PASTURE MANAGEMENT AND PRODUCTIVITY IN THE LLANOS ORIENTALES OF COLOMBIA*

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ABSTRACT

A review of the information available from Carimagua, Colombia, indicates that the cattle production potential of the Colombian Llanos Orientales is presently limited by the low nutritive value of the native species, particularly during the dry season. Higher per ha production can be obtained with the introduction of improved species of grasses, but per animal production remains low. Also in this case, insufficient nutrition seems to be the limiting factor for higher animal production. A short grazing trial with a legume-grass association demonstrated its much higher production potential both per animal and per unit area. The following values characterize the pastures studied: unburned savanna, 28 kg of liveweight gain/an/yr; savanna burned all at once each year, at the end of the rainy season, 75 kg; savanna burned in a sequential way throughout the year, 95 kg. Productivity per ha varies from 6 kg/ha/yr in the unburned savanna to 19 kg in the savanna sequentially burned. Per ha weight gain increases to 58 kg with *Melinis minutiflora* and reaches 147 kg/ha/yr on *Brachiaria decumbens*. Employing high stocking rates during the wet season and low stocking rates in the dry season (3.06 and 0.7 an/ha, respectively), *B. decumbens* can produce as much as 200 kg/ha/yr. Two other grasses studied, *Hyparrhenia rufa* and *Paspalum plicatulum*, had lower productivity than *M. minutiflora*. During the dry season animals gained as much as 500 kg/day on *Stylosanthes guianensis*-grass associations while all of the grasses when planted alone suffered weight losses ranging from 150 to 350 g/an/day. During the rainy season, while plant diseases and insects were not problems, liveweight gains from the legume ranged between 850 and 950 g/an/day. Urea + cassava or urea + molasses supplementation during the dry season to animals grazing the native savanna or *M. minutiflora* pastures had a positive effect, but because of the strong compensatory weight gain produced during the following rainy season the net increment of weight was insufficient to cover the cost of supplementation. It is concluded that to obtain an important improvement in cattle production in the Llanos Orientales it will be necessary to find a tropical legume which, while adapted to the environment, should be productive and persistent in competition with grasses.

Little is known about the tropical savannas of the Llanos Orientales of Colombia, but its potential value as a cattle producing area is intuitively foreseen as very large. In a previous review of the literature (12), the almost total lack of information on the use and productivity of the native savannas was clearly established. At that time, it was

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suggested that because of its low production capacity, "in order to obtain significant progress in production it is necessary to change the grass canopy from its native species to others of high productivity and better nutritional value. The species must be capable of survival in the prevailing ecological conditions. For the Latosols of the American tropics it means, first, finding and employing species which are tolerant to high soil acidity and to the low level of available P in the soil, and second, to find and utilize species capable of maintaining its feeding capacity during the dry period".

Furthermore, it was established that it would be rather difficult to extrapolate results obtained in the native pastures of the tropics and subtropics of Africa or Australia to tropical America, because the soil, the climate and the systems of production are different. Among the important differences are the botanical composition of these areas, and the large variations in their consumption by cattle. In many areas of Africa the predominant species belong to the genera *Heteropogon, Hyparrhenia* and *Cynodon* and in Australia to the genera *Heteropogon, Themeda* and *Bothriochloa,* all of which are generally well-consumed by cattle. In the great majority of the American savannas the predominant genera are *Trachypogon, Andropogon, Leptochoryphium, Axonopus* and *Paspalum,* which are only consumed in early stages of growth. *Paspalum* is perhaps the exception. The predominance of species of *Paspalum,* especially *Paspalum plicatulum* Michx., in some of the Venezuelan savannas of intermediate fertility and humidity make these areas more productive and better accepted by cattle (7, 8, 9).

Spain (14) has described the climate and the soils of the intermediate and high plains of the Colombian Llanos. Following that description, CIAT's research program in pasture utilization and management has directed its attention to: (a) characterizing and quantifying the production capacity of the savannas; (b) measuring the effect on animal production of some of the traditional practices such as burning and some of the non-traditional practices such as N-supplementation during the dry period; (c) determining the improvement in animal production which can be obtained by the introduction of easily-adapted but low-producing grass species such as *Melinis minutiflora* Beauv. and better producers such as *Brachiaria decumbens* Stapf.; (d) identifying the most effective management practices which would improve the productivity of these grass species; and (e) estimating the effects on animal production of introducing tropical legumes.

