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Supplemental Feeding of Steers on Pasture with Protein-Energy Supplements

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SUPPLEMENTAL FEEDING OF STEERS ON PASTURE WITH PROTEIN-ENERGY SUPPLEMENTS[1]

W. V. A. Bisschoff[2], L. R. Quinn[3], G. L. da Rocha[4] and G. O. Mott[5]

Summary

1. Increases in liveweight gain resulting from feeding concentrates on pasture can be accounted for by the increase in caloric intake. No direct response attributable to an increase in protein intake was found in these studies.

2. Grazing animals appear to substitute concentrate for pasture forage but at different rates depending on the quality of forage. During periods of low-quality forage (winter-dry season), each increase of 100 gm. of T.D.N. supplied in the concentrate resulted in a decrease in consumption of 76 gm. of T.D.N. from pasture forage. During periods of high-quality forage (summer-wet season), the substitution rate was 86 gm. of pasture T.D.N. for each 100 gm. of T.D.N. supplied in the concentrate.

3. Nearly all increases in average gain per steer resulting from the feeding of concentrates occurred during the winter-dry season when forage quality was low. Most of these increases in gain per steer disappeared during the subsequent summer seasons, except where 2 kg. or more of concentrate was fed per day.

4. Since the feeding of concentrates on pasture reduces the intake of forage, a true evaluation of concentrates should include the measurement of their effect on the carrying capacity of the pasture.

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5. Rates of gain of steers on pasture were not affected by the addition of vitamin A or terramycin to the supplement.
6. At a level of feeding of 500 gm. of concentrate per steer per day, the amount of salt in the mixture was not effective in reducing the intake during the winter season, but the intake of supplement was reduced with increasing increments of salt during the summer season.

Introduction

The feeding of concentrates to growing-fattening cattle in the tropical and subtropical areas is not a common practice either on pasture or in confinement. In areas where there is a limited supply of either energy or protein feeds, there is seldom any left after the demands are met for direct consumption by humans and by poultry, swine and dairy cattle. As advances in the technology of better crop production are applied in the tropical and subtropical areas, more feed will become available for the beef animal, especially by-product feeds such as molasses and soybean, peanut, cottonseed, babassu oil and castor bean meals. Very little information is available to guide the farmers as to the formulation of supplements to use, how much to feed, and the responses and return which can be expected. This is particularly true when supplements are to be fed under pasture conditions, since little information is available relative to the nutritive value of tropical forage species and the nutritional requirements of the animals which have to be satisfied to make up for the deficiencies of the pasture herbage.

The Brazilian rancher is developing an interest in improved feeding systems to produce a better-quality product more economically. With an increasing demand for beef and more favorable prices, there is a greater incentive to devise higher standards of nutrition for his livestock. Better methods of feeding and management should result in 1) a younger slaughtering age, 2) much lower maintenance costs in terms of feed required and money invested, 3) a smaller acreage requirement of pasture per animal unit and for a shorter length of time, 4) a more rapid turnover of the capital invested in the livestock and as a consequence 5) greater profits from the livestock enterprise.

Some results from feeding supplements on pasture suggest that animals merely substitute all or a part of their supplement consumption for forage, thus reducing their intake of pasture and in effect increasing the carrying capacity of the pasture. McClymont (1956) found that the response to supplements was only about 30% of what might be expected based on the energy consumed in the supplement. Coombe and Tribe (1962), working in Australia, found that supplementing low-quality roughages with molasses and urea increased the feed intake and reduced the rate of liveweight loss of sheep. This suggests that under some conditions, supplements may not replace forage consumption but increase intake, possibly by increasing rate of digestion. Hull and Meyer (1962) fed barley, either rolled or ground, free choice to steers grazing alfalfa pasture and found that the carrying capacity of the pasture could be doubled to 5.4 head per acre, indicating that the cattle were substituting grain for a part of their grass consumption. Smith (1961) studied the effect of supplementing cattle grazing *Hyparrhenia* veld with 2 lb. per head per day of peanut meal during the dry winter season. This resulted in a liveweight gain of .63 lb. as compared with a loss of 1.55 lb. for animals receiving only the grass. The grass contained (Smith, 1962) approximately 50% digestible organic matter and only .6% digestible crude protein at the beginning of the dry season, and dropped to 38% D.O.M. and a negative crude protein digestibility by the middle of the dry season. The voluntary intake of forage dropped from 12 to 8 lb. per 1000-lb. animal per day during the same period. The author states that this forage in the middle of the dry season is grossly deficient in both energy and protein.

Becker *et al.* (1962), in a series of digestibility studies on Brazilian forages, found the following T.D.N. values: *Panicum coloratum*, 43.1%; Buffelgrass, *Pennisetum* *ciliare*, 54.0%; Pangolagrass, *Digitaria decumbens*, 62.7%; Guatemalagrass, *Tripsacum laxum*, 40.2%; and "Alfafa do Nordeste," *Stylosanthes guianensis*, 48.8%. Although these forages were not comparable with each other since they were not grown under the same conditions or harvested at the same stage of growth, the results do indicate the extreme variation in nutritional values of harvested forages.

The purpose of the five trials reported in this paper was to investigate the response of the grazing animal to various types and amounts of supplements when fed on pasture during the winter and subsequent summer season. The trials were conducted on pastures typical of Central Brazil, containing Colonial Guineagrass, *Panicum maximum*, or Batatais-Jaraguagrass, *Paspalum notatum-Hyparrhenia rufa*.

The climate of Central Brazil is subtropical and is characterized by a six to seven months' warm, wet season from October or November to April, followed by five to six months of cool, dry weather from May to September. Experiments 1 and 2 were located on Fazenda Jangada in the Araçatuba district of São Paulo (Location I) and Experiments 3, 4 and 5 at the IRI headquarters near Matão on Fazenda Cambuhy (Location II). These two farms are located in the northwestern and central parts of the state of São Paulo respectively, at elevations of 370 meters for Experiments 1 and 2 and 560 meters for Experiments 3 to 5.

The seasonal temperature and rainfall patterns during the year in which these trials were conducted at each of the two locations are shown in Figure 1. The annual rainfall at Location I was 1093 mm., with a range of zero rainfall in July 1961 to 330 mm. in March 1962. At the IRI headquarters in Matão, the total precipitation for the year was 1180 millimeters. No rain fell in June and July 1961, and the highest rainfall was recorded for December 1961, 282 millimeters. Approximately 95% of the yearly precipitation occurred during the warm period at both locations.

The temperature records at Fazenda Jangada (Location I) indicate an annual mean of 24.2°C; at Matão (Location II), the annual mean was 23.5°C. The coolest months were June and July which had an average mean of 20.8°C, while the hottest months were September through March with fairly constant means ranging from 25.2 to 26.4°C. Similar weather conditions with respect to temperature prevailed at Matão. June and July were the coolest months with an average of 20.3°C, and September through March were the warmest months with mean temperatures ranging from 23.9 to 25.8°C. Average daily maximum temperatures at both locations ranged between 27.9 and 33.8°C during May to September and from 29.8 to 32.5°C from October to April.

The soils are in the class known as *arenito Bauru*, sandy loam (Paiva Neto *et al.*, 1951). This type is derived principally from sandstone parent material. On Fazenda Jangada, the location of the first two experiments, the soil is *Bauru superior* with a pH of 5.8 to 6.0. Experiments 3, 4 and 5 were located on *Bauru inferior*, a poor sandy loam with a soil reaction of pH 5.0.

Materials and Methods

The five experiments reported in this paper had certain aspects of procedure in common. Unique aspects of procedures for each experiment will be considered in the discussion of that particular experiment. All five of the experiments were started early in the winter-dry season of 1961, and each continued into the following summer season using the same tester animals. The only exceptions were some minor adjustments and the reduction of tester animals in Experiment 1 from 15 to 10 at the end of the winter-dry season. All animals were fed on pasture (see Figure 6) and received, in addition to the various supplements, salt and minerals *ad libitum* with the following formula:

Salt-mineral mix	
Iron sulphate	200 gm.
Copper sulphate	200 gm.
Cobalt sulphate	60 gm.
Bone meal	40 kg.
Common salt	59.54 kg.
Total mix	100.00 kg.

