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CURRENT MANAGEMENT OF TROPICAL PASTURES TO FEED LACTATING DAIRY CATTLE IN PUERTO RICO

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ABSTRACT. In order to better understand the role of grazed tropical grass pastures in an intensive Caribbean milk production system, research was initiated in 1996 to study the current grazing management and feeding of lactating dairy cattle in Puerto Rico's dairy industry. Information from the census of 450 dairy farms in Puerto Rico was obtained from official documents. The census data pertained to farm location, pasture acreage, herd size, milk fat test results, and concentrate feed purchases. A representative sample of 100 farms was selected for survey and a subsample of 22 farms chosen for a series of on-farm visits. The survey included pasture management, grazing schedule, and feeding program of the lactating cattle. The series of on-farm visits were used for forage sampling to evaluate the pasture as a feed resource. Forage sampling results indicate that forage nutritive value (14-24% crude protein and 59-72% in vitro digestibility) was higher than expected and forage-on-offer (1.4 - 7.3 T DM/ha) could support more intensive utilization of pasture. Of 67 farms responding to the survey, almost all were practicing rotational grazing with high productivity pasture species - stargrass being dominant on 78% of farms. However, relatively low stocking rates, high levels of concentrates fed (>10 kg/cow) and the island-wide milk butterfat concentration of ~3% indicate that farms needing to reduce feed costs could make greater use of their forage resources.

INTRODUCTION

Dairy farming is the principal agricultural activity of Puerto Rico. Despite limited land resources and a very dense population, Puerto Rico is self-sufficient in milk production. By tropical standards, high levels of per-animal and per-hectare productivity are attained through a combination of the grazing of improved tropical grass pastures and the generous allotment of purchased commercial grain-based concentrate feeds.

Pasture-based dairy farming in a warm climate like Puerto Rico offers significant management challenges. Lactating cattle have high nutritional demands and satisfying these demands involves skillfully managing both animals and plants. Plant-related challenges have been identified by Moore and Mott (1973) who have described how differences in anatomy and composition between temperate and tropical grasses result in lower digestibility of tropical species. An animal-related challenge is the effect of heat stress on animal production. Lactating dairy cattle are particularly sensitive to hot temperatures (Bray et al., 1992) and failure to alleviate this stress can drastically lower milk production, feed intake, and reproductive efficiency.

Given its highly developed milk industry (Greubele and Barahona, 1974) and demonstrated potential for pasture-based production of milk (Caro-Costas and Vicente-Chandler, 1980), Puerto Rico is a candidate for study in order to provide insights into intensive tropical pasture-based dairying.

This evaluation has several objectives:

- learn about current grazing and feeding practices in the commercial dairies of Puerto Rico.
- assess the relative importance of the various feeding program components.
- identify those factors that have the greatest impact on pasture management decision-making.
- determine which aspects of Puerto Rico dairy pasture utilization might offer useful examples for dairy farmers throughout the Caribbean and in other warm regions that are seeking to make greater use of pasture.

MATERIALS AND METHODS

This assessment of pasture utilization and grazing management was conducted using three distinct data collection activities: a Census, a Survey and a series of On-Farm Visits.

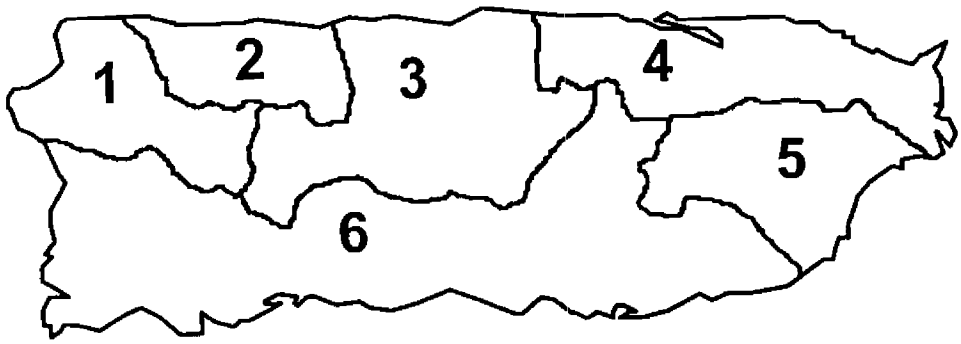
The Census: The census was the initial step in the data collection and was conducted from March to July of 1996. It was designed to give a whole-island picture of the characteristics of dairy farms in Puerto Rico. Data collected included number of farms, their location, their herd and land area sizes, purchases of concentrate feeds, daily milk production and butterfat concentration. This information was collected from official records of the Office of Regulation of the Dairy Industry (ORIL) and quarterly reports of the Agricultural Extension Service of the University of Puerto Rico (SEA-UPR). The extension agents of the Dairy Herd Health Project of the SEA supplemented their quarterly reports with a few additional questions about pasture area for lactating cows and number of paddocks used in the grazing operations that they advise.

