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ANIMAL PRODUCTION FROM NATIVE PASTURES WITH COMPLEMENTARY GRAZING OF *Pueraria phaseoloides* IN THE EASTERN PLAINS OF COLOMBIA

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In an experiment carried out at Carimagua, the effect on animal production of providing 2000 m^2 per animal of *Pueraria phaseoloides* (kudzu) in a pure stand as a protein bank for complementary grazing with natural savannah pasture was studied over four years using a randomised block design with two stocking rates (0.25 and 0.50 animals/ha). Grazing was continuous and burning of 1/2 - 1/3 of the savannah was carried out at the start and finish of the dry season. Access to the protein bank was restricted in the first 3 years and free in fourth (1982). The mean annual output with the low stocking rate (118 kg/animal) was significantly greater ($P < .05$) than that obtained with the higher rate (101 kg/animal), but the effect of stocking rate on liveweight gain per day was only highly significant ($P < .001$) during the dry season of the year, with means of 183 and 78 g/head/day for the low and high stocking rates, respectively. Year effects were highly significant ($P < .002$) due to greater quantity of kudzu on offer in the first two. The year x stocking rate interaction was highly significant ($P < .002$) because access to the protein bank was restricted for 6 months to permit recovery and maintenance fertilization of the kudzu, and this had a particularly marked effect on the output from the higher stocking rate. The results of the study suggest that a potential increase of 30% in production from burned savannah pastures may be obtained by using kudzu for complementary grazing, compared with the best management of native pastures with burning alone, due chiefly to the marked effect of the legume during the dry season of the year.

Key words: Oxisol, savannahs, *Trachypogon vestitus*, *Pueraria phaseoloides*, protein banks.

Tropical savannahs include vast regions defined as a natural ecosystem which is stable in tropical climates and which has a relatively continuous coverage of herbage plants, often interspersed with bush and small trees (Sarmiento & Monasterio 1975). Such savannahs are the result of a particular type of climate, characterised by relatively constant high temperatures throughout the year and a season of heavy rainfall followed by a well-defined dry period.

A general description of these regions in tropical America has been given by Roseveare (1948). They are represented by the Brazilian Cerrados (Kornelius et al 1979), the Colombian plains (llanos) (Blydenstein, 1967), the Venezuelan plains (Blydenstein, 1962) and the Rupununi plains of Guyana (Stevenson, 1949). They have large cattle populations (Blydenstein, 1972), but animal output is relatively low: 10-40 kg/ha (Paladines, 1983). Due to the low quantity and quality of pasture produced in the dry season, weight losses of 30-60 % are recorded in cattle during the drought (Paladines 1975) and, in consequence, they reach market weight of 400-500 kg at over 4-5 years of age (McDowell, 1966). Even with the use of pastures based on improved, adapted grass species, live weight loss may occur in grazing cattle due to low levels of protein in the diet and insufficient dry matter consumption (Tergas et al, 1982; Lascano et al, 1982).

Materials and Methods

The research reported was carried out at the Centro Nacional de Investigaciones Agropecuarias (National Livestock Research Centre - CNIA) at Carimagua, 320 km east of Villavicencio, in the Department of Meta. The Centre is located at 4°37' North, at approximately 175 m above sea level in an area which is representative of the well-drained Colombian plains. Details of the soils and climate have been given by Spain (1979). Mean temperature is 26°C and annual rainfall averages 2017 mm (Table 1), with potential evapotranspiration of 2195 mm and a distinct dry season between mid-December until the end of March. The soils are Oxisols (Tropeptic Haplustox Isohyperthermic) with a pH of 4.5 in water, 86% Al saturated, low in available P (1 ppm Bray II) and low in exchangeable Ca, Mg and K (< 0.2 me/100 g in each case), and are fine clays with excellent physical qualities.

Table 1
Monthly rainfall at the National Livestock Research Centre (CNIA) at Carimagua in the eastern plains of Colombia (1972-1982).

Month	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	$\bar{x}$
	mm											
January	*	4	4	6	11	0	6	2	0	0	0	3
February	*	0	14	43	31	8	4	0	0	58	0	14
March	*	79	9	177	63	18	94	119	107	50	100	74
April	*	123	181	30	273	81	232	362	193	359	376	200
May	*	99	371	421	241	191	308	201	260	223	234	232
June	343	443	*	389	431	458	348	207	402	281	237	321
July	336	334	179	332	430	224	276	275	252	181	355	288
August	242	321	200	321	186	196	171	201	291	352	346	257
September	241	362	242	187	320	272	194	214	318	218	380	268
October	182	251	252	241	141	161	157	359	230	122	110	200
November	116	165	161	137	57	94	105	117	59	88	74	106
December	65	14	3	147	16	18	88	60	0	164	23	54
Total	*	2195	*	2431	2200	1721	1983	2117	2112	2096	2235	2017

The area of *Pueraria phaseoloides* (kudzu) consists of 2000 m^2/animal (protein bank) and was established in 1978 with an application of 100 kg P_2O_5, 50 kg K_2O, 18 kg MgO and 22 kg S per hectare. A maintenance fertilizer application of 22 kg K_2O, 11 kg MgO and 22 kg S per hectare was given in 1981.