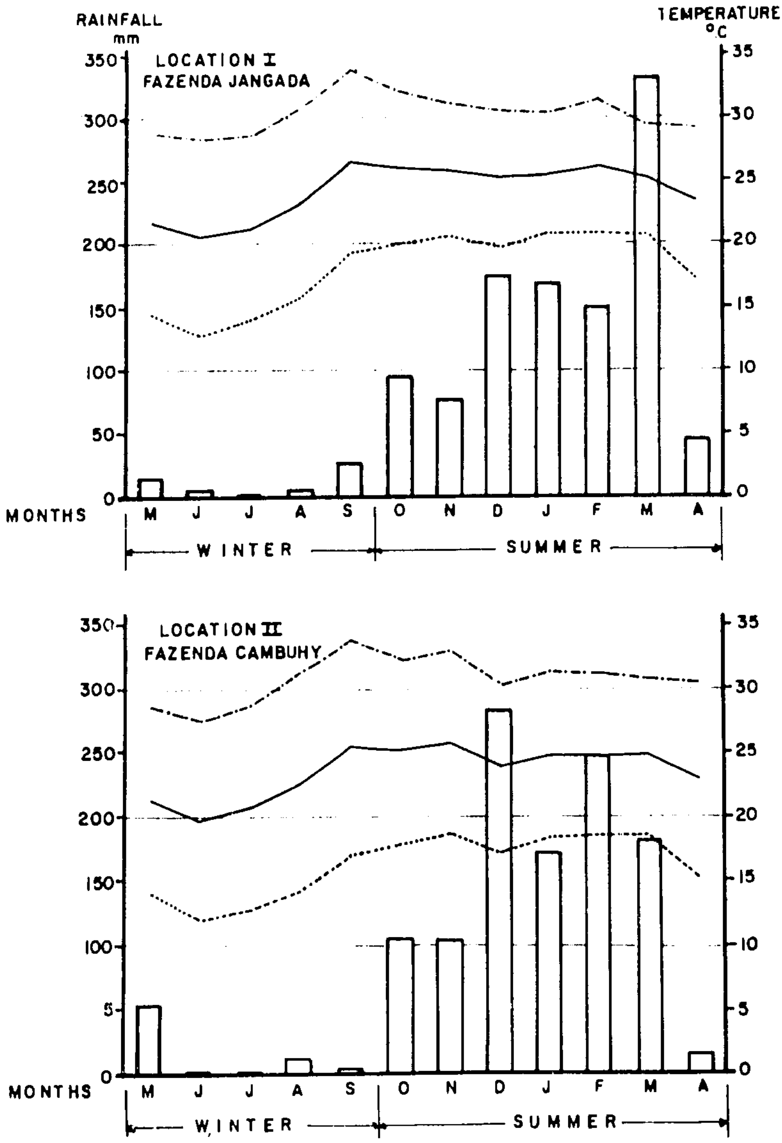

Figure 1. Monthly temperature and rainfall recordings during the period May 1961 through April 1962 at the two trial locations.

The only exception to supplying salt was in Experiment 5, in which salt was a variable.

Either one or both of two protein supplements were fed in all the experiments. These are referred to as high protein (H) meal containing 38.5% digestible protein equivalent and as low protein (L) meal containing either

14.6 or 19.6% digestible protein equivalent. In Experiments 2, 3 and 4, the formula for the L meal was changed at the time the cattle were weighed in September 1961 to increase the protein content and improve palatability. The three formulae used are given in Table 1, and the percentages are based on the feeding standards (Morrison, 1948; Feeds and Feeding, 21st ed.). The ground ear corn used in Experiment 1 was assumed to have total protein content of 7.3%, 5.3% digestible protein and 73.2% T.D.N.

With the exception of Experiment 3, Colonial Guineagrass, *Panicum maximum*, was the principal grass in the pastures grazed by the experimental animals. In Experiment 3, a Jaragua-Batatais, *Hyparrhenia rufa-Paspalum notatum*, pasture was used. In Experiments 1, 4 and 5, either two or three pasture replications were provided. The treatments were arranged in randomized complete block designs. In Experiments 2 and 3, only a single pasture for each treatment was available.

Results and Discussion

Experiment 1 — Ground ear corn, with and without a high-protein concentrate, as a supplement for steers grazing Colonial Guineagrass pasture

The purpose of this experiment was to investigate the response of one- and two-year-old steers to the feeding of ground ear corn with and without a protein concentrate when grazing Colonial Guineagrass pasture. The following numbers of steers were provided in each pasture and treatment as tester animals. Other animals were added and removed from the pasture to maintain the forage in as near optimum grazing condition as possible.

	Number of tester steers		
	Each pasture	Each treatment	Total 7 treatments
	Winter season (3 replications)		
Yearlings	5	15	105
2-year-olds	5	15	105
	Summer season (2 replications)		
Yearlings	5	10	70
2-year-olds	5	10	70

TABLE 1. High (H) and low (L) protein meal formulae—percentages of total protein, digestible protein and T.D.N. from Morrison (1948).

		Total protein		Digestible protein		T.D.N.	
	gm./kg.	%	gm./kg.	%	gm./kg.	%	gm./kg.
H meal formula							
Cottonseed meal	260	41.6	108.2	33.3	86.6	65.2	169.5
Peanut meal	260	41.1	106.9	36.6	95.2	73.3	190.6
Corn gluten meal	200	42.6	85.2	36.2	72.4	78.7	157.4
Molasses	100	2.9	2.9	0.0	—	53.7	53.7
Urea	50	262.0	131.0	262.0	131.0	0.0	—
Bone meal	50	5.5	2.8	0.0	—	0.0	—
Salt	79.20	0.0	—	0.0	—	0.0	—
Copper sulphate	0.25	0.0	—	0.0	—	0.0	—
Cobalt sulphate	0.05	0.0	—	0.0	—	0.0	—
Iron sulphate	0.50	0.0	—	0.0	—	0.0	—
Total, gm.	1,000.00		437.0		385.2		571.2
% in 1 kg. mixture			43.7		38.5		57.1
Original L meal formula							
Cottonseed meal	200	41.6	83.2	33.3	66.6	65.2	130.4
Mandioca	540	2.8	15.1	0.1	0.5	75.0	405.0
Molasses	100	2.9	2.9	0.0	—	53.7	53.7
Urea	30	262.0	78.6	262.0	78.6	0.0	—
Bone meal	50	5.5	2.8	0.0	—	0.0	—
Salt	79.20	0.0	—	0.0	—	0.0	—
Copper sulphate	0.25	0.0	—	0.0	—	0.0	—
Cobalt sulphate	0.05	0.0	—	0.0	—	0.0	—
Iron sulphate	0.50	0.0	—	0.0	—	0.0	—
Total, gm.	1,000.00		182.6		145.7		589.1
% in 1 kg. mixture			18.3		14.6		58.9
Revised L meal formula							
Cottonseed meal	350	41.6	145.6	33.3	116.6	65.2	228.2
Mandioca	390	2.8	10.9	0.1	0.4	75.0	292.5
Molasses	100	2.9	2.9	0.0	—	53.7	53.7
Urea	30	262.0	78.6	262.0	78.6	0.0	—
Bone meal	50	5.5	2.8	0.0	—	0.0	—
Salt	79.20	0.0	—	0.0	—	0.0	—
Copper sulphate	0.25	0.0	—	0.0	—	0.0	—
Cobalt sulphate	0.05	0.0	—	0.0	—	0.0	—
Iron sulphate	0.50	0.0	—	0.0	—	0.0	—
Total, gm.	1,000.00		240.8		195.6		574.4
% in 1 kg. mixture			24.1		19.6		57.4

The pastures averaged about 11 hectares in size and provided an adequate forage supply during the entire period of the experiment.

Response to supplements

During the winter season of 1961, which was very dry at Location I (Figure 1), the forage was of such poor quality that the gains of the yearlings and two-year-olds were only 23.7 and 32.6 kg. respectively ($P<.001$) for the 112-day period (see Table 2). The increase in gain per steer resulting from feeding supplement was almost identical for the yearlings and two-year-olds ($P>.25$). For both age groups, almost no increase in liveweight resulted from 1 kg. of supplement with or without protein, indicating that the animals must have been substituting concentrate for grass on an isocaloric basis at this level of feeding. At the 2-kg. level of feeding, an average of 9.1 kg. of extra liveweight per steer was produced, but at a cost of 224 kg. of concentrate, which gives a conversion rate of (224/9.1) 24.6. Since the amount of forage consumed was not measured, it is not possible to estimate the true conversion rate based on total feed consumption. It is obvious, however, that the animals were substituting concentrate for grass, since the concentrate consumption was far in excess of that required for the increase in performance. The rate of substitution, however, is probably dependent upon the level of grain, the availability and acceptability of the forage to the livestock and its nutritive value. Evidence for this is that at the 4-kg. rate of feeding, the average of all steers showed an increase in liveweight of 31.5 kg. for the 112-day winter period at a cost of 448 kg. of concentrate. This gives a conversion rate of (448/31.5) 14.2.

During the summer months, none of the rations increased the rate of gain ($P>.25$), and there was no difference in the performance of the yearlings and two-year-old steers ($P>.10$). At all levels of grain, very little if any additional advantage was gained by continuing with the grain, and the statistical significance of treatments ($P>.10$) disappeared as a result of combining the gains

TABLE 2. Influence of level of grain and protein supplements upon liveweight gains of Nellore steers grazing on Colonial Guineagrass pasture, 1961-1962—Experiment 1.

Treatments Rations—kg. per steer per day Pasture *ad libitum*—all groups	Steers	Steer age	Winter period 112 days 6.29.61 Av. weight	Winter period 112 days 10.19.61 Av. weight	Winter period 112 days Winter gain / steer	Winter period 112 days Inc. over control	Summer period 112 days 2.8.62 Av. weight	Summer period 112 days Summer gain / steer	Summer period 112 days Inc. over control	Winter plus summer 224 days Total gain / steer	Winter plus summer 224 days Inc. over control	Winter plus summer 224 days Av. daily gain steer	Winter plus summer 224 days Inc. over control	Growth index Control = 100
	No.	yrs.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	gm.	gm.	
Yearling steers														
1. Control — pasture alone	15-10	1	252.9	265.9	13.0	—	374.7	108.8	—	121.8	—	544	—	
2. 1 kg. ground ear corn	15-10	1	254.8	268.9	14.1	1.1	381.5	112.6	3.8	126.7	4.9	566	22	104
3. 2 kg. ground ear corn	15-10	1	258.6	280.1	21.5	8.5	394.4	114.3	5.5	135.8	14.0	606	62	111
4. 4 kg. ground ear corn	15-10	1	257.2	300.7	43.5	30.5	417.5	116.8	8.0	160.3	38.5	716	172	132
5. 1 kg. g.e.c. w/H meal (9:1)	15-10	1	257.0	270.7	13.7	.7	384.3	113.6	4.8	127.3	5.5	568	24	104
6. 2 kg. g.e.c. w/H meal (9:1)	15-10	1	262.2	283.7	21.5	8.5	394.1	110.4	1.6	131.9	10.1	589	45	108
7. 4 kg. g.e.c. w/H meal (9:1)	15-10	1	259.5	298.1	38.6	25.6	403.7	105.6	−3.2	144.2	22.4	644	100	118
Mean for yearlings					23.7			111.7		135.4				
Two-year-old steers														
1. Control — pasture alone	15-10	2	345.1	365.8	20.7	—	468.5	102.7	—	123.4	—	551	—	
2. 1 kg. ground ear corn	15-10	2	344.2	358.6	14.4	−6.3	467.6	109.0	6.3	123.4	0.0	551	0	100
3. 2 kg. ground ear corn	15-10	2	344.2	371.3	27.1	6.4	486.4	115.0	12.3	142.1	18.7	634	83	115
4. 4 kg. ground ear corn	15-10	2	344.8	401.9	57.1	36.4	498.6	96.7	−6.0	153.8	30.4	687	136	125
5. 1 kg. g.e.c. w/H meal (9:1)	15-10	2	340.9	362.2	21.3	.6	470.0	107.8	5.1	129.1	5.7	576	25	105
6. 2 kg. g.e.c. w/H meal (9:1)	15-10	2	342.5	376.1	33.6	12.9	489.0	112.9	10.2	146.5	23.1	654	103	119
7. 4 kg. g.e.c. w/H meal (9:1)	15-10	2	345.1	399.4	54.3	33.6	504.6	105.2	2.5	159.5	36.1	712	161	129
Mean for 2-year-olds					32.6			107.0		139.6				

