Confinement Feeding of Dairy Cows Based on Stargrass as Green Chopped Fodder or Hay[1]

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ABSTRACT

Thirty Holstein and Brown Swiss cows, managed in full confinement in 6 groups of 5 each, were offered ad libitum either green fodder, chopped in the field daily (A) or baled hay (B), averaging 6.21 and 5.59% crude protein (CP) in the dry matter (DM), respectively. Both forages were harvested at intervals exceeding 55 days, from fertilized nonirrigated swards of relatively pure stargrass (*Cynodon nlemfuensis*). Individual supplementation consisted of an 18% CP commercial concentrate, fed at l kg per 2.2 kg of milk produced daily above 6 to 7 or 4 to 5 kg in treatments A and B, respectively, plus 1 kg extra for first lactation cows; minimum daily allowance was arbitrarily set at l kg. Each cow commenced the 168-day experiment 3 weeks after calving. Mean results from 27 animals completing the experiment in treatments A and B (13 and 14 cows) were as follows: proportion of forage DM wasted, 26.1 vs. 18.3%; daily DM intake (DMI) from forage and from concentrates, 10.71 and 2.85 kg vs. 9.92 and 3.14 kg; daily total DMI relative to liveweight (LW), 3.28 vs. 3.11%; daily LW loss, .022 vs. 0.026 kg; daily milk production, 11.00 vs. 9.97 kg; weekly percentage decline in milk yield, 3.61 vs. 3.94; DMI/4% fat-corrected milk produced, 1.40 vs. 1.39 (kg/kg); percentage contents of milk fat and solids-not-fat, 3.21 and 8.11 vs. 3.29 and 8.22, respectively. No differences between treatments were significant (P>0.05). Animal performance was poor in spite of relatively high DMI, indicating inadequate nutritive value of both forages. Higher quality forage, possibly stargrass under irrigation cut at earlier maturity, or more liberal concentrate supplementation would be needed for reasonable production with this type of ration.

INTRODUCTION

Sale of milk generates more income at the farm level in Puerto Rico than any other agricultural product, but the local dairy industry has the disadvantage of a heavy dependence on imported concentrate feeds. A more intensive use of grazed forages could reduce this dependency (19). Experimentation with confined cows fed mechanically harvested forages is also needed, because confinement feeding may become an increasingly important management system in Puerto Rico. Factors which might foster such a trend include the limited land resources of the island and the success of drylot dairying in other countries (4). The present experiment was conducted to test the possibility of employing stargrass from fertilized swards, fed to confined cows as either green fodder or hay, supple-

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mented with only moderate amounts of concentrates, as an alternative feeding system for milk production.

MATERIALS AND METHODS

Thirty cows that calved in the Lajas Substation herd from February to May 1983, including 19 Holstein and 11 Brown Swiss, 10 in first lactation and 20 multiparous, were used. At day 3 postpartum, the cows began a preliminary phase, usually of 18 to 22 days duration, but for a few cows it ranged from 16 to 25 days. Cows in this phase were individually offered 10 kg/day of a commercial concentrate in pelleted form, guaranteed to meet the following specifications: crude protein (CP), 18% minimum; ether extract, 2.5% minimum; crude fiber, 8% maximum. This liberal concentrate feeding was intended to enable the cows to express their initial productive potential. They also had access to green chopped fodder or hay for a few hours daily and grazed mixed gramineous swards together with nonexperimental cows during late afternoon and at night.

Cows completing the preliminary phase were assigned alternately to one of two treatments until 3 groups of 5 per treatment had been formed. Treatments differed in employing either (A) green chopped fodder or (B) baled hay, as the sole forage. Cows were housed in a concrete yard, located beneath a saran shade, and divided by chain-link fence partitions into rectangular 10.1 x 5.9 m pens, each equipped with a watering trough and a raised wooden feed bunk, 3.5 m long by 1.5 m wide and 0.4 m deep, with a metalic rack of sufficient capacity to hold a full day's offering of forage. Enough fresh green fodder or hay was supplied to allow ad libitum intakes. Each morning orts from the previous day were collected, weighed and sampled.

The cows left their respective pens only for 2 daily trips to the milking parlor. Following the a.m. milking they were placed in stanchion and allowed ample time to consume their allowance of concentrate. Individual allowances were calculated periodically, assuming that green fodder and hay provided for body maintenance plus production of 7 or 5 kg of milk daily, respectively. Each additional 2.2 kg of milk was assumed to require 1 kg of concentrate, and an extra 1 kg/day was provided to first lactation cows. A minimum concentrate supplement was arbitrarily set at 1 kg daily. After several months of experimentation assumed daily milk output from forage was reduced to 6 and 4 kg in treatments A and B, respectively.

Each cow remained on the experiment for 168 days, divided into six 28-day subperiods, except for 3 animals that failed to complete the full period. One cow in each treatment was eliminated when milk production nearly ceased and another cow in treatment A because of repeated bloating not related to the experimental treatment. During the final days of the preliminary phase and of each experimental subperiod, an aliquot of the milk of each cow was taken with a Milk-0-Meter.[R3] If a sufficient sample was not obtained from 2 consecutive milkings, the process was extended to 4 milkings. Contents of milk fat and solids-not-fat (SNF) were determined by the Babcock Method and lactometry (18). With approximately the same frequency, cows were weighed on one day, after consuming the morning concentrates, but before having access to drinking water. Animals beyond 60 days postpartum detected in estrus were bred artificially; detection was by casual observation only.