PRODUCTIVITY OF THE SAVANNA

Effect of fire and of the burning systems

It was determined that as the species reached 35 cm or more of height, steer growth was very low as a result of the rapid loss of nutritive value of the native species with age (Table 1). Burning at the beginning of the dry season improved animal production by approximately 350% (Table 2). Animal production on the unburned savannas is so low that it would be impossible to develop a viable livestock industry without the use of fire. This, of course, is very well known by ranchers of this area who regularly burn the savannas.

Cattle can be observed entering the newly burned savannas soon after fire extinguishes and begin avidly consuming the ashes before regrowth starts. Cattle feces consisting totally of ashes can frequently be found as result of the first days of consumption. Feces will rapidly lose ashes so that 10 or 15 days after the burning they have the normal ash content of approximately 15% (Table 3).

With an unrestricted amount of recently burned pasture available with sufficient protein for maximum consumption (Table 1) (11), animals should attain higher gains or at

Table 1. **Protein content of the native savanna of Carimagua, Colombia.(Adapted from 12).**

Days of growth	Height	*Trachypogon vestitus*	Whole savanna
	cm	%	
28	10	10.5	10.0
49	20	8.0	7.5
79	35	6.4	5.8
Dry season	50-80	-	2.7

least they should be able to keep the pasture grazed down and of high nutritive value. Neither of the two things actually occur; the pasture grows to an excessive height while weight gains decrease, making burning necessary the following year to obtain a new regrowth. Low plant density of the savanna may be the cause of insufficient consumption by cattle and dry matter (DM) accumulation (Table 6).

After a recent burn animals pull the young shoots from the base. A hand-plucked sample, simulating grazing, from a savanna 20 days after burning had 10.9% protein, 51% *in vitro* DM digestibility and 0.18% of P, and 126 kg DM/ha. With 5 ha of pasture available it should have been possible for a steer to gain 250 g of weight per day. This however was not the case, the explanation possibly being that to consume enough energy and protein, animals would have to take at least 62,000 bites/day, a number which is above the level of fatigue (14). Insufficient consumption allows an excessive development of the pasture and the consequent decrease in its nutritive value.

The excessive growth of the pasture could possibly also be controlled by burning of the savanna in a sequence to provide periodically a recently burned area to the animals. A sequential burning system, which divided the area into eight parts, was compared with once-a-year burning of the entire area, at the end of the rainy season.

Table 4 shows the five-year average liveweight gains under the two burning systems. The positive effect of sequential burning was influenced by stocking rate and was also different in the two seasons of the year. As expected, weight gains were favored by the burning of the total area at the

Table 2. **Liveweight gain of steers grazing the native savanna of Carimagua, Colombia.(Adapted from 1 and 2).**

Stocking rate	Annual gain			
	Without burning (1971-72)		With burning (1972-73)	
AU/ha	kg/an	kg/ha	kg/an	kg/ha
0.20	28	6	92	18
0.35	38	13	94	33
0.50	2	1	74	37

Table 3. **Chemical composition of feces voided by cattle grazing a burnt savanna. Carimagua, Colombia.**

Days after burning	Protein	P	Ash
		%	
3-4	0.3	1.8	95.5
10-15	7.0	0.25	13.3
20-30	7.2	0.26	15.5

end of the rainy season because, in this case, the area of young forage available to the animals was twice as much as in the sequential burning. During the rainy season, on the other hand, sequential burning was superior to once-a-year burning. The advantage decreased from 52% at the lower stocking rate to 16% at the highest stocking rate. In summary, sequential burning had a beneficial effect which was measured as 27%, or 20 kg of additional weight gain per animal, when the stocking rate was 0.2 an/ha (5 ha/an).

Liveweight gain/ha was 15, 23 and 15 kg at stocking rates of 0.2, 0.35 and 0.5 an/ha, respectively, in the once-a-year burning and 19, 22 and 18 kg for the same stocking rates in the sequential burning.

Grazing management

The excessive growth of the pasture could also be controlled by establishing a rotational grazing system allowing the animals to consume the forage when young and palatable. In a one-year experiment, continuous grazing was compared with a four-paddock rotational grazing system in which the animals grazed for 28 consecutive days in each of the paddocks. The pasture was burned four months before the start of the experiment. A summary of the results is presented in Table 5. Rotational grazing had no beneficial effect on liveweight gain at any of the three stocking rates employed. The results are not surprising and confirm the inability of the animals to maintain a high enough level of consumption in a situation of very low forage nutritive value.

