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THE EFFECT OF FEEDING CONCENTRATES
WITH DIFFERENT MODULI AND WATER
CONTENTS ON THE EATING TIME
AND MILKING TIME IN DAIRY CATTLE

Thesis for the Degree of M. S.
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Major professor

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THE EFFECT OF FEEDING CONCENTRATES WITH
DIFFERENT MODULI AND WATER CONTENTS
ON THE EATING TIME AND MILKING
TIME IN DAIRY CATTLE

By

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INTRODUCTION

The pen-type barn is becoming increasingly popular in certain dairy sections of the United States. Many dairymen are concerned about the fact that their high-producing cows do not have time to consume sufficient grain while in the milking parlor. Some dairymen were of the opinion that the cows could be trained to eat faster by driving them out of the parlor at the completion of milking. However, this has not been as successful as was hoped. Other dairymen thought that all the cows should be fed a certain amount of feed while in the milking parlor and then allowed free access to grain in a feed trough common to all the cattle. This is not satisfactory because some cows still would not be able to get the amount of grain they needed.

This investigation was undertaken to study some of the factors which affect the rate of grain consumption by dairy cows when being milked in a milking parlor.

REVIEW OF LITERATURE

Fineness of Grind

The fineness to which grain should be ground for dairy cattle is a debatable question. However, the trend among livestock men is to grind grain coarser than they formerly did. This change has been made because of the lessened importance, from a nutritional viewpoint, attached to the fineness to which the grain is ground. The modulus of fineness is the only accurate method of representing the degree of fineness of grind. It is the method adopted by the American Society of Agricultural Engineers. The modulus of fineness is a number given to the average size of particles in a representative sample.

Silver (1931) made an extensive investigation of feed grinders as related to modulus of fineness. The grains were ground to various degrees of fineness and turned over to the Animal Husbandry Department of the Ohio State University for their approval. They recommended the finenesses of grinding and moduli of certain grains for dairy cattle as follows: shelled corn, medium, 3.60; ear corn, medium, 3.60; oats, medium, 2.80;

barley, medium coarse, 3.60; soybeans, fine-medium, 3.10; and wheat, medium, 3.20.

Morrison (1948) stated that grain should be ground to a medium degree of fineness for livestock and that it should be ground so as to be gritty, and not mealy or floury. He also mentioned that fine grinding not only takes more time and power, but it often makes the grain less palatable due to its dusty nature.

According to Schalk and Amadon (1928) dairy cows fed 5 pounds of ground feed per day required 2.8 minutes to ingest a pound of feed. The cows formed and swallowed 3-1/4 boli per minute.

Kick et al. (1937), in an experiment with four rumen fistula steers varying in age from 28 to 42 months, found that when shelled corn with a modulus of 6.01 and a protein supplement with a modulus of 2.01 were fed, it required from 117 to 185 chews per pound of feed before it was swallowed. When ground corn with a modulus of 3.56 and a protein supplement with a modulus of 2.01 were fed, it required from 159 to 243 chews per pound of feed before being swallowed. When the shelled corn was fed, prehension was rapid and the corn was

swallowed as soon as it was sufficiently covered with saliva to allow easy deglutition. Apparently the reduction in the size of the particles was not a major factor in the mastication of the feed. In the case of the ground corn it appeared that the increased number of chews could be explained only on the basis of the difficulty of insalivation. Shelled corn kernels, protected by an outer coating high in fiber, were not capable of absorbing as much saliva as the ground corn. It was apparent that it was more difficult to prepare the ground corn for deglutition. Therefore, it increased the number of chews and length of time required to swallow the feed.

Harshbarger (1949) made a study to determine the average rate at which cows ate grain, silage, and hay. The study was made on Ayrshire, Guernsey, Holstein, Brown Swiss, and Jersey cows. He found the average rates of eating ranged from about 2 to 3 minutes per pound of grain, 1.75 to 2.75 minutes per pound of silage, and 7 to 16 minutes per pound of hay. For each type of feed, the rate of eating was greatest for Holsteins and least for Jerseys.

Preparation of the Udder and Let Down of Milk

Dodd et al. (1950) ran an experiment using thirty-eight first-calf heifers divided into two equal groups for complete lactations to determine the effect of rigidly controlled milking. The duration of the milkings was either 4 or 8 minutes. They found that the treatment had no major effect on the milking rate of either group. While 4 minutes was insufficient time to completely milk out the udders of about half of the animals on this treatment, the machines on the 8-minute treatment were generally left on for a period after the milk flow had stopped. There was no significant difference between the 305-day lactation yields or in the persistency of the lactations of the two groups. The 4-minute treatment did decrease the yield of milk and fat in early lactation. The 8-minute cows had more clinical and subclinical mastitis but they did not have a higher proportion of eroded teats, or the milk did not show higher Whiteside test readings.

Baxter et al. (1950) made a study of the milking of the two hind quarters of four cows by teat cup and by teat cannula at three levels of vacuum and by teat cannula at atmospheric pressure. The eight quarters milked at significantly different

maximum rates by teat cup but at nearly the same rate through a teat cannula, suggesting that the teat orifice is a very important factor controlling rate of milking. The maximum rate of milking by both teat cup and teat cannula increased with increasing level of vacuum from 11 to 20 inches of mercury. The rate of increase in the teat cup milking was greater than in the cannula milking, suggesting that the teat orifice was stretched open at the higher levels of vacuum. They found the average amount of strippings increased at the higher level of vacuum in teat cup milking, apparently due to teat cup crawl.

Dodd et al. (1949) used three different methods of preparation for milking cows that had been accustomed to a 1-minute stimulation period before the teat cups were put on. On single mornings they were (1) milked without preparation, (2) milked 3 minutes after preparation, and (3) milked 6 minutes after preparation. On the first treatment let down was delayed; thereafter milking rate was not abnormal. On the second treatment there was no pronounced effect on milking efficiency. The third treatment resulted in a slightly slower rate of milking and a reduced yield of milk and butterfat. In a second experiment a comparison was made between two established routines, in

one of which udder washing, fore milking, and concentrate feeding was done less than a minute before milking, and in the other, 20 minutes before milking. The data showed that milking immediately after preparation was the more efficient routine, although the difference was not great.

The effect of washing the udder with hot water and the effect of reducing milking time was studied by Dodd and Foot (1947). During the first 2 weeks and last 2 weeks of a 9-week period, nine cows, milked by machine, were prepared for milking by hosing and washing the udders with cold water 15 minutes to 1 hour before milking, while in the intervening 5 weeks the udders only were washed with water at 115° to 120° F. immediately before milking. The hot-water routine had no pronounced effect on the yield and quality of milk from the majority of the cows, although one reacted unfavorably to a change back to the cold-water routine and had to be stripped by hand. The gradual restriction, over an interval of 4 to 6 weeks, in the milking time from 100 to 60 percent of the previous normal flow period for three cows in mid-lactation had no great influence on the maximum rate of flow from the udder, even when hot-water washing of the udder immediately before milking

was introduced late in the experiment. The maximum rate of flow was reached slightly sooner after putting on the teat cups. The restriction in milking time caused only a small reduction in yield as the flow during the latter part of the flow period had in any case been small. The fat content of the milk of the cows whose milking time was restricted fell somewhat, while the solids-not-fat content remained steady. Washing the udder with hot water or restricting the milking time showed no clear-cut effect on the incidence of mastitis.

In another experiment Dodd and Foot (1949) studied the effect of reducing the milking time and washing the udder with hot and cold water. The study was made on twenty cows for 9 weeks. The cows were washed with water at 120° F. and 60° F. and the milking time was reduced to 60 percent of the normal flow period. The temperature of the water had no measurable effect on the output of milk or the speed of milking. The reduction in milking time failed to increase the rate of flow of milk and resulted in a fall in milk yield. They also reported an experiment with ten cows in which the teat cups were for a period of 6 weeks left on at each milking twice as long as was necessary to carry out the normal milking process.

Neither the yield or quality of milk, nor the rate of milking were affected.

Smith and Petersen (1948) showed that when the cow was prepared for milking by a 10- to 15-second massage with water at a temperature between 120° and 130° F. 2 minutes before the teat cups were placed on, the rate of milking increased and the time required for the milking process decreased as compared with no preparation.

Ward and Smith (1949) conducted an experiment to determine whether there was any difference in production when cows were milked at 4, 8, 12, 16, and 20 minutes after a conditional stimulation as compared with 2 minutes after stimulation. Four of the five cows tested showed a decrease in production when milking began 8 minutes after stimulation had been applied. The results indicated that in general practice milking should begin within 8 minutes of stimulation if maximum production is to be obtained. There was a highly significant decrease in production when cows were milked 12 minutes or more after a conditioned stimulation.

Knoop and Monroe (1950) showed that the temperature of the udder wash water (45°, 100°, and 132° F.) was a minor

factor in the stimulation of milk let down. Proper stimulation of the udders at required intervals (1-minute interval as used in this experiment) before milking was necessary for maximum speed of let down of milk. A cleaning, massaging period of 10 to 15 seconds with a cool, damp rag or a wet towel rung from water gave the required stimulation for rapid let down of milk. A similar treatment with the dry hand or the use of a strip cup was inadequate. Bathing udders in hot water (120° F.) for a period of 10 to 15 seconds as a means of premilking preparation did not appear to be any more effective than the use of a damp towel. Without the premilking treatment of the udder, the milking period was prolonged approximately 1 minute, as compared with proper preparation, due to the slow let down. Total milk production remained fairly constant throughout the experiments regardless of the method of udder preparation.

OBJECT

The object of this experiment was to determine how the eating time of concentrate feeds of different moduli of fineness could be decreased to a point where the cows consuming the large amounts of feed could eat all their feed while in the milking parlor. If there was to be a change in eating time, it was desired to find out what effect it might have on the milking time.

EXPERIMENTAL PROCEDURE

The pen-type barn recently erected at Michigan State College provided the ideal situation for the experiment. The herd at the beginning of the experiment consisted of twelve Brown Swiss cows. During the second trial, the herd consisted of eleven Brown Swiss and two Holstein cows. Ten of the Brown Swiss cows in the first trial were also used in the second trial. The two Holsteins were not on the experiment during the last 2 weeks of the second trial since each cow had been implanted with 1.5 grams of diethylstilbesterol. It was deemed wise from their drop in production and nymphomaniac actions to remove the animals to a conventional barn.

The grain ration used in this experiment consisted of 20 parts soybean oil meal, 10 parts rye, 50 parts corn, 20 parts oats, and 1 part salt. This grain ration was the one in use for the Michigan State College dairy herd at the time the experiment started.

The feed was ground in a B. J. Humdinger mill, and the modulus of each grind was determined by the method recommended by the American Society of Agricultural Engineers.

The screen size used in the mill and the modulus obtained, respectively, were (1) 3/32 inch, 3.18; (2) 4/32 inch, 3.60; and (3) 6/32 inch, 4.01, in order of increasing particle size. Figures 1, 2, and 3 show the physical nature of the feed at these three degrees of fineness. The feeds were sampled and dried to constant weight at 100° C. The modulus was obtained on a 250-gram aliquot of this dried sample. A Neinzer sieve shaker, with screen sizes 10, 20, 40, 60, 80, and 100-mesh per inch, was used. Each sample was shaken for 5 minutes.