Management and sampling: The savannah, including the area of legume, has been managed at two stocking rates (0.25 and 0.50 head/ha) under continuous grazing with two repetitions. During the first two years, half the area of savannah was burned at the end of the rainy season and the other half at the end of the dry season. During the last two years, however, only a third of the area was burned at the end of the first rainy season, a third at the end of the dry season and a third at the end of the next rainy season. This change in the burning practice was made in order to obtain a better utilization of the savannah dry matter and an improved consumption by the animals of the mature pasture by having easier access to the protein bank.

During the first three years, the animals' access to the kudzu was restricted in order to improve the persistency of the stand. In 1979, the protein bank was closed off for 90 days to avoid overgrazing and, in the following year, the cattle were only allowed access for four days each week. In 1981, access was restricted for 186 days to allow recovery after the maintenance fertilizer application, and since that time the cattle have had completely free access to the protein bank.

Two Criollo x Brahman crossbred steers of 12 months of age and weighing 150-170 kg at the start of the experiment were used in each treatment and these were replaced by similar animals at the end of each calendar year. All the cattle received mineral supplements and water *ad libitum*. During the first two years, the animals were fasted for 16 hours previous to weighing but subsequently they were weighed directly from the field.

The amount of dry matter available in the protein bank and in the savannah was determined in the dry and rainy seasons, initially by samples cut at random and later by the method of Haydock and Shaw (1975). The samples were mixed and dried at 60°C for 48 hours for dry matter determination.

Statistical analysis: The experimental design was a randomized block with two stocking rate treatments (0.25 and 0.50 head/ha) and two replications. The four years' results were analysed by analysis of variance over all the years and for each year separately. The daily liveweight gains per head during the dry and rainy seasons were used as dependent variables and the stocking rates and years as sources of variation.

In the model used for the analysis across all years, the animals' live weight gains in each year were regarded as measurements repeated in time and the model used was $Y_{ijk} = \mu + R_i + C_j + (R \times C)_{ij} + A_k + (C \times A)_{jk} + e_{ijk}$, where A_k = the effect of year k and $(C \times A)_{jk}$ = the effect of the interaction stocking rate j x year k. In the analysis for each year, the model used was $Y_{ijk} = \mu + R_i + C_j + e_{ijk}$, where Y_{ijk} = the daily liveweight gain of steer k in stocking rate j of replicate i, R_i = the effect of the replicate i, C_j = the effect of stocking rate j and e_{ijk} = the experimental error. Means were compared by Duncan's Multiple Range Test in cases where a level of significance of $P < .05$ was obtained.

Results and Discussion

Table 2 shows the mean live weight gains of the steers by year and across the four years during the dry and rainy seasons, according to stocking

Table 2:

Mean liveweight gains of steers on native savannah pasture with complementary grazing of Pueraria phaseoloides at Carimagua (1979-1982).

Year	Treatment (Head/ha)	Season Dry	Season Wet	Total per year
		g/head/day)		
1979	0.25	172 a[1]	476 a	397 a
	0.50	68 a	423 a	330 a
1980	0.25	127 a	395 b	309 a
	0.50	53 b	491 a	350 a
1981	0.25	138 a	420 a	335 a
	0.50	98 a	194 b	165 b
1982	0.25	296 a	241 b	260 a
	0.50	94 b	353 a	267 a
Mean	0.25	183 a	383 a	325 a
	0.50	78 b	365 a	228 b

[1] Values in each column corresponding to the same year followed by different letters are significantly different (P < .05)

rate. Taking all years together, the effect of stocking rate was significant (P < .05) during the dry season and over the year as a whole, although not during the rainy season (P > .05). The effect of year was highly significant (P < .002) as was the interaction stocking rate x year (P < .002), due the restricted access to the protein bank during 6 months to 1981 to allow recovery of the kudzu after maintenance fertilization, which particularly affected the results of the higher stocking rate. During the first year, there was no significant difference (P > .05) due to stocking rate in either season. The following year, there were significant differences (P < .05) reflecting higher weight gains on the lower stocking rate in the dry season and on the higher stocking rate in the rains. As a result, there was no difference over the year as a whole in the liveweight obtained (P > .05). In 1981, no difference (P > .05) was observed in the dry season but the weight gains in the rainy season and over the whole year were significantly greater (P < .05) on the low stocking rate. During the last year, higher liveweight gains (P < .05) were observed on the low stocking rate during the dry season and on the high stocking rate during the rainy season, with no total difference for the whole year (P > .05).