Statistics — Gain/steer, kg.:	Winter	Summer	Winter plus summer
Between treatments	s = 19.0 P < .001	s = 14.2 P > .25	s = 36.8 P > .10
Between age groups	s = 13.5 P < .001	s = 15.6 P > .10	s = 20.6 P > .10
Treatment × Age	s = 13.5 P > .25	s = 15.6 P > .25	s = 20.6 P > .25
C.V. (Treatments) =	67.4%	13.0%	26.5%

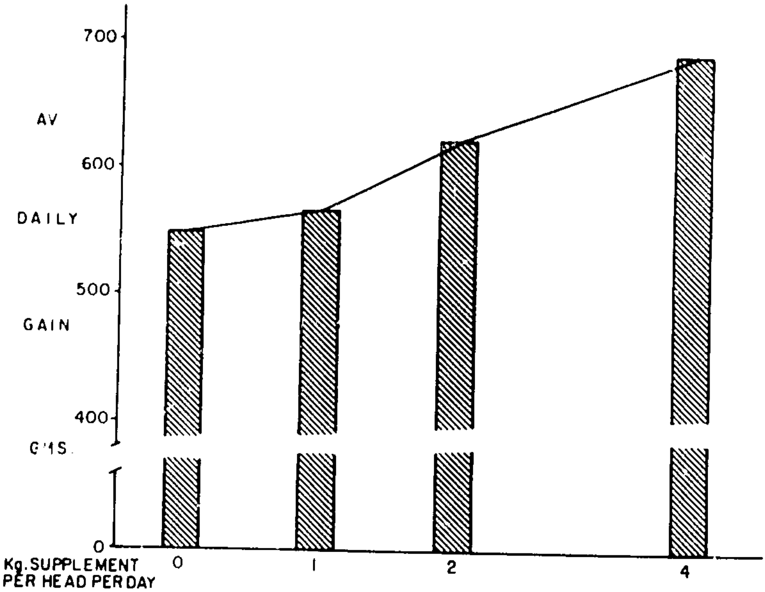

Figure 2. Response to increasing increments of supplemental feeding of steers on Colonial Guineagrass pasture—average of yearlings and two-year-olds; of ground ear corn with and without protein supplement (Experiment 1).

of the winter and summer periods. By combining the data for both yearlings and two-year-old steers, and the results obtained from the three levels of concentrate with and without protein with the ground ear corn, a linear relationship ($P<.025$) was found between level of concentrate fed and gain per steer (see Figure 2). The quadratic was not significant ($P>.25$). The seasonal response to the 4-kg. rate of concentrate is shown in Figure 3, illustrating that most of the response occurred during the winter months with no further increase during the subsequent summer.

Experiments 2 and 3 – The relationship of pasture quality to the response of feed supplements in the form of high- and low-protein concentrates

The quality of herbage in the pastures of Brazil is extremely variable both in different pastures and at different times of the year. This extreme variation complicates the problem of formulating a supplement suitable

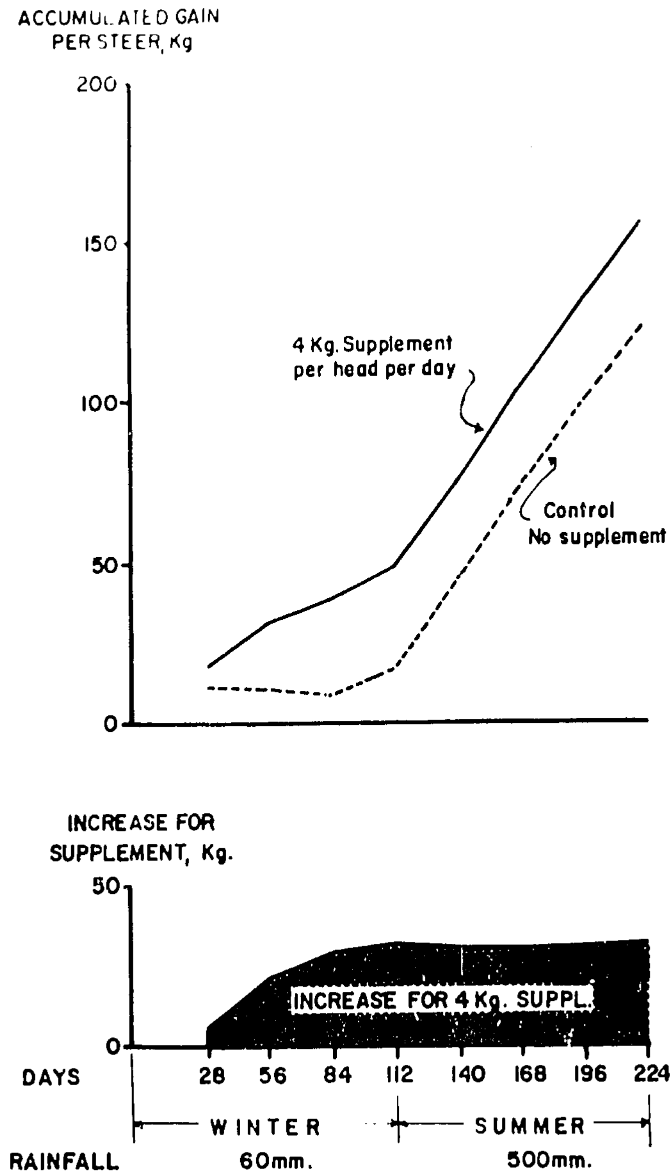

Figure 3. Seasonal response to 4 kg. of feed to yearlings and two-year-old steers on pasture, 1961-1962 (Experiment 1).

for all conditions. The purpose of these two experiments was to determine if differences in response could be expected on pastures of different quality, at what level of intake the differences would most likely occur and at what season of the year.

Two pastures were selected: the first, on Fazenda Jangada (Location I), a good-quality Colonial Guineagrass pasture of about 96 ha., which was fenced to provide for six pastures of 16 ha. each; the second, on Fazenda Cambuhy (Location II), a medium-quality pasture of Jaragua, *Hyparrhenia rufa,* and Batatais, *Paspalum notatum,* which was fenced to provide six pastures of about 30 ha. each. At Location I, 16 two-year-old tester steers of the Nellore type were allocated at random to each of the six pastures. At Location II, 20 three-year-old mixed-breed Zebu steers were allocated at random to each of the six pastures.

The formulae for the protein supplements used in these trials are given in Table 1. The low protein (L) supplement was fed at ½ and 1 kg. per steer daily, and the high protein (H) at ½, 1 and 2 kg. per steer daily.

The results are presented in Tables 3 and 4 for the winter and summer seasons and the combined periods.

Response to supplements

During the winter season of 1961, there was no increase in gain per animal on the Colonial Guineagrass pasture except when the H meal was fed at 2 kg. per head daily. Up to this level, the steers were apparently substituting the supplement for forage on an isocaloric basis. The 2-kg. level, however, gave an increase over the control group of 12.6 kg. ($P<.001$). On the medium-quality pasture at Fazenda Cambuhy, the control steers which received no supplement lost weight, and substantial increases over the control steers were obtained from feeding supplements. The data suggest that the higher protein meal (H) produced higher rates of gain than the low protein feed (L). For the 2-kg. rate of H meal, the average daily gains per steer were not greatly different at the two locations. They were 305 gm. and 334 gm. at Locations I and II respectively. Since these gains represent feed: liveweight increase ratios of 6.6 and 6.0 respectively, the steers in these groups must have been obtaining about half of their energy from the supplement and about half from the pasture.

TABLE 3. Influence of low- and high-protein concentrates upon liveweight gains of Nellore steers grazing on good-quality Colonial Guineagrass pasture, 1961-1962—Experiment 2.