Most of the fields providing stargrass were harvested exclusively for green fodder or hay, but a few served both purposes during the experiment (essentially March through November). Most swards were fertilized trimonthly with approximately 0.56 metric tons/ha of 15-5-10 analysis. However, since irrigation was not used, herbage growth varied considerably with rainfall distribution and it was impractical to harvest at a fixed interval. Age of stargrass at harvest varied from 55 days upward, depending upon the time required to obtain a reasonable yield. Green chopping was usually done p.m. and the fodder fed the following a.m., but it was sometimes harvested for immediate use a.m. Daily chopping was difficult during occasional periods of heavy rains and resulted in mechanical damage to the sward. Hay from a number of different lots was used. Most of it was dried in the field under favorable conditions and stored only a short time prior to use.

All forage offerings and orts (both those left in the feed bunk and those recovered from the floor of the pens) were sampled daily. Green fodder and ort samples were dried immediately in an oven at 60°-80° C to determine dry matter (DM) content. Samples of hay offered and of concentrate were accumulated for 2 weeks or more before oven drying. Dried samples of orts recovered from the floor were discarded. Other dried samples were ground through a 1-mm screen and composited as follows: 2-week composites of forages offered, 4 to 6-week composites of forage orts, and approximately 3-month composites of concentrates. Contents of CP and ash (1) in these samples were determined.

Milk production and final LW data, in which the experimental unit was the individual cow, were subjected to analysis of covariance (13), with adjustment for corresponding values from the preliminary phase. Individual cow data on milk composition were subjected to analysis of variance appropriate to a nested design (pens in treatments). Forage DM intake (DMI) data, in which pens were the experimental units, were compared by unpaired *t* test (13). Regression analysis was used to esti-

[3]Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment of materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

mate rates of change in LW and milk production with time. In the latter case natural logarithms of the dependent variable (subperiod means) were employed.

RESULTS AND DISCUSSION

The DM content of green fodder offerings seldom remained stable for more than a few consecutive days, and on many occasions fluctuated drastically from one day to the next. A frequency distribution plot of 265 observations obtained from daily samplings (fig. 1), suggests either a bimodal distribution or a curve skewed to the right. The mean was 32.2% DM, but the mode was 39.5%. Forage chopped in the field early a.m. was always wet with dew and tended to have a lower DM content than that chopped p.m. This operation was conducted a.m. when the amount of green fodder required was rather small, i.e., during approximately the first 10 weeks (late February to early May) and again during the final

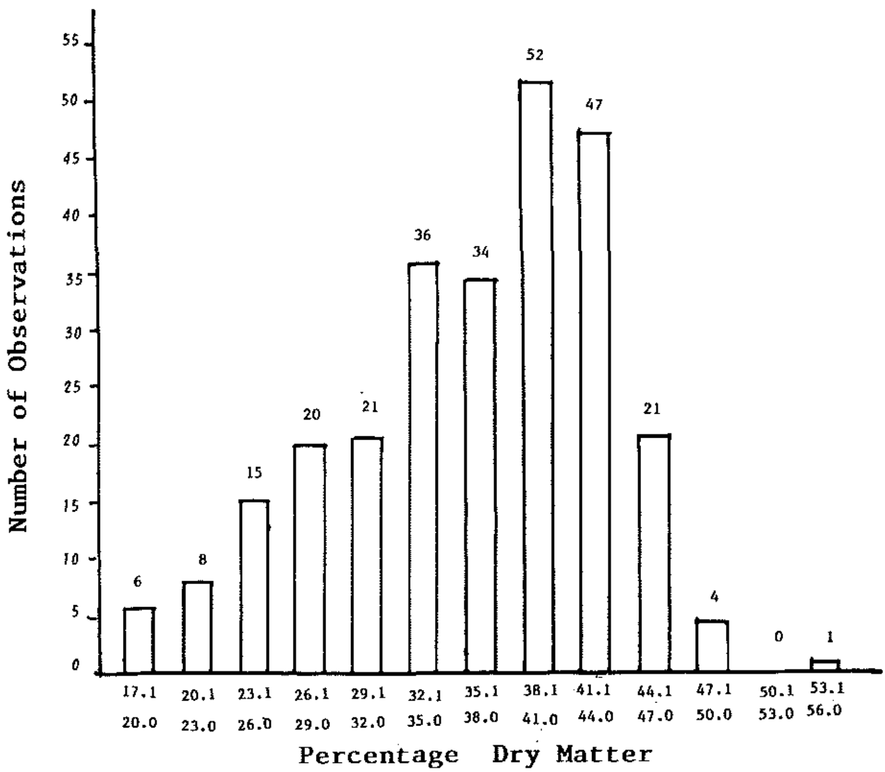

FIG. 1.—Frequency distribution of dry matter content in daily samples of green chopped fodder.

weeks in November; during the middle stages p.m., chopping was the rule (weather permitting). Figure 2 shows the trend in consecutive 2-week means of green fodder DM percentage.