The material retained on the coarsest screen was weighed first. Then the material on the next finer screen was weighed and added to the first weight. Then the next finer material was weighed and added to the first two weights, and so on, leaving out the material that passed the 100-mesh screen. These weights were reduced to percentages by dividing by 250 (original sample weight), totaling, and dividing by 100. An example of the modulus determination is given on page 17.

The grain was stored in a hopper above the milking parlor. There were four feed chutes, one coming to each of the four mangers. The grain was fed into the manger by means

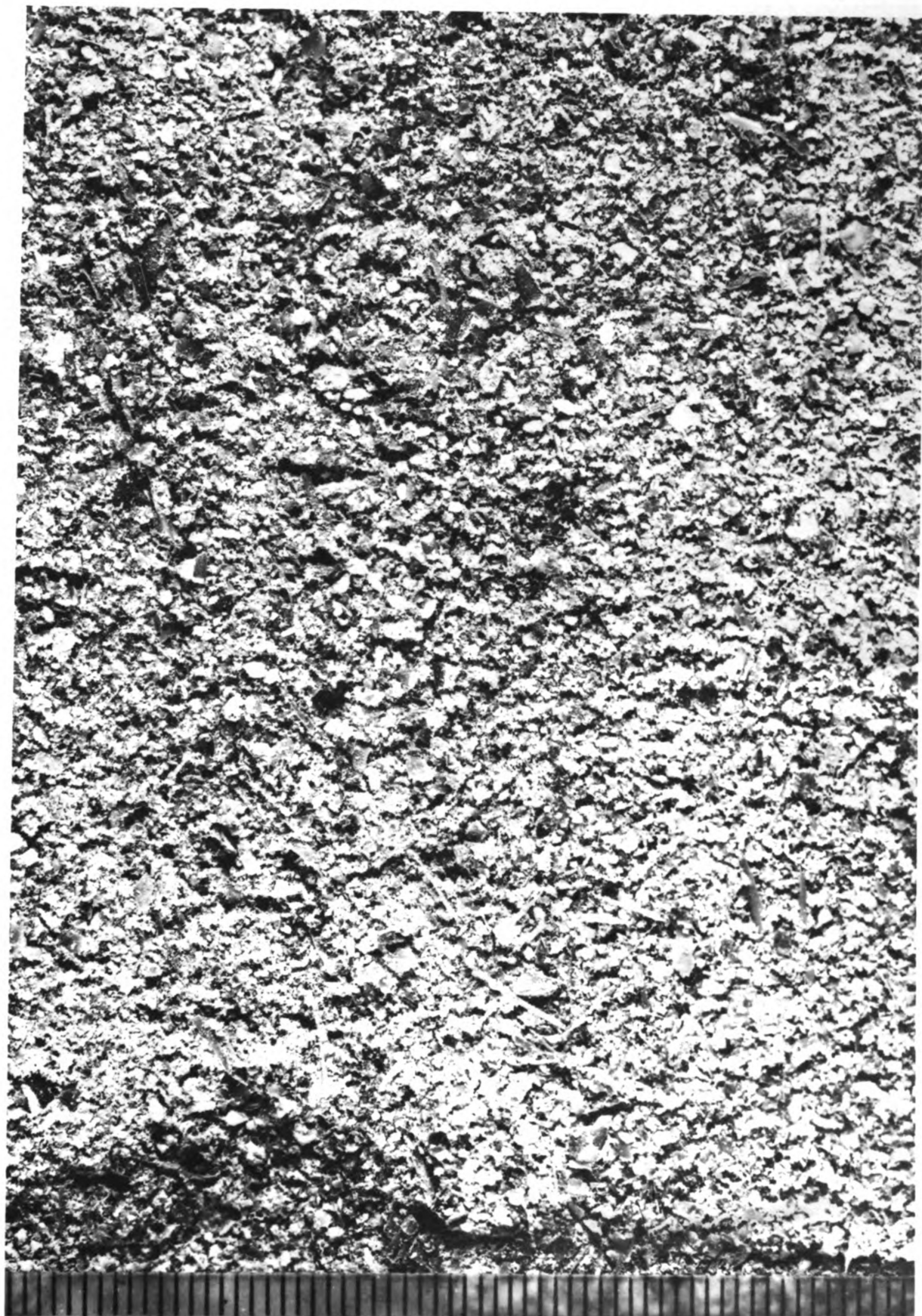


Figure 1. Grain ration ground to a modulus of 3.18 (each division equals 1 mm.).

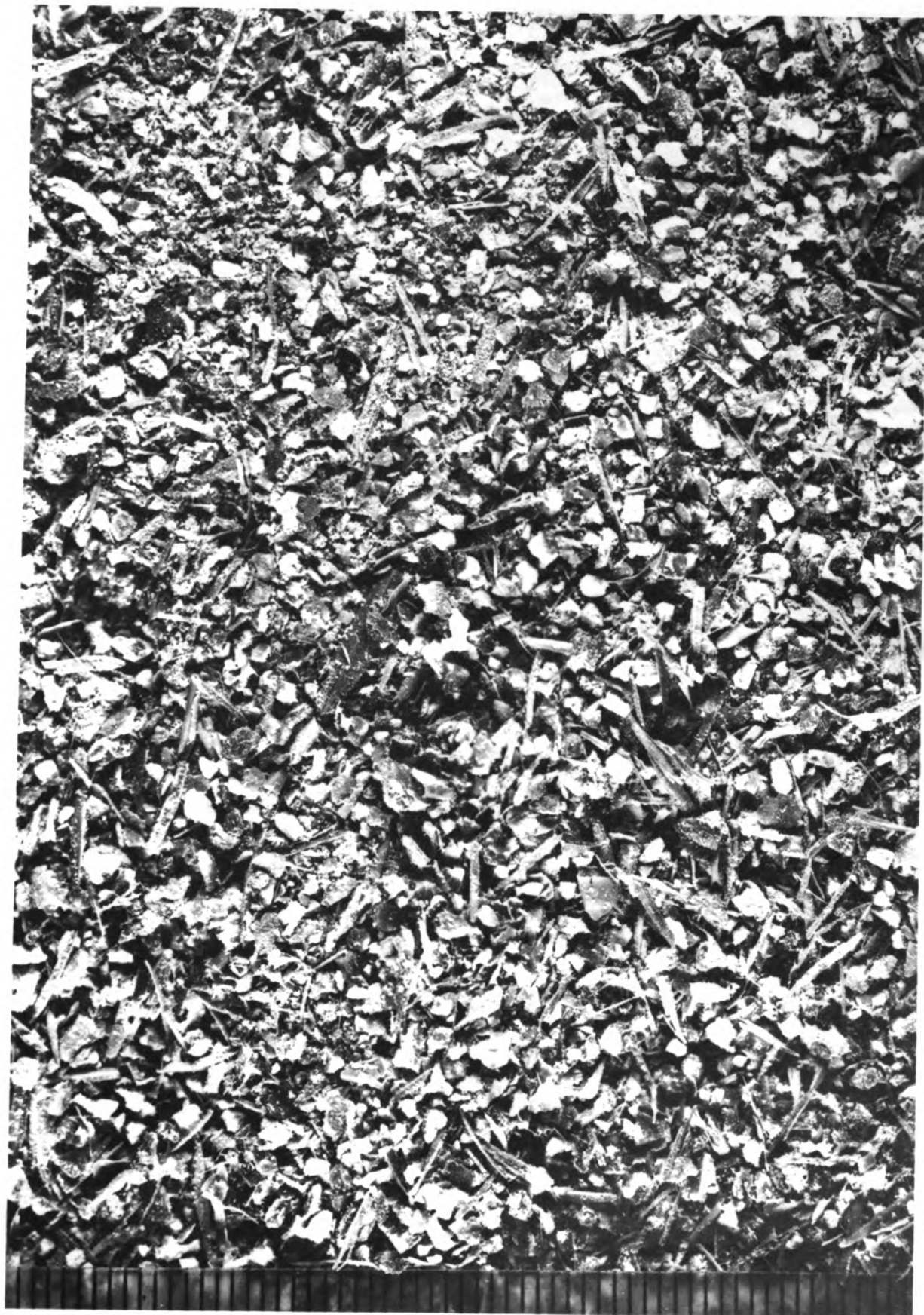


Figure 2. Grain ration ground to a modulus of 3.60 (each division equals 1 mm.).



Figure 3. Grain ration ground to a modulus of 4.01 (each division equals 1 mm.).

Screen Size	Individual Weight	Total Weights	Percent
	(grams)	(grams)	
10	11	11	0.44
20	134.7	145.7	58.28
40	48.8	194.5	77.80
60	19.2	213.7	85.48
80	8.0	221.7	88.68
100	5.4	227.1	90.84
			<u>401.52</u>

$$\text{Modulus} = 401.52/100 = 4.01$$

of an auger. The augers were standardized so that one turn released 2 pounds of feed.

Each modulus was fed (1) normal (air-dry), (2) 1/2 pound of water per pound of feed, (3) 1 pound of water per pound of feed, and (4) 1-1/2 pounds of water per pound of feed. In each case where water was added to the grain, the water was measured into the manger and the feed augered in on top of the water. The feed and water were mixed by hand just as soon as the feed hit the water. Where 1-1/2 pounds of water were added per pound of feed, thorough mixing was unnecessary since all the feed became wet immediately. All the water was not absorbed by the feed in the case of the 4.01 modulus when it

had 1-1/2 pounds of water added per pound of feed. It was completely absorbed in all other cases.

The grain described above, fed at normal moisture content (air-dry) with a modulus of 3.60, was used during the control period of the experiment in both the first and second trials. The control period for the first trial consisted of 12 days at the beginning of the trial. The control period for the second trial consisted of the 6 days following the period of feeding the 4.01 modulus while the cows were on pasture. Feed of modulus 3.60 was fed for 3 days at a ratio of 1-1/2 pounds of water per pound of feed following the control period. Each modulus was fed at each of four moisture levels for one 3-day period. There was a 1-day interval between different moduli to permit clearance of residual feed of the modulus previously used.

For 6 days prior to the beginning of the experiment a general study of the cattle was made. At that time it was observed, by viewing the milk as it entered the glass pails of the milking machine, that the let down of milk did not fully materialize until about 2 minutes after stimulation. For this reason the 2-minute period between stimulation and application of the teat cups was used.

Throughout all these trials the cows received their feed at the same time that the teat cups were put on. The cows' udders were washed with water at 125° to 132° F. During the first trial and until 2 weeks before the second trial was finished the cows were washed with paper towels. During the last two weeks they were washed with flannel cloths; the temperature of the water was still 125° to 132° F.

The milking machine used in this experiment was a "Chore Boy," pipe-line delivery, operating at forty-two pulsations per minute and with a vacuum of 11 inches of mercury.

The cows were machine stripped. The milking-machine operator massaged the udders by hand during the last of the milking process in order to get all the milk possible.

The data were collected as follows: The time at which the feed was augered into the manger was recorded as the starting time of eating. The time at which the cow had licked the manger clean and raised her head from the manger was recorded as the finishing time of eating. When a cow did not eat all the allotted feed, the amount remaining in the manger was weighed and the eating time was calculated on the basis of the amount actually consumed.