Table 4. **Liveweight changes of steers grazing the native savanna of Carimagua under two systems of burning. Average of five years. (Adapted from 2-6).**

Stocking rate	Liveweight changes			Advantage of sequential burning		
	Dry season	Rainy season	Annual	Dry season	Rainy season	Annual
AU/ha	kg/an			%		
Total burning						
0.20	15	60	75	-	-	-
0.35	- 7	73	67	-	-	-
0.50	-24	55	31	-	-	-
Sequential burning						
0.20	4	91	95	-275	52	27
0.35	-25	87	62	-257	19	- 7
0.50	-29	64	35	- 21	16	13

Table 5. **Liveweight changes of steers under continuous and rotational grazing on the native savanna during 131 days of the dry season and 234 days of the rainy season, in Carimagua, Colombia. (Adapted from 1).**

	Liveweight change/period					
	Continuous grazing			Rotational grazing		
Stocking rate	Dry season	Rainy season	Total	Dry season	Rainy season	Total
AU /ha	kg/an					
0.20	-21	49	28	-22	33	11
0.35	-25	63	38	-35	34	- 1
0.50	-33	35	2	-32	16	-16

Forage availability and botanical composition

It is important to point out the low density of plants observed in the savannas. Table 6 shows that the number of plants in the better-known genera decreased significantly over the years. Included under the heading of "other species" are representatives of the genera *Ciperus, Rhyncospora, Aristida, Eragrostis, Digitaria, Desmodium, Phaseolus* and some unidentified herbs. The decrease in plant density is associated with the reduction in DM available per ha. Forage availability decreased 39, 47 and 39% between 1971 and 1976, for the three stocking rates of the annually burned pastures, and may be associated with frequent burning. In farm practice, the savanna is not burned every year, but every two or three years. Stocking rate is also lower in the area. There are only 2 million head of cattle in 20 million ha of savanna, that is 10 ha per head. Table 7 shows the availability of DM/ha was not affected by stocking rate, although weight gain decreased significantly as stocking rate increased (Table 4). The very intensive selection by the grazing animal for the most nutritious portion of the plant is probably responsible for the lack of correlation between total forage availability and animal weight gain.

Table 6. **Number of plants per meter of linear transect in the native savanna of Carimagua, Colombia.**

Stocking rate	Year	*T. vestitus*	*L. lanatus*	*Paspalum Andropogon Axonopus Panicum*	Other	Total
AU/ha						
	1971	3.25	1.85	1.86	0.91	7.87
0.20	1976	1.60	0.40	0.90	0.95	3.90
	Difference	-51%	-78%	-52%	4%	-50%
	1971	2.45	1.45	2.40	1.06	7.36
0.35	1976	1.10	0.35	0.73	1.83	4.01
	Difference	-55%	-76%	-70%	73%	-46%
	1971	2.90	1.75	1.81	0.81	7.27
0.50	1976	0.90	0.35	1.07	2.02	4.34
	Difference	-69%	-80%	-41%	149%	-40%

Table 7. **Available dry matter during the rainy season on the native savanna of Carimagua, Colombia. Average of five years.**

Stocking rate	Burning system	
	Total	Sequential
AU/ha	t/ha	
0.20	2.70 ± 0.65	2.54 ± 0.85
0.35	3.15 ± 0.59	2.34 ± 1.03
0.50	2.58 ± 0.53	2.13 ± 0.88

Nitrogen supplementation

During the dry season, the protein content of the grass falls below 3%; at this protein level the animal cannot obtain a diet of sufficient nutritive value for the maintenance of weight. The volume of DM and energy available is however considerable and could be better utilized supplementing the animal's diet with a small quantity of N to stimulate bacterial activity in the rumen. This practice is extensively used in some areas of the subtropics.

Zemmelink (3) studied the nutritional value of the savanna during the dry period. DM digestibility of the forage increased from 32.2% to 39.7% when supplemented with urea + molasses and DM intake increased by 34%, resulting in an increased intake of digestible DM from 15 g/$W^{.75}$, in the case of unsupplemented grass to 27.4 g when supplemented. With the consumption of 15 g digestible DM only 60% of the maintenance requirement of the animal is met.