Rainfall was another factor tending to reduce green fodder DM content on only a rather small proportion of days over-all. Precipitation registered during the successive months from February to November was as follows: 18, 121, 105, 243, 16, 31, 133, 39, 137, and 160 mm, totaling 1003 mm. An opposite effect on DM percentage of green fodder was exerted by the presence of a high proportion of dead material. This condition was not so obvious in forage offered, which usually presented a bright green color, but was quite evident in orts left in the feed bunk.

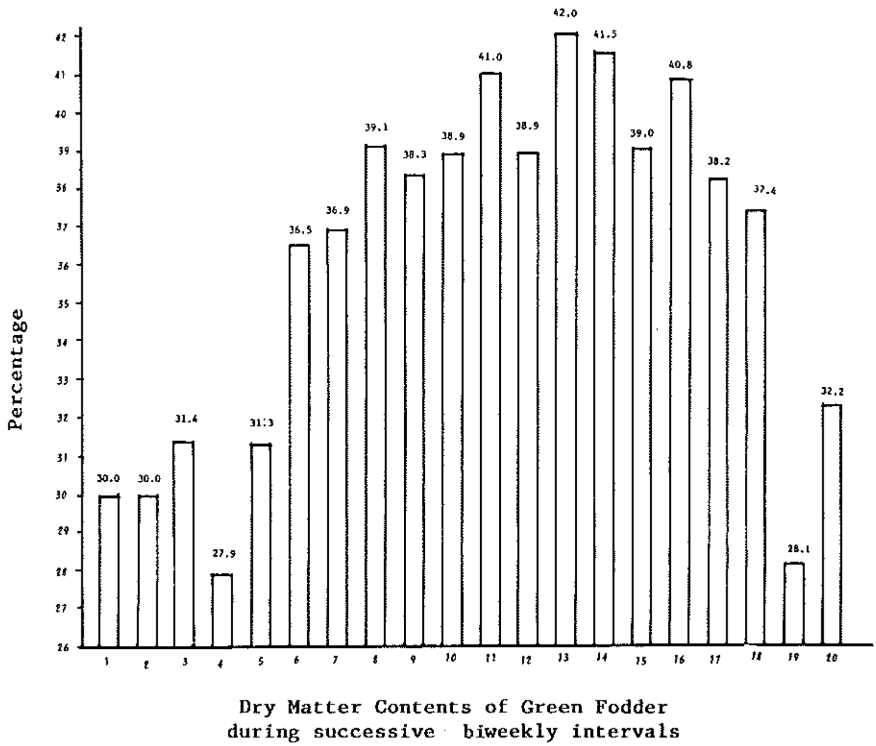

FIG. 2.—Mean biweekly dry matter contents in green chopped fodder.

DATE (DAY AND MONTH)—

1. 26 Feb. - 11 Mar.; 2. 12 Mar. - 25 Mar.; 3. 26 Mar. - 08 Apr.; 4. 09 Apr. - 22 Apr.; 5. 23 Apr. - 06 May; 6. 07 May - 03 Jun.; 7. 21 May - 20 May; 8. 04 Jun. - 17 Jun.; 9. 18 Jun. - 01 Jul.; 10. 02 Jul. - 15 Jul.; 11. 16 Jul. - 29 Jul.; 12. 30 Jul. - 12 Aug.; 13. 13 Aug. - 26 Aug.; 14. 27 Aug. - 09 Sept.; 15. 10 Sept. - 23 Sept.; 16. 24 Sept. - 07 Oct.; 17. 08 Oct. - 21 Oct.; 18. 22 Oct. - 04 Nov.; 19. 05 Nov. - 18 Nov.; 20. 19 Nov. - 23 Nov.

Cows practiced a considerable degree of selective eating, concentrating dead vegetative matter in the leftovers. The creeping growth habit of stargrass, with accumulation of dead matter in the lower strata, made it impractical to harvest nearly pure live matter with a common field chopper.

No problem was encountered with overnight spoilage of chopped green fodder. This finding agrees with that of Pratt et al. (12) in Ohio. Occasionally, when harvesting difficulties were experienced, part of the offering was 2-day-old material, which had been stored under a roof in woven plastic sacks. At this stage it had a pale green color and detectable fermentation odor, but generally was well accepted by the animals.

DM percentages of hay and concentrate were not highly variable. On the basis of 20 samples, hay ranged from 83.1 to 89.0%, with a mean and SD of 87.3 ± 1.6 and CV = 1.9%; corresponding figures for 12 samples of concentrate were 87.5 to 90.8, 89.5 ± 1.1 and 1.2%. Since DM percentage of forage orts would be difficult to interpret, because of wetting of material in feed bunks with saliva, splashed drinking water and rainfall these are not presented; all data are on a dry basis.