An example of the calculations follows:

Number of Cows: 9		
	<u>Total</u>	<u>Average</u>
Pounds of Feed	33	3.66
Eating Time (in minutes)	85	9.44
Pounds of Milk	185.6	20.62
Milking Time (in minutes)	78	8.66

$9.44/3.66 = 2.57$ minutes = time to eat 1 pound of grain.

$8.66/20.62 = 0.41$ minute = time to milk 1 pound of milk.

The experiment was divided into two parts. The data for the first trial were collected from January 8, 1952, to March 1, 1952, inclusive. Since it was desired to see what effect grazing on good pasture would have on the grain-eating habits of cattle and the let down of milk, data were collected during a second period from April 15, 1952, to June 3, 1952, inclusive. During this period the cattle were turned first on rye pasture, and later on native pasture.

The times at which the cow was stimulated, at which the teat cups were put on and at which the teat cups were removed were recorded as well as the amount of milk produced. The

time interval between the start of stimulation and putting on of the teat cups was as near to 2 minutes as could be attained. This interval was maintained as nearly as possible throughout the first and second trials.

The average pounds of grain consumed, the average eating time per cow, the average milking time per cow, and the average milk yield per cow were calculated for each 3-day period. From these averages the average time required to eat 1 pound of feed and the average time required to milk 1 pound of milk were determined.

Concurrently with the second trial of this experiment, two cows (371 and 377) that produced average amounts of milk and ate average amounts of feed were put on a different schedule of stimulation. The purpose was to study the effects of different intervals of stimulation upon the let-down process. The procedure for determining the time required to eat 1 pound of feed and to milk 1 pound of milk was the same as that previously described. The various intervals between stimulation and the time the teat cups were placed on were: 30 seconds, 1 minute, 2 minutes, 3 minutes, 4 minutes, 5 minutes, and 6 minutes.

For purposes of record, the temperature in the loafing area of the barn and the temperature on the outside was taken at each milking. The thermometer in the loafing area was placed in the center of the barn 5-1/2 feet above the floor level.

RESULTS

First Trial

The results of the first trial are shown in Table I and summarized in Table II. The different moduli of fineness were fed in the order shown, and the feeds, with regard to the amount of water added, were fed in the order listed. The feed data listed under modulus of 3.60, normal moisture, is the control data for this period. The cows took more time to eat a pound of feed having a modulus of 3.18, normal moisture, than they did modulus 3.60, normal moisture. They also took more time to eat a pound of modulus 3.60, normal moisture, than they did to eat a pound of 4.01 modulus, normal moisture. Within each of the moduli there was a similar decrease in eating time per pound of feed as the amount of water was increased. This information is shown graphically in Figure 4 and on the basis of percentage change in Figure 5.

Table II shows that as the time to eat 1 pound of feed decreased, the time to milk 1 pound of milk decreased. The rate was not directly proportional, but followed the same pattern

TABLE I

FIRST TRIAL--SUMMARY OF EXPERIMENTAL DATA

Modulus	Water per lb. of Feed	Avg. Amt. Feed	Avg. Time of Eating	Avg. Time to Eat 1 lb. Feed	Avg. Milk Prod.
	(lb.)	(lb.)	(min.)	(min.)	(lb.)
3.60 Control	Normal (13.8%)	5.29	10.05	1.90	15.13
	1/2	5.96	9.97	1.65	15.85
	1	5.79	5.68	1.00	15.06
	1-1/2	5.83	5.39	0.91	15.75
3.18	Normal (14.0%)	5.30	10.65	1.95	14.88
	1/2	5.59	9.45	1.69	15.36
	1	5.49	6.05	1.10	14.97
	1-1/2	6.03	4.20	0.69	15.02
4.01	Normal (14.0%)	4.68	8.48	1.70	13.77
	1/2	5.44	6.77	1.24	14.24
	1	6.51	5.58	0.85	15.55
	1-1/2	7.37	4.58	0.61	17.33

TABLE I (Continued)

Avg. Time of Milk- ing	Avg. Time to Milk 1 lb.	Avg. Time of Stim- ulation	Avg. Temp. Loaf- ing Area Barn	Avg. Temp. Out	Experi- mental Obser- vations
(min.)	(min.)	(min.)	(° F.)	(° F.)	(no.)
8.30	0.54	2.0	33	30	72
8.32	0.46	2.1	26	22	72
6.65	0.43	2.1	36	37	72
6.64	0.41	2.1	32	23	72
8.38	0.52	2.0	20	13	66
7.39	0.47	2.0	38	36	62
7.53	0.45	2.1	36	30	62
6.61	0.43	2.0	31	25	72
6.40	0.45	1.9	29	24	70
6.48	0.45	2.1	28	17	68
6.49	0.41	2.1	25	25	72
6.86	0.39	2.0	30	25	72

TABLE II

FIRST TRIAL--COMPARISON OF EATING AND MILKING TIMES WITH CONTROL

Modulus	Water per lb. of Feed	Avg. Time to Eat 1 lb. Feed	Decrease	Change from Control Feed	Avg. Time to Milk 1 lb.	Decrease	Change from Control Milk
	(lb.)	(min.)	(%)	(%)	(min.)	(%)	(%)
3.60 Control	Normal	1.90			0.54		
	(13.8%) 1/2	1.65	13	13	0.46	15	15
	1	1.00	47	47	0.43	22	22
	1-1/2	0.91	52	52	0.41	24	24
3.18	Normal	1.95		-3	0.53		2
	(14.0%) 1/2	1.69	13	11	0.47	11	13
	1	1.10	44	42	0.45	15	17
	1-1/2	0.69	65	66	0.43	19	20
4.01	Normal	1.70		11	0.45		17
	(14.0%) 1/2	1.24	27	35	0.45	0	17
	1	0.85	50	55	0.41	9	24
	1-1/2	0.61	64	68	0.39	13	28

