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Pasture production, diet selection and liveweight gains of cattle grazing *Brachiaria brizantha* with or without *Arachis pintoi* at two stocking rates in the Atlantic Zone of Costa Rica

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Abstract

Pastures of *Brachiaria brizantha (Bb)* alone or with *Arachis pintoi (Bb + Ap)* were rotationally grazed by 3 (LSR) and 6 (HSR) hd/ha. Mean 4-weekly forage DM on offer ranged from 3.5 t/ha at the HSR for *Bb* to 6 t/ha at the LSR for both pasture types. Mean dry weight proportion of *Ap* was 6% at the LSR and 34% at the HSR.

The amount of *Ap* in the diet of steers was about 50% at the HSR and 10% at the LSR. During two 7-day grazing cycles, the mean crude protein concentration of the diet at both stocking rates in *Bb* and at the LSR in *Bb + Ap* ranged from 7–9.5%, but at the HSR in *Bb + Ap*, it ranged from 15–18%. *In vitro* dry matter digestibility of the diet ranged from 61–66% in all treatments, except for *Bb* at the HSR in which it fell to 54.1% on the last day of grazing.

Average daily gain was lowest for *Bb* at the HSR (291–377 g) and highest for *Bb + Ap* at the LSR (452–551 g). The mean annual liveweight gain (LWG) per animal ranged from 119 kg for *Bb* at HSR to 178 kg for *Bb + Ap* at the LSR. LWG/ha/yr ranged from 478 kg for *Bb* at the LSR to 937 kg for *Bb + Ap* at the HSR. Including *Ap* increased LWG/ha by 30% at the HSR and 11% at the LSR. It was concluded that *Ap* is the best herbaceous legume presently available for the humid tropics of Costa Rica.

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Introduction

Cattle production from pastures is the main land use in the Atlantic Zone of Costa Rica. About 60% of the total deforested area is taken up by grasslands. The main agricultural products from this region are bananas, beef, milk, plantain, root and tuber crops and ornamental plants. Economically, beef and milk production are second only to bananas, but the banana industry is 80% foreign-owned and the cattle industry is wholly Costa Rican-owned and operated. Animal production is, however, practised on a very extensive scale, with low levels of inputs and management. About 77% of the total area under pasture is dominated by very unproductive naturalised and native grasses, the main species being *Ischaemum ciliare, Axonopus compressus, Brachiaria radicans* and *Paspalum* spp. The remainder consists of sown grasses, mainly *Cynodon nlemfuensis* (14%), *Brachiaria* spp. (6%) and *Hyparrhenia rufa* (3%) (SEPSA-CNP 1990). The use of pasture legumes is virtually unknown.

Relative to crop production, animal production on the grasslands which dominate this area is inefficient in terms of land use and there is an urgent need to increase production. More intensive animal production through pasture improvement would require less land for pastures and allow large areas in the Atlantic Zone to be replanted to forest.

Studies by the Tropical Agricultural Research and Education Centre (CATIE), the Ministry of Agriculture and Animal Production (MAG), the International Center for Tropical Agriculture (CIAT, Colombia) and Ibrahim *et al.* (1993) have shown that the humid, warm climate and the generally fertile volcanic soils are very well suited for pasture production, provided productive species, including pasture legumes, are used. The unimproved native pastures produce 8–10 t DM/ha/annum of poor quality, which is about 30–35% of the potential production from well managed *Brachiaria* pastures (CATIE 1989; Veldkamp 1993). In addition, the nutritive value of forage from native pastures is of low digestibility (40–55%) and low crude protein concentration (frequently <7%), compared with selected improved grasses, with digestibility values ranging up to 64% and crude protein values around 12% (Vallejos 1988; CATIE 1990; Ibrahim 1994).

However, many of the sown grass pastures are in an advanced stage of degradation because of overgrazing and the lack of nitrogen input, as no legumes are used and nitrogen fertiliser is applied only on a very limited scale in the Atlantic Zone for more intensive dairy production. The main weeds invading such degraded pastures are *Mimosa pudica, I. ciliare, B. radicans* and *Paspalum fasciculatum* (Ibrahim 1994).

Recent studies by CIAT in the Atlantic Zone have shown that a range of grasses and legumes is adapted to the climate and soils of the region (Vallejos 1988; Roig 1989). The most promising grass–legume mixture for the well drained soils of the region is *Brachiaria brizantha* cv. Marandu (CIAT 6780) and *Arachis pintoi* [CIAT 17434, released as cv. Amarillo in Australia (Cook 1992)] (Ibrahim 1994).