Once complete, the census gave us the means and range of the above characteristics along with a geographical distribution of the dairy farms. Based on this distribution we were able to identify distinct production areas and to divide the island into six dairying regions (Table 1). Regions were selected to represent economic factors such as population pressure and land prices as well as agroecological factors such as rainfall, soil types, forage species, and topography. Regions are depicted in Figure 1.

Once the farms had been grouped into regions, they were ranked according to their milk-test butterfat concentration. Butterfat was considered an important criterion because it reflected a direct measurement taken on all commercial dairy farms and it gave a good indication of dietary fiber consumed by the lactating cows. Farms with less than 2.5% butterfat were excluded from further study, assuming that they were relying very little on pasture for their nutritional program. We also excluded farms that had been established within the last year, those about which census data were not obtainable, and the ten farms located in the sprawling arid south (Region 6). Remaining farms of each region were then divided into quartiles from which we selected the representative samples. We selected farms that represented the range of farm types within each region considering variables such as herd size, concentrate fed per cow, production per cow, stocking rate, and number of paddocks used.

Table 1. Regions of dairy farming established by the census.

Region	Number of farms	Description Important municipalities	Features
1	45	Northwest- Pepino Valley San Sebastian	hilly to mountainous
2	181	"Little Wisconsin" Hatillo, Isabela, Camuy, Quebradillas	flat, with numerous dairies, stargrass is main forage
3	105	North Central- Arecibo, Manati, Corozal	coastal plain to mountainous,
4	24	Northeast- Metropolitan area- Carolina, Canovanas, Dorado, Fajardo	coastal plain to hilly, urban influenced
5	74	Southeast Caguas, Gurabo, Naguabo, Humacao	mountainous and very humid
6	10	Southern belt - Cabo Rojo to Juana Diaz	arid a large part of the year - requiring irrigation



The Survey: Based on data gathered in the census, 100 farms were selected for the survey activity. The survey was designed to generate information that included farm history, operator attitudes, production practices focusing on feeding practices, pasture and grazing management, and farm inventories of land, animals, and equipment. An integral section of the survey quantified daily feed allotments and the prices of feedstuffs. By determining purchases of feed and harvested forage, we could estimate each farmer's reliance on grazed forage to feed his lactating cattle. In most cases, the survey was administered to the dairy farmer by his extension agent during their regular quarterly visit. Of the 100 farms selected, responses were received from 67 between August of 1996 and March of 1997.

The On-Farm Visits: Dairies selected for the on-farm visits were a subset of those being surveyed. In order to accommodate two somewhat contradictory objectives, geographical distribution and logistical efficiency, farms were selected from the four most important dairying regions. The arid southern belt (region 6 with 10 farms) and the metropolitan area (region 4 with 24 farms) were eliminated from the on-farm visit phase. We selected 30 farms based on specific criteria within the database while also considering recommendations of extension specialists, other researchers, and veterinarians. After visiting 30 farms we were able to identify 22 that made significant use of pasture and that were distributed proportionally across our four regions of interest. To evaluate pastures during a variety of seasons, on-farm visits were conducted three times during 1996: late June, early August, and mid-December.