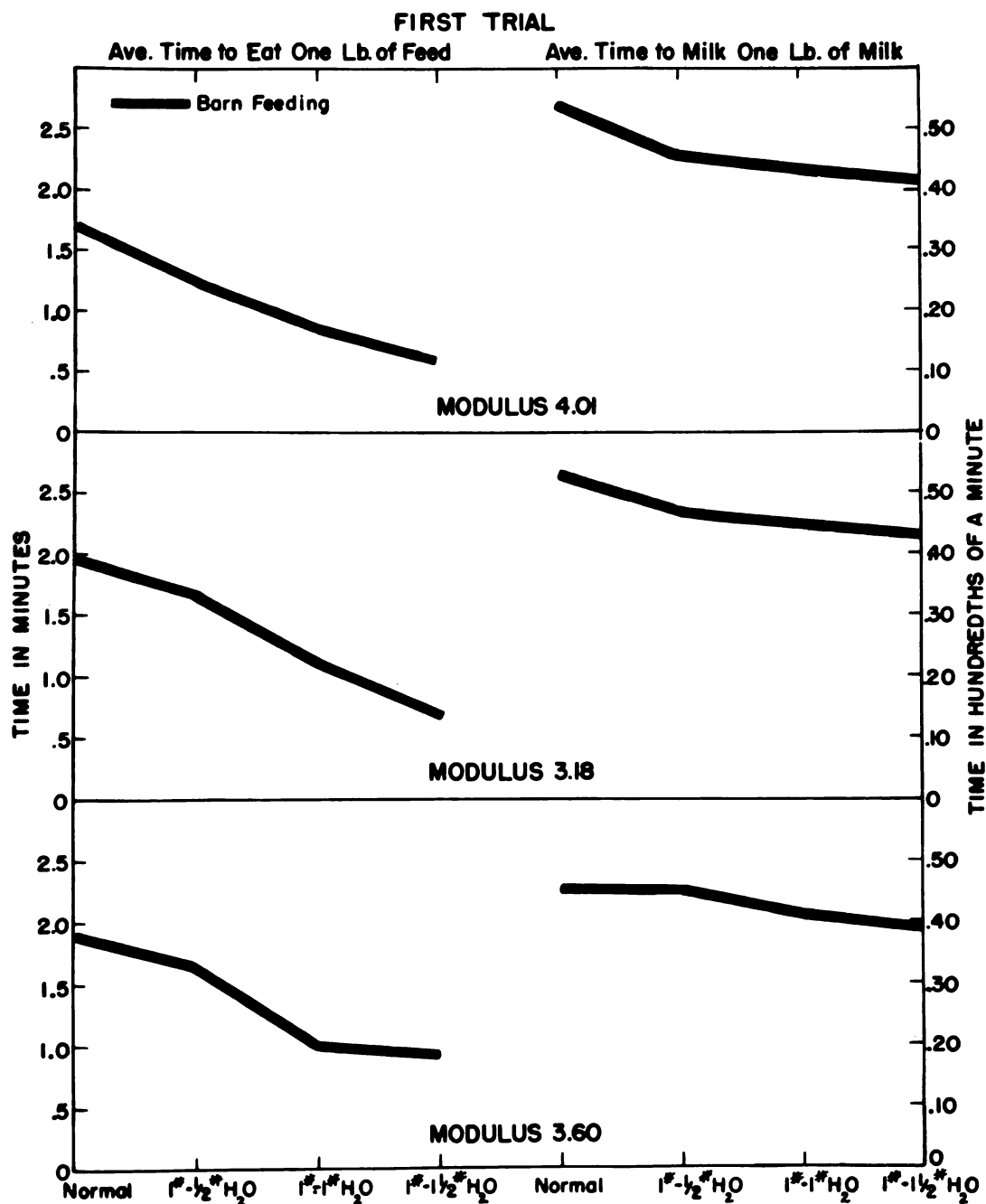


Figure 4

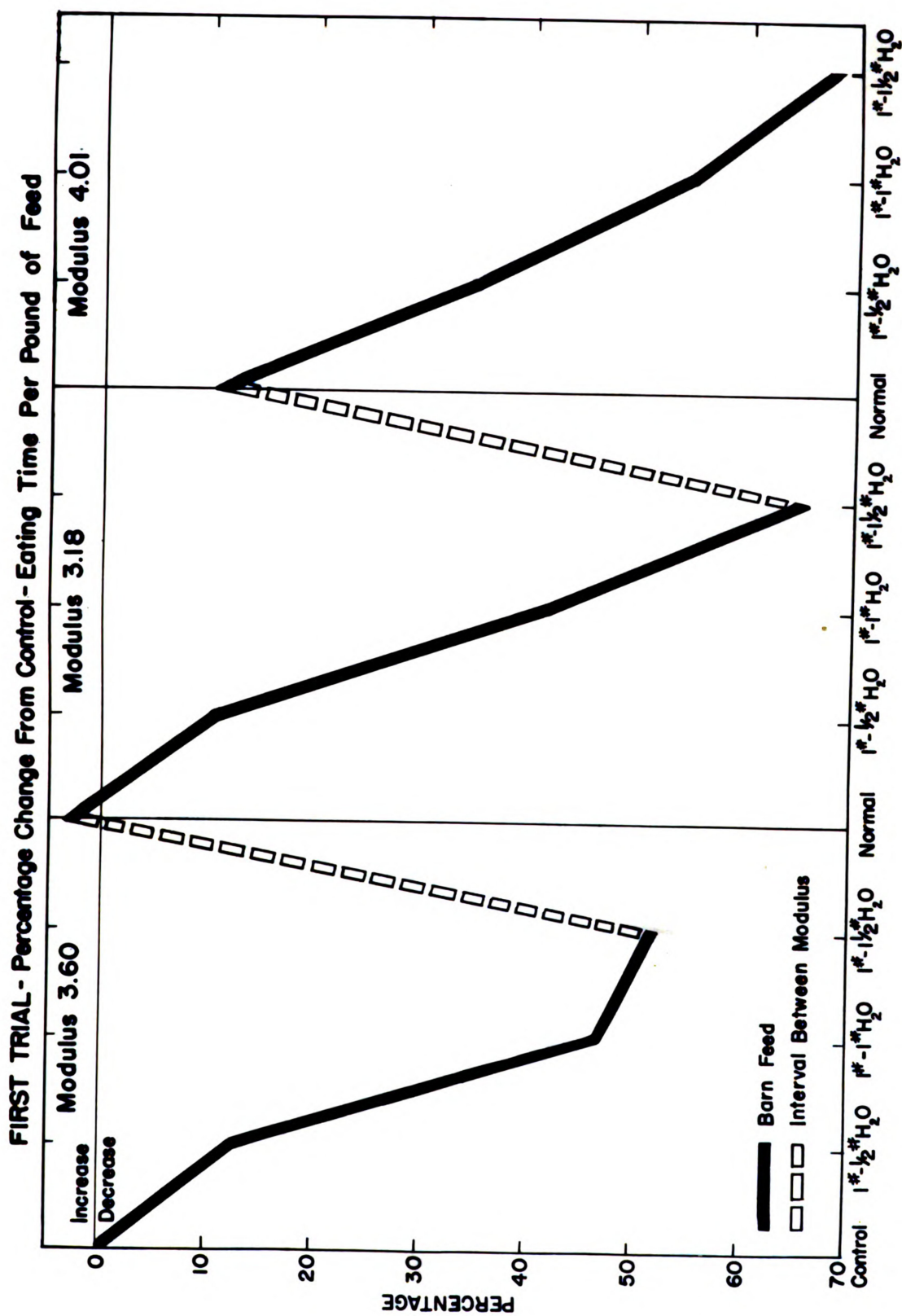


Figure 5

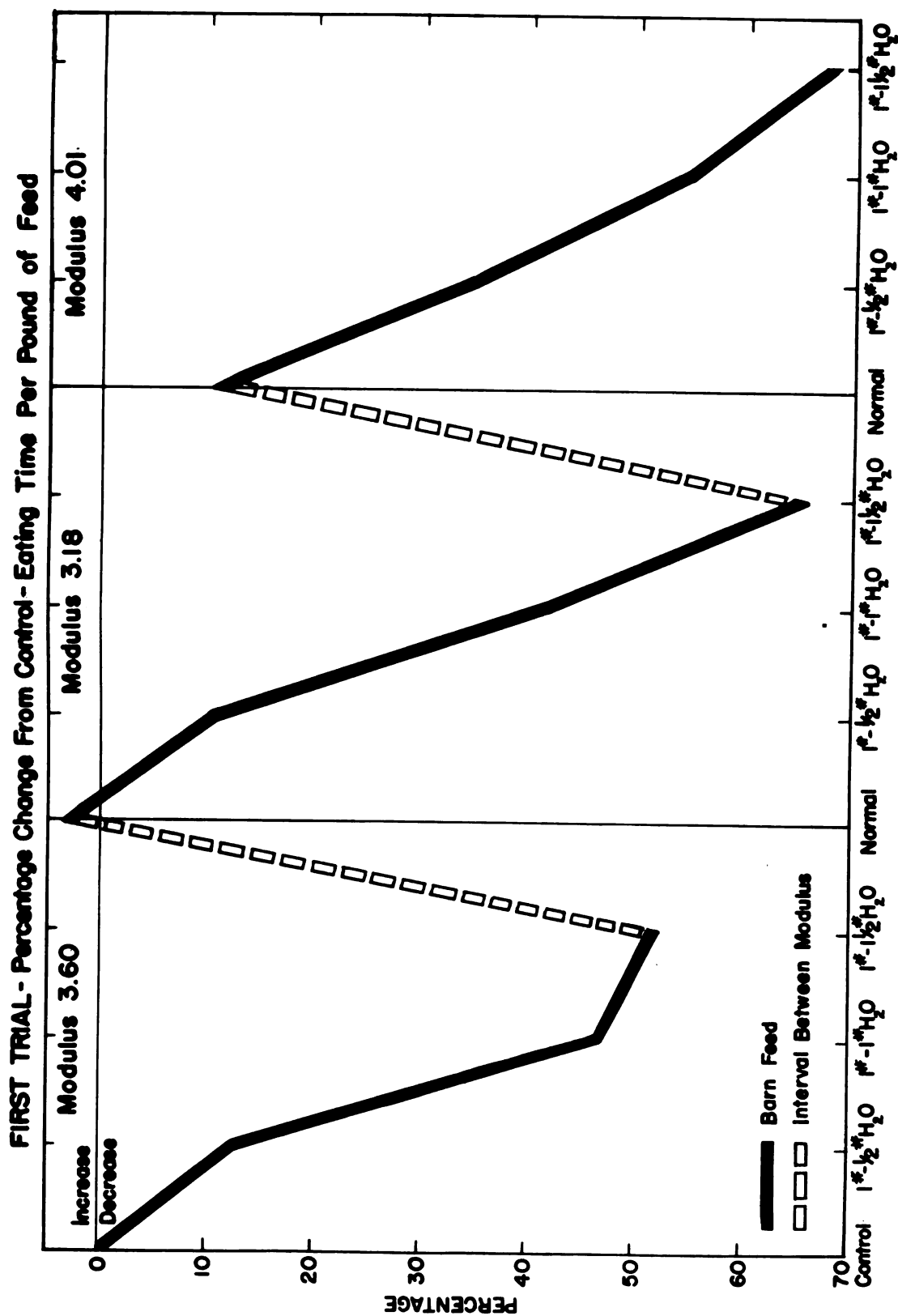


Figure 5

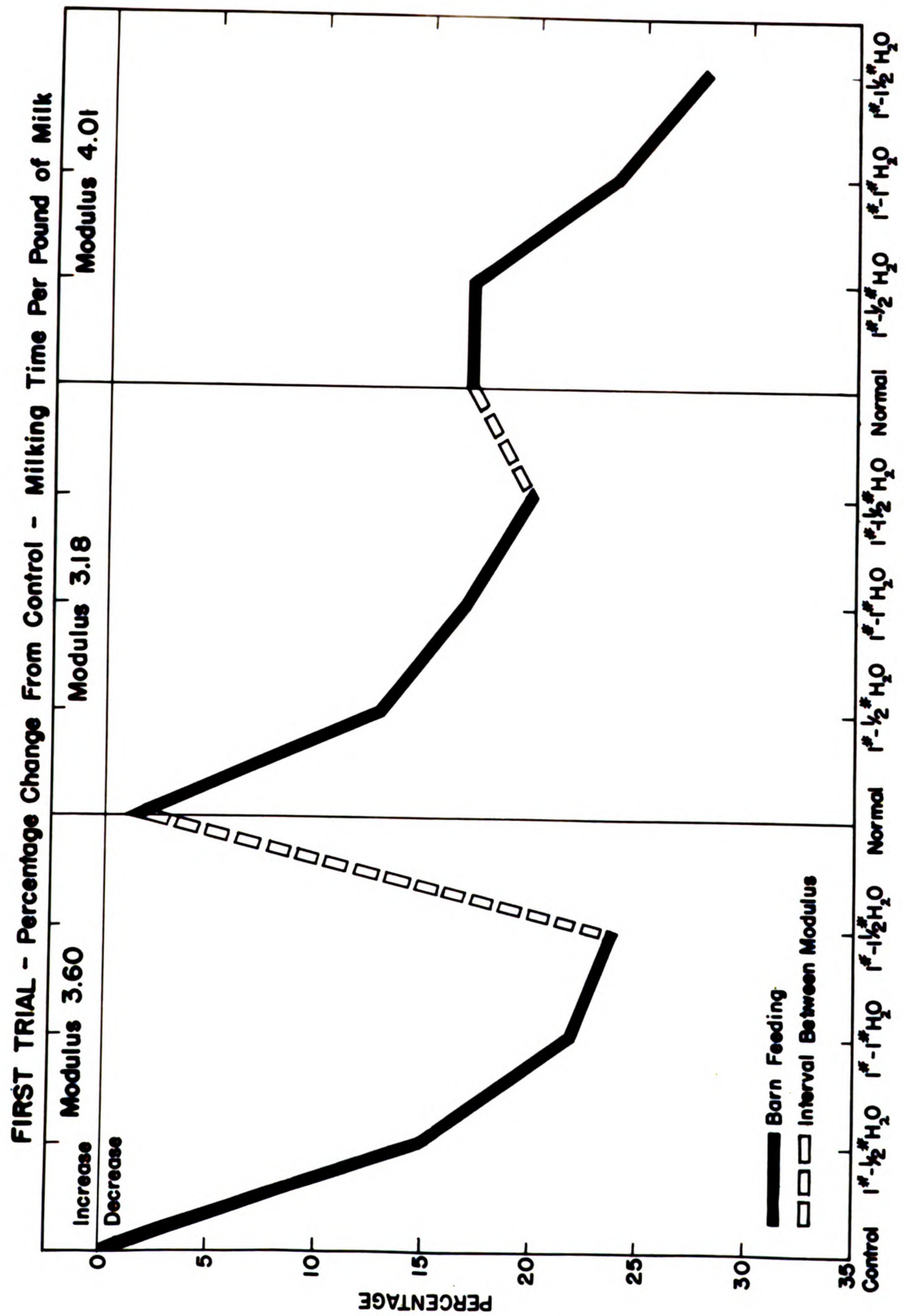


Figure 6

throughout the period of feeding each modulus and each series of changes of water-to-feed ratios. The decrease in time on a minute basis is shown in Figure 4, and on a percentage basis in Figure 6. When the 4.01 modulus was fed at normal moisture and at a ratio of 1/2 pound of water per pound of feed, the milking time was essentially the same. However, there was a decrease in both periods from the control period. The largest decrease in eating time in all instances occurred when the feed had 1-1/2 pounds of water added per pound of feed. The largest decrease in milking time was reached when the feed had 1-1/2 pounds of water added per pound of feed.

