2) Chopped alfalfa hay	23.9	5.6	24	12	26.9	3.3	12	11
3) Sorgo silage and chopped alfalfa hay	33.6	4.7	14	6	25.8	7.0	27	4
B) Low level pellet feeding								
4) Pellets, sorgo silage, and chopped alfalfa hay	29.1	3.9	13	6	37.4	6.1	19	3
C) High level pellet feeding								
5) Pellets and sorgo silage	12.7	4.5	36	4	19.2	12.4	64	3
6) Pellets (75%), alfalfa hay (25%)	10.1	2.4	23	6	11.6	3.4	25	6
D) All pellet ration								
7) Dehydrated alfalfa pellets	5.7	4.1	72	17	6.9	4.3	62	14
8) Sun-cured alfalfa pellets	3.4	1.7	49	6	7.9	2.8	35	5

* Rumination time = $\frac{\text{Minutes of rumination x 100}}{\text{Minutes in observational period}}$

Table 12. Average distribution of ruminating time in minutes during an average 24-hour period.

Roughage groups	No. of observations	Hours of the day											
		6	7	8	9	10	11	12	1	2	3	4	5
H-P	14	5.0	0.7	0.7	5.5	2.1	5.9	11.0	13.4	14.9	1.9	4.8	3.0
P	15	0.0	1.1	0.6	2.5	3.2	2.4	7.1	6.7	4.2	5.5	3.6	0.4
H	16	11.6	1.6	0.8	16.3	17.8	21.7	22.1	21.3	22.9	15.9	18.3	8.1
SCP	7	0.0	1.4	0.0	2.3	2.9	14.4	5.0	1.9	1.7	9.1	2.7	4.3
P-S	3	0.0	9.0	0.7	0.0	13.3	0.7	9.0	18.3	0.3	34.0	13.0	12.7
H-S	5	9.2	4.4	11.0	15.6	20.8	19.2	36.6	19.4	21.2	26.0	17.8	3.8
							Night						
H-P		3.0	5.7	5.4	13.5	5.4	3.9	9.9	9.6	14.1	14.8	14.9	3.9
P		0.0	0.4	0.0	1.6	5.9	4.1	10.3	6.1	11.8	6.6	8.8	2.3
H		5.4	7.4	15.9	14.4	11.6	22.9	17.4	28.3	28.3	22.5	19.4	15.9
SCP		0.0	0.6	1.4	2.1	0.9	4.6	3.1	7.4	13.3	11.4	9.4	1.7
P-S		4.0	16.0	11.3	6.3	0.0	22.3	6.0	25.0	4.0	42.0	22.6	5.7
H-S		9.4	13.2	21.8	22.0	13.6	15.4	18.0	6.0	21.6	21.8	13.0	0.0

Table 13. The effect of forms and types of roughage on certain physiological activities of breeds of dairy cows.

Breed	Number of cows	Number of obs.	Average number/24 hours: Drinks	Uri-nations	Defe-cations	Number of cows	Number of obs.	Average number/minute: Pulse	Respira-tion	Average body temp. °F.
Dehydrated alfalfa pellets										
Ayrshire	3	3	7.0	7.0	7.3	4	14	69.4	27.6	101.5
Guernsey	4	4	6.5	8.8	9.8	2	6	81.3	33.5	101.9
Holstein	6	5	6.2	7.6	12.0	6	21	66.7	27.4	101.3
Jersey	2	3	3.7	8.0	13.0	2	8	66.5	31.4	101.5
75% dehydrated alfalfa pellets, 25% alfalfa hay										
Ayrshire	2	3	10.3	9.0	10.7	2	11	67.5	25.6	101.6
Guernsey	1	4	10.8	9.3	12.8	1	6	77.0	32.0	101.4
Holstein	2	4	5.8	5.3	14.8	2	12	61.0	25.8	101.5
Jersey	1	3	10.0	6.3	13.3	1	5	61.2	28.6	101.3
Sun-cured alfalfa pellets										
Ayrshire	1	1	5.0	6.0	12.0	2	7	72.0	24.9	101.4
Guernsey	2	4	7.5	6.0	14.3	2	14	78.1	32.9	102.3
Holstein	2	2	7.0	6.0	16.0	2	7	67.1	27.3	101.3
Jersey	-	-	-	-	-	-	-	-	-	-
Chopped alfalfa hay										
Ayrshire	3	5	6.4	7.4	9.6	3	10	67.8	33.5	101.4
Guernsey	3	5	10.8	7.8	11.6	3	7	66.6	32.1	102.0
Holstein	4	5	7.0	8.6	14.8	2	7	66.6	31.7	101.3
Jersey	1	1	6.0	10.0	14.0	-	-	-	-	-
Sorgo silage, dehydrated alfalfa pellets										
Ayrshire	-	-	-	-	-	1	1	68.0	26.0	101.6
Guernsey	-	-	-	-	-	-	-	-	-	-
Holstein	2	2	7.5	8.0	13.0	2	8	68.3	28.8	101.6
Jersey	1	1	4.0	8.0	21.0	1	4	76.0	30.5	101.4
Sorgo silage, alfalfa hay										
Ayrshire	2	2	7.5	3.0	9.0	2	11	68.5	29.8	101.7
Guernsey	1	2	4.0	7.0	11.5	1	8	84.8	32.1	101.9
Holstein	-	-	-	-	-	-	-	-	-	-
Jersey	-	-	-	-	-	-	-	-	-	-

Table 14. Percentage of moisture in feces of dairy cows.

Cow No.	Breed	Dates sampled 2/28/50	3/7/50	3/9/50	3/10/50	3/14/50	3/17/50	3/21/50	3/23/50	3/24/50	3/25/50
					Silage and dehydrated alfalfa pellets						
363 A	Jer.	82.79			82.92		83.00[1]				
249 A	Ayr.		81.20								
137 A	Hol.			80.28		80.35					
125 A	Hol.			78.30		79.78[2]					
					Sun-cured alfalfa pellets						
145 A	Hol.			79.64		79.10					
255 A	Ayr.			80.28		81.45				81.02	80.60
256 A	Ayr		80.19								
474 A	Guer.				76.21		78.87	79.91		80.69	79.62
470 A	Guer.	80.41			80.21		80.49	78.41	79.90	79.93	79.43
		Hay and pellets			Transition period[3]		Dehydrated alfalfa pellets				
111 A	Hol.			78.23		77.46					
153 A	Hol.		82.59								
267 A	Ayr.		79.93					78.63	76.95	77.75	75.90
395 A	Jer.	80.63			79.03		77.69	78.31	78.99	77.36	77.03
482 A	Guer.	82.14			81.72		81.92	81.28	81.83	81.32	82.41
					Hay and silage						
483 A	Guer.	83.12			83.47		82.71				

[1] Hay added to ration.

[2] Severe bloat, not fed.

[3] Samples taken during change from hay and pellets to 100% dehydrated alfalfa pellets.

Table 15. Average daily water consumption of cows fed dehydrated alfalfa pellets.

Cow number	Breed	Body weight	Average gallons/day for weeks ending 4/7/50	4/14/50	4/21/50	4/28/50	5/5/50	5/12/50*	Av.gal./day for 5-wk. period	Av.gal./day for 100# body weight
267 A	Ayrshire	998	13.8	13.8	14.7	14.5	10.8	13.9	13.5	1.35
248 A	Ayrshire	1019	9.9	10.1	10.8	8.8	11.3	12.4	10.2	1.00
255 A	Ayrshire	1206	9.8	10.5	12.3	13.8	11.3	14.6	11.5	0.95
482 A	Guernsey	905	12.0	10.5	11.6	11.6	13.0	11.4	11.7	1.29
474 A	Guernsey	879	8.6	8.6	10.6	9.8	8.4	--	9.2	1.04
153 A	Holstein	1273	13.8	15.4	18.2	14.7	17.7	14.6	16.0	1.26
163 A	Holstein	1339	16.9	16.5	19.0	17.6	17.3	17.9	17.5	1.31
145 A	Holstein	1257	16.8	16.7	15.1	15.6	19.0	18.2	16.3	1.32
111 A	Holstein	1601	11.9	11.2	11.3	13.6	11.6	13.9	11.9	0.74
396 A	Jersey	962	7.7	7.4	7.4	9.4	8.9	10.3	8.2	0.85
483 A**	Guernsey	856	11.9	13.4	9.7	10.1	9.0	8.1	10.4	1.21

* All cows changed to alfalfa hay and silage at beginning of week; this week not included in average.

** Fed sorgo silage and alfalfa hay ad. lib. entire time.

Table 16. The effects of types and forms of roughage on ruminating activity of dairy cows.