The objective of the pasture sampling was to observe directly a variety of farm management styles and evaluate the pasture resource of each farm. Data collected included estimations of herbage mass (HM), nutritive value, and botanical composition of the swards. During each visit, if an owner, manager, or other employee was available we would conduct a brief interview about current grazing rotation, quantity of parlor feeds used during that season, and any recent problems associated with the grazing and feeding operations.

Herbage mass estimation of stoloniferous forage grasses: The majority of pastures sampled were comprised of stoloniferous grasses such as stargrass (*Cynodon nlemfuensis* and *C. plectostachyum*), digitgrass (*Digitaria eriantha*), caribgrass (*Eriochloa polystachya*) and various *Brachiaria* species. With these, herbage mass was determined by double-sampling techniques using a disk meter (Santillan et al., 1979). Disk measurements were taken at 25 to 40 locations regularly distributed throughout the paddock. Disk meter measurements were calibrated with direct measurements of additional sites within the paddock whose disk heights covered the range of heights already measured: high, medium-high, medium, medium-low, and low. After the height of each of these five sites was recorded, the forage from the area covered by each disk-drop (0.25 m^2) was clipped to a stubble height of 5 cm. Clipped samples were individually bagged and oven dried at 55° C for more than 72 hours to obtain their dry weights. Equations describing the relationship between direct and indirect measurements were developed using regression techniques. These equations were used to predict herbage mass of a paddock based on its average disk height.

Herbage mass estimation of erect bunch-grasses: While most often the forage species in use could be adequately estimated using the disk meter, guineagrass (*Panicum maximum*) was the principal forage in some paddocks and its growth habit did not lend itself to disk-meter measurement. Instead we placed a 4-m^2 quadrant in 10 areas within the guineagrass pasture. Distinct guineagrass clumps or plants were counted and recorded for each site and a representative pair of plants were harvested. The sample from each quadrant was bagged and oven dried for 72 hours to determine dry weights. Dry weight was divided by two and multiplied by the number of plants within the quadrant to determine forage mass of each 4-m^2 area. From these averages, herbage mass for the guineagrass paddocks were calculated.

Nutritive value analyses: Composite samples for nutritive value analysis were taken by clipping hand-plucked samples from at least 25 sites well-distributed within each paddock. Samples were collected to represent what was being grazed by the cattle, viz; pasture species

and plant parts (most often the top 20-40 cm of the plant). Clipped samples were bagged, labeled, and kept on ice in a shaded 20-L cooler until they could be placed in the forage oven for at least 48 hours at 55° C. Dried samples were ground to 1-mm particle size and bagged for shipment to the University of Florida Forage Evaluation Support Laboratory. Samples were analyzed for N using a micro-Kjeldahl technique, for neutral detergent fiber using the procedure of Golding et al. (1985), and for in vitro organic matter digestibility (IVOMD) using the procedure of Moore and Mott (1974).

Botanical composition using visual estimations: During herbage mass and nutritive value sampling, two complete passes were made through the paddock of interest. Visual estimations were made of percent ground cover by forage species, weeds, and uncovered soil/area without vegetation.

RESULTS AND DISCUSSION

Census Results: The Census demonstrated that there is a tremendous range of all the key variables among farms (Table 2). By geographically grouping these farms, we found that regional differences emerged in terms of herd size and density of farms per community as well as production practices such as stocking rate and number of paddock enclosures per farm. Region 1 (San Sebastian) was comprised of farms with smaller herd sizes and more area of pasture per cow, particularly when contrasted with Region 2 (Hatillo). Despite greater forage availability due to the lower stocking rate, Region 1 had the lowest production per cow and an average butterfat concentration of less than 3%, meaning that many farmers are not meeting the milk quality standard set by the island's industry.

Based on our calculations from reported feed purchases, there was a great range of concentrates fed on farms within regions, but the average of approximately 10 kg/head/day appeared consistent across regions.

Survey Results: Of 100 surveys, 67 were returned giving us a sample that is about 15% of the total number of dairy farms. Several common features were noted among the respondents. Holstein was the principal breed on 97% of dairy farms. Only one respondent (1.5%) operated a dual purpose farm (milk and beef). While most farms (69%) did purchase replacement heifers, almost all (95.5%) raised at least some of their own replacements.