Table 1 presents CP and ash contents of the feeds. In earlier research with stargrass produced under heavy fertilization and irrigated at the same Lajas location, Gutiérrez-Vargas et al. (5) reported a CP content in manually harvested hay, cut at 60 days of growth, of 6.6%, only 1% higher than the present result, whereas Méndez-Cruz et al. (11) found a much higher CP level (11.3%) in hay mechanically harvested at 55-day intervals. In the latter study a 0.43-ha plot of stargrass was maintained in exceptionally good condition. The 6.21% CP content found in green fodder is markedly lower than that of 9.9% reported by Vicente-Chandler et al. (16) in well fertilized stargrass cut at 60-day interval in other regions of Puerto Rico. An effect of animal selection is discernable for both green fodder and hay (table 1), CP contents of orts being 1.67 and 1.36% less than in offerings, respectively.

TABLE 1.—*Percentage crude protein and ash contents (dry basis) of experimental feeds, including mean, standard deviation and coeficient of variation*

Feed	Number of samples	Crude protein			Ash		
		Mean	S.D.	C.V.	Mean	S.D.	C.V.
Green fodder							
offered	19	6.21	1.01	16.2	9.58	0.98	10.2
ords	20[1]	4.54	0.87	19.2	8.40	1.92	22.9
Hay							
offered	20	5.59	0.86	15.4	8.56	1.32	15.4
orts	21[2]	4.23	0.72	16.9	6.94	1.20	17.4
Concentrates	3	19.7	–	–	10.9	–	–

[1]Six observations from group 1, and 7 from each of groups 2 and 3.
[2]Seven observations per group.

Animal selectivity is also noted with respect to forage ash contents (table 1). Furthermore, variability about the mean was twice as great in green fodder recovered from the feed bunks than in that offered; orts samples ranged from 5.64 to 14.2% ash. Variable discrimination by the animals against soil contamination would seem to be the most likely explanation of this finding. A certain amount of soil in the chopped fodder could usually be seen upon inspection. Mean CP percentage of the concentrate was 19.7 in the DM, which corresponds to 17.7 on an as-fed basis and nearly agrees with the manufacturer's guarantee.

Table 2 presents forage feeding data by group and treatment. Over-all daily offering of DM was 3.19 kg per cow greater from green fodder than from hay, wheras the difference between treatments in forage DM intake was only 1.49 kg (P<O.10). Trends in forage DM intake with stage of lactation generally conformed to expectations. When summarized by successive 2-week periods (fig. 3), intake of green fodder DM was lowest (8.55 kg/day) during the first interval, increased to a maximum (11.45 - 11.46 kg) during weeks 9-12, and thereafter showed moderate, apparently random fluctuations; intake of hay DM was also minimal during the first 2 weeks (7.84 kg/day), and increased gradually, though irregularly, to a maximum (9.80 kg) during weeks 21-22. The latter represents a weekly rate of increase of close to 0.1 kg. By comparison, Johnson et al. (6) observed a mean weekly increase of 0.19 kg in daily forage DM intake over the first 15 weeks of lactation by Holstein cows fed hay (mixed clover-alfalfa-timothy) ad libitum, together with a fixed amount of corn silage.

Consumed forage represented 74 and 82% of that offered as green fodder and hay, respectively (table 2). Daily per cow wastage of green

TABLE 2.—*Mean daily dry matter offerings, wastages and consumption of experimental forages*

		Kilograms per cow				As percentage of offering			
Group	Number of animals	Offered	Left in feed bunk	Lost on floor	Consumed	Offered	Left in feed bunk	Lost on floor	Consumed
				Treatment 1 (green fodder)					
1	5	14.29	3.21	0.74	10.34	100	22	5	72
2	5	13.85	3.21	0.44	10.19	10	23	3	74
3	3	15.59	2.46	1.24	11.90	100	16	8	76
All	13	14.48	3.01	10.71	100	21	5	74	
				Treatment 2 (hay)					
1	4	12.37	1.28	1.21	9.98	100	10	80	
2	5	10.92	0.52	1.36	9.05	100	5	12	83
3	5	20.74	0.67	1.24	8.83	100	6	12	82
All	14	11.29	0.80	1.27	9.22	100	7	11	82