Dry season supplementation of animals weighing 150-250 kg was studied offering 80 g of urea and 400 g of cassava meal per head, during 118 days of the dry season. Results summarized in Table 8 indicate that although an improvement in weight gain is obtained when urea + cassava meal are provided during the dry season, compensatory weight gain during the rainy season eliminates a large part of the difference; at the end of the year, the advantage obtained with supplementation is only 14%. This advantage is not high enough to pay for the cost of supplementation. It was estimated that, in the area where the experiment was conducted, 10 kg of weight difference in favor of supplementation with urea + cassava is needed to pay the cost of the supplement and 20 kg if the supplement is urea + molasses. Molasses is produced in distant areas while cassava is produced locally.

When considering the practical implications of supplementation it is important to remenber that animals will make a strong compensatory weight gain during the following rainy season. From experience in Carimagua, compensatory gain makes up for approximately 75% of the weight loss (6), so the cost of supplementation should only be

Table 8. **Liveweight changes of steers supplemented and unsupplemented with urea + cassava meal during the dry season on the native savanna of Carimagua, Colombia. Average of two years.**

Season	Treatment		Advantage of supplementation
	Without urea + cassava	With urea + cassava*	
	kg/an		%
Dry	-11	4	136
Rainy	48	38	-21
Annual	37	42	14

* 80 g urea + 400 g ground dried cassava/an/day were provided for an average of 121 days during the dry season.

matched against 25% of the dry period's advantage.

Mineral supplementation

The level of P in native species is so low that deficiencies are to be expected in cattle. Commercial producers avoid handling their animals for fear of bone fractures. However, "pica" is infrequent in the area and there are no known cases of boutulosis in cattle which can be associated with the consumption of bones.

Figure 1 summarizes the results of a study to determine the mineral status for P and Ca of the pastures in Carimagua. Sampling was done by plucking forage, simulating the grazing animal (10).

P content was about 0.10% throughout the year with small increments associated with pasture regrowth after burning. Ca content, on the other hand, was not affected by burning and decreased only slightly during the dry season. Both P and Ca were insufficient for adequate cattle growth. Other minerals such as Mg, K, Na, Fe, Mn, Zn, Cu, Mo and Co did not appear as deficient for cattle growth (10).

Liveweight and reproduction increased with mineral supplementation in a study comparing herds receiving a complete mineral supplement and unsupplemented herds (Table 9). This result applies to growing animals of 3, 9 and 19 months as well as to cow weight and all measures of conception. Supplementation also notably decreased the high level of abortions (6).

All information collected clearly indicated the need for supplementation of cattle with, at least, P and Ca. The economic analysis of