Second Trial

The results of the second trial are presented in Table III and summarized in Table IV. There was a decrease in eating time at all water-to-feed ratios on the 3.60 modulus, as compared to the first trial. However, the same pattern of eating times was shown in the second trial as was shown in the first. With the 3.18 modulus there was not as wide a spread in the eating times with the various water-to-feed ratios as was shown in the first trial. The cows went on pasture during

TABLE III

SECOND TRIAL--SUMMARY OF EXPERIMENTAL DATA

Modulus	Water per lb. of Feed	Avg. Amt. Feed	Avg. Time of Eating	Avg. Time to Eat 1 lb. Feed	Avg. Milk Prod.
	(lb.)	(lb.)	(min.)	(min.)	(lb.)
3.60	Normal (14.0%)	5.27	8.32	1.54	16.02
	1/2	5.16	6.52	1.22	16.17
	1	5.04	3.90	0.77	16.98
	1-1/2	8.08	3.54	0.69	15.57
3.18	Normal (14.2%)	4.87	7.90	1.61	17.65
	1/2	4.80	6.45	1.33	17.55
On pasture	1	4.49	5.46	1.23	16.92
On pasture	1-1/2	4.55	5.00	1.09	18.84
4.01	Normal				
On pasture	(14.1%)	4.12	10.02	2.51	18.24
On pasture	1/2	4.34	7.56	1.73	18.60
On pasture	1	4.00	4.90	1.22	19.26
On pasture	1-1/2	4.45	3.45	0.77	19.18
3.60					
Control on	Normal				
pasture	(14.1%)	3.94	9.51	2.41	20.77
On pasture	1-1/2	4.77	3.40	0.71	20.18

TABLE III (Continued)

Avg. Time of Milk- ing	Avg. Time to Milk 1 lb.	Avg. Time of Stim- ulation	Avg. Temp. Loaf- ing Area Barn	Avg. Temp. Out	Experi- mental Obser- vations
(min.)	(min.)	(min.)	(° F.)	(° F.)	(no.)
7.10	0.44	1.9	44	43	66
5.93	0.36	2.1	57	60	66
5.44	0.31	2.0	56	52	66
5.49	0.35	2.0	53	52	66
7.59	0.43	2.0	52	53	62
7.58	0.42	2.0	59	56	66
5.72	0.33	2.0	59	59	66
6.24	0.32	2.0	53	51	66
7.64	0.41	2.0	53	51	56
7.35	0.39	2.0	52	51	66
6.87	0.35	2.0	50	51	66
5.22	0.26	2.0	56	59	54
8.88	0.42	2.0	56	58	108
6.10	0.30	2.0	52	53	54

TABLE IV

SECOND TRIAL--COMPARISON OF EATING AND MILKING TIMES WITH CONTROL

Modulus	Water per lb. of Feed	Avg. Time to Eat 1 lb. Feed	De- crease	Change from Con- trol Feed	Avg. Time to Milk 1 lb.	De- crease	Change from Con- trol Milk
	(lb.)	(min.)	(%)	(%)	(min.)	(%)	(%)
3.60	Normal (13.8%)	1.54		36	0.44		-5
	1/2	1.22	15	49	0.36	18	14
	1	0.77	50	68	0.31	30	26
	1-1/2	0.69	55	71	0.35	20	14
3.18	Normal (14.2%)	1.61		33	0.43		-2
	1/2	1.33	17	45	0.42	2	0
	1	1.23	24	49	0.33	23	21
	1-1/2	1.09	32	55	0.32	26	24
4.01	Normal (14.1%)	2.51		-4	0.41		2
	1/2	1.73	31	28	0.39	5	7
	1	1.22	51	49	0.35	15	17
	1-1/2	0.77	69	68	0.26	37	38
3.60	Normal (14.1%)	2.41			0.42		
	Control on pasture						
	1-1/2	0.70	70	70	0.30	29	29

this period and they did not eat grain as rapidly as they did while being barn fed and had free access to roughage. When the 4.01 modulus was fed there was an increase in eating time as compared to the control period and the other moduli fed at normal moisture. The other water-to-feed ratios of the 4.01 modulus showed the same pattern of decrease in eating times as was obtained in the other two moduli both in the first and second trials. The cows required more time to eat the control feed when they were on pasture than they did when being barn fed. However, when the 3.60 modulus was fed at the ratio of 1-1/2 pounds of water per pound of feed, the decrease in eating time was the same when the cows were on pasture as when they were being barn fed. The resulting changes in eating times are shown in Table V. The eating time is shown graphically in Figure 7 and on a percentage change basis in Figure 9.

The cows showed the same pattern of decreased milking time in this trial as was shown in the first trial. When each modulus had the ratio of water to feed increased, the milking time decreased along with the decrease in eating time. These results are shown on a time basis in Table V and graphically

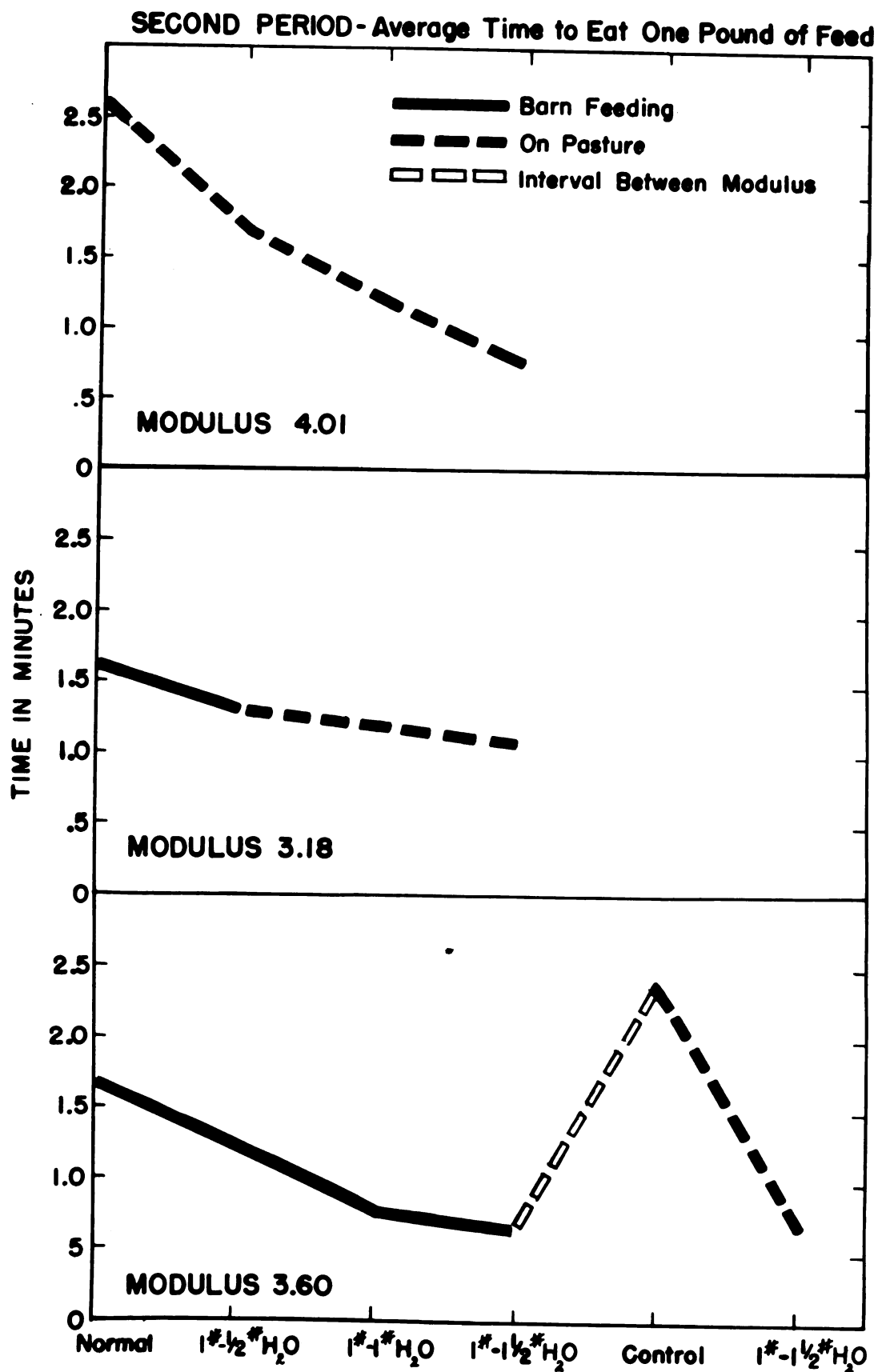
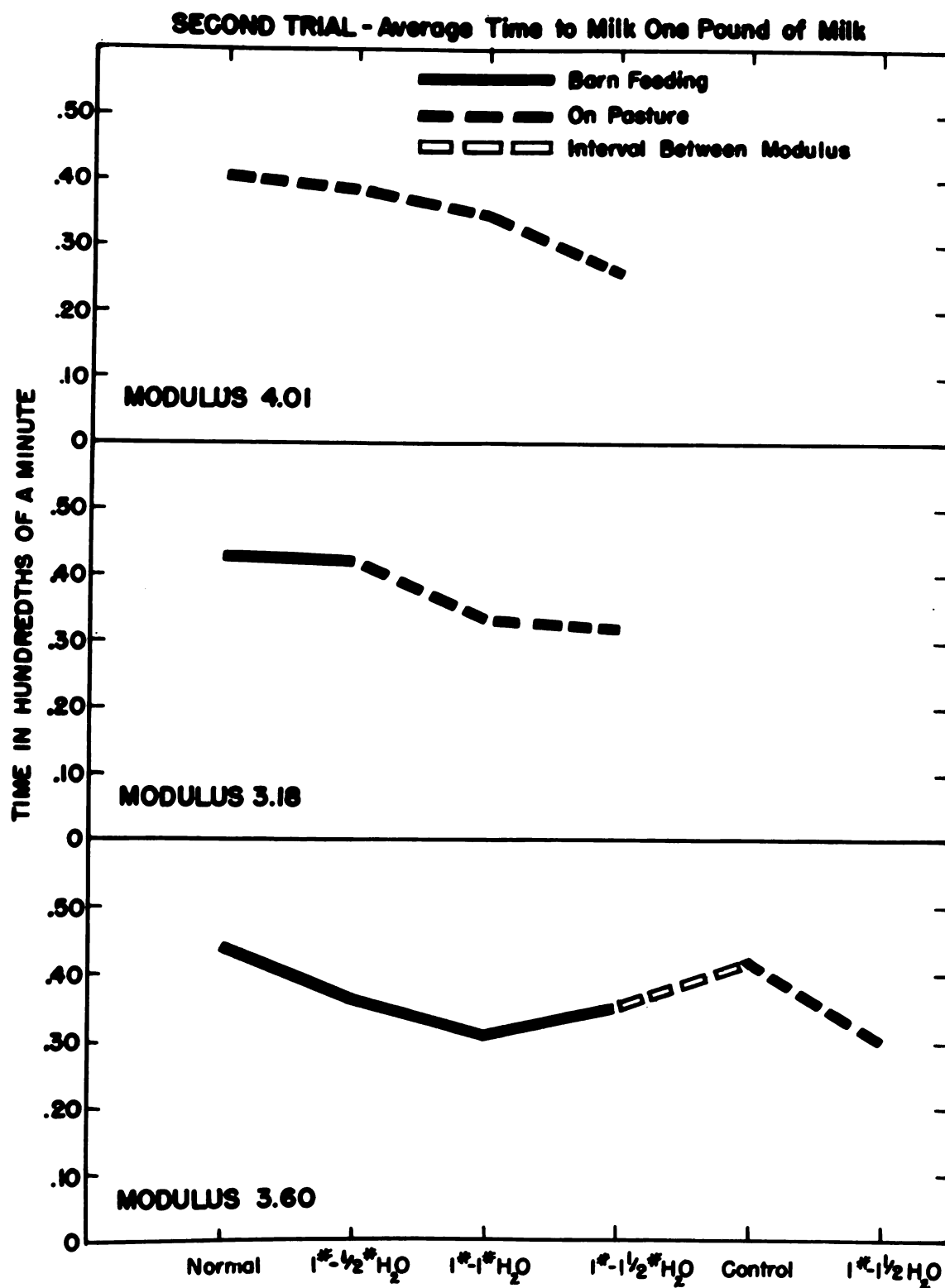