All farms surveyed were practicing some form of rotational grazing with an average of 53 ha pasture (range 5-243) divided into an average of 13 paddocks (range 3-31) for the lactating herd. Improved pasture species occupied 95% of the total pasture area with stargrass being the principal forage on 78% of those farms (Table 3). Only seven farms had >10 ha of native or mixed pasture, with only two farms being principally native pasture. Twenty three farms (34%) were raising forages for harvest with an average of 15 ha being harvested an average of 4.3 times per year.

Table 2. Census data: means within regions.

	Island Means (Range)	Means by region				
		1	2	3	4	5
# of farms	453	45	181	105	24	74
lactating cows	149 (15-680)	117	147	166	136	160
ha pasture	44 (0-324)	57	38	63	61	49
SR (cow/ha)	3.39	2.05	3.87	2.63	2.23	3.26
paddocks/farm	11 (0-31)	16	11	9	11	13
kg conc/cow	9.9 (3.4-19.2)	9.8	9.9	9.8	10.1	10.4
liters milk/cow	14.5 (7.6-24.6)	11.9	14.6	14.8	13.4	14.9
milk fat %	3.16	2.99	3.13	3.15	3.25	3.25

Most farmers (61 of 67) reported application of commercial fertilizers to pastures. An average of 178 kg N/ha/yr. was applied in 2.9 applications per year, with most of those farmers (58 of 61) using a 15-5-10 formulation. Two thirds of farmers reported using herbicides to maintain their pastures while only one fourth reported using insecticides. On 88% of farms, animal wastes were channeled to a pond/lagoon which would periodically be applied to pastures. On two farms (3%) honey wagons were used to apply effluent to pastures. Only two farmers (3%) irrigated their pastures with other sources of water. With the exception of the unsurveyed arid south, dairy pastures in Puerto Rico are generally rain-fed. Overall, one could rate this pasture management system as fairly intensive by Latin American and Caribbean standards.

There were many difficulties with the completion of the survey's daily feeding tables (Table 4). Not all farmers kept precise records. Some make feed purchases every few days, others weekly or biweekly. Very few respondents were able to let us know exactly what was being fed daily. Many do not weigh out what they are feeding. Others change their feeding programs regularly to address specific nutritional problems or to take advantage of the availability of seasonal feeds.

Table 3. Survey results: area of forage species for pasture and for harvest.

	Star	Digit	Carib*	Guinea	Mixed/ Native	Unknown
ha of each pasture species combined total of 67 farms	2145	503	261	214	247	192
% of 3562 ha total	60	14	7	6	7	5
ha for harvest of each species combined total of 23 farms	133	126	23	44	17	1
% of 343 ha total	39	37	7	13	5	0

*Caribgrass (*Eriochloa polystachya*) also indicates a group of associated forages that includes several *Brachiaria* spp - Signalgrass (*B. brizantha*), Paragrass (*B. mutica*) and Tanner grass (*B. decumbens*)

The feeding of grain- and seed-based concentrates is a costly, but near universal, practice with a large variability among farms. The feeding of various harvested forages also indicates an emphasis on feeding cattle while they are confined. The average was 10.7 kg concentrate per cow per day, with some farms feeding each cow quantities as much as 18 kg concentrate per day. Daily maximums of harvested or purchased feeds were 18 kg green chop, 16 kg silage and/or 7 kg hay (as fed basis), sometimes supplemented with a variety of other minor feeds, i.e. pelleted alfalfa hay, molasses, ground orange peels, and distillers grains. The non-pasture portion of the diet of some animals may leave little room for significant/substantial intake of grazed forage.