Cow	Breed	Observations: No. of periods	Observations: Total time min.	Ruminating time: No. of periods	Ruminating time: Total for all periods min.	Ruminating time: Av. time per rumination period min.	Ruminating time: % of observation period	Ruminating time: Standing %	Ruminating time: Lying %	Total time: Standing %	Total time: Lying %
12-hour constant observation - dehydrated alfalfa pellets											
248 A	Ayrshire	3	2160	9	129	14.3	6.0	51.2	48.8	67.5	32.5
256 A	Ayrshire	2	1440	1	5	5.0	0.4	100.0	0.0	91.0	9.0
267 A	Ayrshire	3	2160	17	258	15.2	11.9	72.1	27.9	78.2	21.8
249 A	Ayrshire	3	2160	6	82	13.7	3.8	89.0	11.0	83.6	16.4
255 A	Ayrshire	4	2880	10	159	15.9	5.5	40.9	59.1	70.7	29.3
483 A	Guernsey	1	720	1	15	15.0	2.1	100.0	0.0	71.3	28.7
482 A	Guernsey	3	2160	11	170	15.5	7.9	43.5	56.5	52.5	47.5
474 A	Guernsey	2	1440	5	76	15.2	5.3	50.0	50.0	53.5	46.5
470 A	Guernsey	2	1440	4	46	11.5	3.2	0.0	100.0	48.5	51.5
153 A	Holstein	3	2160	13	335	25.8	15.5	63.3	36.7	69.5	30.5
163 A	Holstein	3	2160	9	223	24.8	10.3	33.2	66.8	56.8	43.2
111 A	Holstein	4	2880	5	70	14.0	2.4	80.0	20.0	74.9	25.1
125 A	Holstein	2	1440	3	42	14.0	3.0	100.0	0.0	80.9	19.1
137 A	Holstein	2	1440	6	107	17.8	7.4	62.6	37.4	72.2	27.8
115 A	Holstein	4	2880	14	228	16.3	7.9	69.7	30.3	58.0	42.0
395 A	Jersey	3	2160	8	103	12.9	4.8	89.3	10.7	82.0	18.0
363 A	Jersey	2	1440	0	0	—	—	—	—	71.9	28.1
24-hour constant observation - dehydrated alfalfa pellets											
245 A	Ayrshire	1	1440	6	111	18.5	7.7	27.0	73.0	56.8	43.2
249 A	Ayrshire	1	1440	10	132	13.2	9.2	47.0	53.0	61.7	38.3
255 A	Ayrshire	1	1440	7	95	13.6	6.6	9.0	81.0	58.0	42.0
483 A	Guernsey	1	1440	3	17	5.7	1.2	0.0	100.0	54.7	45.3
482 A	Guernsey	1	1440	10	224	22.4	15.6	11.6	88.4	45.6	54.4
474 A	Guernsey	1	1440	4	66	16.5	5.6	72.7	27.3	53.7	46.3
470 A	Guernsey	1	1440	5	68	13.6	4.7	25.0	75.0	52.3	47.7
163 A	Holstein	1	1440	7	199	28.4	13.8	30.7	69.3	57.0	43.0
111 A	Holstein	1	1440	2	21	10.5	1.5	71.0	29.0	55.5	44.5

Table 16 (cont.).

Cow	Breed	Observations: No. of periods	Observations: Total time min.	Ruminating time: No. of periods	Ruminating time: Total periods for all	Ruminating time: Av. time per ruminating period min.	Ruminating time: % of observation period	Total time: Standing %	Total time: Lying %	Total time: Standing %	Total time: Lying %
125 A	Holstein	1	1440	9	104	11.6	7.2	60.6	39.4	55.8	44.2
137 A	Holstein	1	1440	8	147	18.4	10.2	41.5	58.5	61.0	39.0
145 A	Holstein	1	1440	6	88	14.7	6.1	94.3	5.7	74.0	26.0
395 A	Jersey	1	1440	6	98	16.3	6.8	22.4	77.6	58.9	41.1
363 A	Jersey	2	2880	5	57	11.4	2.0	29.8	70.2	61.5	38.5
12-hour observation - sun-cured alfalfa pellets											
256 A	Ayrshire	2	1440	4	37	9.3	2.6	0.0	100.0	62.8	37.2
255 A	Ayrshire	4	2880	2	36	18.0	1.3	0.0	100.0	73.6	26.4
474 A	Guernsey	5	3600	10	127	12.7	3.5	37.0	63.0	56.6	43.4
470 A	Guernsey	5	3600	9	111	12.3	3.1	14.4	85.6	57.8	42.2
163 A	Holstein	1	720	1	46	46.0	6.4	26.1	73.9	65.1	34.9
145 A	Holstein	4	2880	6	109	18.2	3.8	42.2	51.8	66.2	33.8
24-hour observation - sun-cured alfalfa pellets											
255 A	Ayrshire	1	1440	6	127	21.2	8.8	11.8	88.2	56.1	43.9
474 A	Guernsey	2	2880	11	171	15.6	5.9	1.8	98.2	51.2	48.8
470 A	Guernsey	2	2880	8	118	14.8	4.1	5.1	94.9	51.7	48.3
163 A	Holstein	1	1440	5	146	29.2	10.1	57.5	42.5	54.0	46.0
145 A	Holstein	1	1440	8	150	18.8	10.4	82.0	18.0	63.2	36.8
12-hour observation - 75% dehydrated alfalfa pellets, 25% alfalfa hay											
248 A	Ayrshire	7	5040	29	543	18.7	10.8	56.7	43.3	75.0	25.0
267 A	Ayrshire	7	5040	34	537	15.8	10.7	60.7	39.3	77.5	22.5
482 A	Guernsey	6	4320	30	604	20.1	14.0	38.9	61.1	59.0	41.0
153 A	Holstein	7	5040	34	501	14.7	10.0	72.0	28.0	72.6	27.4
111 A	Holstein	6	4320	19	339	17.8	7.9	83.5	16.5	67.5	32.5
395 A	Jersey	6	4320	20	328	16.4	7.6	92.1	7.9	85.8	14.2

Table 16 (cont.).

Cow	Breed	Observations: No. of periods	Observations: Total time min.	Ruminating time: No. of periods	Ruminating time: Total for all periods min.	Ruminating time: Av. time per rumination period min.	Ruminating time: % of observation period	Standing %	Lying %	Total time: Standing %	Total time: Lying %
24-hour observation - 75% dehydrated alfalfa pellets, 25% alfalfa hay											
248 A	Ayrshire	1	1440	13	252	19.4	17.5	55.6	44.4	70.2	29.8
267 A	Ayrshire	2	2880	23	393	17.1	13.7	39.9	60.1	62.2	37.8
482 A	Guernsey	4	5760	41	731	17.8	12.7	28.7	71.3	53.6	46.4
153 A	Holstein	1	1440	12	241	20.1	16.7	57.7	42.3	54.0	46.0
111 A	Holstein	3	4320	24	521	21.7	12.1	92.3	7.7	55.4	44.6
395 A	Jersey	3	4320	20	350	17.5	8.1	57.7	42.3	66.0	34.0
12-hour observation - chopped alfalfa hay											
245 A	Ayrshire	2	1440	15	369	24.6	25.6	63.4	36.6	72.0	28.0
256 A	Ayrshire	4	2880	29	484	16.7	16.8	48.8	51.2	70.0	30.0
249 A	Ayrshire	3	2160	15	247	16.5	11.4	62.3	37.7	74.6	25.4
255 A	Ayrshire	3	2160	22	475	21.6	22.0	48.8	51.2	65.9	34.1
483 A	Guernsey	3	2160	20	458	22.9	21.2	49.8	50.2	56.4	43.6
474 A	Guernsey	2	1440	12	399	33.3	27.7	42.4	57.6	57.2	42.8
470 A	Guernsey	2	1440	17	349	20.5	24.2	47.6	52.4	62.0	38.0
163 A	Holstein	3	2160	20	619	31.0	28.7	68.3	31.7	67.0	33.0
125 A	Holstein	1	720	6	174	29.0	22.9	100.0	0.0	79.0	21.0
137 A	Holstein	1	720	7	230	32.9	31.9	67.4	32.6	62.0	38.0
145 A	Holstein	3	2160	24	550	22.9	25.5	67.6	32.4	66.6	33.4
363 A	Jersey	2	1440	13	410	31.5	28.5	50.5	49.5	60.5	39.5
24-hour observation - chopped alfalfa hay											
256 A	Ayrshire	2	2880	31	562	18.1	19.5	42.0	58.0	57.4	42.6
249 A	Ayrshire	1	1440	14	397	28.4	27.6	53.7	46.3	65.1	34.9
255 A	Ayrshire	2	2880	30	811	27.0	28.2	41.3	58.7	57.0	43.0
483 A	Guernsey	1	1440	13	330	25.4	22.9	19.1	80.9	54.0	46.0
474 A	Guernsey	2	2880	32	851	26.6	29.6	42.4	57.6	57.9	42.1
163 A	Holstein	2	2880	30	924	30.8	32.1	42.9	57.1	47.4	52.6

Table 16 (cont.).