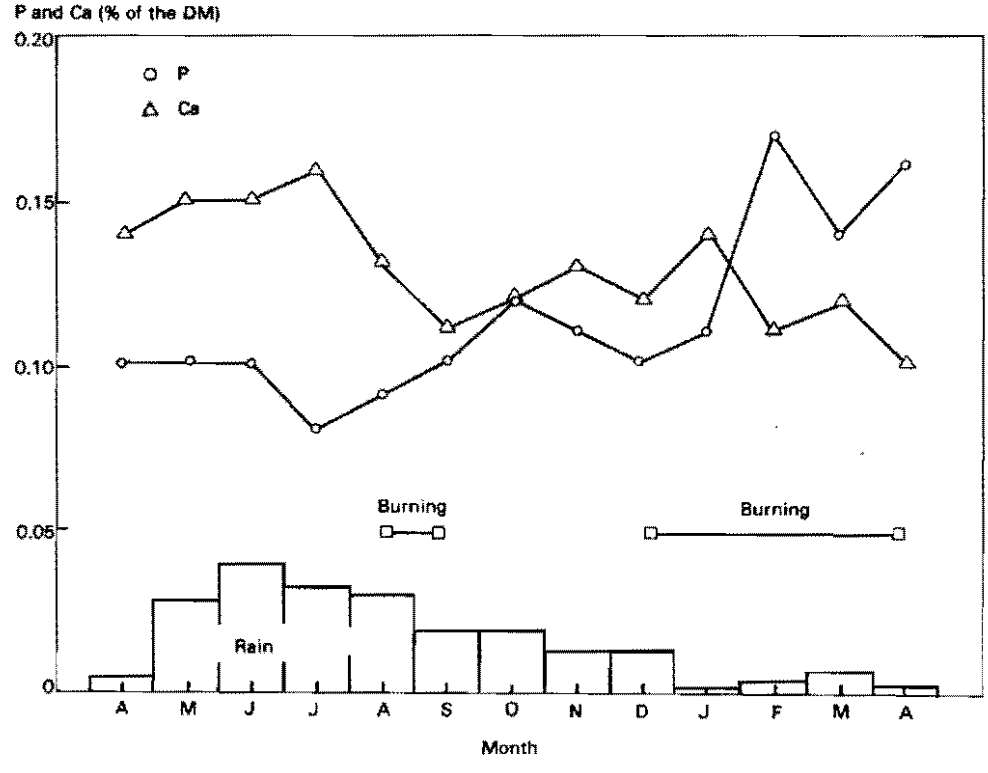

Figure 1. P and Ca content of the native savanna of Carimagua, Colombia.(Adapted from 10).

this information indicates the practice to be highly beneficial economically for the farmer (6).

INTRODUCTION OF NEW FORAGE SPECIES

The impossibility of improving the low productivity of the native savanna through management or supplementation has directed attention to the introduction of new germplasm. The sequence followed was to study first those species known to be adapted to the ecological conditions of the area and those for which seed was available. In the following sections the information available for *M. minutiflora, Hyparrhenia rufa* (Nees) Stapf., *P. plicatulum, B. decumbens* and in a more limited way for *Indigofera hirsuta* L. and *Stylosanthes guianensis* (Aubl.) Sw. will be reviewed.

Melinis minutiflora

This one of the few grasses known in the area, but even then the commercial pastures planted were small and scattered. Producers use it preferentially for fattening, since fattening is not possible on the native savanna alone.

An area of 178 ha was seeded with *M. minutiflora* to study the effect of P and K fertilization on liveweight gain. After two years, the same area was used for a study on the grazing management of the pasture, including N supplementation.

Effect of fertilizer application on animal productivity of *M. minutiflora*

M. minutiflora has invaded large areas of the Campo Cerrado of Brazil and, although this species is not native to the area, its high degree of adaptation has allowed it to become naturalized. This is, however, not the case in the Colombian Llanos Orientales, but the fact that the grass does not respond after establishment to P and K indicates its high degree of adaptation to low-fertility soils (Table 10). The grass has not spread, probably because it was only recently that movement inwards in the plains has occurred and also because there have not been large areas established allowing natural spreading.

A frequent observation in this area is that *M. minutiflora* does not seed during the year of establishment and animals gain weight

Table 9. **Comparison between cattle herds supplemented with salt and salt + minerals at Carimagua, Colombia. (Adapted from 6).**

Parameter	Salt	Salt + minerals	Advantage of minerals
	kg		%
Liveweight of heifers at			
3 months of age	67	78	16
9 months of age	117	147	26
18 months of age	150	175	17
Liveweight of cows at			
service	292	316	8
calving	335	369	10
weaning	272	305	12
Cow's fertility		%	
Conception (by palpation)	69.5	76.8	11
Abortions	9.3	0.4	96
Calvings	59.4	76.4	29

Table 10. **Liveweight gain of steers on *M. minutiflora*, fertilized and unfertilized at the time of establishment in Carimagua, Colombia. (Adapted from 1 and 2).**

Stocking rate	0	P	P + K
AU/ha	kg/ha/yr		
0.44	49	51	42
0.88*	83	103	89
Mean	66	77	66

* Stocking rate during the dry season was 0.44 AU/ha.

during the first dry season. From the second year onwards the animals lose weight during the dry season. Loss of weight is associated with flowering which occurs at the beginning of the dry season, causing a marked decrease in digestibility and protein content and a marked decrease in animals' consumption of the grass. Zemmelink (2) found the digestibility during the dry season to be 40.7% and an increase of 8% when 20% of the grass was replaced by the tropical legume *S. guianensis*. Even more important was the improvement in consumption from 15.6 to 25.6 g of digestible DM/$W^{.75}$. Consumption of 25 g is approximately the amount required for weight maintenance of these animals. Increased consumption was associated both with the intake of the legume per se and by the increment in protein provided by the legume which stimulated a higher relative consumption of the grass. The weight loss of 300 to 500 g/day/an at Carimagua registered during the dry season with this species can be explained totally by the low level of ingestion of digestible DM.

Effect of rest and of supplementation with urea + molasses during the dry season

Weight losses during the dry season when grazing *M. minutiflora* present a very serious problem in the management of cattle, since animals lose up to 70 kg of weight during the season. There are two alternative solutions: resting the pasture and utilizing it only in the rainy season, or supplementing the grazing animals with a source of N.