Figure 7



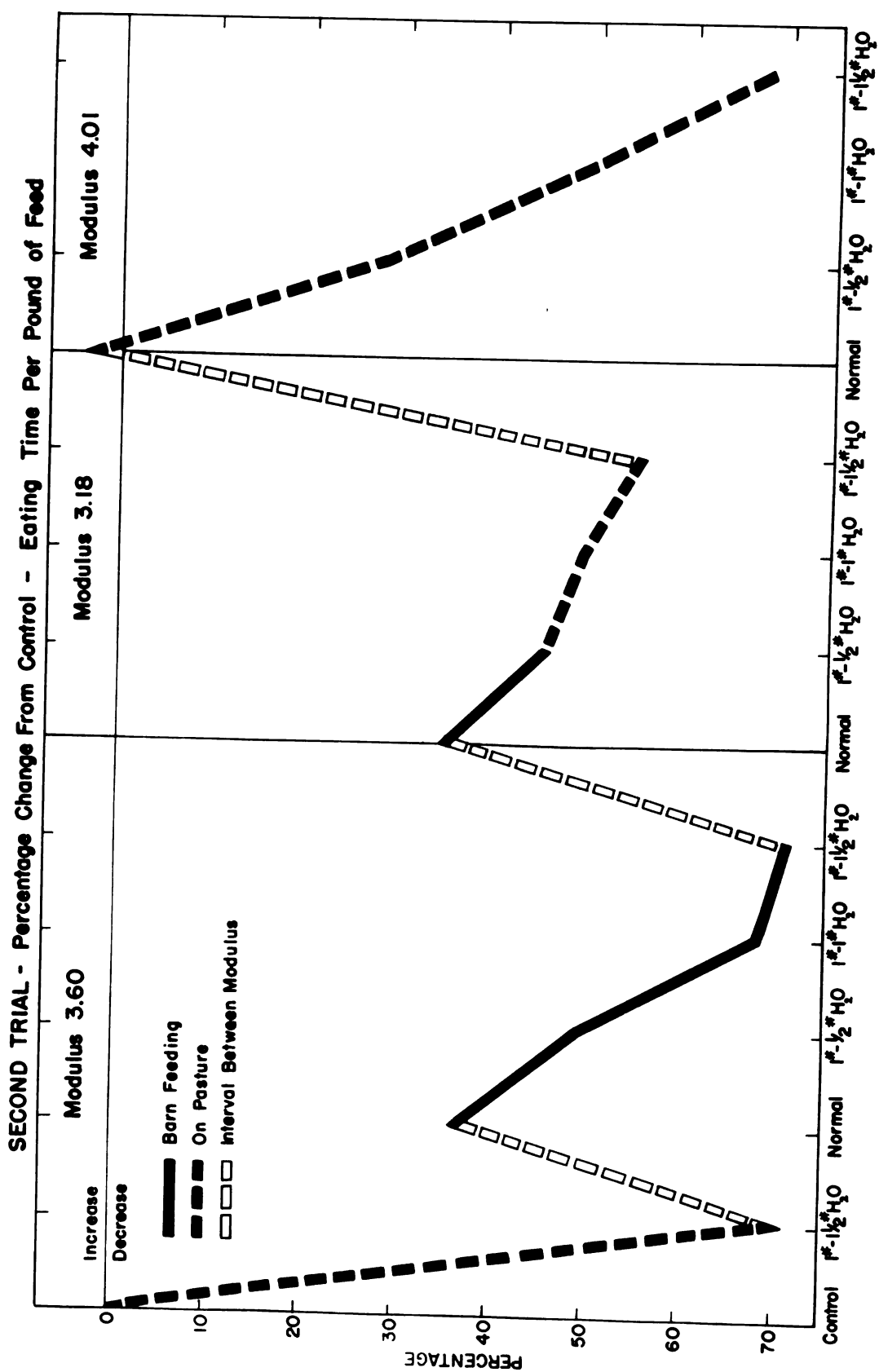


Figure 9



in Figure 8. They are shown on a percentage change basis in Figure 10.

The data for milking time for modulus 3.60, 1-1/2 pounds of water per pound of feed, when the cows were not on pasture, was not collected under conditions comparable to those under which the remainder of the data in this experiment were collected. During this period a new relief milker, not familiar with the routine, was doing the milking. Although the milking time and eating time during his 3 days of relief were in line with prior and subsequent periods, the volume of milk during this period was 8.4 percent less than that for the previous 3 days and 11.8 percent less than that for the subsequent 3 days. This information may be noted in Table III. Failure to properly massage the cows' udders during the final portion of the milking period was the probable reason for the decrease in milk produced per cow.

Stimulation Trial

In the experiment to determine the effects of different periods of stimulation, varying from 1/2 minute to 6 minutes, no differences attributable to the change in the interval after

stimulation were noted. The pattern of eating was the same as that shown in the other two trials. These results are shown in Table V and summarized in Table VI. The time of eating for each modulus is shown in Figure 11, and is shown on a percentage basis in Figure 13. The decrease in milking time, in minutes, for each modulus and the time of stimulation are shown in Figure 12. The percentage change and time of stimulation are shown in Figure 14. The decrease in milking time followed the decrease in eating time, regardless of the length of the stimulation period.

TABLE V

STIMULATION TRIAL--SUMMARY OF EXPERIMENTAL DATA

Modulus	Water per lb. of Feed	Avg. Amt. Feed	Avg. Time of Eating	Avg. Time to Eat 1 lb. Feed	Avg. Milk Prod.
	(lb.)	(lb.)	(min.)	(min.)	(lb.)
3.60	Normal (14.0%)	6.00	8.25	1.37	17.98
	1/2	6.10	6.20	1.03	17.17
	1	6.00	4.50	0.75	18.04
	1-1/2	6.00	3.20	0.53	18.16
3.18	Normal (14.2%)	6.00	7.50	1.24	17.71
	1/2	6.00	5.91	0.98	18.48
On pasture	1	5.41	4.55	0.92	17.97
On pasture	1-1/2	5.00	3.90	0.78	19.13
4.01	Normal (14.1%)	4.83	9.08	1.91	19.84
On pasture	1/2	5.00	5.58	1.10	19.44
On pasture	1	5.00	5.02	1.00	20.46
On pasture	1-1/2	5.00	2.75	0.55	20.70
3.60	Normal (14.1%)	4.83	8.83	1.84	21.04
Control on pasture	1-1/2	5.00	3.20	0.64	20.01

AL DATA

TABLE V (Continued)

Avg. ME Prod	Avg. Time of Milk- ing	Avg. Time to Milk 1 lb.	Avg. Time of Stim- ulation	Avg. Temp. Loaf- ing Area Barn	Avg. Temp. Out	Experi- mental Obser- vations
(lb.)	(min.)	(min.)	(min.)	(° F.)	(° F.)	(no.)
17.45	7.62	0.42	2.0	44	43	12
17.7	6.30	0.37	2.0	57	60	12
18.3	5.40	0.30	0.5	52	57	12
18.3	5.20	0.28	1.0	52	52	12
17.7	7.30	0.41	1.0	53	52	12
18.4	7.41	0.40	3.0	56	59	12
17.8	5.25	0.29	3.0	59	59	12
19.1	5.08	0.26	3.0	51	53	12
18.9	7.83	0.39	4.0	51	53	12
18.4	7.25	0.37	4.0	51	52	12
20.4	6.12	0.29	5.0	50	51	12
20.7	4.50	0.21	6.0	56	59	12
21.04	8.58	0.40	2.0	56	58	24
20.01	4.27	0.21	2.0	52	53	12

TABLE VI

STIMULATION TRIAL--COMPARISON OF EATING AND MILKING TIMES WITH CONTROL

Modulus	Water per lb. of Feed	Avg. Time to Eat 1 lb. Feed	De- crease	Change from Control	Avg. Time to Milk 1 lb.	De- crease	Change from Control	Time of Stim- ulation
	(lb.)	(min.)	(%)	(%)	(min.)	(%)	(%)	(min.)
3.60	Normal	1.37		26	0.42		-5	2.0
	(13.8%)							
	1/2	1.03	25	44	0.37	12	8	2.0
	1	0.75	45	59	0.30	29	25	0.5
	1-1/2	0.53	61	71	0.28	33	30	1.0
3.18	Normal	1.24		33	0.41		-2	1.0
	(14.2%)							
	1/2	0.98	21	47	0.40	2	0	3.0
	1	0.92	26	50	0.29	29	28	3.0
On pasture	1-1/2	0.78	37	58	0.26	37	35	3.0
4.01	Normal	1.91		-4	0.39		2	4.0
	(14.1%)							
	1/2	1.10	42	40	0.37	5	8	4.0
	1	1.00	48	46	0.29	26	28	5.0
On pasture	1-1/2	0.55	71	70	0.21	46	48	6.0
3.60	Normal	1.84			0.40			2.0
	(14.1%)							
	1-1/2	0.64	65	65	0.21	48	48	2.0