Cow	Breed	Observations: No. of periods	Observations: Total time min.	Ruminating time: No. of periods	Ruminating time: Total for all periods min.	Ruminating time: Av. time per rumination period min.	Ruminating time: % of observation period	Standing %	Lying %	Total time: Standing %	Total time: Lying %
125 A	Holstein	1	1440	14	388	27.7	26.9	64.4	35.6	63.7	36.3
137 A	Holstein	1	1440	11	394	35.8	27.4	50.3	49.7	56.0	44.0
145 A	Holstein	1	1440	16	408	25.5	28.3	71.0	29.0	62.2	37.8
363 A	Jersey	1	1440	11	393	35.7	27.3	49.0	51.0	60.0	40.0
			12-hour observation - sorgo silage and alfalfa hay								
245 A	Ayrshire	6	4320	40	1075	26.9	24.9	60.8	39.2	74.1	25.9
256 A	Ayrshire	3	2160	14	340	24.3	14.9	47.0	53.0	59.7	40.3
262 A	Ayrshire	2	1320	14	312	22.3	23.6	61.2	38.8	81.0	19.0
251 A	Ayrshire	2	1320	10	350	35.0	26.5	63.0	37.1	78.1	21.9
274 A	Ayrshire	2	1320	9	336	37.3	25.5	57.4	42.6	77.3	22.7
268 A	Ayrshire	2	1320	9	273	30.3	20.7	57.9	42.1	82.3	17.7
483 A	Guernsey	6	4320	46	1127	24.5	26.1	19.7	80.3	52.4	47.6
495 A	Guernsey	3	2160	14	714	51.0	33.1	56.9	43.1	75.1	24.9
497 A	Guernsey	2	1320	12	289	24.1	21.9	60.9	39.1	81.5	18.5
125 A	Holstein	4	2880	29	911	31.4	31.6	45.0	55.0	62.4	37.6
137 A	Holstein	4	2880	29	898	31.0	31.2	47.4	52.6	66.7	33.3
164 A	Holstein	7	5040	56	1617	28.9	32.1	56.4	43.6	65.8	34.2
160 A	Holstein	7	5040	49	1513	31.5	30.6	28.8	71.2	56.5	43.5
140 A	Holstein	4	2880	23	563	24.5	19.6	59.3	40.7	74.8	25.2
165 A	Holstein	7	5040	54	1414	26.2	28.1	64.5	35.5	69.9	30.1
150 A	Holstein	2	1320	13	433	33.3	32.8	69.7	30.3	80.3	19.7
155 A	Holstein	6	4320	43	955	22.2	22.1	57.6	42.4	66.4	33.6
170 A	Holstein	7	5040	55	2095	38.1	41.6	38.0	62.0	60.2	39.8
363 A	Jersey	2	1440	13	500	38.5	34.7	60.0	40.0	58.1	41.9

Table 15 (cont.).

Cow	Breed	Observations: No. of periods	Observations: Total time min.	Ruminating time: No. of periods	Ruminating time: Total for all periods min.	Ruminating time: Av. time per ruminating period min.	Ruminating time: % of observation period	Total time: Standing %	Total time: Lying %	Standing %	Lying %
				24-hour observation - sorgo silage and alfalfa hay							
245 A	Ayrshire	1	1440	13	450	34.6	31.3	39.6	60.4	61.9	38.1
256 A	Ayrshire	1	1440	10	226	22.6	15.7	26.5	73.5	39.3	60.7
483 A	Guernsey	2	2880	24	843	35.1	29.3	22.8	77.2	45.1	54.9
152 A	Holstein	1	1440	14	385	27.5	26.7	55.1	44.9	53.1	46.9
				12-hour observation - sorgo silage and dehydrated alfalfa pellets							
249 A	Ayrshire	1	720	5	91	18.2	12.6	100.0	0.0	91.4	8.6
125 A	Holstein	3	2160	14	405	28.9	17.8	54.3	45.7	65.6	34.4
137 A	Holstein	3	2160	12	294	24.5	13.6	40.5	59.5	69.8	30.2
363 A	Jersey	3	2160	8	148	18.5	6.9	22.3	77.7	76.7	23.3
				24-hour observation - sorgo silage and dehydrated alfalfa pellets							
125 A	Holstein	1	1440	12	396	33.0	27.5	61.1	38.9	61.2	38.8
137 A	Holstein	1	1440	14	361	25.3	25.1	24.1	75.9	48.5	51.5
363 A	Jersey	1	1440	5	72	14.4	5.0	38.9	61.1	60.5	39.5

Table 16 (concl.).

Cow	Breed	Observations: No. of periods	Observations: Total time min.	Ruminating time: No. of periods	Ruminating time: Total for all periods min.	Ruminating time: Av. time per rumi-nating period min.	Ruminating time: % of obser-vation period	Total time: Standing %	Total time: Lying %	Standing	Lying
12-hour observation - dehydrated alfalfa pellets[1], sorgo silage, and chopped alfalfa hay											
164 A	Holstein	1	390[2]	5	119	23.8	30.5	62.2	37.8	54.9	45.1
160 A	Holstein	2	1440	16	459	28.7	31.9	89.1	10.9	81.0	19.0
128 A	Holstein	2	1440	14	399	28.5	27.7	39.8	60.2	61.0	39.0
144 A	Holstein	2	1440	14	417	29.8	29.0	60.7	39.3	71.5	28.5
253 A	Ayrshire	1	390[2]	3	87	29.0	22.3	72.4	27.6	85.6	14.4
115 A	Holstein	1	390[2]	4	129	32.3	33.1	100.0	0.0	90.5	9.5
24-hour observation - dehydrated alfalfa pellets[1], sorgo silage, and chopped alfalfa hay											
160 A	Holstein	1	1440	12	359	30.0	25.0	52.9	47.1	57.9	42.1
128 A	Holstein	1	1440	13	502	38.6	34.9	25.7	74.3	41.7	58.3
144 A	Holstein	1	1440	16	519	32.4	36.0	29.1	70.9	47.2	52.8
12-hour observation - sorgo silage and chopped alfalfa hay											
253 A	Ayrshire	2	1440	15	393	26.2	27.3	61.6	38.4	77.5	22.5
164 A	Holstein	2	1440	19	469	24.7	32.6	48.6	51.4	59.7	40.3
160 A	Holstein	1	390[2]	4	156	39.0	40.0	16.7	83.3	57.7	42.3
128 A	Holstein	1	390[2]	4	137	34.3	35.1	24.1	75.9	49.0	51.0
144 A	Holstein	1	390[2]	4	143	35.8	36.7	69.2	30.8	53.3	46.7
152 A	Holstein	2	1440	14	427	30.5	29.7	82.0	18.0	70.3	29.7
24-hour observation - sorgo silage and chopped alfalfa hay											
253 A	Ayrshire	1	1440	14	483	34.5	33.5	28.4	71.6	46.0	54.0
164 A	Holstein	1	1440	19	417	22.0	29.0	59.5	40.5	61.0	39.0
152 A	Holstein	1	1440	17	523	30.8	36.3	44.2	55.8	50.7	49.3

[1] Dehydrated alfalfa pellets fed at the rate of 0.5 lb. per 100 lb. body weight.

[2] Observation for 6.5 hours.

Table 17. Observations on some physiological functions of individual dairy cows as affected by types and forms of roughages fed.

Date	Observation period	Roughage ration*	Total rumi-nating periods no.	Range in rumi-nating periods min.	Ruminating time: Total	Ruminating time: Standing min.	Ruminating time: Lying min.	Total time: Standing min.	Total time: Lying min.	Times drank	Times urinated no.	Times defecated no.
Quaintness - 145 A - Holstein												
12- 3-49	11:30AM - 11:30PM	P	0	-	0	0	0	436	284	5	9	9
12-16-49	3:10PM - 3:10PM	P	6	4-29	88	83	5	1062	378	9	9	16
1-10-50	5:30PM - 5:30AM	H	8	5-48	209	188	21	484	236	2	4	5
2- 7-50	6:10AM - 6:10PM	H	8	9-35	182	101	81	481	239	7	4	8
2-11-50	6:15AM - 6:15AM	H	16	8-37	408	291	117	895	545	9	10	14
2-17-50	6:00AM - 6:00PM	H	8	5-29	159	83	76	474	246	4	4	6
2-21-50	6:00PM - 6:00PM	H-SCP	18	5-40	463	210	253	793	647	8	8	15
2-23-50	6:00AM - 6:00PM	H-SCP	9	15-41	207	135	72	516	204	5	6	8
2-25-50	6:00AM - 6:00AM	H-SCP	17	6-30	352	188	164	751	689	6	9	18
3- 3-50	6:00AM - 6:00PM	SCP	1	-	7	0	7	450	270	6	3	10
3- 9-50	6:00AM - 6:00PM	SCP	1	-	19	19	0	507	213	5	4	10
3-14-50	6:00AM - 6:00PM	SCP	1	-	15	0	15	483	237	3	6	5
3-18-50	6:00AM - 6:00AM	SCP	8	9-33	150	123	27	910	530	8	9	16
3-24-50	6:00AM - 6:00PM	SCP	3	10-33	68	27	41	468	252	5	1	10
3-30-50	6:00AM - 6:00PM	P	4	9-25	69	34	35	363	357	2	4	9
4- 4-50	6:00AM - 6:00PM	P	5	6-20	73	67	6	514	206	4	4	8
4- 6-50	6:10AM - 6:10PM	P	5	8-25	86	58	28	356	364	3	5	7
Gala - 249 A - Ayrshire												
12- 6-49	11:00AM - 11:00PM	H	4	8-18	58	58	0	558	162	6	5	3
12-13-49	11:00AM - 11:00PM	H	8	5-22	128	35	93	429	291	4	4	5
1-28-50	5:00AM - 5:00AM	P	10	6-31	132	62	70	889	551	10	5	6
2- 9-50	6:35AM - 6:35PM	P	1	-	12	12	0	539	181	2	4	4
2-16-50	6:05AM - 6:05PM	P	3	9-14	36	36	0	672	48	1	5	3
2-21-50	6:00AM - 6:00PM	P	2	9-25	34	25	9	595	125	1	6	6
2-21-50	6:00PM - 6:00PM	P-Sl	5	4-18	53	9	44	1029	411	14	9	10
3- 2-50	6:00AM - 6:00PM	P-S	5	14-22	91	91	0	658	62	1	5	7
3- 7-50	6:00AM - 6:00PM	H	3	9-42	61	61	0	625	95	4	5	5
3-11-50	6:00AM - 6:00AM	H	14	7-81	397	213	184	937	503	6	6	7

Table 17(cont.).