The output per head (Table 3) was directly related to the mean annual daily liveweight gain and output per hectare rose noticeably with the increase in stocking rate (Table 3). These results represent an increase of about 30% in output per head and of 180% in output per hectare compared with the best results obtained with sequential burning of savannahs (Paladines and Leal, 1979), due principally to the beneficial effect of the legume in increasing animal output by preventing loss of weight in the dry season. The effect of supplementary grazing of kudzu was also superior to that obtained from supplementation with 80 g urea and 400 g cassava meal

Table 3:

Animal output from native savannah pasture with complementary grazing of Pueraria phaseoloides at Carimagua (1979-1982).

Year	Treatment (Head/ha)	Output per Head	Output per ha
		kg	kg
1979	0.25	145 a[1]	36
	0.50	120 a	60
1980	0.25	113 a	28
	0.50	128 a	64
1981	0.25	122 a	30
	0.50	60 b	30
1982	0.25	95 a	24
	0.50	97 a	49
Mean	0.25	118 a	30
	0.50	101 b	51

[1] Values in each column corresponding to the same year followed by different letters are significantly different ($P < .05$).

per head as reported by Paladines and Leal (1979), although in the latter case dry season weight loss was also prevented. The results obtained at Carimagua are similar to those obtained with *Stylosanthes humilis* in natural grazings in Nigeria (Haggar et al, 1971) and in Australia (Woods, 1970).

The amount of herbage on offer per hectare and the composition of the plants in the unburned savannah (Table 4) did not differ between seasons of the year and were very similar in the two different stocking rates, which agrees with results published by CIAT (1973). The quantity of leaf on offer seems not to have been a limiting factor to animal output. However, in the dry season, the crude protein content averaged only 3.8%, compared with 6.5% in the rainy season, which accounts for the poor utilization of the herbage on offer and the low levels of animal production from these pastures.

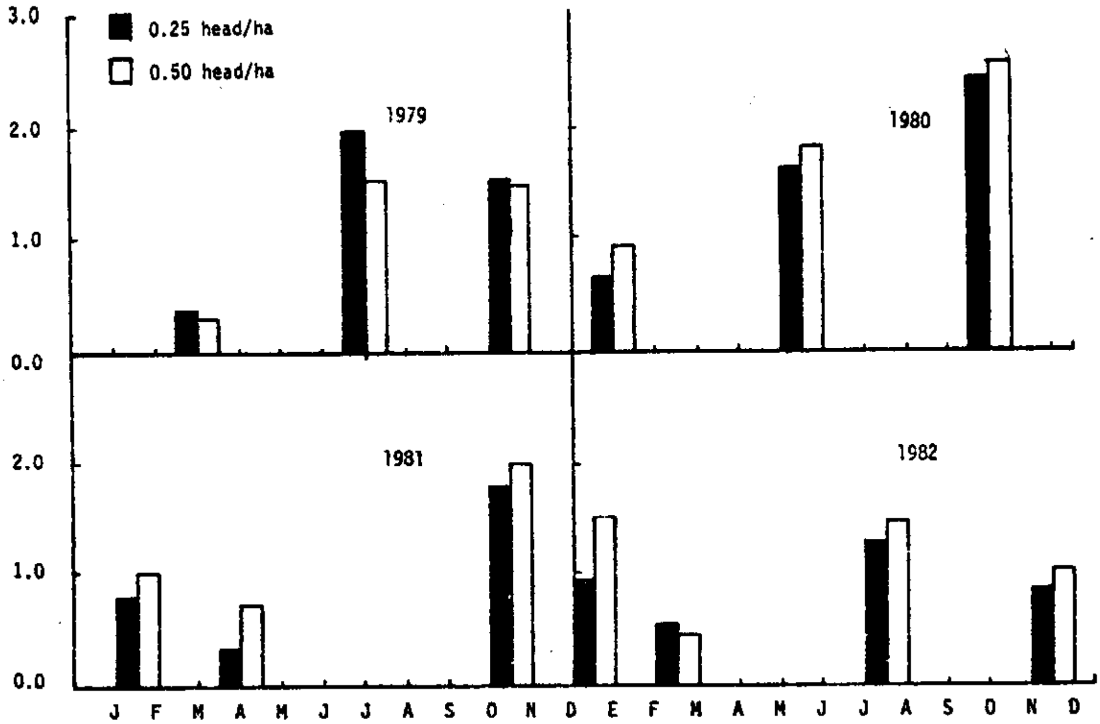
The quantity of legume leaf on offer for each stocking rate during the four years (Figure 1) shows that there were more important differences between seasons of the year than between stocking rates. The mean crude protein content of the kudzu leaves was 18.4%, without important seasonal differences except at the start of the rainy season when the crude protein content of the new shoots reached 27.5%. This explains the contribution of the legume as a complement to savannah grazing, since it provides the necessary protein supplement to animals on a basically protein-deficient diet, especially during the dry season. In addition, the mean levels of P (0.27 - 0.31 %), Ca (0.70 - 0.82 %) and S (0.20 - 0.23 %) in the kudzu will have improved the mineral balance of the animals grazing savannah, in which the levels of these elements, especially P and Ca, are too low for satisfactory growth (Paladines and Leal, 1979).