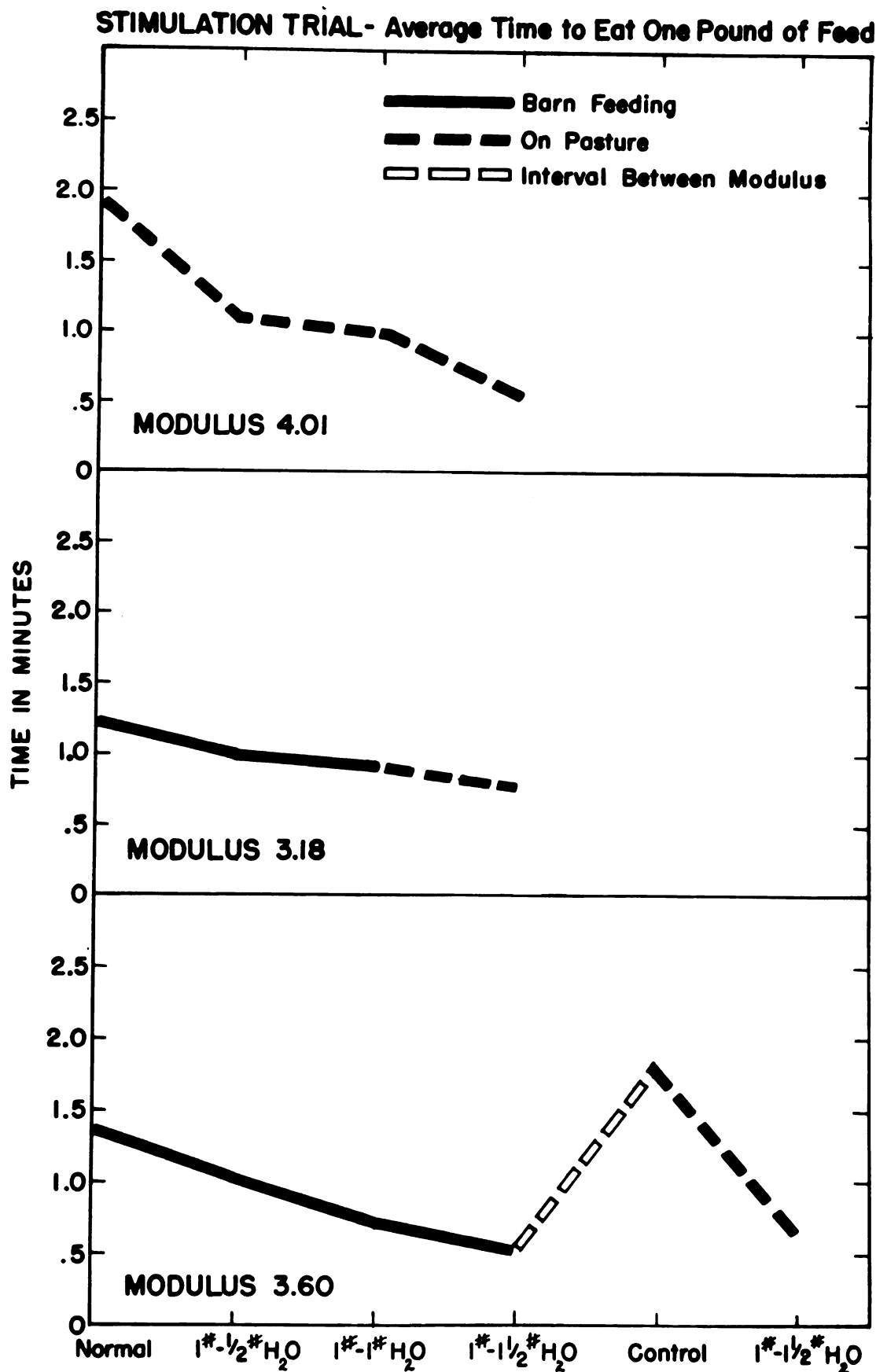


Figure 11

STIMULATION TRIAL- Average Time to Milk One Pound of Milk

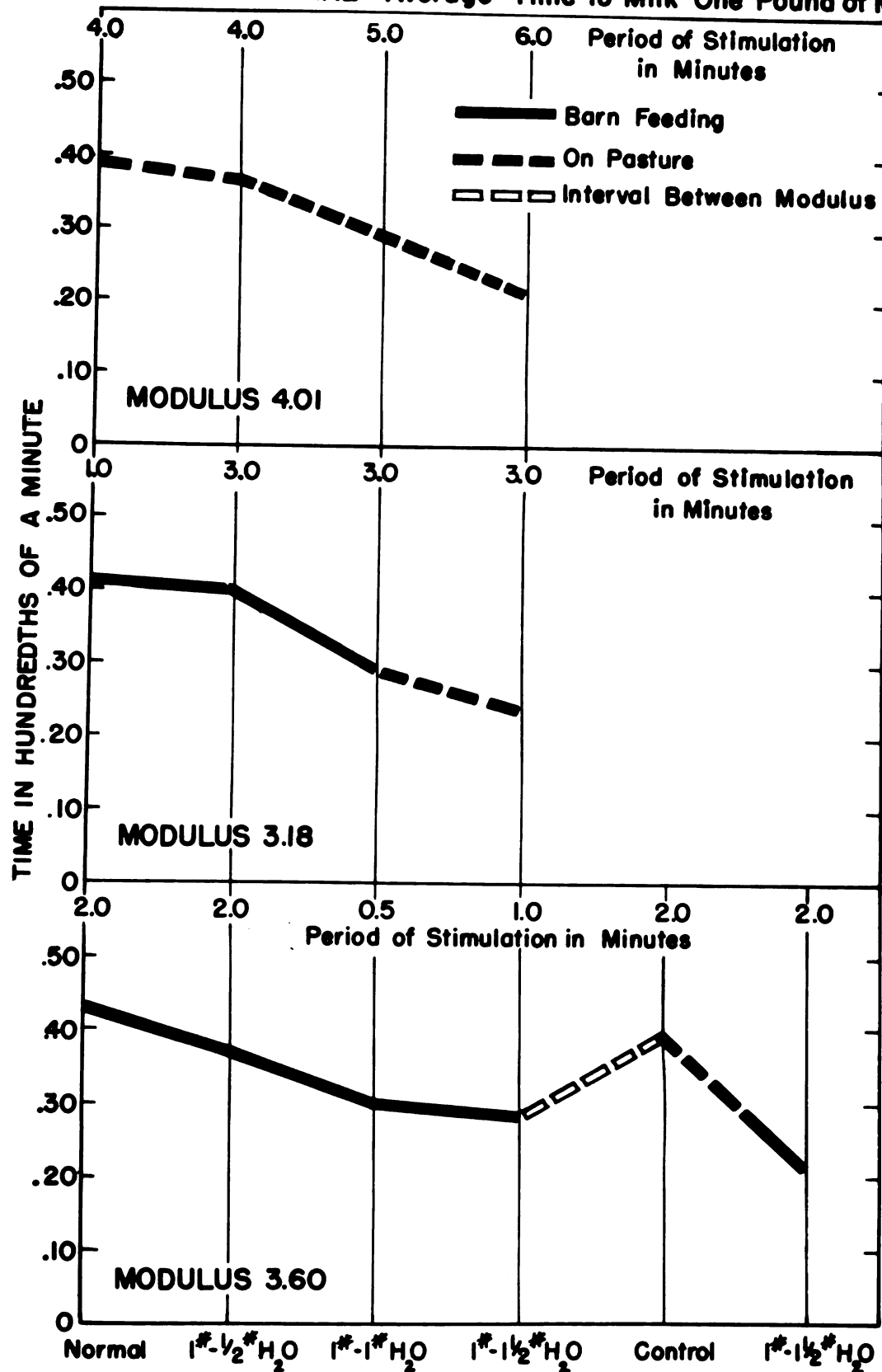


Figure 12

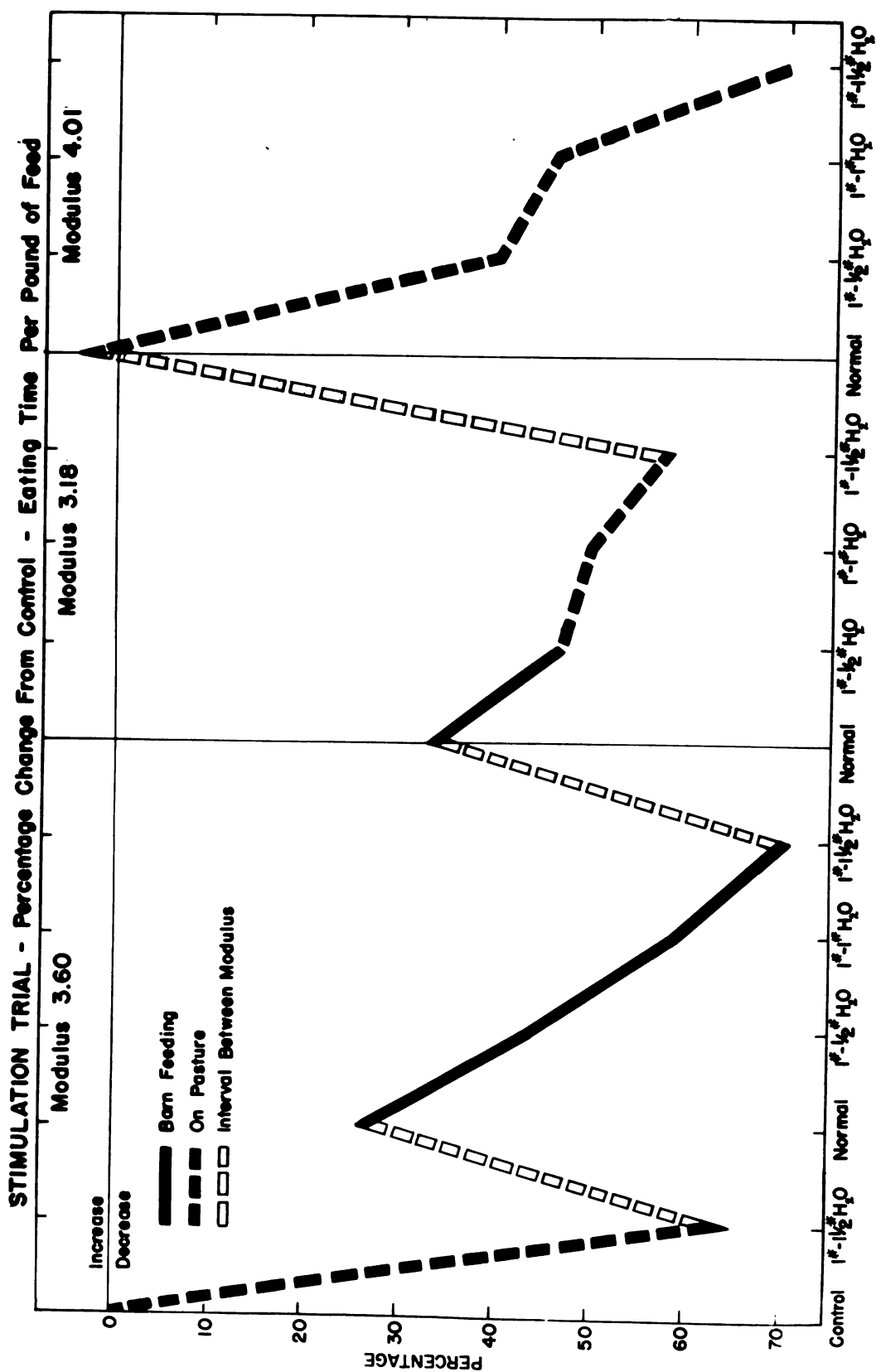


Figure 13

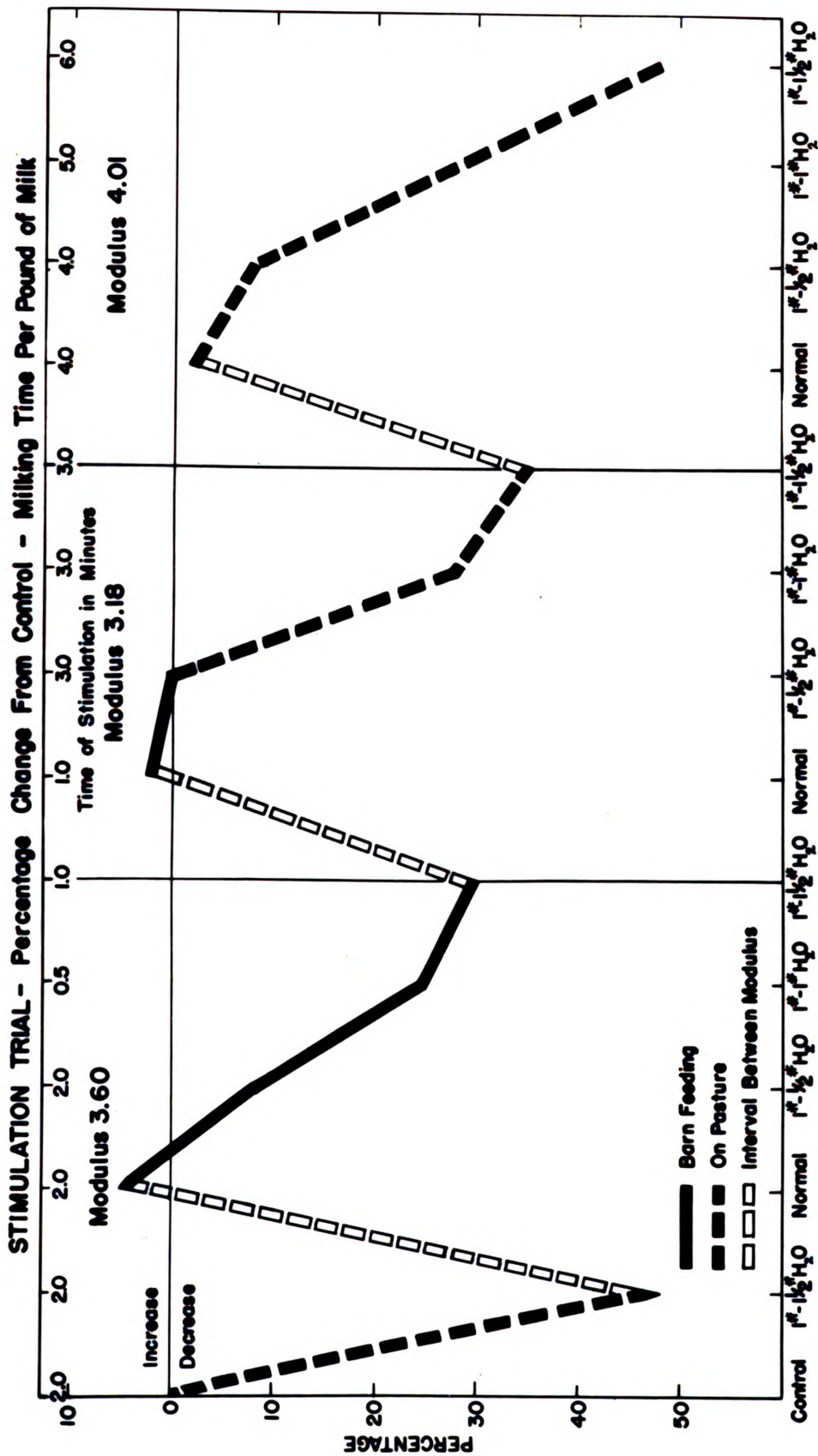


Figure 14

DISCUSSION

First Trial

The cows took longer to eat feed with a modulus of 3.18 when fed at normal moisture than they did the 3.60 modulus feed, because of the increased need for saliva. Since the modulus 3.18 was finer it apparently took more saliva with which to moisten the grain sufficiently for swallowing. As the modulus increased, the grain did not have as much surface area per unit of weight. Therefore, the cow neither had to keep the feed in her mouth as long a time nor use as much saliva to moisten it sufficiently for swallowing. Careful observation of the cows while eating revealed that when each modulus was fed at normal moisture the cows did not pick up the feed with their mouths but with their tongues. The tongue was placed in the feed and the amount that stuck to the tongue was drawn into the mouth.

When 1/2 pound of water was added per pound of feed, the mixture was sticky and tended to ball up. Many dry particles were enclosed in a wet coating. When each modulus was fed at this water-to-feed ratio the cows used their tongues to

pull the feed into their mouths. It was not picked up by the tongue. The cows could get more feed into their mouths when the feed was sticky and partially moistened. The addition of water brought about a decreased eating time since less moisture was required to condition it for swallowing.

The eating time was decreased further when the ratio of water to feed was increased to 1:1. The cows used a different method of prehension with this ratio than they did when less water was used, regardless of the modulus. The feed of all moduli was completely moist. The cows put their mouths into the feed and swallowed the amount that was enclosed in the mouth each time it was opened and closed. However, the movement of the jaws was not as rapid as was observed in the first two water-to-feed ratios. The cows did not need to moisten the feed with saliva and they could swallow it immediately. Therefore, because of the larger mouthful and elimination of moistening time in the mouth, there was a decreased eating time.

When 1-1/2 pounds of water were added per pound of feed, the feed was sloppy in the case of the 3.18 modulus and very sloppy in the case of the 4.01 modulus. The cows drank

the feed at this water-to-feed ratio for all moduli. They then used their tongues to clean out the mangers. Very little jaw movement was noted until the last of the feed was consumed. Due to the ease of getting the feed into the mouth and the fact that the animal did not need to moisten the feed, there was a very great decrease in eating time below that required for feed of normal moisture content.

It was observed that the main factor causing variations between the eating times of various cows and also of the herd as a whole was the degree of hunger. Two cows in the herd (367 and 369) required more time to eat when fed at all water-to-feed ratios and at all moduli than did the other cows of the herd. It was observed that they were always eating hay in the morning and at night just prior to the time of milking. The other cows were seldom, if ever, eating at these times. It seemed that these two cows had eaten so much hay that they were not hungry when they came into the milking parlor. Their long milking times corresponded to their long eating times. When these cows came into estrus they were restricted to an individual box stall. They were fed some hay but did not have silage during these days. When Cow 369 was in estrus and

kept in the box stall she showed a 71 percent decrease in eating time and a 48 percent decrease in milking time for the following milking, as compared to the next milking when she had had free choice of hay and her usual ration of silage. Cow 367, under the same estrus conditions, showed a 68 percent decrease in eating time and a 47 percent decrease in milking time, as compared to the next milking, when she had free choice of hay and silage. Another example of the influence of hunger occurred when the herd was fastened in the barn loafing area to permit the cleaning of the exercise lot. The cows were fastened in the barn at 9:00 a.m. They had eaten most of the silage ration for the day. They did not have access to hay during the day. At the afternoon milking there was a decrease in eating time of 39 percent and a decrease in milking time of 13 percent as compared to the morning milking. Other examples of the hunger factor were observed, but the ones given were the most outstanding.

The decreased time of milking, as related to a decreased time of eating, is very difficult to explain. It is likely, however, that the decreased milking time was the result of a decreased eating time. To substantiate this theory, an observation

is presented. In all cases where the cows failed to eat any feed while in the milking parlor it took a longer time to milk them, on a per-pound basis, than it did to milk them when they did eat. This was true at all water-to-feed ratios for all moduli. When a cow did not eat, the data for that milking were not included in the 3-day average.

No previous reports have mentioned a decrease in milking time as related to a decrease in eating time. No data obtained during this experiment indicated how this phenomenon took place. However, it is believed that it was brought about by two things: (1) a conditioned reflex, and (2) an increased feeling of satisfaction associated with the ease of eating. As brought out earlier in this report, the cows were fed at the same time that the teat cups were put on. Therefore, the act of eating served as the stimulus for the let down of milk. This conditioned reflex of eating and letting down the milk at the same time replaced the other stimuli for the let-down process. With regard to the increased feeling of satisfaction, it is believed that the cows relaxed more when they could eat faster and did not have to use their own energy to moisten the feed enough to swallow it. Both the conditioned reflex and the feeling