Date	Observation period	Roughage* ration	Total rumi-nating periods no.	Range in rumi-nating periods min.	Ruminating time: Total	Ruminating time: Standing	Ruminating time: Lying	Total time: Standing	Total time: Lying	Times drank	Times uri-nated	Times defe-cated
					min.			min.			no.	
			Muffin - 255 A - Ayrshire									
12- 3-49	11:30AM - 11:30PM	P	3	5-12	29	12	17	445	275	3	3	7
12-16-49	3:10PM - 3:10PM	P	7	6-24	95	9	86	835	605	6	9	9
1-10-50	5:30PM - 5:30AM	H	3	10-38	83	0	83	334	386	3	4	3
2- 7-50	6:10AM - 6:10PM	H	10	4-39	188	139	49	577	143	4	3	6
2-11-50	6:15AM - 6:15AM	H	16	9-42	410	196	214	873	567	3	10	13
2-17-50	6:00AM - 6:00PM	H	9	2-50	204	93	111	512	208	4	3	7
2-21-50	6:00PM - 6:00PM	H	14	9-48	401	139	262	768	672	8	9	12
2-23-50	6:00AM - 6:00PM	H-SCP	8	3-42	151	76	75	488	232	5	4	8
2-25-50	6:00AM - 6:00AM	H-SCP	12	12-35	255	25	230	645	785	5	8	17
2- 3-50	6:00AM - 6:00PM	SCP	0	-	0	0	0	502	218	4	4	6
3- 9-50	6:00AM - 6:00PM	SCP	1	-	25	0	25	590	130	2	5	5
3-14-50	6:00AM - 6:00PM	SCP	0	-	0	0	0	500	220	2	3	7
3-18-50	6:00AM - 6:00AM	SCP	6	12-39	127	15	112	808	632	5	6	12
3-24-50	6:00AM - 6:00PM	SCP	1	-	11	0	11	528	192	2	4	7
3-30-50	6:00AM - 6:00PM	P	5	7-34	91	53	38	527	193	1	6	9
4- 4-50	6:00AM - 6:00PM	P	1	-	20	0	20	605	115	7	2	4
4- 6-50	6:10AM - 6:10PM	P	1	-	19	0	19	459	261	3	2	5
			Cream Puff - 245 A - Ayrshire									
12- 6-49	11:00AM - 11:00PM	H	8	7-30	192	139	53	577	143	5	6	7
12-13-49	11:00AM - 11:00PM	H	7	14-39	177	95	82	460	260	5	6	9
1-28-50	5:00AM - 5:00AM	P	6	7-30	111	30	81	818	622	5	7	7
2-21-50	6:00AM - 6:00PM	H-S	7	12-25	129	92	37	535	185	4	7	7
3- 2-50	6:00AM - 6:00PM	H-S	5	28-39	167	108	59	540	180	5	5	11
3- 7-50	6:00AM - 6:00PM	H-S	6	27-39	184	101	83	530	190	4	4	12
3-11-50	6:00AM - 6:00AM	H-S	13	8-55	450	178	272	891	549	5	5	16
3-16-50	6:00AM - 6:00PM	H-S	7	19-49	223	129	94	545	175	2	4	12
3-21-50	6:15AM - 6:15PM	H-S	8	9-43	216	138	78	478	242	1	3	7
3-31-50	6:00AM - 6:00PM	H-S	7	13-27	156	86	70	574	146	2	5	8

Table 17 (cont.).

Date	Observation period	Roughage ration*	Total rumi-nating periods no.	Range in rumi-nating periods min.	Ruminating time Total	Ruminating time Stand-ing	Ruminating time Lying	Total time Stand-ing	Total time Lying	Times drank	Times uri-nated	Times defe-cated
					Lullabye - 395 A - Jersey							
12- 7-49	12:00M - 12:00PM	H-P	5	9-27	83	66	17	456	264	5	4	7
12- 9-49	3:16PM - 3:16PM	H-P	9	6-40	192	97	95	954	486	18	9	11
12-14-49	12:00M - 12:00PM	H-P	3	9-18	43	34	9	525	195	6	4	9
1-27-50	6:10AM - 6:10AM	H-P	7	7-28	101	79	22	1069	371	5	7	16
2-10-50	6:45AM - 6:45PM	H-P	2	13-14	27	27	0	671	49	6	4	8
2-11-50	6:00AM - 6:00PM	H-P	3	6-29	98	58	0	673	47	3	4	6
2-24-50	6:00AM - 6:00PM	H-P	4	6-27	54	54	0	663	57	5	3	8
2-28-50	6:00AM - 6:00PM	H-P	3	13-34	63	63	0	717	3	6	5	2
3- 4-50	6:00AM - 6:00AM	H-P	4	1-31	57	26	31	828	612	7	3	13
3-10-50	6:00AM - 6:00PM	P[3]	2	8-23	31	31	0	650	70	6	2	8
3-17-50	6:00AM - 6:00PM	P	4	5-16	38	38	0	661	59	2	2	6
3-23-50	6:10AM - 6:10PM	P	2	11-27	38	27	11	534	186	3	3	6
3-25-50	6:00AM - 6:00AM	P	6	6-22	98	22	76	848	592	2	6	10
3-28-50	6:00AM - 6:00PM	P	2	12-15	27	27	0	577	143	2	1	2
					Irma - 483 A - Guernsey							
12- 7-49	13:00M - 12:00PM	H	8	6-36	192	84	108	389	331	2	5	3
12- 9-49	3:16PM - 3:16PM	H	13	12-43	330	63	267	778	662	10	9	9
12-14-49	12:00M - 12:00PM	H	7	11-24	114	28	86	336	384	3	4	5
1-27-50	6:10AM - 6:10AM	P	3	3-10	17	0	17	788	652	8	9	9
2-10-50	6:45AM - 6:45PM	P	1	-	15	15	0	513	207	3	3	4
2-14-50	6:00AM - 6:00PM	H	5	7-68	152	116	36	494	226	4	3	3
2-24-50	6:00AM - 6:00PM	H-S[2]	7	6-50	149	26	123	388	332	6	4	6
2-28-50	6:00AM - 6:00PM	H-S	9	11-32	190	29	161	381	339	4	4	10
3- 4-50	6:00AM - 6:00AM	H-S	12	16-61	441	74	367	611	829	4	7	13
3-10-50	6:00AM - 6:00PM	H-S	7	17-35	186	71	115	520	200	3	2	7
3-17-50	6:00AM - 6:00PM	H-S	8	21-33	222	51	171	347	373	2	4	6
3-23-50	6:10AM - 6:10PM	H-S	7	11-33	168	0	168	324	396	3	3	5
3-25-50	6:00AM - 6:00AM	H-S	12	7-80	402	118	284	688	752	4	7	10
3-28-50	6:00AM - 6:00PM	H-S	8	20-38	212	45	167	302	418	3	3	6

Table 17 (cont.).

Date	Observation period	Roughage ration*	Total ruminating periods no.	Range in ruminating periods min.	Ruminating time: Total	Ruminating time: Standing	Ruminating time: Lying	Total time: Standing	Total time: Lying	Times drank	Times urinated	Times defecated
					Impudence - 137 A - Holstein							
12- 3-49	11:30AM - 11:30PM	H	7	24-46	230	155	75	445	275	8	5	7
12-16-49	3:10PM - 3:10PM	H	11	16-80	394	198	196	809	631	10	11	15
2- 6-50	6:10AM - 6:10PM	P	4	9-20	55	42	13	519	201	6	3	9
2-11-50	6:15AM - 6:15AM	P	8	8-38	147	61	86	879	561	9	10	13
2-17-50	6:00AM - 6:00PM	P	2	25-27	52	25	27	521	199	6	5	6
2-21-50	6:00PM - 6:00PM	P-S[1]	9	13-35	201	101	100	838	602	11	7	13
2-23-50	6:00AM - 6:00PM	P-S	5	13-38	111	61	50	555	165	7	5	8
2-25-50	6:00AM - 6:00AM	P-S	14	12-56	361	87	274	699	741	7	8	14
3- 3-50	6:00AM - 6:00PM	P-S	4	6-30	87	25	62	450	270	6	4	7
3- 9-50	6:00AM - 6:00PM	P-S	3	23-40	96	33	63	503	217	4	5	9
3-14-50	6:00AM - 6:00PM	P-S-H[4]	6	16-36	140	122	18	601	119	2	3	10
3-18-50	6:00AM - 6:00AM	P-S-H[5]	11	11-86	446	193	253	847	593	7	6	16
3-24-50	6:00AM - 6:00PM	H-S	7	18-42	222	95	127	432	288	2	3	9
3-30-50	6:00AM - 6:00PM	H-S	7	20-55	248	108	140	410	310	3	4	9
4- 4-50	6:00AM - 6:00PM	H-S	9	12-40	252	144	108	517	203	4	6	7
4- 6-50	6:10AM - 6:10PM	H-S	6	19-36	176	79	97	561	159	1	1	6
					Frolic - 248 A - Ayrshire							
12- 6-49	11:00AM - 11:00PM	H-P	4	6-20	55	36	19	502	218	4	7	6
12-13-49	11:00AM - 11:00PM	H-P	5	9-37	107	47	60	466	254	8	3	6
1-28-50	5:00AM - 5:00AM	H-P	13	6-38	252	140	112	1011	429	10	9	11
2- 9-50	6:35AM - 6:35PM	H-P	4	7-24	60	60	0	575	145	6	4	5
2-16-50	6:05AM - 6:05PM	H-P	4	7-17	40	23	17	561	159	6	5	6
2-21-50	6:00AM - 6:00PM	H-P	5	9-55	133	60	73	552	168	5	5	8
3- 2-50	6:00AM - 6:00PM	H-P	4	10-34	81	50	31	590	130	3	5	7
3- 7-50	6:00AM - 6:00PM	H-P	3	13-35	67	32	35	533	187	3	5	8
3-11-50	6:00AM - 6:00AM	P[3]	10	8-38	184	41	143	777	663	14	5	9
3-16-50	6:00AM - 6:00PM	P	3	7-16	34	17	17	477	243	4	2	5
3-21-50	6:15AM - 6:15PM	P	3	16-20	54	12	42	455	265	1	5	5
3-31-50	6:00AM - 6:00PM	P	3	5-21	41	37	4	527	193	2	4	6

Table 17 (cont.).