Surveyed farmers cultivate large areas of improved pastures (Table 3) and have access to the equipment and inputs necessary to make them productive. This should facilitate maximum benefit from this resource. Responses to survey questions, however, indicated a tendency of farmers to pursue non-pasture-related solutions to management problems. When asked which of the following they would adjust to cope with a shortfall in milk production: 66% would buy animals, 31% would feed more concentrate, 18% would purchase harvested forage, and only 7% would fertilize their pastures. When asked which of the following they would do when pasture is running out: 49% would feed more "bulky", a cottonseed-based concentrate, 43% would fertilize pastures, 30% would feed more grain-based concentrate, 28% would purchase alfalfa hay, and 28% would irrigate pastures. These responses indicate that for the majority of farmers the initial response to a feed shortage or to lower-than-expected milk production is to purchase more feed, not to grow more forage on pasture. Given the economic advantages of growing grass over buying corn, one asks why? Some farmers mentioned their concern with the low nutritive value of the forages they were able to grow. In the current research program, a series of on-farm visits were used to sample the pastures grazed by the dairy cattle and characterize their herbage mass and nutritive value.

Table 4. Survey results: feeding of concentrates and harvested forages.

FEED ITEM	# of farms feeding this	% of total	kg fed per cow range of survey responses	Cost per ton in $ US (1996 prices)
concentrate (corn-based, cotton-seed based, or combination)	67	100%	4.5 - 18.2 (mean = 10.7 kg)	$231
alfalfa hay	8	12%	0.2 - 1.4 kg	$293
grass hay*	21	31%	up to 6.8 kg	$132*
green chop*	6	9%	up to 18 kg	$18*
silage*	5	7%	up to 16 kg	$88*

*prices of these domestically-grown harvested forages can be greatly increased by delivery charges

On-farm Visits / Forage Sampling Results: Overall, forage nutritive value measures were not consistent with the stereotypic notion of low-quality tropical forages (Table 5). The selective hand-plucking sampling technique obtains values that are greater than those of whole-canopy samples. Values reported here are similar to those obtained through hand-plucking by Caro-Costas et al. (1976). Forage nutritive value did not differ between regions. Greatest seasonal and regional differences occurred for herbage mass. Herbage mass was considerably less during the December visit (3.2 t/ha) than in June (4.5 t/ha) or August (4.9 t/ha), likely due to lower rainfall and shorter daylength in December. Differences between regions may be due to microclimate, soil type, topography, and forage species. Interestingly, the greatest herbage mass was found in the Region 2 pastures that are grazed by the greatest density of animals (4.72 cow/ha). This may be due to the effect of forage species. Stargrass is well adapted to the flat rain-fed pastures around Hatillo and its superior productivity in the Puerto Rican environment has been documented (Caro-Costas et al., 1976).

Relationships between data: The three information gathering activities generated a large quantity of data. Analysis revealed few conclusive high-correlation relationships. This is consistent with the nature of a study that attempts to integrate on-farm measurements with a large quantity of highly variable data from many sources. However several interesting patterns did emerge. When the visited farms were sorted by size of lactating herd, larger farms typically had higher stocking rates, more forage on offer, higher milk production, higher milk fat, and fed more concentrate and more harvested feed per cow (Table 6).

Table 5. Forage digestibility and chemical composition, herbage mass, dominant species and pasture management practices by region.

	Region 1:	Region 2:	Region 3:	Region 5:
	Pepino Valley	Hatillo	Arecibo	Caguas
	NW hilly	NW Central flat coast	N Central flat to hilly	S East hilly to mts.
# of farms	n = 3	10	5	4
NDF	71.1	70.5	69.7	65.9
CP	17.7	19.2	16.1	18.2
IVOMD	65.1	63.7	61.2	66.9
ton DM/ha	4.2	4.6	3.8	3.6
cow/Ha	2.69	4.72	3.41	2.59
paddocks	21	13	9	16
kg N/ha/yr.	118	221	189	177
time fert./yr	2.2	2.75	3.4	2.25
Forages	Star, Carib*	Star, Guinea	Star, Carib*	Star, Carib*

*Caribgrass group includes several *Brachiaria* spp - *B. brizantha, B. decumbens, B. mutica*

Some pasture measurements were correlated with management practices. Herbage mass was positively correlated with pasture rest period during the summer months, and with the amount of concentrate fed per cow in all three periods (Table 7).