Rainy season grazing was not different to year-round grazing in a four-year trial at Carimagua (Table 11). In the year-round grazing treatments, animals lost an average of 18 kg of weight during the dry season, but losses were totally recovered in the next rainy season. A heavier stocking rate, up to 1.3 an/ha, was possible when the pasture was rested during the dry season. This was not possible with the pastures grazed year-round. When grazed all year, pastures produced weight gains of 78 and 98 kg/an/yr at stocking rates of 0.88 and 0.44 an/ha, respectively. These weight gains are similar to the best obtained on the native savanna (Table 4).

Urea + molasses supplemented during the dry season had the effect of preventing

Table 11. **Liveweight changes of steers grazing *M. minutiflora* all year or only during the rainy season at Carimagua, Colombia. Average of four years.**

Grazing system	Stocking rate	Liveweight change/season		
		Dry	Rainy	Year
	AU/ha	kg/ha		
All year	0.44	-18	61	43
	0.88*	-18	87	69
Rainy season only	0.44	-	50	50
	0.88	-	67	67
	1.30	-	69	69

* Stocking rate during the dry season was 0.44 AU/ha.

weight losses. However, also in this case the favorable effect was partially compensated during the rainy season, causing at the end of the year a difference of 15 kg/ha/yr in the low stocking rate and 12 kg in the high stocking rate. These relationships are shown in Figure 2 (16). In economical terms, in Carimagua the additional weight gain is not sufficient to pay for the cost of the supplement.

Hyparrhenia rufa and *Paspalum plicatulum*

H. rufa is possibly the most extensively used grass in Colombia, yet it has not spread to the Llanos Orientales. *P. plicatulum*, on the other hand, is a native of the tropical savannas and well-known in Venezuela. Possibly because it is not as frequent a component of high plains it is not known in Colombia.

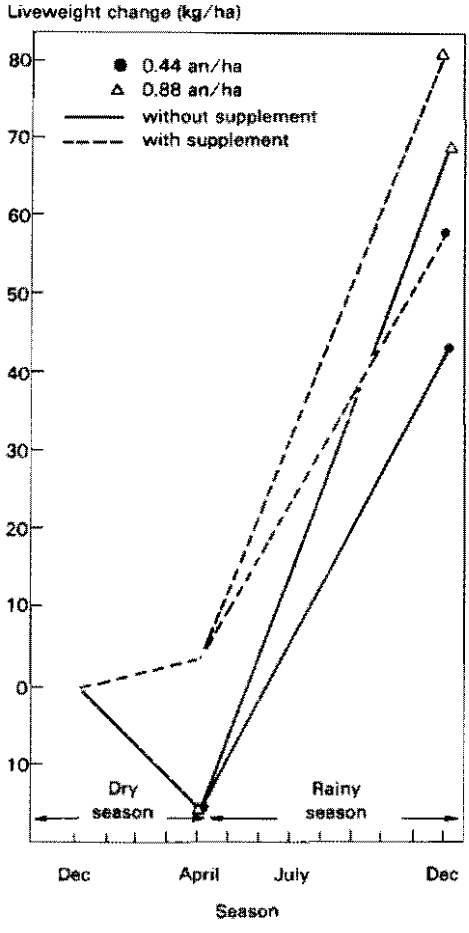

Figure 2. **Liveweight changes of steers on *M. minutiflora* unsupplemented and supplemented with urea + molasses, during the dry season at Carimagua, Colombia. Average of four years (6).**

Table 12 shows that animals lost weight during the dry season both in *H. rufa* and *P. plicatulum*. Losses were high, reaching 43 and 56 kg/an, respectively. During the rainy season all groups gained weight, but gains in *H. rufa* and *P. plicatulum* were inferior to those in *M. minutiflora*.

During the first year, the balance for the two species was rather poor. In the two subsequent years production increased without reaching the level of *M. minutiflora*. Grazing of *H. rufa* was suspended early in the third year because the animals continued to lose weight and the lack of persistence of the species was evident. Spain (6) found *H. rufa* to be very sensitive to the presence of Al in the soil solution; its roots do not develop, and growth is inferior to other tropical species. This can explain the rapid disappearance of the species in the pastures.