Date	Observation period	Roughage ration*	Total ruminating periods	Range in ruminating periods	Ruminating time: Total	Ruminating time: Standing	Ruminating time: Lying	Total time: Standing	Total time: Lying	Times drank	Times urinated	Times defecated
			no.	min.	min.			min.			no.	
				Replica - 125 A - Holstein								
12- 3-49	11:30AM - 11:30PM	H	6	7-50	174	174	0	567	153	6	8	7
12-16-49	3:10PM - 3:10PM	H	14	5-45	388	250	138	917	523	8	10	14
2- 7-50	6:10AM - 6:10PM	P	2	7-19	26	26	0	607	113	4	5	4
2-11-50	6:15AM - 6:15AM	P	9	5-21	104	41	63	804	636	6	9	6
2-17-50	6:00AM - 6:00PM	P	1	-	16	16	0	558	162	5	5	4
2-21-50	6:00PM - 6:00PM	P-S[1]	5	12-32	111	29	82	740	700	4	6	6
2-23-50	6:00AM - 6:00PM	P-S	4	12-46	109	36	73	505	215	1	3	2
2-25-50	6:00AM - 6:00AM	P-S	12	2-52	396	242	154	882	558	8	8	12
3- 3-50	6:00AM - 6:00PM	P-S	7	6-55	195	145	50	517	203	3	3	8
3- 9-50	6:00AM - 6:00PM	P-S	3	25-39	101	39	62	475	245	4	6	6
3-14-50	6:00AM - 6:00PM	Bloat[6]	1	-	48	0	48	597	123	0	2	3
3-18-50	6:00AM - 6:00AM	Bloat	9	13-45	247	36	211	743	697	3	5	13
3-24-50	6:00AM - 6:00PM	H-S	7	9-64	242	103	139	404	316	2	5	4
3-30-50	6:00AM - 6:00PM	H-S	7	13-52	193	54	139	415	305	2	6	6
4- 4-50	6:00AM - 6:00PM	H-S	8	18-56	255	126	129	449	271	2	6	7
4- 6-50	6:10AM - 6:10PM	H-S	7	15-59	221	127	94	530	190	1	5	9
				Gesture - 153 A - Holstein								
12- 6-49	11:00AM - 11:00PM	H-P	3	10-16	41	41	0	542	178	4	6	7
12-13-49	11:00AM - 11:00PM	H-P	4	7-14	41	41	0	616	104	7	4	7
1-28-50	5:00AM - 5:00AM	H-P	12	10-29	241	139	102	775	665	11	6	15
2- 9-50	6:35AM - 6:35PM	H-P	7	9-22	97	65	32	535	185	4	4	6
2-16-50	6:05AM - 6:05PM	H-P	7	7-20	101	69	32	525	195	1	4	9
2-21-50	6:00AM - 6:00PM	H-P	5	4-28	89	80	9	529	191	2	5	7
3- 2-50	6:00AM - 6:00PM	H-P	3	6-17	30	24	6	521	199	2	6	9
3- 7-50	6:00AM - 6:00PM	H-P	5	9-26	102	41	61	391	329	3	5	9
3-11-50	6:00AM - 6:00AM	P[3]	17	14-82	495	428	67	1042	398	4	7	14
3-16-50	6:00AM - 6:00PM	P	6	15-36	153	76	77	495	225	2	4	7
3-21-50	6:15AM - 6:15PM	P	2	8-27	35	35	0	551	169	1	5	6
3-31-50	6:00AM - 6:00PM	P	5	13-49	147	101	46	455	265	3	2	10

Table 17 (cont.).

Date	Observation period	Roughage ration*	Total rumi-nating periods no.	Range in rumi-nating periods min.	Ruminating time: Total	Ruminating time: Standing	Ruminating time: Lying	Total time: Standing	Total time: Lying	Times drank	Times urinated	Times defecated
					min.			min.			no.	
				Halo - 482 A - Guernsey								
12- 7-49	12:00 M - 12:00PM	H-P	7	9-23	102	61	41	447	273	9	5	8
12- 9-49	3:16PM - 3:16PM	H-P	9	9-24	127	12	115	762	678	17	11	10
12-14-49	12:00 M - 12:00PM	H-P	7	12-25	132	71	61	417	303	6	5	7
1-27-50	6:10AM - 6:10AM	H-P	8	10-24	137	55	82	867	573	7	9	11
2-10-50	6:45AM - 6:45PM	H-P	4	2-30	51	7	44	430	290	9	4	8
2-14-50	6:00AM - 6:00PM	H-P	2	38-42	80	0	80	395	325	3	6	8
2-21-50	6:00PM - 6:00PM	H-P	11	5-40	209	92	117	735	705	9	7	13
2-24-50	6:00AM - 6:00PM	H-P	4	23-28	98	33	65	420	300	6	5	6
2-28-50	6:00AM - 6:00PM	H-P	6	18-38	141	63	78	441	279	4	4	10
3- 4-50	6:00AM - 6:00AM	H-P	13	2-39	258	51	207	725	715	10	10	17
3-10-50	6:00AM - 6:00PM	P[3]	6	8-34	124	35	89	407	313	2	4	9
3-17-50	6:00AM - 6:00PM	P	4	10-20	56	42	14	412	308	3	5	12
3-23-50	6:10AM - 6:10PM	P	0	-	0	0	0	358	362	4	3	5
3-25-50	6:00AM - 6:00AM	P	10	8-32	224	26	198	657	783	3	9	13
3-28-50	6:00AM - 6:00PM	P	7	7-32	114	32	82	364	356	3	3	6
				Gleam - 267 A - Ayrshire								
12- 6-49	11:00AM - 11:00PM	H-P	7	4-22	85	71	14	526	194	6	6	4
12-13-49	11:00AM - 11:00PM	H-P	7	3-31	116	68	48	477	243	5	8	6
1-28-50	5:00AM - 5:00AM	H-P	10	9-25	176	85	91	899	541	13	10	9
2- 9-50	6:35AM - 6:35PM	H-P	3	12-26	51	13	38	577	143	3	5	2
2-16-50	6:05AM - 6:05PM	H-P	5	15-21	92	55	37	612	108	2	5	5
2-21-50	6:00AM - 6:00PM	H-P	4	5-26	64	58	6	637	83	4	6	6
2-21-50	6:00PM - 6:00PM	H-P	13	1-35	217	72	145	893	547	8	8	12
3- 2-50	6:00AM - 6:00PM	H-P	4	16-30	85	45	40	553	167	4	4	6
3- 7-50	6:00AM - 6:00PM	H-P	4	7-19	44	16	28	524	196	4	7	7
3-11-50	6:00AM - 6:00AM	P[3]	10	9-35	159	88	71	983	457	7	7	11
3-16-50	6:00AM - 6:00PM	P	6	8-21	86	69	17	622	98	2	5	3
3-21-50	6:15AM - 6:15PM	P	6	15-26	121	89	32	535	185	1	4	6
3-31-50	6:00AM - 6:00PM	P	5	4-15	51	28	23	533	187	2	6	6

Table 17 (cont.).

Date	Observation period	Roughage ration*	Total ruminating periods	Range in ruminating periods	Ruminating time: Total	Ruminating time: Standing	Ruminating time: Lying	Total time: Standing	Total time: Lying	Times drank	Times urinated	Times defecated
			no.	min.	min.			min.		no.		
					Novelty - 256 A - Ayrshire							
12- 6-49	11:00AM - 11:00PM	P	1	-	5	5	0	720	0	8	3	5
12-13-49	11:00AM - 11:00PM	P	0	-	0	0	0	596	124	7	4	4
1-10-50	5:30PM - 5:30AM	H	6	17-38	145	47	98	385	335	7	3	3
1-28-50	5:00AM - 5:00AM	H	16	5-30	299	137	162	829	611	9	6	5
2- 9-50	6:35AM - 6:35PM	H	7	4-27	100	47	53	543	177	6	2	4
2-16-50	6:05AM - 6:05PM	H	7	7-31	130	68	62	535	185	3	4	6
2-21-50	6:00AM - 6:00PM	H	9	7-22	109	74	35	562	158	6	4	5
2-21-50	6:00PM - 6:00PM	H	15	5-59	263	99	164	825	615	6	6	11
3- 2-50	6:00AM - 6:00PM	SCP	3	5-9	21	0	21	480	240	1	3	6
3- 7-50	6:00AM - 6:00PM	SCP	1	-	16	0	16	425	295	3	2	3
3-11-50	6:00AM - 6:00AM	H-S[2]	10	8-56	226	60	166	566	874	10	1	2
3-16-50	6:00AM - 6:00PM	H-S	3	11-37	81	11	70	481	239	3	2	3
3-21-50	6:15AM - 6:15PM	H-S	5	22-50	146	87	59	441	279	3	3	4
3-31-50	6:00AM - 6:00PM	H-S	6	11-37	113	62	51	439	281	1	3	4
					Kit - 363 A - Jersey							
12- 7-49	12:00 M - 12:00PM	H	6	20-41	187	75	112	410	310	2	5	6
12- 9-49	3:16PM - 3:16PM	H	11	4-67	393	193	200	868	572	6	10	14
12-14-49	12:00 M - 12:00PM	H	7	2-67	223	132	91	461	259	4	6	8
1-27-50	6:10AM - 6:10AM	P	1	-	11	11	0	878	562	4	8	14
2-10-50	6:45AM - 6:45PM	P	0	-	0	0	0	496	224	3	6	7
2-14-50	6:00AM - 6:00PM	P	0	-	0	0	0	539	181	2	5	6
2-21-50	6:00PM - 6:00PM	P	4	6-19	46	6	40	893	547	5	10	15
2-24-50	6:00AM - 6:00PM	P-S	3	15-26	64	24	40	482	238	4	6	11
2-28-50	6:00AM - 6:00PM	P-S	2	13-28	41	1	40	565	155	3	4	10
3- 4-50	6:00AM - 6:00AM	P-S	5	7-30	72	28	44	871	569	4	8	21
3-10-50	6:00AM - 6:00PM	P-S	3	5-21	43	8	35	610	110	2	5	10
3-17-50	6:00AM - 6:00PM	P-S-H[7]	3	22-79	132	101	31	551	169	2	5	10
3-21-50	6:15AM - 6:15PM	H-S	6	23-53	221	164	57	425	295	2	4	9
3-31-50	6:00AM - 6:00PM	H-S	7	16-89	279	136	143	412	308	1	3	7