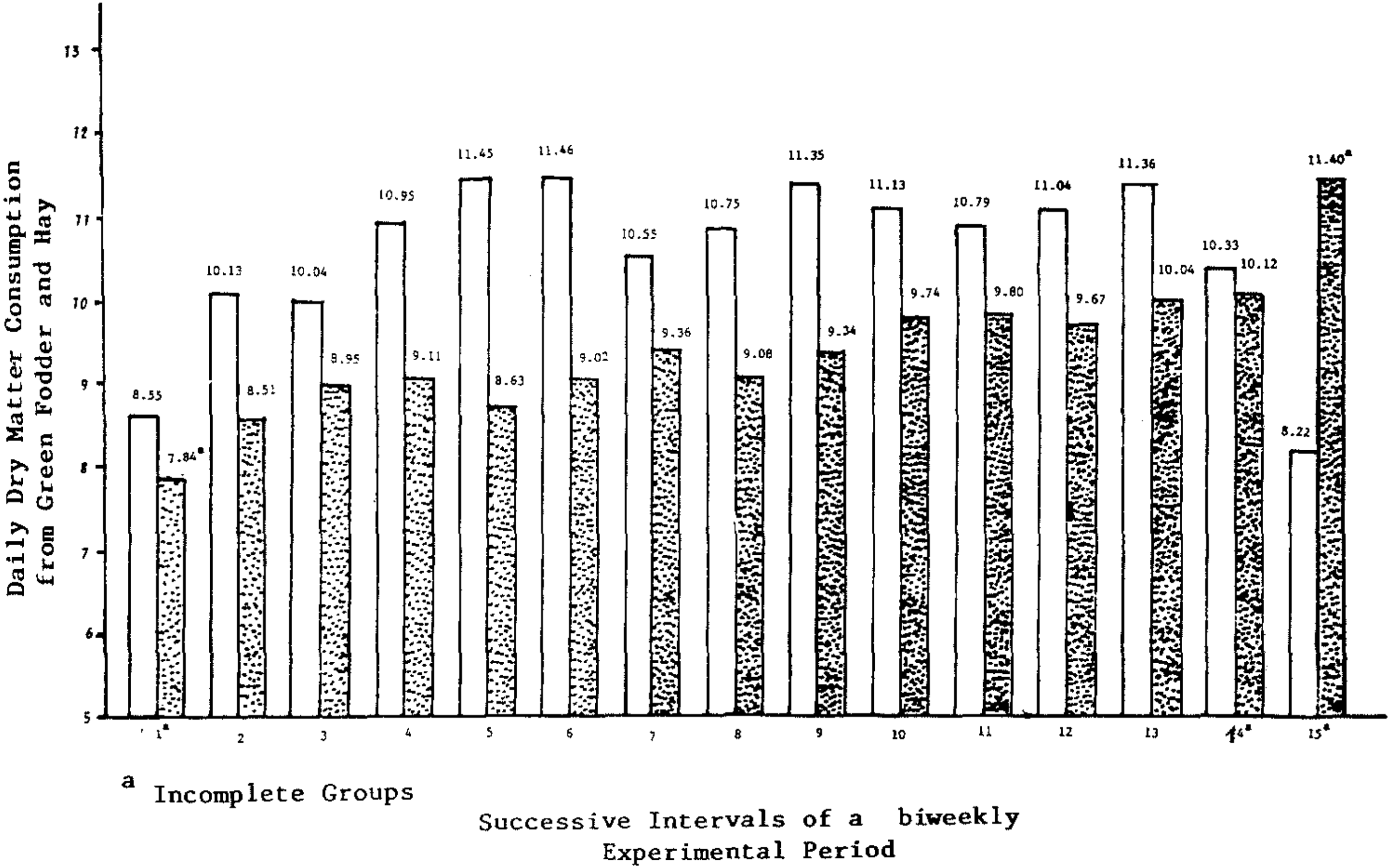

FIG. 3.—Mean daily dry matter consumption from green fodder and hay during successive 2-week intervals of the experimental period.

fodder DM included 3.01 kg left in the feed bunk and 0.77 kg dropped to the floor, for a total of 3.78 kg (26% of offering). Corresponding figures for hay were only 0.80 kg left in the manger, but 1.27 kg lost under foot, giving 2.07 kg total (18% of DM offered). A larger amount of green fodder had to be supplied to ensure ad libitum intake, becaue of the selective eating mentioned above. Leftover hay recovered from feed bunks tended to be mostly coarse parts of forage plants and extraneous matter, such as twigs, small stones and lumps of soil or dried manure, that had been trapped in the bales. At least 10% of hay DM fed was lost on the floor by all 3 groups in treatment B; this loss was facilitated by the ease with which cows pulled interwoven strands of baled hay out of the feed bunk while eating. At one point a test was made of not removing the twine from the bales upon placing them in the racks; this seemed to prevent some hay loss on the floor during initial exposure to the animals, but in a 24-hour cycle there was as much waste as previously. Some hay from the floor was eaten at first but gradually it was trod under and often contaminated with feces and urine. Smaller particle size of chopped green fodder helped to reduce losses on the floor, but even in treatment-A groups, such losses amounted to 3 to 8% of DM offered.

Most cows, especially those of smaller body size, were unable to eat their full 10 kg daily allowance of concentrate during the preliminary phase; only 7 of 30 animals had a mean daily refusal of less than 0.5 kg; mean intake was 8.96 ± 0.71 kg. By contrast, refusals of concentrate were a rarity during the experimental period; mean initial daily allowances of 5.15 and 5.09 kg for cows in treatments A and B declined finally to 1.69 and 1.76 kg, respectively.

Over-all mean daily DMI from concentrate was 0.29 kg greater in treatment B animals (table 3), because of method of allotment. The advantage of treatment A in forage DMI was thus partially offset, reducing mean difference in total DMI to 1.20 kg. Forage provided the great majority of DM consumed. Proportions of forage: concentrate intake averaged 79:21 and 75:25 in the respective treatments, and varied among individual groups from 82:18 in groups 2 and 3 of A to 73:27 in group 1 of B. Daily forage DMI represented 2.59 and 2.32% of LW in cows fed green fodder and hay, respectively, with relatively little variation among groups within treatments. Méndez-Cruz et al. (11) conducted trials with steers fed 55-day stargrass hay as the sole ration and observed daily DMI equivalent to 2.14% of LW. With addition of 0.69 and 0.79% of LW equivalent from concentrate, mean total DMI represented 3.28 and 3.11% of LW in treatments A and B, respectively. Only group 2 of treatment B fell slightly short of a DMI equivalent to 3% of LW daily (2.98%); maximum was 3.4% in group 3 of treatment A.