Treatments Rations—kg. per steer per day Pasture *ad libitum*—all groups	Steers	Steer age	Winter period 105 days				Summer period 195 days			Winter plus summer 300 days				
			7.7.61 Av. weight	10.20.61 Av. weight	Winter gain/steer	Inc. over control	5.3.62 Av. weight	Summer gain/steer	Inc. over control	Total gain/steer	Inc. over control	Av. daily gain/steer	Inc. over control	Growth index Control = 100
	No.	yrs.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	gm.	gm.	
1. Control — pasture alone	16	2	322.7	342.1	19.4	—	480.6	138.5	—	157.9	—	526	—	
2. ½ kg. L meal	16	2	321.6	335.4	13.8	–5.6	483.4	148.0	9.5	161.8	3.9	539	13	102
3. 1 kg. L meal	16	2	319.8	334.2	14.4	–5.0	475.6	141.4	2.9	155.8	–2.1	519	– 7	99
4. ½ kg. H meal	16	2	324.1	342.3	18.2	–1.2	478.5	136.2	–2.3	154.4	–3.5	514	–12	98
5. 1 kg. H meal	16	2	324.4	350.7	26.3	6.9	486.2	135.5	–3.0	161.8	3.9	539	13	102
6. 2 kg. H meal	16	2	319.6	351.6	32.0	12.6	499.2	147.6	9.1	179.6	21.7	598	72	114
Statistics — Gain/steer, kg.:				s = 10.1 P < .001 C.V. = 48.9%				s = 16.9 P > .10 C.V. = 12.0%		s = 20.6 P < .025 C.V. = 12.7%				

TABLE 4. Influence of low- and high-protein concentrates upon liveweight gains of mixed-breed Zebu steers grazing on medium-quality Jaragua-Batatais pasture, 1961-1962—Experiment 3.

Treatments Rations—kg. per steer per day Pasture *ad libitum*—all groups	Steers	Steer age	Winter period 140 days: 6.6.61 Av. weight	Winter period 140 days: 10.24.61 Av. weight	Winter period 140 days: Winter gain steer	Winter period 140 days: Inc. over control	Summer period 168 days: 4.10.62 Av. weight	Summer period 168 days: Summer gain/steer	Summer period 168 days: Inc. over control	Winter plus summer 308 days: Total gain/steer	Winter plus summer 308 days: Inc. over control	Winter plus summer 308 days: Av. daily gain/steer	Winter plus summer 308 days: Inc. over control	Growth index Control = 100
	No.	yrs.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	gm.	gm.	
1. Control — pasture alone	20	3	295.4	282.0	−13.4	—	406.0	124.0	—	110.6	—	359	—	
2. ½ kg. L meal	20	3	295.0	291.4	− 3.6	9.8	424.9	133.5	9.5	129.9	19.3	422	63	117
3. 1 kg. L meal	20	3	298.8	292.6	− 6.2	7.2	432.7	140.1	16.1	133.9	23.3	435	76	121
4. ½ kg. H meal	20	3	300.0	307.6	7.6	21.0	431.0	123.4	− .6	131.0	20.4	425	66	118
5. 1 kg. H meal	20	3	301.7	330.7	29.0	42.4	449.0	118.3	−5.7	147.3	36.7	478	119	133
6. 2 kg. H meal	20	3	292.2	339.0	46.8	60.2	465.2	126.2	2.2	173.0	62.4	562	203	156
Statistics — Gain/steer, kg.:					s = 10.4			s = 14.9		s = 16.9				
					P < .001			P < .001		P < .001				
					C.V. = 104.0%			C.V. = 11.6%		C.V. = 12.2%				

During the subsequent summer season at Location I, there was no response to the supplements ($P>.10$), which attests to the high quality of Colonial Guineagrass as a feed. With the exception of the 2-kg. rate of H meal ($P<.025$), there were no differences in the gains per animal for the combined winter and summer seasons. At Location I on the good-quality pasture, there is no evidence that the H meal was any better than the L meal. It appears that the response can be accounted for solely on the basis of the added energy intake from the 2-kg. rate.

At Location II on the medium-quality pasture, the advantage for the H meal which appeared during the previous winter season disappeared during the following summer season. Although the differences in liveweight gain per animal were significant ($P<.001$), it appears that the gains of the various groups were compensatory and, with the exception of the 2-kg. rate of H meal, no difference was found among the treatments.

Compensatory growth has been studied in beef cattle by Winchester and Ellis (1957), Winchester *et al.* (1957) and by Carroll *et al.* (1963), and all have found large increases in growth during a subsequent liberal feeding period after a previous period of energy or protein restriction. It is apparent that the winter-dry period in Brazil subjects the animals to a period of restricted energy and/or protein intake which is usually followed by a period of liberal feeding on high-quality forage. This has the effect of wiping out or leveling off any previous effect which the supplements might have in meeting the protein-energy requirements of the animals on pasture.

The seasonal pattern of response to the 2-kg. rate of H meal at each of the two locations is well illustrated in Figures 4 and 5. The differences in the increase for the 2 kg. of H meal of 72 gm. and 203 gm. at the two locations respectively reveal the complexity of the problem of supplementation of growing-fattening steers on pasture. The results also indicate that small amounts of supplement are not effective in changing the rate of growth during periods which extend into the summer season.

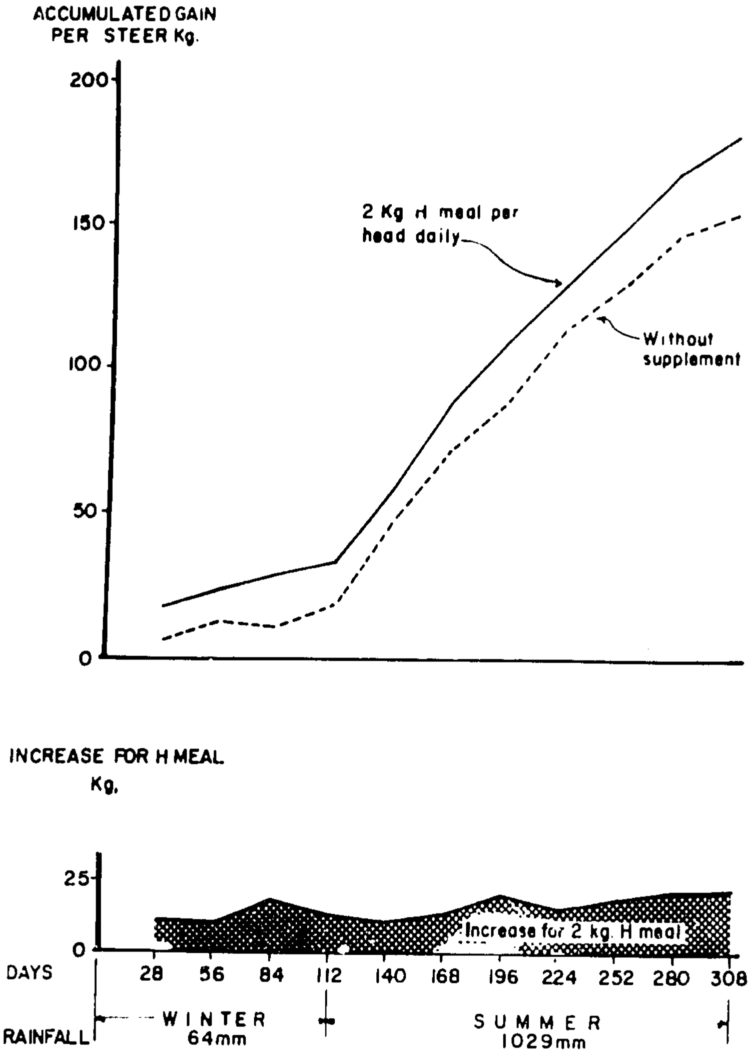

Figure 4. Seasonal response to 2 kg. of supplement fed to two-year-old steers on good-quality Colonial Guineagrass pasture, 1961-1962 (Experiment 2).

Experiment 4 — Feeding of low levels of protein concentrates and feed additives to three-year-old Zebu steers

Little is known relative to the vitamin A requirements of the Zebu animal and whether the forage species found in the pastures of Brazil will supply its requirements. The source of vitamin A in most forages is β-carotene, and it is not known whether the Zebu animal is effective in converting β-carotene into vitamin A, although it has long been recognized that there are breed differences, e.g. the Guernsey and the Holstein breeds. Chapman *et al.* (1964) fed vitamin A to two-year-old steers in a fattening ration on St. Augustinegrass pasture, *Stenotaphrum secundatum*, at levels to provide intake of 25,000

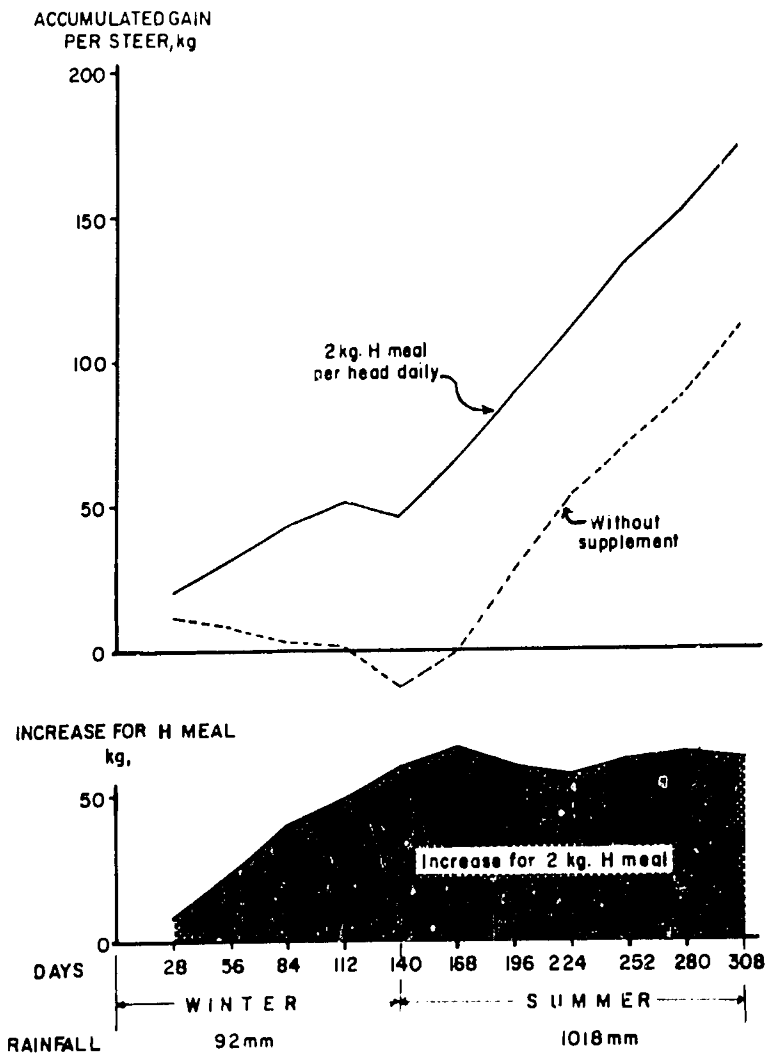

Figure 5. Seasonal response to 2 kg. of supplement fed to three-year-old steers on medium-quality Jaragua-Batatais pasture, 1961-1962 (Experiment 3).