Table 17 (cont.)

Date	Observation period	Roughage ration*	Total rumi-nating periods no.	Range in rumi-nating periods min.	Ruminating time Total	Ruminating time Stand-ing	Ruminating time Lying	Total time Stand-ing	Total time Lying	Times drank	Times uri-nated	Times defe-cated
					Questa - 163 A - Holstein							
12- 3-49	11:30AM - 11:30PM	P	0	-	0	0	0	364	356	7	3	5
12-16-49	3:10PM - 3:10PM	P	7	4-54	199	61	138	821	619	6	6	13
1-10-50	5:30PM - 5:30AM	H	3	63-83	210	174	36	464	256	3	3	8
2- 7-50	6:10AM - 6:10PM	H	10	4-41	216	131	85	499	221	3	4	10
2-11-50	6:15AM - 6:15AM	H	15	12-51	488	275	213	813	627	5	5	15
2-17-50	6:00AM - 6:00PM	H	7	12-56	193	118	75	485	235	2	5	8
2-21-50	6:00PM - 6:00PM	H	15	8-65	436	121	315	552	888	3	7	16
2-23-50	6:00AM - 6:00PM	H-SCP	8	8-46	172	133	39	505	215	2	5	10
3-18-50	6:00AM - 6:00AM	SCP	5	15-57	146	84	62	778	662	6	3	16
3-24-50	6:00AM - 6:00PM	SCP	1	-	46	12	34	469	251	1	4	9
4- 4-50	6:00AM - 6:00PM	P	5	12-48	129	30	99	388	332	1	3	6
4- 6-50	6:10AM - 6:10PM	P	4	7-37	94	44	50	475	245	3	4	9
					Becky - 470 A - Guernsey							
12- 7-49	12:00 M - 12:00PM	P	2	13-14	27	0	27	334	386	2	3	4
12- 9-49	3:16PM - 3:16PM	P	5	9-20	68	17	51	753	687	7	8	10
12-14-49	12:00 M - 12:00PM	P	2	8-11	19	0	19	365	355	3	5	6
1-27-50	6:10AM - 6:10AM	H	16	3-40	347	222	125	936	504	15	5	14
2-10-50	6:45AM - 6:45PM	H	7	9-38	168	70	98	417	303	2	2	9
2-14-50	6:00AM - 6:00PM	H	10	7-28	181	96	85	476	244	3	2	6
2-21-50	6:00PM - 6:00PM	H	17	4-80	400	120	280	733	707	12	6	13
2-24-50	6:00AM - 6:00PM	H-SCP	7	9-25	114	84	30	414	306	6	4	11
2-28-50	6:00AM - 6:00PM	SCP	3	12-16	42	0	42	389	331	7	3	11
3- 4-50	6:00AM - 6:00AM	SCP	4	10-15	53	0	53	715	725	9	6	18
3-10-50	6:00AM - 6:00PM	SCP	1	-	6	0	6	472	248	7	4	8
3-17-50	6:00AM - 6:00PM	SCP	2	5-13	18	8	10	414	306	7	3	8
3-23-50	6:10AM - 6:10PM	SCP	3	8-27	45	8	37	391	329	4	4	12
3-25-50	6:00AM - 6:00AM	SCP	4	4-30	65	6	59	773	667	7	5	16
3-28-50	6:00AM - 6:00PM	SCP	0	-	0	0	0	416	304	4	3	5

Table 17 (cont.).

Date	Observation period	Roughage ration*	Total rumi-nating periods no.	Range in rumi-nating periods min.	Ruminating time: Total	Ruminating time: Standing	Ruminating time: Lying	Total time: Standing	Total time: Lying	Times drank	Times urinated	Times defecated
					min.			min.			no.	
Alpha - 474 A - Guernsey												
12- 7-49	12:00 M - 12:00PM	P	2	6-30	36	6	30	350	370	3	4	4
12- 9-49	3:16PM - 3:16PM	P	4	6-22	66	48	18	773	667	8	9	7
12-11-49	12:00 M - 12:00PM	P	3	5-27	40	32	8	421	299	3	5	4
1-27-50	6:10AM - 6:10AM	H	17	3-59	452	215	237	916	494	11	8	11
2-10-50	6:45AM - 6:45PM	H	5	30-57	195	84	111	407	313	3	3	7
2-11-50	6:00AM - 6:00PM	H	7	8-46	204	85	119	416	304	2	4	7
2-21-50	6:00PM - 6:00PM	H	15	8-48	399	146	253	722	718	6	11	11
2-21-50	6:00AM - 6:00PM	H-SCP	5	14-34	99	49	50	377	343	4	3	8
2-28-50	6:00AM - 6:00PM	SCP	2	17-20	37	0	37	383	337	3	3	5
3- 4-50	6:00AM - 6:00AM	SCP	7	2-23	89	3	86	755	685	7	8	13
3-10-50	6:00AM - 6:00PM	SCP	2	5-16	21	13	8	473	247	2	4	4
3-17-50	6:00AM - 6:00PM	SCP	2	4-8	12	8	4	395	325	3	3	7
3-23-50	6:10AM - 6:10PM	SCP	1	-	20	0	20	366	354	2	2	5
3-25-50	6:00AM - 6:00AM	SCP	4	7-31	82	0	82	721	719	7	5	10
3-28-50	6:00AM - 6:00PM	SCP	3	8-18	37	26	11	421	299	3	4	7
Revel - 164 A - Holstein												
1-10-50	11:00AM - 5:30PM	P-S-AH	5	12-34	119	74	45	214	176	0	2	3
2-13-50	6:10AM - 6:10PM	S-AH	10	7-35	233	108	125	414	306	4	5	5
2-18-50	6:00AM - 6:00AM	S-AH	19	7-40	417	248	169	882	558	4	10	8
2-20-50	6:10AM - 6:10PM	S-AH	9	4-43	236	120	116	446	274	3	5	6
3-20-50	6:00AM - 6:00PM	H-S	9	21-36	258	183	75	523	197	2	3	7
3-27-50	6:00AM - 6:00PM	H-S	11	5-65	278	135	143	389	331	2	4	7
4- 3-50	6:00AM - 6:00PM	H-S	8	9-38	209	173	36	505	215	2	6	6
4-13-50	6:00AM - 6:00PM	H-S	7	21-39	204	60	144	432	288	3	4	3
4-16-50	6:00AM - 6:00PM	H-S	8	16-56	259	172	87	483	237	2	3	4
4-24-50	6:00AM - 6:00PM	H-S	9	4-44	250	92	158	432	288	2	3	5
5- 1-50	6:10AM - 6:10PM	H-S	4	21-62	159	97	62	555	165	0	1	1

Table 17 (cont.).