After producing 15.27 and 14.33 kg/day of milk during the preliminary phase, cows assigned to treatments A and B increased only slightly dur-

TABLE 3.—*Mean daily dry matter intakes of forages and concentrates and their relation to animal liveweight*

Group	Number of animals	Kilograms per cow			As percentage of liveweight			Mean live-weight
		Forage	Concentrates	Total	Forage	Concentrates	Total	
			Treatment 1 (green fodder)					*kg*
1	5	10.34	3.59	13.93	2.47	0.86	3.33	418
2	5	10.19	2.30	12.49	2.54	0.57	3.11	401
3	3	11.90	2.59	14.49	2.79	0.61	3.40	426
All	13	10.71	2.85	13.56	2.59	0.69	3.28	414
			Treatment 1 (green hay)					
1	4	9.88	3.60	13.48	2.33	0.85	3.18	424
2	5	9.05	3.17	12.22	2.21	0.77	2.98	410
3	5	8.83	2.70	11.53	2.44	0.75	3.19	362
All	14	9.22	3.14	12.36	2.32	0.79	3.11	398

ing the initial 4-week experimental subperiod to 15.60 and 14.46 kg, respectively. Thereafter the lactational curves described a rapid downward course throughout the rest of the experiment. Linear regressions relating natural logarithms of mean milk production per subperiod vs. time gave negative slopes indicating production losses of 3.61 and 3.94% weekly in treatments A and B, respectively. These steep declines, which are almost double the anticipated rate (2), led to means of only 7.90 and 6.66 kg of milk per day in the final 4-week subperiod for the two respective treatments. Cows completing the experiment were approximately 190 days into lactation. Most of them were dried off soon thereafter because of low production, instead of completing lactations of normal length.

Over-all milk production was 1.03 kg/day greater in treatment A (table 4). However, with covariance adjustment for production during preliminary phase, means of the two respective treatments differed ($P>0.05$) by only 0.33 kg/day (10.64 vs. 10.31 kg). Expressed as 4% fat-corrected-milk (FCM), the relative advantage of A is 0.79 kg (table 4). With regard to lactational response the conclusion is clear both treatments were inadequate either to maximize peak milk output or to maintain high production over an extended period.

At preliminary sampling, mean milk fat percentages of treatment A and B cows were 2.73 (datum of one cow lacking) and 2.92, respectively. Several low values, including 5 below 2.0%, were observed in milk of individual cows. Depression in fat content was infrequent thereafter and limited to the lst and 2nd 4-week subperiods. Normal milk fat content resulted once a relatively high roughage to concentrate ratio was established. This finding agrees with a well-established norm (7). Throughout

TABLE 4.—*Mean daily milk production and milk composition*

Group	Number of animals	Kilograms per cow			Percentage	
		Milk	Fat-corrected milk	Fat	Solids non-fat	Total solids
		Treatment 1 (green fodder)				
1	5	12.26	10.73	3.17	8.09	11.26
2	5	9.60	8.79	3.44	8.21	11.65
3	3	11.22	9.55	2.98	7.99	10.69
All	13	11.00	9.70	3.21	8.11	11.32
		Treatment 2 (hay)				
1	4	11.68	10.53	3.34	8.36	11.70
2	5	12.26	8.97	3.16	8.15	11.32
3	5	8.31	7.56	3.40	8.15	11.55
All	14	9.97	8.91	3.29	8.22	11.52

the study, fat percentages generally conformed to expectations and showed more variability among cows within groups and among groups within treatments than between treatments. The slight over-all advantage (0.08%) favored hay over green fodder (table 4).

Normal milk SNF contents were generally found at preliminary sampling and means were 8.39 and 8.61% for treatment A and B cows, respectively. After switching to the experimental rations, most cows registered a decrease in SNF levels. Means of 8.14 and 8.23% observed over the full experiment (table 4), were 0.25 and 0.38% below preliminary values for the respective treatments. These substandard SNF contents, taken together with poor results in milk production, indicate inadequate intake of nutrients for lactation. A positive relationship between plane of nutrition and milk SNF content is well known (8). Mean difference in SNF content between treatments of 0.11% in favor of B did not approach $P = 0.05$. Mean total solids (TS) content of milk of treatment B exceeded ($P>0.05$) that of A by 0.20% (table 4). However, milk TS production slightly favored the latter (1.24 vs 1.15 kg/day).

This absence of differences in milk production and composition between rations based on stargrass fed as either green fodder or hay agrees with analogous findings for alfalfa by Stiles et al. (14), wherein Holstein cows of about 560 kg LW consumed 13.6 and 14.7 kg of DM/day from forage in these two respective forms, in combination with 5.4 and 6.3 kg from concentrate, and produced 23.3 and 22.1 kg of milk daily.

DMI per unit of FCM produced (kg/kg) was calculated as a measure of gross feed efficiency; mean results were nearly identical in both treatments (1.40 vs. 1.39). Forage and concentrate portions of this DMI differed somewhat between the respective treatments (1.10 and 0.30 kg vs.