Figure 6. Mixed-breed Zebu steers being fed protein concentrates on medium-quality Jaragua-Batatais pasture during the winter-dry season of 1961 (Experiment 3).

Figure 7. Mixed-breed Zebu steers grazing Jaragua-Batatais pasture near the end of the summer-wet season of 1961-1962 (Experiment 3). Note the excellent condition of the cattle.

and 50,000 I.U. per steer per day. The 25,000 I.U. increased the rate of growth by 11%, and the 50,000 I.U. by 17% during the winter season, but had no effect during the summer season. Beeson *et al.* (1961) fed vitamin A at levels from 10,000 to 50,000 I.U. per steer daily with and without alfalfa pellets containing about 14.2 mg. of caro-

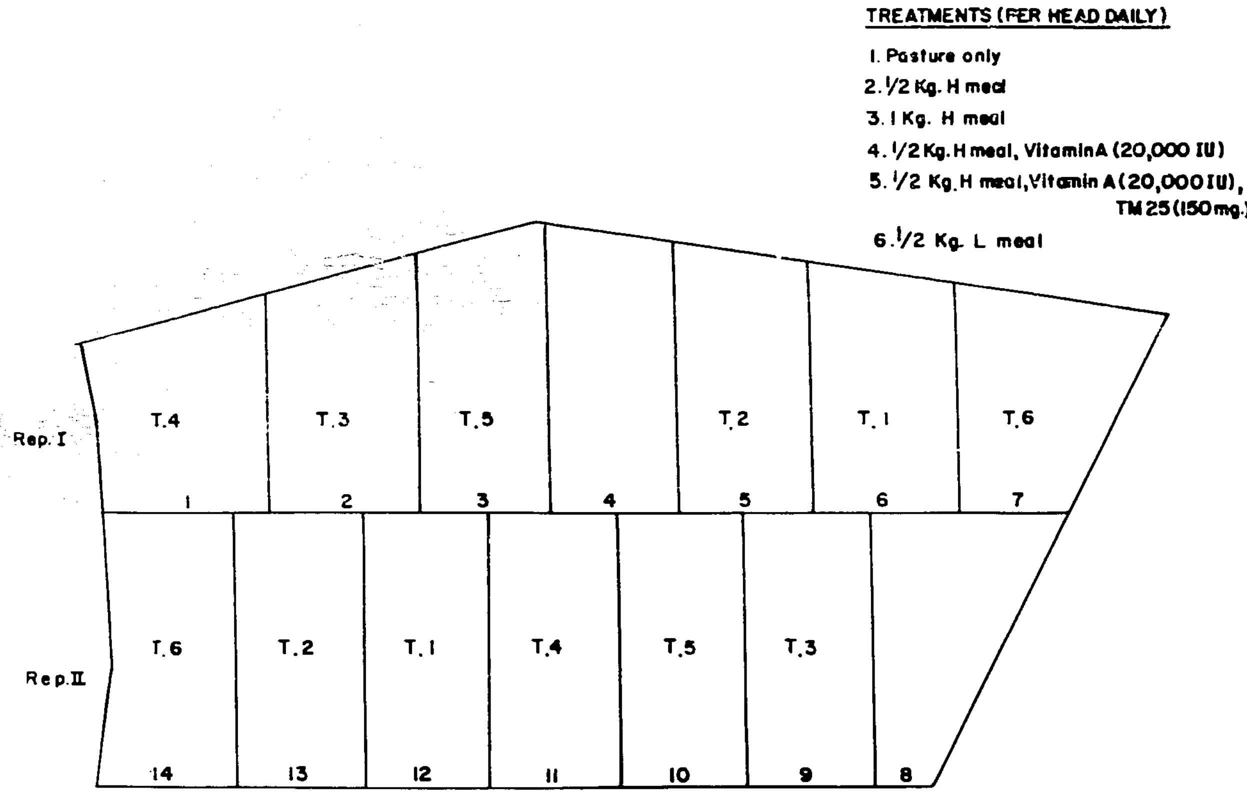

Figure 8. Field plan of Experiment 4. Pastures are 8.9 ha. and held 8 tester animals each.

tene per pound. Without the alfalfa in the basal ration, a 22% increase in average daily gain was obtained when 20,000 I.U. of vitamin A was included in the ration. With alfalfa constituting 10% of the ration, there was no response to the vitamin A additive.

It was the purpose of Experiment 4 to determine whether certain feed additives would contribute to the nutrition of steers on pastures and whether their addition might be economically feasible. Included in this trial were vitamin A and terramycin. Terramycin has been used extensively in feed rations to reduce the level of parasitism in livestock, but its effectiveness is greatly dependent upon the level of parasitic infection in any given herd. If there is little or no infection, then responses to terramycin are usually negligible. Vitamin A, palmitate was supplied at the rate of 20,000 I.U. per 500 gm. of H meal, and terramycin at 150 mg. per 500 gm. of H meal.

The experiment consisted of six treatments in two field replications. Twelve pastures of 8.9 ha. each were provided which furnished sufficient forage for eight tester animals per pasture throughout the 308 days of the trial (see Figure 8). The animals were three-year-old mixed-breed Zebu steers. The H and L meal formulae are given in Table 1. The treatments used in the trial and the results of the experiment are given in Table 5.

Response to supplements and additives

During the winter months, the control steers which did not receive any supplement lost an average of 5.7 kg. per steer. All steers receiving the supplement gained weight, and the greatest gains occurred with the steers receiving the H meal at 1 kg. per steer daily. Satisfactory responses were also obtained from steers receiving ½ kg. of H meal and ½ kg. of H meal, vitamin A and TM-25 ($P < .025$).

During the summer months, none of the treatments gave significant increases in liveweight gain, and all differences disappeared for the combined winter and summer seasons ($P > .05$).

It is obvious that steers grazing good pastures are

TABLE 5. Influence of protein supplements and feed additives upon liveweight gains of mixed-breed Zebu steers grazing on Colonial Guineagrass pasture, 1961-1962—Experiment 4.

Treatment[a] Rations—kg. per steer per day Pasture *ad libitum*—all groups	Steers	Steer age	Winter period 112 days: 6.27.61 Av. weight	Winter period 112 days: 10.17.61 Av. weight	Winter period 112 days: Winter gain/ steer	Winter period 112 days: Inc. over control	Summer period 196 days: 5.1.62 Av. weight	Summer period 196 days: Summer gain/ steer	Summer period 196 days: Inc. over control	Winter plus summer 308 days: Total gain/ steer	Winter plus summer 308 days: Inc. over control	Winter plus summer 308 days: Av. daily gain/ steer	Winter plus summer 308 days: Inc. over control	Growth index Control = 100
	No.	yrs.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	gm.	gm.	
1. Control — pasture alone	16	3	292.8	287.1	–5.7	—	443.0	155.9	—	150.2	—	488	—	
2. ½ kg. H meal	16	3	287.2	300.2	13.0	18.7	463.6	163.4	7.5	176.4	26.2	573	85	117
3. 1 kg. H meal	16	3	285.4	309.7	24.3	30.0	468.7	159.0	3.1	183.3	33.1	595	107	122
4. ½ kg. H meal w/vitamin A (20,000 IU)	16	3	288.4	297.4	9.0	14.7	464.8	167.4	11.5	176.4	26.2	573	85	117
5. ½ kg. H meal w/vitamin A (20,000 IU) & TM–25 (150 mg.)	16	3	289.4	308.7	19.3	25.0	455.6	146.9	–9.0	166.2	16.0	540	52	111
6. ½ kg. L meal	16	3	288.2	292.5	4.3	10.0	450.1	157.6	1.7	161.9	11.7	526	38	108
Statistics — Gain/steer, kg.:					s = 13.5 P < .025 C.V. = 127.2%			s = 17.0 P > .05 C.V. = 10.6%		s = 24.6 P > .05 C.V. = 14.4%				

[a]Supplements and feed additives furnished by Pfizer Corporation do Brasil.

able to meet their protein requirements during most of the year with the possible exception of short periods during the winter months. From this experiment and others presented in this paper, the first limiting factor appears to be energy. The supplement is a supplier of energy as well as protein, but the responses obtained can be explained on the basis of the added energy consumed. If rates of liveweight gain are to be increased above 500-600 gm. per steer per day, additional energy must be supplied since this is about the gain that can be expected from pasture alone.