Date	Observation period	Roughage ration*	Total rumi-nating periods no.	Range in rumi-nating periods min.	Ruminating time: Stand-ing min.	Ruminating time: Lying min.	Total time: Stand-ing min.	Total time: Lying min.	Times drank no.	Times uri-nated no.	Times defe-cated no.
				Estella - 111 A - Holstein							
12- 3-49	11:30AM - 11:30PM	H-P	3	7-31	54	4	50	317	403	3	3	6
12-16-49	3:10PM - 3:10PM	H-P	7	8-47	202	183	19	765	675	6	6	17
2- 7-50	6:10AM - 6:10PM	H-P	4	6-19	45	39	6	556	164	3	3	8
2-11-50	6:15AM - 6:15AM	H-P	9	6-24	142	134	8	880	560	2	4	9
2-17-50	6:00AM - 6:00PM	H-P	3	9-25	59	59	0	551	169	2	1	7
2-23-50	6:00AM - 6:00PM	H-P	3	20-28	69	69	0	488	232	3	2	7
2-25-50	6:00AM - 6:00AM	H-P	8	13-32	177	164	13	747	693	4	5	18
3- 3-50	6:00AM - 6:00PM	H-P	4	13-20	69	69	0	476	244	3	3	10
3- 9-50	6:00AM - 6:00PM	H-P	2	20-23	43	43	0	526	194	2	4	8
3-14-50	6:00AM - 6:00PM	P[3]	2	7-33	40	37	3	479	241	1	2	7
3-18-50	6:00AM - 6:00AM	P	2	6-15	21	15	6	799	641	1	4	12
3-24-50	6:00AM - 6:00PM	P	1	-	14	0	14	535	185	1	5	12
3-30-50	6:00AM - 6:00PM	P	0	-	0	0	0	512	208	0	3	6
4- 4-50	6:00AM - 6:00PM	P	2	11-23	34	34	0	548	172	1	3	8
4- 6-50	6:00AM - 6:00PM	P	2	6-16	22	22	0	563	157	1	2	5
				Nancy - 160 A - Holstein							
1-10-50	11:00AM - 5:30PM	S-AH	4	29-50	156	26	130	225	165	0	1	2
2-13-50	6:10AM - 6:10PM	P-S-AH	9	10-39	240	240	0	665	55	5	5	7
2-18-50	6:00AM - 6:00AM	P-S-AH	12	14-65	359	190	169	834	606	12	10	14
2-20-50	6:10AM - 6:10PM	P-S-AH	7	18-53	219	169	50	502	218	4	3	4
3-20-50	6:00AM - 6:00PM	H-S	8	19-53	250	62	188	389	331	1	3	8
3-27-50	6:00AM - 6:00PM	H-S	7	9-83	276	34	242	324	396	0	0	4
4- 3-50	6:00AM - 6:00PM	H-S	8	7-84	306	80	226	335	385	1	5	6
4-13-50	6:00AM - 6:00PM	H-S	5	20-59	163	67	96	473	247	3	4	5
4-16-50	6:00AM - 6:00PM	H-S	7	7-61	214	66	148	422	298	1	3	7
4-24-50	6:00AM - 6:00PM	H-S	8	8-35	192	56	136	418	302	3	3	6
5- 1-50	6:10AM - 6:10PM	H-S	6	12-37	142	79	63	487	233	2	3	5

Table 17 (cont.).

Date	Observation period	Roughage ration*	Total rumi-nating periods no.	Range in rumi-nating periods min.	Ruminating time: Total	Ruminating time: Standing	Ruminating time: Lying	Total time: Standing	Total time: Lying	Times drank	Times urinated	Times defecated
					min.			min.			no.	
Applesauce - 128 A - Holstein												
1-10-50	11:00AM - 5:30PM	S-AH	4	23-49	137	93	104	191	199	0	4	3
2-13-50	6:10AM - 6:10PM	P-S-AH	8	2-55	188	94	94	420	300	1	4	5
2-18-50	6:00AM - 6:00AM	P-S-AH	13	21-62	502	129	373	601	839	6	8	10
2-20-50	6:10AM - 6:10PM	P-S-AH	6	21-50	211	65	146	459	261	4	4	7
Primrose - 144 A - Holstein												
1-10-50	11:00AM - 5:30PM	S-AH	4	25-43	143	99	44	208	182	0	1	1
2-13-50	6:10AM - 6:10PM	P-S-AH	6	23-57	215	128	87	508	212	6	5	6
2-18-50	6:00AM - 6:00AM	P-S-AH	16	9-51	519	151	368	679	761	9	11	13
2-20-50	6:10AM - 6:10PM	P-S-AH	8	3-38	202	125	77	521	199	6	6	8
Kringle - 253 A - Ayrshire												
1-10-50	11:00AM - 5:30PM	P-S-AH	3	23-40	87	63	24	334	56	0	3	4
2-13-50	6:10AM - 6:10PM	S-AH	7	8-43	194	110	84	536	184	4	6	8
2-18-50	6:00AM - 6:00AM	S-AH	14	4-61	483	137	346	663	777	2	9	10
2-20-50	6:10AM - 6:10PM	S-AH	8	5-45	199	132	67	580	140	2	6	7
Lovely - 140 A - Holstein												
3-20-50	6:00AM - 6:00PM	H-S	7	18-41	191	177	14	635	85	3	3	7
4-13-50	6:00AM - 6:00PM	H-S	3	17-42	85	34	51	513	207	4	6	4
4-16-50	6:00AM - 6:00PM	H-S	7	6-33	143	63	80	544	176	3	3	7
4-21-50	6:00AM - 6:00PM	H-S	6	19-28	144	60	84	461	259	1	4	4
Fantasy - 152 A - Holstein												
2-13-50	6:10AM - 6:10PM	S-AH	7	6-54	194	130	64	466	254	2	5	4
2-18-50	6:00AM - 6:00AM	S-AH	17	6-58	523	231	292	730	710	4	7	13
2-20-50	6:10AM - 6:10PM	S-AH	7	9-54	233	220	13	546	174	3	5	4
2-25-50	6:00AM - 6:00AM	H-S	14	6-51	385	212	173	765	675	3	9	11

Table 17 (cont.).

Date	Observation period	Roughage ration*	Total rumi-nating periods no.	Range in rumi-nating periods min.	Ruminating time: Total	Ruminating time: Stand-ing	Ruminating time: Lying	Total time: Stand-ing	Total time: Lying	Times drank	Times uri-nated no.	Times defe-cated
					min.			min.				
Stardust - 165 A - Holstein												
3-20-50	6:00AM - 6:00PM	H-S	9	6-54	213	175	38	580	140	5	12	9
3-27-50	6:00AM - 6:00PM	H-S	8	14-48	190	93	97	473	247	2	6	8
4- 3-50	6:00AM - 6:00PM	H-S	8	17-69	275	209	66	471	249	6	6	6
4-13-50	6:00AM - 6:00PM	H-S	6	15-39	140	90	50	567	153	2	4	6
4-16-50	6:00AM - 6:00PM	H-S	8	7-44	217	128	89	483	237	2	3	4
4-24-50	6:00AM - 6:00PM	H-S	8	10-40	204	93	111	493	227	5	7	6
5- 1-50	6:10AM - 6:10PM	H-S	7	9-73	175	124	51	454	266	3	6	4
Dream - 150 A - Holstein												
3- 6-50	6:00AM - 4:00PM	H-S	6	13-79	203	168	35	501	99	1	2	9
3-13-50	6:00AM - 6:00PM	H-S	7	16-57	230	134	96	559	161	2	3	9
Isabelle - 155 A - Holstein												
3-20-50	6:00AM - 6:00PM	H-S	8	2-35	162	82	80	444	276	8	4	11
3-27-50	6:00AM - 6:00PM	H-S	9	6-24	151	77	74	491	229	2	2	4
4- 3-50	6:00AM - 6:00PM	H-S	9	11-32	195	122	73	361	359	6	7	6
4-16-50	6:00AM - 6:00PM	H-S	6	13-56	160	118	42	604	116	2	5	8
4-24-50	6:00AM - 6:00PM	H-S	6	9-35	154	51	103	373	347	1	3	7
5- 1-50	6:10AM - 6:10PM	H-S	5	16-43	133	100	33	596	124	3	3	6
Blend - 262 A - Ayrshire												
3- 6-50	6:00AM - 4:00PM	H-S	7	6-50	172	93	79	451	149	2	3	9
3-13-50	6:00AM - 6:00PM	H-S	7	10-36	140	98	42	618	102	2	5	7
Artless - 495 A - Guernsey												
3-27-50	6:00AM - 6:00PM	H-S	5	29-74	279	194	85	599	121	1	3	2
4- 3-50	6:00AM - 6:00PM	H-S	6	25-70	282	142	140	496	224	2	3	7
5- 1-50	6:10AM - 6:10PM	H-S	3	15-89	153	70	83	528	192	1	2	3

Table 17 (cont.).

Date	Observation period	Roughage ration*	Total rumi-nating periods no.	Range in rumi-nating periods min.	Ruminating time: Total	Ruminating time: Stand-ing	Ruminating time: Lying	Total time: Stand-ing	Total time: Lying	Times drank	Times uri-nated	Times defe-cated
					min.			min.			no.	
Xenia - 170 A - Holstein												
3-20-50	6:00AM - 6:00PM	H-S	9	5-77	330	108	222	469	251	3	4	5
3-27-50	6:00AM - 6:00PM	H-S	10	5-64	364	175	189	464	256	3	3	5
4- 3-50	6:00AM - 6:00PM	H-S	8	21-80	328	135	193	280	440	2	4	5
4-13-50	6:00AM - 6:00PM	H-S	6	21-58	202	88	114	520	200	3	4	6
4-16-50	6:00AM - 6:00PM	H-S	7	16-89	275	143	132	495	225	3	4	6
4-24-50	6:00AM - 6:00PM	H-S	8	4-64	259	67	192	384	336	2	4	6
5- 1-50	6:10AM - 6:10PM	H-S	7	4-92	337	80	257	421	299	3	5	6
Helen - 115 A - Holstein												
1-10-50	11:00AM - 5:30PM	P-S-AH	4	29-38	129	129	0	353	37	1	2	5
Illation - 251 A - Ayrshire												
3- 6-50	6:00AM - 4:00PM	H-S	4	16-57	163	118	45	482	118	2	5	9
3-13-50	6:00AM - 6:00PM	H-S	6	8-46	187	102	85	549	171	2	7	7
Cleone - 497 A - Guernsey												
3- 6-50	6:00AM - 4:00PM	H-S	6	2-52	152	98	54	524	76	4	2	12
3-13-50	6:00AM - 6:00PM	H-S	6	8-31	137	78	59	552	168	3	1	6
Butterscotch - 274 A - Ayrshire												
3- 6-50	6:00AM - 4:00PM	H-S	4	22-98	182	118	64	480	120	1	5	6
3-13-50	6:00AM - 6:00PM	H-S	5	7-55	154	75	79	541	179	1	6	7
Hanna - 268 A - Ayrshire												
3- 6-50	6:00AM - 4:00PM	H-S	4	9-46	113	51	62	475	125	2	3	9
3-13-50	6:00AM - 6:00PM	H-S	5	18-52	160	107	53	612	108	1	7	9

Table 17 (concl.).