Among the 67 farms surveyed, concentrate per cow was correlated positively with production per cow during the 3 quarters while it was correlated negatively with number of fertilizer applications per year (Table 8). This suggests that farms striving for maximum production per cow will rely more on concentrate while being less likely to make frequent investments in fertilizer to increase pasture forage production.

Table 6. Key variables from visited farms sorted by herd size.

	Farms grouped by size of lactating herd		
range of herd sizes (average of group) sample size	40-100 (69) 4 farms	101-200 (136) 12 farms	200-540 (323) 6 farms
ha pasture	26	47	85
ton DM/ha	3.23	4.23	4.68
cows/ha	2.6	2.9	4.1
# paddocks	7	17	11
times fert./yr.	2.5	2.75	2.83
kg N ha/yr.	103	174	154
kg Conc./cow	8.2	10.0	11.9
kg milk/cow/day	15.1	15.3	17.3
butterfat	3.08	3.13	3.23
ha forage for harvest	0	2	18

CONCLUSIONS

The majority of dairy farms in Puerto Rico possess a rich pasture resource. Rotationally grazed tropical grass pastures consist of improved species with relatively high nutritive value and herbage mass. Despite Puerto Rico's dense human population and resultant pressure on agricultural land, most of these farms still possess adequate land area to stock their lactating herds at approximately 3 cows per hectare. Seasonal fluctuations in forage quantity offer the major impediment to increasing stocking rates on the dairy farms. These seasonal shortfalls can perhaps be overcome by increasing the capacity to harvest and conserve forage grown during periods of greatest productivity. Research in this area is needed. This tremendous forage resource, however, is not utilized to its fullest potential during much of the year. The feeding programs surveyed rely heavily on purchased concentrate and high fiber feeds. Many farmers are offering purchased feeds in such quantities that intake of grazed pasture is likely depressed. For a significant number of the island's farms, concentrates comprise the primary feed while grazed pasture might be considered the "supplement".

Table 7. Correlations among herbage mass over three sampling periods, pasture rest period and concentrate fed per cow per day on visited farms.

	paddock rest period		concentrate/cow/day as per survey	
	r	p value	r	p value
pasture herbage mass - June	.37	.09	.44	.04
pasture HM - August	.50	.02	.41	.06
pasture HM - December	.12	.59	.47	.03

Table 8. Correlations among concentrate per cow over three seasons, milk production, and fertilization frequency for surveyed farms.

	milk production per cow in the corresponding quarter		number of fertilizer applications per year	
	r	p value	r	p value
concentrate per cow - Spring	.43	.0004	-.37	.002
concentrate per cow - Summer	.35	.005	-.30	.02
concentrate per cow - Fall	.36	.005	-.21	.1

Three obvious factors may be affecting farmers'attitudes and decision-making. First, many farmers maintain close association with the North American production system via contacts with enterprises such as livestock breeders and brokers, grain marketers and dairy consultants as well as organizations such as DHIA, Holstein associations and a U.S. land-grant model extension service. Second, the trend in the Puerto Rico dairy industry is toward fewer farms with larger herds. This study revealed that larger farms make greater use of both purchased concentrates as well as harvested forages. Thus if consolidation into larger farms continues, utilization of grazed pasture in Puerto Rico stands to decrease. The third and perhaps most important factor is governmental intervention. Puerto Rico's current system uses mandated milk orders (quotas) which are filled by producers while prices are set by the government based on current costs of production. Under such a system, farmers are protected from economic impetus (market factors) which would stimulate greater pasture utilization as a means to effect savings in the feeding budget. An uncoupling of the price of

milk from the cost of imported feedstuffs may unleash market forces that would create tremendous incentive to implement intensive grazing. Prioritization of grazing-related research and extension is another way the government can influence pasture utilization, possibly reducing grain imports to the island.

The lessons learned from this study of the dairy industry may not apply to many tropical settings where minimal opportunities exist to emulate North American production systems. The high-input nature of large Holstein herds fed grain concentrates requires more imports than many developing economies can afford. Yet, as many Caribbean islands are net importers of food products, aspects of this system may offer a possible means to produce milk making use of an island's limited land resources.

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