Experiment 5 — Ratio of supplement to salt for regulating intake of supplement by grazing Zebu steers

The relatively uniform consumption rate of salt by grazing animals has been used as a means of controlling the rate of intake of range cattle supplements. By mixing salt with an appropriate amount of supplement, the amount of supplement consumed may be controlled. The purpose of this trial was to determine the ratio of supplement to salt which would result in the consumption of regulated amounts of supplement by the Zebu animal when grazing Colonial Guineagrass pastures.

Figure 9. Steers receiving protein concentrate during the winter-dry season of 1961 on Colonial Guineagrass pasture (Experiment 4).

The experiment consisted of five treatments in two field replications, or a total of ten pastures arranged in two randomized complete blocks. Mixed-breed Zebu steers, three years of age, were used as tester animals in this trial. Four animals were allocated at random to each of the ten pastures, making a total of eight steers per treatment.

The results are presented in Tables 6 and 7 and in Figure 10. The steers in Treatment 1 received 500 gm. of H meal per day. Salt and minerals were fed *ad libitum*. This group was considered the control group. The amount of supplement consumed per steer per day for the various concentrate-salt ratios is given in Table 6 for both the winter and summer seasons. During the four months of the winter season, the amount of H meal consumed by the five groups was not reduced by the amount of salt mixed

TABLE 6. Summary of H meal consumption by 28-day periods during the winter and summer periods of 1961-1962—Experiment 5.

28-day period	Treatments[a] 1 Salt *ad lib.*	2 H:salt 20:1	3 H:salt 10:1	4 H:salt 5:1	5 H:salt 2½:1
	Consumption of H meal, grams per head per day				
Winter 1961 (112 days)					
July 7 to Aug. 4	500	500	500	500	500
Aug. 4 to Sept. 1	500	500	500	500	500
Sept. 1 to Sept. 29	500	500	500	500	500
Sept. 29 to Oct. 27	500	495	483	467	437
Av. winter consumption per steer	500	499	496	492	484
Summer 1961-1962 (196 days)					
Oct. 27 to Nov. 24	500	471	383	399	241
Nov. 24 to Dec. 22	500	500	483	473	357
Dec. 22 to Jan. 19	500	500	474	473	375
Jan. 19 to Feb. 16	500	482	455	375	304
Feb. 16 to Mar. 16	500	491	437	375	357
Mar. 16 to Apr. 13	500	500	411	339	286
Apr. 13 to May 11	500	500	474	367	286
Av. summer consumption per steer	500	492	445	400	315

[a] 500 gm. H meal supplement furnished per steer per day in all treatments.

TABLE 7. Influence of a high-protein supplement and level of salt upon liveweight gains of mixed-breed Zebu steers grazing on Colonial Guineagrass pasture, 1961-1962—Experiment 5.

Treatments Rations—kg. per steer per day Pasture *ad libitum*—all groups	Steers	Steer age	Winter period 112 days 7.7.61 Av. weight	10.27.61 Av. weight	Winter gain/steer	Inc. over control	Summer period 196 days 5.11.62 Av. weight	Summer gain/steer	Inc. over control	Winter plus summer 308 days Total gain/steer	Inc. over control	Av. daily gain/steer	Inc. over control	Growth index Control = 100
	No.	yrs.	kg.	kg.	kg.	kg.	kg.	kg.	kg	kg.	kg.	gm.	gm.	
1. 500 gm. H meal + salt *ad lib.*	8	3	290.2	293.3	3.1	—	461.7	168.4	—	171.5	—	557	—	
2. 500 gm. H meal + 25 gm. salt	8	3	287.3	300.9	13.6	10.5	472.3	171.4	3.0	185.0	13.5	601	44	108
3. 500 gm. H meal + 50 gm. salt	8	3	297.2	314.2	17.0	13.9	480.2	166.0	-2.4	183.0	11.5	594	37	107
4. 500 gm. H meal + 100 gm. salt	8	3	284.8	301.6	16.8	13.7	465.2	163.6	-4.8	180.4	8.9	586	29	105
5. 500 gm. H meal + 200 gm. salt	8	3	280.8	286.5	5.7	2.6	441.5	155.5	-13.4	160.7	-10.8	522	-35	94
Statistics — Gain/steer, kg.:					s = 12.4 P > .25 C.V. = 108.0%			s = 22.6 P > .25 C.V. = 13.7%		s = 24.0 P > .25 C.V. = 13.6%				

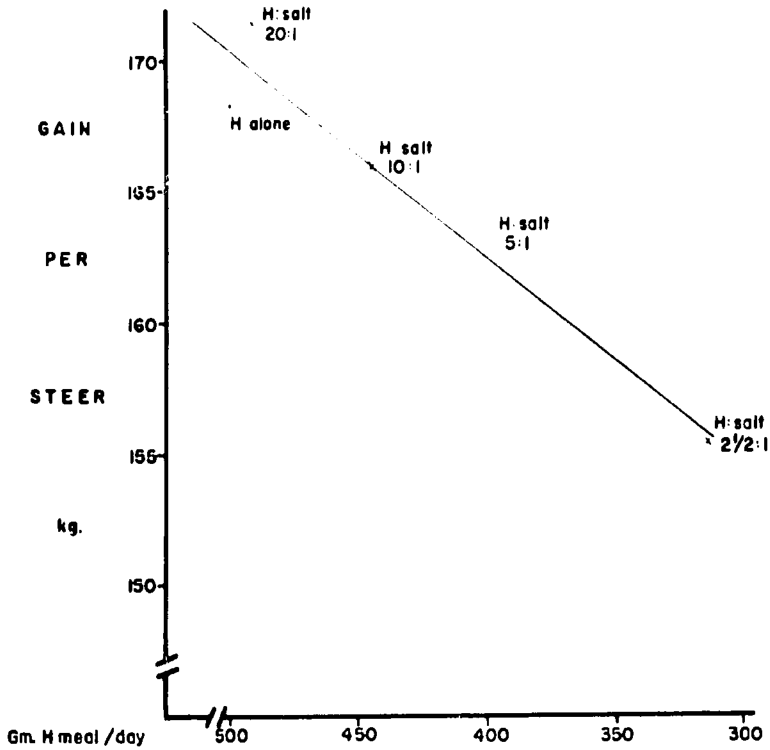

Figure 10. Relationship of protein supplement consumption, as regulated by salt concentration, upon the gain per steer; summer-wet season of 1961-1962 (Experiment 5).

with the supplement. Beginning with the summer season, the amount of H meal consumed was reduced as the amount of salt in the mixture was increased.

The gain per steer during the winter, the summer, and the combined winter and summer periods appears not to have been influenced by the level of salt supplied with the H meal (P>.25, Table 7). There is some evidence, however, that increasing the salt did reduce the consumption of H meal (Table 6) and consequently the gain per animal during the summer season (see Figure 10), but the differences were not great enough to be significant (Table 7). During the winter-dry season, when the quantity and quality of the forage were at a relatively low level, the steers consumed all the supplement regardless of the salt concentration. These preliminary results indicate that the salt concentration in a supplement may be effective in controlling the intake of the supplement during the summer season when forage quality is high, but that the upper limit on salt consumption was not reached during the winter season when forage quality was low. The change in quality of the pasture during the winter and summer seasons is well illustrated by the crude protein content of the forage sampled periodically during the period of this trial (see Figure 11). The crude protein content during most of the winter season was about 3%, rising to over 10% during the months of January and February.

Additional studies will be needed at higher levels of supplement consumption to determine at what level will salt concentration be effective in regulating intake.

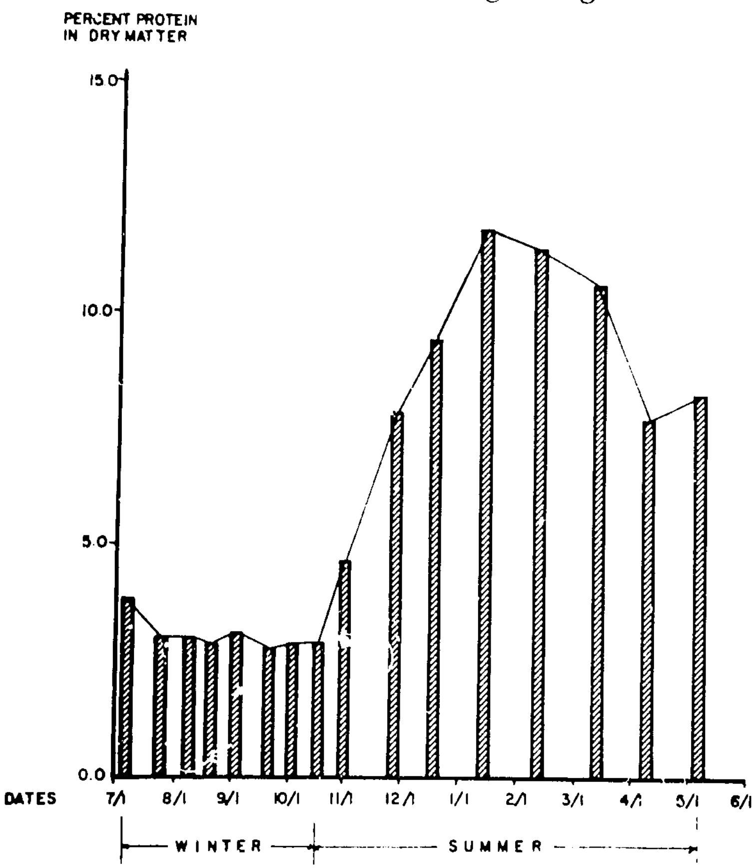

Figure 11. Crude protein content of pasture forage during the dry and wet seasons of 1961-1962 (Experiment 5).