Although *P. plicatulum* is the only native species among those studied it is at the same time the one suffering continuously problems of diseases and pests. During the three years of grazing it suffered from infestations of *Helminthosporium*, a stem-borer (Lepidoptera, Colephoridae) and a false army worm (Lepidoptera, Noctuidae-*Mocis* spp.), which forced the removal of the animals for variable periods of time to give the pasture an opportunity to recover.

In some areas of Venezuela, the native legume *I. hirsuta* has prospered and contributed significantly to livestock production when the native, degraded pastures of *P. plicatulum* received an application of P (7, 8). In Carimagua, this species developed rapidly, achieving good establishment with *P. plicatulum*, with the application of 75 kg/ha

Table 12. **Liveweight production of several forage species at Carimagua, Colombia.**

Species	Stocking rate	1974 - 1975 Dry season	1974 - 1975 Rainy season	1974 - 1975 Year	1976 Rainy season	1977 Rainy season
	AU/ha	kg/ha				
M. minutiflora	0.7		50	50	40	66
	1.0		51	51	47	74
	1.4		56	56	36	52
H. rufa	0.5	-22				
	0.7		30	8	24	
	1.0		37	15	29	
	1.4		27	5	34	
P. plicatulum	0.5	-28				
	0.7		46	18	46	34
	1.0		34	6	35	19
	1.4		55	27	73	17
P. plicatulum + *I. hirsuta*	0.9		-37	-37		
	1.3		22	22		
	1.7		-60	-60		

of P_2O_5 at seeding, but the animals refused to consume the legume. Steers were finally removed during the second rainy season after losing much weight; three animals died, apparently of under-nutrition. These results in Carimagua are taken to be conclusive and agree with communications from other areas of Venezuela. The superior performance at medium stocking rates was due apparently to a high population of *P. plicatulum* (Table 12).

Brachiaria decumbens

This tropical grass deserves special mention because of its good adaptation to low pH and to high concentrations of Al in soils. This is the first introduced species which is being planted in large scale in the Colombian Llanos, as has happened in many areas of Brazil.

Tables 13 and 14 show the production with this species in Carimagua. Liveweight gains per animal are not superior to those obtained with *M. minutiflora*, but its high stocking rate allows more than double production per ha. It would appear that 1.7 an/ha throughout the year is not high enough to reach the maximum productivity per ha. Yet, at this stocking rate, per animal production is only 86 kg/yr, too low for effective fattening, since steers would reach 450 kg between four and five years old. This performance is very similar to the properly burned savanna. As shown in Table 14, employing higher stocking rates during the rainy season it is possible to produce 200 kg/ha, but with a large sacrifice in per-animal productivity.

So far, none of the tropical grasses studied in Carimagua have given per-animal weight gains high enough for optimal fattening of steers. For effective fattening, one should think of 150 kg liveweight gain per year, to send steers to market at three years of age weighing 450 kg.

Many reports have indicated toxicity problems with *B. decumbens*, primarily with young stock grazing fresh pastures in an

Table 13. **Liveweight changes of steers grazing for the third year on *B. decumbens* under fixed stocking at Carimagua, Colombia (6).**

Stocking rate	Liveweight change/season					
	Dry	Rainy	Year	Dry	Rainy	Year
AU/ha	kg/an			kg/ha		
0.9	- 6	124	118	- 5	11	106
1.3	-21	118	97	-27	153	126
1.7	-19	105	86	-32	179	147

active stage of growth. In Carimagua, only one event of this nature was observed with steers weighing between 150 and 200 kg. The animals were put in the pasture early in the rainy season in its first year of grazing. Several of the younger animals died even though they were moved away from the pasture as soon as the first symptoms were observed. Symptoms of toxicity were swelling at the base of the horns, in the ears and in the dewlap, followed by photosensitization of the skin. Although no special precautions have been taken since, there has been no symptoms of toxicity. Farmers in the area are aware of the problem which is overcomed by grazing at very high stocking rates early in the grazing season to remove rapidly the first growth.

Legume-grass associations

Primarily because the grasses studied so far do not provide the nutritional level required for effective growth of cattle throughout the year, it has become necessary to find tropical legumes which complement the feeding value of the grass, especially during the dry season. When interpreting the data on animal growth on grasses, one must remember that the total gain during the rainy season includes a compensatory gain effect from the previous dry season. In the case of an animal gaining 118 kg during the rainy season (Table 13), its gain includes at least 10 kg of compensatory weight (50% of the previous loss), thus the real weight gain of the rainy season is less than 500 g/an/day.