Table 4:
Herbage on offer and plant composition in unburned[1] savannah at Carimagua (1981).

Treatment (Head/ha)	Season	Dry matter on offer				
		Total		Leaf	Stem	Dead material
		kg/ha				
0.25	Dry	5666	NS	1257	314	4095
	Wet	5160	NS	1492	124	3543
0.50	Dry	4142	NS	1050	194	2938
	Wet	4678	NS	1248	345	3085

[1] **Average of two repetitions, estimated in April and November.**

Figure 1:
Quantity of leaf of Pueraria phaseoloides on offer for complementary grazing with native pastures under two stocking rates at Carimagua (1979-1982).



Observations showed (Tergas and Lascano, 1982) that the animals on the low stocking rate spent more time grazing the protein bank in the dry season before burning and even after burning once the rains started, than the animals from the higher stocking rate. This may help to explain the difference in weight gain between treatments. On the other hand, it was also observed that the animals on both stocking rates at first spent less time grazing the protein bank as the rainy season progressed, but then time spent grazing the legume increased again as the pasture available in the savannah which was burned at the start of the rains rapidly matured.

In Australia, another system of complementary grazing of legumes established in strips has been shown to lead to significant increases in animal production per hectare (Woods, 1970). This is chiefly due to the use of higher stocking rates than those reported in the present study in Colombia. The system has the disadvantage that the legumes are vulnerable to burning (Haggar et al, 1971) and may therefore not be attractive under present conditions in the eastern plains of Colombia. This emphasises the need to select legumes which are more tolerant of burning and which might be successfully introduced into native pastures (Gardener, 1980; Mott, 1982), contributing not only to an increase in output per animal but also per unit area.

Another important aspect of the management of systems of native pastures with complementary grazing of legumes which must be considered is the possible change in the botanical composition of the savannah which might take place due the substitution of desirable perennial grasses by annual grasses and weeds. This might be expected as a consequence of overgrazing of the palatable species due to the increased dry matter consumption resulting from the supplementation, especially at high stocking rates (CSIRO, 1982; Woods, 1970). A preliminary report of a study of the effects of burning and grazing on the succession of species in native pastures at Carimagua shows a tendency for the herbage cover to increase as a result of burning and for *Trachypogon vestitus* to become dominant after burning with low stocking rates (Hayashi, personal communication). While the reduced liveweight production observed in the present study in the fourth year of continuous grazing may have been partly due to a reduction in the quantity of herbage offered by the legume, it is not possible to state at present whether changes in the botanical composition of the savannah occurred due to grazing and burning, which might have affected the results described.

Conclusions

The results of this study show the potential of a complementary grazing system using *Pueraria phaseoloides* in protein banks as a relatively easy and practical way of increasing the utilization of native pastures and animal production in the eastern plains of Colombia, or in similar ecosystems in the savannahs of tropical America. A similar potential may be assumed for other adapted legumes which are productive in the dry season, especially those of high nutritive value such as *Stylosanthes* spp. generally are.

With regard to the management of the protein bank, it would appear that the strategic use of burning at the end of the rainy season to prolong the availability of good quality grass favours the accumulation of legume biomass which continues growing at the start of the dry season. On the other hand, burning at the end of the dry season reduces the grazing pressure on the protein bank, preventing overgrazing and allowing a rapid recuperation at the start of the rainy season. Thus, if there exists a strongly established legume stand and an adequate maintenance fertilizer programme, it is possible to control access to the protein bank at all times by the strategic use of burning.

This study also emphasises the need to study the botanical changes in the native savannah which result from the system of management and which may, in the long term, affect the stability of the species components and the animal output.

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