1.04 and 0.35 kg/kg FCM). Reciprocals of the figures representing concentrate portion indicate that 3.3 and 2.9 kg of FCM were produced for each kg of concentrate DM ingested. Expressed thus the levels of concentrate feeding seem less restrictive than they were. This signifies a failure to achieve high efficiency in use of concentrate and is the result of cows partitioning most of their nutrient supply for body maintenance. The hypothesis under test, i.e., that forage intake would supply nutrients for maintenance plus an appreciable surplus for lactation, was found to be unrealistic under the condition of this study.

Mean LW's of treatment A and B cows upon starting the experimental period were 419 ± 43 and 407 ± 50 kg, respectively. Only 2 animals exceeded 500 kg, whereas nearly half weighed less than 400 kg. At the time of this experiment, undersized animals were representative of the Lajas herd and this probably contributed to their poor productive performance. LW change during the experiment was erratic in cows of treatment A; minimum mean LW (400 kg) was observed at 5th weighing (after 113.5 days), but an increase to 412 kg occurred thereafter. The downward trend in treafment B was continuous and gave a mean of 396 kg at final observation (after 164.8 days). Treatments did not differ ($P>0.05$) in final LW. Since 6 periodic weighings subsequent to the initial one were at approximate rather than exact 4-week intervals, regression analysis was used to relate mean LW vs. time. LW change of hay-fed cows was adequately described by a linear regression ($P<0.01$), with a slope of -0.026 kg/day, S_b = 0.004 kg and r^2 = 0.89 However, a linear regression obtained with treatment A data did not approach P = 0.05. The coefficient of regression was -0.022 kg/day, but not a close fit, with S_b = 0.016 kg and r^2 = 0.27. A second order polynomial regression was tried with the latter data and R^2 increased to 0.45, but neither the multiple regression nor its linear or quadratic components was sigificant ($P>0.05$). If calculated from initial and final LW only, a mean daily loss in this treatment of 0.037 kg is obtained; the corresponding result for treatment B is 0.068 kg. These over-all LW losses further support the conclusion of insufficient nutrient intakes. Immature cows that should have been growing were unable to do so. Twenty-eight animals participated in the experiment long enough for evaluation of reproductive performance, including one that conceived before going dry after 118 days in treatment A. Nine of 14 in each treatment were diagnosed pregnant, but 3 cows aborted. The rate of effective rebreeding was, therefore, 8/14 and 7/14 in treatments A and B, respectively. Mean interval from parturition to conception was 109 and 79 days if pregnancies ending in abortion are included, and 115 and 87 days if excluded, respectively. Thus cows that conceived during the experiment did so after a reasonably short interval, but the fact that almost half were still open when finishing the 168 days is a further possible indicator of relative undernutrition, although more stringent methods of heat detection would have been necessary to confirm a nutritional role in this reproductive inefficiency.

One primaparous purebred Holstein, imported from the USA a few months prior to calving and included in this experiment, conceived again on time, but after about 4 months in treatment A showed a debilitated condition (possibly associated with subclinical ketosis), that required veterinary attention, including intravenous infusion of glucose and amino acids. This animal responded to therapy and was able to finish the experiment, but lost 49 kg of LW therein. A second purebred imported Holstein, also in treatment A, completed the study without conceiving and registered an extreme LW loss of 70 kg. Both of these animals returned to normal condition within a few months post-experiment, while receiving a high level of nutrition.

The over-all conclusion from this study is evident. Our attempt to use harvested stargrass as the principal source of nutrients for lactating cows, while markedly restricting concentrate intake, was unsuccessful. Far better results, obtained with similar rations incorporating excellent quality temperate zone forages, are illustrated by two examples, as follows: Lamb et al. (9) fed Holstein cows alfalfa hay and concentrate at four rates, 1 kg per 4.0, 2.67, 2.0 or 1.6 kg of FCM produced above the first 9.1 kg daily, over full 305-day lactations in 4 consecutive years. Concentrate feeding was more restricted in both the first and second treatments than in the present experiment, yet milk yields of 6,308 and 6,664 kg per lactation (20.7 and 21.8 kg/day) were obtained. Cows at the lowest concentrate level (LW not reported) consumed only 2.76 kg of concentrate DM, together with 15.84 kg of hay DM/day. By comparison, cows in treatment B of the present study consumed 0.38 kg more concentrate DM, but 6.26 less hay DM (table 3), and their milk production, if extended to 305 days, would be less than half that of the Utah cows (9).

Donker et al. (3) fed alfalfa haylage and corn silage to Holsteins as the forage part of the ration in combination with low, medium or high concentrate levels (1 kg per 5.0, 3.0 or 1.5 kg of milk in excess of 9.1 kg daily). For the former two treatments, daily DMI's were 2.2 and 3.8 kg from concentrates, 15.6 and 14.5 kg from forage, and 17.8 and 18.3 kg total. The latter figures represent 3.25 and 3.32% of LW, respectively, and differ little from corresponding percentages (3.28 and 3.11) for treatments A and B of the present experiment (table 3). However, cows in the Minnesota study (3) on low and medium concentrate produced 18.7 and 19.9 kg of milk daily over 300-day lacations and gained LW as lacation progressed.