of satiety probably work through the endocrine system to cause the cow to decrease her milking time through faster let down.

Second Trial

The discussion of the first trial covers the same points for the second trial, also, from the standpoint of relationship of the eating time to milking time. However, it should be pointed out that when the cows went on pasture there was not as great a decrease in eating time for the 3.18 modulus fed at the ratios of 1 pound and 1-1/2 pounds of water per pound of feed as was obtained when the cows were not on pasture. It appeared that the cows were too full of grass to be hungry. When the 4.01 modulus was fed at normal moisture the cows took longer to eat it than they did to eat the control feed, modulus 3.60. This may be explained by the fact that the cows were on good grass, had just been changed from a period in which the ratio was 1-1/2 pounds of water per pound of grain, and did not adjust quickly to the grain containing a normal amount of water. They became adjusted to the control feed, fed at normal moisture, within the 6 days and were eating it faster at the close of the period than they did for the first few

feedings. The general pattern of decreased eating time was the same for each modulus, and the same pattern as was shown in the first trial.

The decreased milking time followed the same pattern for each modulus fed at the same water-to-feed ratio. As was noted in the first trial, the greatest decrease in milking time was obtained when the water-to-feed ratio was 1-1/2 pounds of water per pound of feed.

The effect of the pasture was to slow down both the eating and milking processes, probably because the cows were not hungry. However, when the water-to-feed ratio was increased, the cows again showed the same relative decrease in eating and milking times as when they were being barn fed.

Stimulation Trial

The two cows in this trial followed the same pattern in eating and milking times as did the cows in the other two trials. The different intervals of stimulation had no effect upon the let down of milk during this trial. It is granted that the number of cows used was too small to be conclusive. However, the evidence should be considered as an indication. As was the

case throughout the experiment, the teat cups were put on the cow at the time of feeding. Therefore, it appears that the stimulus for let down of milk came from the eating of feed rather than the previous stimulation of the udder. The fact that the decrease in milking time was slightly greater for a 6-minute stimulation than for a 1/2-minute stimulation bears this out. The decreased milking time followed the decreased eating time, and not the period of stimulation. The results of this trial are in agreement with conclusions reported by Smith and Petersen (1948) and by Ward and Smith (1949), but they do not agree in full with the work of Knoop and Monroe (1950), who found that a regular interval was necessary to obtain a maximum let down of milk.

These two animals ate faster and milked faster than the other animals but showed the same relative decrease in both milking and eating times as the other animals did. The effect of the pasture was to slow down eating and milking times due to the probability that they were not as hungry when they came into the milking parlor. However, when the ratio of 1-1/2 pounds of water per pound of feed was fed, they showed a sharp decrease in eating and milking times.

SUMMARY AND CONCLUSIONS

Two experimental trials were run to determine the effects of four different water-to-feed ratios and three different moduli of grain rations upon the eating time and the milking time of dairy cows. One trial was run while the cows were being barn fed and one was run during the change-over from barn feeding to pasture. Another experimental trial was run to determine the effects of different periods of udder stimulation upon the let down of milk, in connection with the effects of different amounts of water in feed and different moduli as pertained to the eating and milking times.

There was no change of any note in the eating time for the three different moduli of fineness. As the water per pound of feed was increased, there was a concurrent decrease in eating time for each modulus. As the eating time decreased, there was a corresponding, but not directly proportional, decrease in milking time. The cows ate normal-moisture feed more slowly on pasture than they did when they were barn fed. When the water-to-feed ratio was 1-1/2 pounds of water per pound of feed the eating time on pasture was relatively the same as when

the cows were barn fed; the milking time when the cows were on pasture showed a decrease as compared to the time they were not on pasture. The proportional change was nearly the same for each water-to-feed ratio.

Periods of stimulation varying from 1/2 minute to 6 minutes made no noticeable difference in their effect upon the let down of milk. The cows responded to the increased water-to-feed ratio, as in the other two trials, rather than to the period of stimulation.

Cows fed grain with a modulus of fineness to which grains are commonly ground can consume the grain they require while in the milking parlor if it is mixed with water at a ratio of 1-1/2 pounds of water per pound of grain. It is concluded that an increased rate of eating results in a decreased milking time.

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