Interpretation of Results and Conclusions

Feeding concentrates to beef cattle on pasture might be expected to have one or more of several beneficial effects. The concentrate may furnish 1) additional energy to the animal, 2) supplemental protein, or 3) supply some other nutritional factor not available or deficient in the pasture forage. If any one of these effects is operating in a given situation, an increase in gain per animal might be expected.

The results from these trials indicate that the extra protein supplied in the supplements was not effective in increasing gains over that which can be accounted for by an increase in caloric intake. At low levels of concentrate feeding, either of a low or high protein percentage, increases in rates of gain were negligible. This suggests that the steers were reducing their consumption of pasture forage with increasing rates of concentrate consumption. However, since the concentrate gave greater increases in gain during the winter season than during the following summer season, the rate of pasture forage replacement by the concentrate must have been different for the two seasons. It was possible to make some estimates of this substitution rate from the results obtained in Experiment 1. In this experiment, the daily T.D.N. requirements of steers for maintenance and gain were computed at the four levels of concentrate feeding: 0, 1, 2 and 4 kg. per day. The results of this computation are illustrated graphically in Figure 12. During the winter months, when the forage quality was inferior to that in the summer, the effective T.D.N. consumption from pasture alone was much lower—about 3000 gm. of T.D.N. in the winter season versus over 5000 gm. in the summer. The reduction in effective T.D.N. consumption from pasture resulting from increasing increments of concentrate was less in the winter-dry season than during the following summer season. Each increase of 100 gm. of T.D.N. supplied in the concentrate reduced the consumption of pasture T.D.N. by 76 gm. during the winter season and during the summer by 86 grams. Based upon the requirements for maintenance and increased gain in liveweight, one must con-

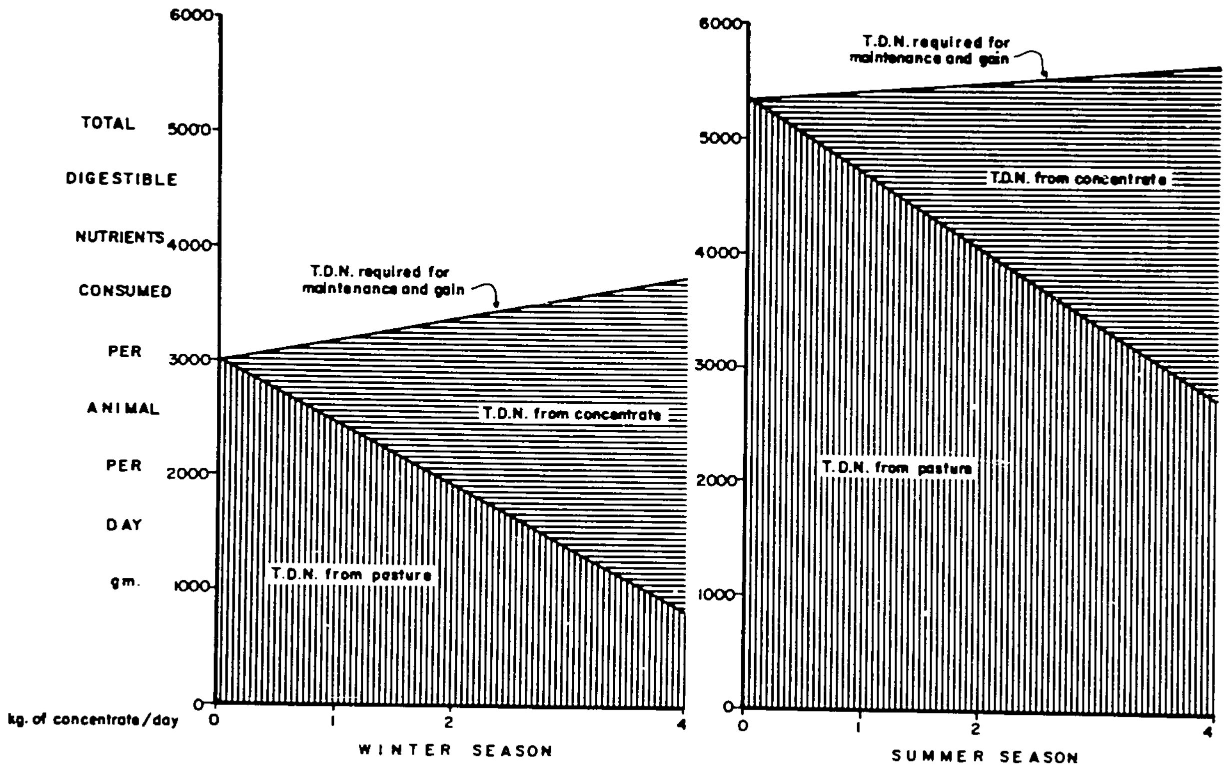

Figure 12. Consumption of total digestible nutrients from Colonial Guinea-grass pasture and concentrate at increasing levels of concentrate feeding (Experiment 1).

clude that the net gain in T.D.N. consumption, resulting from each increment of 100 gm. of T.D.N. in concentrate, was 24 gm. during the winter-dry season and 14 gm. during the summer-wet season. The remainder of the T.D.N. was accounted for by its replacement or substitution for an equivalent amount of effective T.D.N. from pasture forage. (NOTE: A complete substitution of 100 gm. of effective T.D.N. in concentrate for 100 gm. in pasture forage would have resulted in zero increase in gain as a result of feeding increasing amounts of concentrates.)

From Figure 12 it is evident that as the amount of concentrate consumption increases, the amount of forage consumed decreases. This, then, has the effect of increasing the number of animals which a given area of pasture may carry as the amount of concentrate fed increases. In Experiment 1, the carrying capacity of the pastures was not measured, but it was evident that the amount of forage being consumed by the animals without supplement was greater than where concentrate was being fed. Future experiments with concentrates on pastures should include the measurement of carrying capacity as well as measuring the effect upon the animal performance since it now appears that the animal substitutes concentrate for pasture forage. If the effect of concentrate feeding upon the carrying capacity is not measured, then the pasture-sparing effect of concentrate will not be properly evaluated. Likewise, if the farmer who feeds concentrates to his cattle on pasture does not take advantage of the extra pasture available by adding more animals on a unit area of pasture, only a part of the true value of concentrate will be realized.

As feed additives, neither vitamin A nor terramycin gave any response as indicated by increases in rate of gain.

The use of varying amounts of salt in concentrate mixtures to control intake did not prove effective when the forage supply was of poor quality, but evidence is presented which indicates that salt may be used effectively to control intake on pastures of high quality.

Literature Cited

Becker, M., G. L. da Rocha, M. I. Montagnini e P. F. Gandra. 1962. Ensaios de digestibilidade (aparente) de plantas forrageiras. Rev. Indústria Animal, São Paulo, Nova Série 20:297.

Beeson, W. M., T. W. Perry, M. T. Mohler and W. H. Smith. 1961. Levels of supplemental vitamin A with and without sun-cured alfalfa meal for fattening steer calves. Purdue U. Agri. Exp. Sta. Mimeo AS-297.

Carroll, F. D., J. David Ellsworth and Dietrich Kroger. 1963. Compensatory carcass growth in steers following protein and energy restriction. J. Animal Sci. 22:197.

Chapman, H. L., Jr., R. L. Shirley, A. Z. Palmer, C. E. Haines, J. W. Carpenter and T. J. Cunha. 1964. Vitamins A and E in steer fattening rations on pasture. J. Animal Sci. 23:669.

Coombe, J. B. and D. E. Tribe. 1962. The feeding of urea supplements to sheep and cattle: the results of pen feeding and grazing experiments. J. Agri. Sci. 59:125.

Hull, J. L. and J. H. Meyer. 1962. A new method of feeding beef cattle on pasture. California Agri. 16:12.

McClymont, G. L. 1956. Response of stock to supplementary feeding on pasture. Proc. Australian Soc. An. Prod. 1:63.

Morrison, Frank B. 1948. Feeds and feeding (21st ed.). The Morrison Publishing Co., Ithaca, New York.

Paiva Neto, J. E., R. A. Catani, A. Kupper, H. P. Medina, F. C. Verdade, M. Gutmans e A. C. Nascimento. 1951. Observações gerais sôbre os grandes tipos de solo do Estado de São Paulo. Bragantia 11:227-253.

Smith, C. A. 1961. The utilization of *Hyparrhenia* veld for the nutrition of cattle in the dry season. II Veld hay compared with *in situ* grazing of the mature forage, and the effects of feeding supplemental nitrogen. J. Agri. Sci. 57:311.

Smith, C. A. 1962. The utilization of *Hyparrhenia* veld for the nutrition of cattle in the dry season. III Studies on the digestibility of the produce of mature veld and veld

hay, and the effect of feeding supplementary protein and urea. J. Agri. Sci. 58:173.
Winchester, C. F. and N. R. Ellis. 1957. Delayed growth of beef cattle. U.S.D.A. Tech. Bull. No. 1159.
Winchester, C. F., R. L. Hiner and V. C. Scarborough. 1957. Some effects on beef cattle of protein and energy restriction. J. Animal Sci. 16:426.

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Studies on the Flowering of Coffea Arabica L., Portugaliae Acta Biologica, vol. 4 no. 4, Vol. 5 no. 1, Lisbon 1957 (English edition) 1957.

Estudios Sobre La Florescencia Del Coffea Arabica L. (Spanish edition) 1958.

Estudios Sôbre o Florescimento de Coffea Arabica L. (Portuguese edition) 1958.

Bulletin #15 — Quinn, L. R., Mott, G. O., Bischoff, W. B., and McClung, A. C.

Stilbestrol and Its Effects on Pasture Fed Zebu Steers (English edition) 1958.