Table 15 shows one example of a legume-grass association in which the animals gained between 400 and 500 g/day during the dry season and maintained very high gains during the months in which the mixture persisted. When the legume decreased appreciably, because of diseases and pests, weight gains decreased to the

Table 14. **Liveweight changes of steers grazing for the second year on *B. decumbens* under low stocking during the dry season and variable stocking during the rainy season, at Carimagua, Colombia (6).**

Stocking rate		Liveweight change/season				
Dry season	Rainy season	Dry	Rainy	Dry	Rainy	Year
AU/ha		kg/an		kg/ha		
0.7	1.63	-11	81	- 8	132	124
0.7	2.34	-16	77	-12	180	168
0.7	3.06	16	63	12	193	205

Table 15. **Liveweight gain of steers grazing associations of grasses and *S. guianensis*, at Carimagua, Colombia during 1973-74 (3).**

Stocking rate	Liveweight gain			
	XII/73-IV/74	IV-VI/74	VI-VIII/74	VIII-X/74
AU/ha	g/an/day			
S. guianensis + *M. minutiflora*				
0.50	532	-	-	-
0.90	-	864	976	345
1.30	-	886	885	397
1.70	-	681	940	310
S. guianensis + spontaneous grasses				
0.50	446	-	-	-
0.90	-	1140	976	397
1.30	-	1182	952	379
1.70	-	1209	855	310

level of that of a pure grass pasture. The legume was established in this case with an application of 75 kg/ha of P_2O_5 and did not receive additional fertilization.

The introduction of legumes seems to be the only viable solution to obtain the improvement needed for beef production in a practical and economical sense.

CONCLUSION

In the Colombian Llanos Orientales the native savanna is a natural resource which is only now beginning to be known. This knowledge helps explain the lack of development of the area which should have taken place faster in relation to its broad extension and its large forage availability. Even if a very low stocking rate is used, the low nutritive value of the species limits animal production. A sequence of change in the techniques of pasture management, including the introduction of other species (Table 16), indicates that with the best burning management, liveweight gains per year do not surpass 100 kg per animal and that in the best of cases, the maximum obtainable weight gain is about 130 kg/an/yr on *M. minutiflora*, when grazed under very low stocking rates and with animals receiving N supplementation during the dry season. Production per ha in this case is too low to justify the high investment in the new pasture, and the additional advantage of supplementation does not cover the cost of the supplement. With *B. decumbens*, liveweight gain per ha was tripled, compared to *M. minutiflora*, and multiplied 10 times in relation to the native savanna, but even then, there is no improvement obtained in terms of liveweight gain per animal.

It would seem unlikely, at this point, that a grass species could be found that is adapted to the conditions of the area, particularly the very low soil fertility, which while allowing a high enough per animal weight gain would maintain a stocking rate sufficiently high to reach the necessary per ha weight gain.

As indicated before (12), the challenge continues to be finding a tropical legume capable of producing in this environment, competing with the grasses and providing a higher nutritive value to the pasture.

Table 16. **Liveweight gain of steers under increasing technologies in the Llanos Orientales of Colombia.**

	Maximum/animal*		Maximum/ha**	
	Per animal	Per ha	Per animal	Per ha
	kg/yr			
Unburnt savanna,				
0.35/an/ha	38	13	38	13
Savanna burnt in the dry season,				
0.20 an/ha	75	15	-	-
0.35 an/ha	-	-	67	23
Savanna burnt sequentially during the year,				
0.20 an/ha	95	19	-	-
0.35 an/ha	-	-	62	22
M. minutiflora, grazed all year,				
0.44 an/ha	98	43	-	-
0.44/0.88 an/ha	-	-	58	69
M. minutiflora with urea + molasses during the dry season,				
0.44 an/ha	130	58	-	-
0.44/0.88 an/ha	-	-	102	81
H. rufa, grazed during rainy season,				
0.70 an/ha	34	24	-	-
1.40 an/ha	-	-	24	34
P. plicatulum, grazed during rainy season,				
0.70 an/ha	66	40	-	-
1.40 an/ha	-	-	32	45
B. decumbens, grazed all year,				
0.90 an/ha	118	106	-	-
1.70 an/ha	-	-	86	147

* Weight gain corresponding to the stocking rate in which per animal weight gain was maximum

** Weight gain corresponding to the stocking rate in which per ha weight gain was maximum

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