Quality of stargrass forage employed herein as green fodder or hay was such that the rations failed to provide sufficient nutrients for satisfactory animal performance, as expressed by milk production and milk solids content, growth of immature cows, and timely conception, in spite of adequate forage DMI relative to LW. The latter might seem anomalous, since poor forages tend to be associated with low intakes (17). Possible explanations of these relationships are intriging. One factor that often contributes to low intakes of poor quality forage is an inadequate supply of CP for rumen microbes. According to Van Soest (15), 7% CP in the DM is a critical point in this regard for tropical forages. Concentrate supplementation was presumably sufficient in the present case to avoid this limitation. However, for rations of this type to support adequate milk production by cows under confinement conditions, higher contents of available energy and protein would be required in the forage. Depending on what production level is deemed adequate, this might be achieved by harvesting more immature stargras under irrigation or forage from better tropical varieties.

Napiergrass (*Pennisetum purpureum*) is presently the most popular forage for green chopping in Puerto Rico because ef its ease of establishment and tremendous yield capacity. However, McDowell (10) estimated theoretically that to support milk production of 4,200 kg per 10-month lactation, green chopped napiergrass including coarse stems (42% digestibility and 5% CP), if fed in addition to a fixed daily allowance of 1.4 kg of cane molasses, would require concentrate supplementation at 12 kg daily during the first month of lactation and thereafter 1 kg/day less in each successive month. Over-all, 7.5 kg of concentrate would be consumed daily, and milk to concentrate ratio would be 1.9:1. Better quality napiergrass can be harvested under more ideal conditions. Vicente-Chandler et al. (16) reported a mean CP content of 7.5% and digestibility of about 50% in DM from this species when well fertilized and cut at 60-day intervals; on the negative side, DM content is low (18.9%). It has yet to be demonstrated whether napiergrass could fulfill the need in question, but this seems unlikely.

Milk producers contemplating use of harvested forages for confinement feeding of dairy cows in Puerto Rico should be advised that rather high levels of concentrate supplementation will be needed to maintain milk production of 15 kg/day or more, unless forages of considerably better quality than those of the present study can be supplied consistently. At present it is not known which forage variety and what system of harvest management could achieve the goal of markedly reducing inputs of concentrate, while still resulting in the desired milk production.

RESUMEN

Alimentación de vacas lecheras en confinamiento con yerba estrella picada o henificada

Con treinta vacas Holstein y Suizas Pardas, alojadas en confinamiento total en 6 grupos de 5 cada uno, se ensayaron dos raciones basadas principalmente en forraje verde cortado diariamente en el campo (A) o heno

empacado (B), suplidos a libre albedrío. Ambos forrajes se cosecharon a intervalos de más de 55 días de predios de yerba estrella (*Cynodon nlemfuensis*) relativamente pura, bien abonados, pero sin riego y de crecimiento forrajero variable durante los 9 meses de experimentación. La suplementación individual fue con un alimento concentrado comercial con 18% de proteína bruta (CP), a razón de 1 kg. por 2.2 kg. de leche producida, a partir de los primeros 6-7 kg. ó 4-5 kg. de leche diarios en tratamientos A y B, respectivamente, pero fijando un mínimo de 1 kg. de alimento concentrado diario por animal y 1 kg. adicional para las primerizas. Las vacas entraban individualmente en el período experimental de 168 días de duración, a las 3 semanas de paridas, habiendo recibido entretanto una dieta diaria fija de 10 kg. de alimento concentrado desde el tercer día posparto. Dos vacas se eliminaron del experimento al mermar marcadamente su producción de leche y una tercera por problemas de timpanismo.

Se observaron los siguientes resultados medios para los tratamientos A (13 vacas) y B (14 vacas) durante el experimento completo: porcentaje de materia seca (DM) de forraje desperdiciado, 26.1 contra 18.3; consumo diario de DM forrajera y de pienso concentrado, 10.71 y 2.85 contra 9.22 y 3.14 kg.; consumo diario de DM total como porcentaje del peso vivo (LW), 3.28 contra 3.11; pérdida diaria de LW estimada por regresión lineal 0.022 y 0.026 kg.; producción diaria de leche y de leche corregida a 4% de grasa (FCM), 11.00 y 9.70 contra 9.97 y 8.91 kg.; reducción porcentual en la producción de leche semanalmente, 3.61 y 3.94; DM consumida por kg. de FCM producida, 1.40 contra 1.39; contenidos porcentuales de grasa y sólidos no grasos lácteos, 3.21 y 8.11 contra 3.29 y 8.22, respectivaente. No se hallaron diferencias significativas entre tratamientos.

La yerba verde de corte y heno evaluados, conteniendo 6.21 y 5.59% de proteína bruta (CP) a base seca, respectivamente, no reunían calidades nutritivas adecuadas para permitir una producción satisfactoria, a pesar del consumo de DM relativamente alto. Se concluye que para lograr una producción razonable con este tipo de ración, sería preciso contar con forrajes cosechados de mejor calidad que los presentes, tal vez yerba estrella con riego cortada a una etapa de madurez más temprana; si no, se tendría que recurrir a una mayor suplementación con alimento concentrado.

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