El Estilbestrol y sus Efectos en Novillos Cebú Criados en Pastizales (Spanish Edition) 1958.

O "Stilbestrol" e Seu Efeito Sôbre Novilhos Zebu Alimentados em Pastos (Portuguese edition) 1958.

Bulletin #16 — Franco, Coaracy M.

Influence of Temperature on Growth of Coffee Plant (English edition) 1958.

Influencia da Temperatura no Crescimento do Cafeeiro (Portuguese edition) 1959.

Influencia de la Temperatura en el Desarrollo del Cafeto (Spanish edition) 1958.

Bulletin #17 — McClung, A. C., de Freitas, L. M. M., and Lott, W. L.

Analyses of Several Brazilian Soils in Relation to Plant Responses to Sulfur. Soil Science Society of America Proceedings, Vol. 23, No. 3, May-June 1959, pages 221-229 (English edition) 1959.

Estudos Sôbre o Enxôfre em Solos de São Paulo (Portuguese edition) 1959.

Análisis de varios suelos brasileños en relación con las respuestas de las plantas al azufre (Spanish edition) 1959.

Bulletin #18 — McClung, A. C. and Quinn, L. R.

Sulfur and Phosphorus Responses of Batatais Grass (Paspalum notatum) (English edition) 1959.

Respuestas de la graminacea (Paspalum notatum) a las aplicaciones de azufre y fósforo (Spanish edition) 1959.

Respostas da Grama Batatais (Paspalum notatum) às Aplicações de Enxôfre e Fósforo (Portuguese edition) 1959.

Bulletin #19 – MEDCALF, J. C. AND DE VITA R.

The Use of Pre-Emerge Herbicides for Weed Control During Coffee Harvest (English edition) 1960.

O Uso de Ervicidas de Pré-emergência para o Contrôle de Ervas Daninhas durante a Colheita do Café (Portuguese edition) 1960.

El uso de herbicidas pregerminativos para el control de las malas hierbas durante la recolección del cafe (Spanish edition) 1960.

Bulletin #20 – IGUE, KOZEN AND GALLO, J. ROMANO

Zinc Deficiency of Corn in São Paulo (English edition) 1960.

Deficiencias de Zinc en Plantaciones de Maíz del Estado Brasileño de San Pablo (Spanish edition) 1959.

Deficiência de Zinco em Milho no Estado de São Paulo (Portuguese edition) 1960.

Bulletin #21 – DE FREITAS, L. M. M., MCCLUNG, A. C., AND LOTT, W. L.

Field Studies on Fertility Problems of Two Brazilian Campos Cerrados 1958-1959 (English edition) 1960.

Experimentos de abonos en dos zonas de tierras altas de sabana del Brasil 1958-1959 (Spanish edition) 1962.

Experimentos de Adubação em Dois Solos de Campo Cerrado (Portuguese edition) 1960.

Bulletin #22 – LOTT, W. L., MCCLUNG, A. C. AND MEDCALF, J. C.

Sulfur Deficiency in Coffee (English edition) 1960.

Deficiencia de azufre en el cafeto (Spanish edition) 1962.

Deficiência de Enxofre no Cafeeiro (Portuguese edition) 1960.

Bulletin #23 – QUINN, L. R., MOTT, G. O. AND BISSCHOFF, W. V. A.

The Influence of Stilbestrol upon Pasture Fed Zebu Steers and Male Suckling Calves (English edition) 1960.

Influencia del estilbestrol en el desarrollo de terneros mamantones y novillos cebú criados en pastizales (Spanish edition) 1962.

A Influencia do Estilbestrol Sôbre Novilhos e Bezerros Zebu Alimentados em Pastos (Portuguese edition) 1962.

Bulletin #24 – QUINN, L. R., MOTT, G. O. AND BISSCHOFF, W. V. A.

Fertilization of Colonial Guinea Grass Pastures and Beef Production with Zebu Steers (English edition) 1961.

Fertilización de pastizales de hierba guinea y producción de carne con novillos cebú (Spanish edition) 1962.

Fertilização de Pastos de Capim Colonião e Produção de Carne com Novilhos Zebu (Portuguese edition) 1962.

Bulletin #25 – Medcalf, J. C., Bontempo, A. and Favre, C.

The Use of Pre-Emerge Herbicides for Weed Control in Young Coffee (English edition) 1961.

El uso de herbicidas pregerminativos para el control de las malas hierbas en cafetales nuevos (Spanish edition) 1962.

O Uso de Ervicidas de Pré-Emergência no Contrôle de Ervas Daninhas em Cafèzal Novo (Portuguese edition) 1962.

Bulletin #26 – Lott, W. L., McClung, A. C., de Vita, R. and Gallo, J. R.

A Survey of Coffee Fields in São Paulo and Paraná by Foliar Analysis (English edition) 1961.

Estudio de cafetales de San Pablo y Paraná mediante el análisis foliar (Spanish edition) 1962.

Levantamento de Cafèzais em São Paulo e Paraná pela Análise Foliar (Portuguese edition) 1962.

Bulletin #27 – McClung, A. C., de Freitas, L. M. M., Mikkelsen, D. S. and Lott, W. L.

Cotton Fertilization on Campo Cerrado Soils State of São Paulo, Brazil (English edition) 1962.

La fertilización de algodonales en suelos de sabanas del Estado brasileño de San Pablo (Spanish edition) 1962.

A Adubação do Algodoeiro em Solos de Campo Cerrado no Estado de São Paulo (Portuguese edition) 1962.

Bulletin #28 – Quinn, L. R., Mott, G. O., Bisschoff, W. V. A. and da Rocha, G. L.

Beef Production of Six Tropical Grasses. (English edition) 1963.

Produção de carne de bovinos submetidos a pastoreio em seis gramineas tropicais. (Portuguese edition) (Reprinted from Boletim da Industria Animal DPA, Vol. XX, Dezembro de 1962, São Paulo, Brasil).

Bulletin #29 – Mikkelsen, D. S., de Freitas, L. M. M., and McClung, A. C.

Effects of Liming and Fertilizing Cotton, Corn and Soybeans on Campo Cerrado Soils – State of São Paulo, Brazil (English edition) 1963.

Bulletin #30 – Quinn, L., Mott, G. O., Bischoff, W. V. A. and da Rocha, G. Leme

The Response of Male Zebu Calves To Creep Feeding, Castration, Diethylstilbestrol and Supplemental Feeding on Pasture (English Edition) 1966.

Bulletin #31 – PRATT, P. F. AND ALVAHYDO, R.

Cation-Exchange Characteristics of Soils of São Paulo, Brazil (English Edition) 1966.

Bulletin #32 – ESTIMA, A. L., CALDAS, G. C., VIANA, S. P. AND CAVALCANTE, M. F. DE M.; DE CARVALHO, A. R. L. AND FARIAS, M. S.; AND LOFGREEN, G. P.

Molasses, Cassava and Cottonseed Meal as Supplements to Fresh and Ensiled Sugarcane Tops (English Edition) 1967.

Bulletin #33 – NORRIS, D. O., LOPES, E. S. AND MASCARENHAS, H.

The Response of *Astragalus Sinicus* L. (Chinese Milk Vetch) to Lime and Inoculation (English Edition) 1970.

Bulletin #34 – QUINN, L. R., MOTT, G. O. AND BISSCHOFF, W. V. A.

The Effect of Diethylstilbestrol Upon the Performance of Pasture-Fed Zebu Steers. (English Edition) 1970.

Technical Note #1 – DE FREITAS, L. M. M., MCCLUNG, A. C. AND QUINN, L. R.

Stimulation of Winter Growth of a Brazilian Pasture Grass by Gibberellic Acid.

Estimulo Producido por el Acido Giberélico en el Crecimiento Invernal de un Forraje Brasileño (Spanish edition).

Acido Giberélico: Algumas Observações Sôbre uma Aplicação em Capim Colonião. Revista de Agricultura, Vol. XXXIII, N. 1 pp. 63-66 Março de 1958 (Portuguese edition).

Technical Note #2 – MCCLUNG, A. C. AND DE FREITAS, L. M. M.

Sulfur Deficiency in Soils from Brazilian Campos Ecology, Vol. 40, No. 2, April 1959 (English edition).

Deficiencia de azufre en los suelos de las tierras altas de sabana brasileñas (Spanish edition) 1960.

Technical Note #3 – GRIFFING, JOHN B.

Aplicação do Nitrogênio no Melhoramento das Pastagens.

Technical Note #5 – FISHER, C. E. AND QUINN, L. R.

Contrôle de Três Espécies Importantes de Arbustos Praguejadores em Terras de Pastagem nos Estados Unidos, Cuba e Brasil.

Technical Note #6 – QUINN, LAWRENCE R.

O Contrôle de Arbustos nas Pastagens do Brasil.

Miscellaneous Pub. #1 – Griffing, J. B.

O Emprêgo de Cobertura Morta em Cafeeiros (Separata do Boletim de Superintendência dos Servicios do Café No. 363, 1957, São Paulo).

Miscellaneous Pub. #2 – Quinn, L. R. and Griffing, J. B.

O Contrôle do "Leiteiro" e do "Amendoim" em Pastagens, 1958.

Miscellaneous Pub. #3 – Fisher, C. E. and Quinn, L. R.

Control of Three Major Brush Species on Grazing Lands in the United States, Cuba and Brazil. Reprinted from the Journal of Range Management, Vol. 12, No. 5 September 1959.

Miscellaneous Pub. #4 – Griffing, John B.

Gramas (ao invés de Toneladas) de Fertilizantes (Separata da Revista "FIR", Ano. I, Março de 1959, No. 7, São Paulo).