P	Dehydrated alfalfa pellets.
H	Chopped alfalfa hay.
H-SCP	Transition period - H to SCP.
SCP	Sun-cured alfalfa pellets.
P-S	Sorgo silage (2 lb./100 lb. body wt.) and dehydrated alfalfa pellets.
H-P	75% dehydrated alfalfa pellets, 25% alfalfa hay.
P-S-AH	Sorgo silage (2 lb./100 lb. body wt.), dehydrated alfalfa pellets (1/2 lb./100 lb. body wt.) and chopped alfalfa hay (ad. lib.).
S-AH	Sorgo silage (2 lb./100 lb. body wt.) and chopped alfalfa hay (ad. lib.).
H-S	Sorgo silage (2 lb./100 lb. body wt.) and alfalfa hay (ad. lib.).

1. Observation made during change in roughage ration from pellets alone to silage and pellets.
2. Taken off experiment and placed on normal herd ration.
3. Observation during change in roughage ration from H-P to P.
4. Observation taken during gradual change in roughage ration from P-S to H-S.
   Fed 26.0 lb. silage, 19.0 lb. pellets, and 2.0 lb. hay.
5. Observation taken during gradual change in roughage ration, from P-S to H-S.
   Fed 26.0 lb. silage, 9.0 lb. pellets, and 12.0 lb. hay.
6. Severe bloat from new silage. Off experiment.
7. Observation taken during gradual change in roughage ration from P-S to H-S.
   Fed 17.0 lb. silage, 4.4 lb. pellets, and 8.0 lb. hay.

EXPERIMENTAL OBSERVATIONS

Nov. 6, 1949: Three groups with 8 cows to a group placed on experimental roughage rations (75 percent pellets, 25 percent hay, pellets alone, and chopped hay).

Dec. 3. 1949: First observations made on physiological responses to roughage rations.

255A (P) observed licking the feed trough excessively. Rumination slow with as long as one minute duration between boluses.

Dec. 6, 1949: 256A (P) Poor rumination. Boluses seemed small and were chewed for relatively short time. A long pause between boluses.

249A (H) Unable to get water from drinking cup. When cup was fixed, she drank excessively (7:34 p.m.).

Dec. 7, 1949: 470A (P) Excessive chewing of the tongue and licking of the nose. Ate a few shavings.

395A (HP) Chewing on wood mangers.

Dec. 13, 1949: 256A (P) Eating shavings.

Dec. 14, 1949: 248A (HP) Aborted.

470A (P) Eating shavings.

483A (H) Chewing on wood mangers.

Jan. 10, 1950: Roughage groups changed. Pellet to hay, hay to pellets, and hay and pellet group remained on the same ration.

Feb. 7, 1950: 137A (P) Eating shavings.

255A (H) Eating shavings.

163A (H) Eating shavings.

245A (P) Eating shavings. Severe anorexia removed from experiment and fed hay.

Feb. 9, 1950: 248A (HP) Eating shavings.

249A (P) Eating shavings.

267A (HP) Eating shavings.

Feb. 10, 1950: 482A (HP) Eating shavings.

483A (P) Eating shavings.

395A (HP) Eating shavings.

Feb. 13, 1950: 483A (P) Severe anorexia. Removed from experiment and fed hay.

Feb. 14, 1950: 470A (H) Liming of floor caused cessation of rumination 10:08 a.m.

483A Removed from experiment 2-13 and fed hay but still eating shavings.

Feb. 16, 1950: 267A (HP) Eating shavings.

Feb. 17, 1950: 255A (H) Eating shavings.

Feb. 21, 1950: Cows weighed during observation period.

Rumens palpated: 3-4 p.m.

249A (P) Very weak rumen motions and of short duration, about 2 every three or four minutes.

125A (P) Contractions even and mild with no strong forceful movements. About 2 a minute.

137A (P) Similar to 125A. Weak and milk contractions.

363A (P) Smooth, long, mild contractions.

Hay fed cows - strong contractions irregular and volcanic in nature. More tone than pellet group. 2-3 contractions per minute.

Hay and pellet-fed cows - smooth contractions but relatively weak. Rumens a little firmer than in the pellet-fed group.

Feb. 22, 1950: Roughage groups changed. Pellet to silage and pellets, hay to sun-cured pellets, and hay and pellet group remained the same.

Rumens palpated: 6:00 p.m.

363A - (P to S-P at a.m. feeding) Smooth, long, mild contractions. About 3 per minute.

Feb. 23, 1950: 163A (SCP) aborted (Trichomoniasis).

125A (S-P) off feed.

Feb. 25, 1950: Rumens palpated:

137A (S-P) - Smooth, moderate contractions.

125A (S-P) - Contractions of slightly more intensity than 137A. Not normal however.

249A (S-P) - Similar to 125A.

363A (S-P) - Smooth, weak contractions.

Feb. 28, 1950: Rumens palpated:

125A (S-P) Strong, forceful contractions.

137A (S-P) Smooth, even contractions, noticeably weaker than 125A.

249A (S-P) Similar to 137A.

363A (S-P) Smooth, weak contractions. A bit stronger than on Feb. 25th but not as strong as others observed.

March 6, 1950: 256A (P) Off feed for previous two days. Rumen palpated. Smooth, weak contractions. Rumen tone very poor, rumen flabby. Possibly one contraction every three minutes.

March 7, 1950: 256A (P) Eating shavings.

153A (H-P) Eating shavings.

245A - Normal ration since anorexia from pellets Feb. 7, 1950. Eating shavings.

Hay and pellet-fed cows changed to pellets.

249A (S-P) Removed from experiment.

267A (change to pellets from hay and pellets). Eating shavings.

March 9, 1950: 137A (S-P) Eating shavings.

255A (SCP) Eating shavings.

March 14,1950: 125A (S-P) Bloat, rope tied in her mouth 1:25 p.m., for about 20 minutes. (Opened new silo). Fed hay.

255A (SCP) Eating shavings.

March 15,1950: Group receiving silage and pellets changed to hay and silage.

March 16,1950: 248A (P) Weak ruminations, eating shavings.

March 21,1950: 248A (P) Eating shavings.

245A (H-S) Eating shavings.

363A (H-S) Eating shavings.

March 23,1950: 395A (P) Eating shavings.

March 29,1950: Sun-cured pellet group changed to dehydrated pellets.

March 30,1950: 255A (P) Eating shavings.

April 6, 1950: 163A (P) Eating shavings.

May 6, 1950: All cows fed hay.

FACTORS AFFECTING RUMEN MOTILITY AND RUMINATION IN DAIRY CATTLE

by

JAMES ELWOOD KNOX

B. S., Mississippi State College, 1948

AN ABSTRACT OF A THESIS

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Kansas ranks second among the states in the production of dehydrated alfalfa meal. Practically all commercial formula feed manufacturers use some dehydrated forage in their mixes. Due to the widespread usage of dehydrated forages and since it is used in finely ground form, a study was made of the rumination, rumen motility, and other physiological behavior of dairy cows when fed varying amounts of this finely ground roughage.

Twenty-four cows fed different amounts of dehydrated alfalfa pellets were observed for a total of 151 periods of 12-hours each, and 58 periods of 24-hours each. Also, 12 cows fed coarsely chopped hay and silage rations were observed for 78 periods of 12-hours each and 8 periods of 24-hours each. Actual clock time was recorded for the time each cow ruminated, time standing and time lying, drinking activities, urinations, and defecations. Pulse and respiration rates, and rectal temperatures were taken of cows during observation periods. The tone and contractions of the rumina of cows fed varying levels of dehydrated pellets, were determined by palpation. Rumen motility was recorded on kymograph tracings, by use of the Dougherty-Crumb pneumatic piston apparatus.

Rumination was markedly decreased when 75 percent or 100 percent of the roughage ration was finely ground (fed in pellet form). However, when the finely ground roughage comprised 20 percent of the roughage ration, no reduction in rumination time was evident.

Reduction in rumination time for cows fed dehydrated alfalfa pellets was due to the fineness of grind rather than to the dehydrating process, since sun-cured pellets retarded rumination equally as much.

Fifty-seven percent of the time while ruminating was while the cows were lying. However, the cows were lying only 44 percent of the total time. A cyclic distribution of rumination time occurred during the 24-hour day, but this may have been due to the feeding regimen.

Water consumption of cows fed dehydrated alfalfa pellets was no greater than a cow receiving coarse ground roughage, nor was there a material change in water consumption when the pellet-fed cows were changed to a hay ration. The moisture content of feces samples from cows fed pelleted rations was slightly below normal. No consistent differences were noted in pulse rates, respiration rates, or rectal temperatures of cows on the different roughages fed.

In Phase II, rumen motility was studied in 18 lactating cows in various roughage treatment groups. A lack of tone of the rumina of pellet-fed cows was observed by rumen palpation. Weak, soft rumen contractions were noted in contrast to strong, forceful movements of the hay-fed cows.

By use of the Dougherty-Crumb pneumatic piston, rumen motility of the pellet-fed cows was found to be slight, if evidenced at all. The number of contractions were appreciably reduced in cows fed pellets as compared with cows fed coarse, chopped hay, and silage.

On the basis of these investigations, it may be stated that the feeding of finely ground roughages to dairy cows adversely affects rumination time, and rumen motility.