This paper reports on pasture dry matter yields, botanical composition, forage quality and selection and liveweight gains (LWG) of cattle grazing *B. brizantha* in monoculture or in combination with *A. pintoi* at 2 stocking rates.

Materials and methods

Site

The experiment was established in June 1989 at the MAG Experimental Station "Los Diamantes" at Guápiles (10° 13′ N, 83° 47′ W, elevation 250 m), with a mean annual rainfall of 4535 mm, with driest months receiving between 200 and 300 mm, a mean annual temperature of 25 °C (min. 19.5 °C, max. 30.5 °C) and a mean relative humidity of 87%. The soil is of volcanic origin, of medium to high fertility and has a pH (H_2O) of 5.6.

Pasture and animal management

The treatments consisted of a factorial of 2 pastures: *Brachiaria brizantha* (cv. Marandu, CIAT 6780) *(Bb)*; and *Bb* in association with *Arachis pintoi* (CIAT 17434) *(Bb + Ap)*; and 2 stocking rates (SR) in a completely randomised block design with 2 replicates. Nominal SR's were 3.0 (LSR) and 6.0 (HSR) hd/ha, equivalent to 600 and 1200 kg LW/ha, respectively, at the beginning of each grazing period. No fertilisers were applied.

Paddock size for each replicate was 0.67 ha for the LSR and 0.33 ha for the HSR. Each of these paddocks was subdivided equally into 4 plots to establish a rotational grazing cycle of 21 days resting and 7 days grazing. Each pasture treatment in each replicate was grazed by 1 heifer and 1 steer. The animals were selected from a uniform group 4 weeks after weaning. Animals were routinely treated for internal parasites and had free access to minerals and water. There were 3 contiguous periods of grazing with different groups of animals, starting on June 22, 1990, February 27, 1991 and January 29, 1992.

Measurements

Dry matter presentation yields (DM) and botanical composition before and after grazing were estimated using the Comparative Yield Method of Haydock and Shaw (1975) and the Dry-weight-rank Method of Mannetje and Haydock (1963). These measurements were carried out in each grazing cycle during the first grazing period, but only in the period of minimum and maximum precipitation in the second and third grazing periods.

In April and August 1992, forage quality and selection by the animals were estimated. Each treatment was sampled on days 1, 4 and 7 of a grazing week for botanical composition and diet selection by 4 oesophageally fistulated steers, which had been fasted overnight, between

700–1000 h. Two steers were used to graze each paddock for about 20 minutes and an average sample size of 1 kg extrusa was collected from each animal. Samples from the 2 steers in each paddock were combined and squeezed through muslin cloth. One half of the sample was frozen for later determination of grass leaf and stem, legume, volunteer spp. and dead fractions using the microscope point-hit technique developed by Harker *et al.* (1964). The other portion of the extrusa was dried at 65 °C for 48 hours, ground through a 1 mm screen and analysed for nitrogen (Kjeldahl) and *in vitro* dry matter digestibility (IVDMD) (Tilley and Terry 1963).

The animals were weighed after 16 hours overnight fasting with only water available after each grazing cycle in the first period and after every 2 grazing cycles in the second and third periods.

Statistical analysis

The data on DM yield and botanical composition before grazing were analysed as for a split-plot design to consider the time effect. Pasture and stocking rate treatments and replicate were assigned to main plots and grazing cycles to subplots. There were no significant differences in diet composition and quality between the 2 sampling dates and therefore the mean of the 2 sampling dates was taken and also analysed as for a split-plot design. In this instance, day of grazing was considered as subplot.

A regression analysis of LWG/an against grazing time (days) in each grazing period was carried out to estimate average daily gain (ADG). Subsequently, an analysis of variance was carried out to determine treatment effects on ADG in each period. Least significant difference (LSD) and Duncan's multiple range tests were used to test differences between treatment means where necessary.

Results

Pasture dry matter on offer and botanical composition

The mean DM yield and botanical composition on offer over the 2.8 years of grazing are shown in Table 1. The main effect on DM yield was caused by SR. There was no significant difference in DM yield between *Bb* and *Bb*+*Ap* at the LSR, but at the HSR, *Ap* had a significant ($P<0.05$) positive effect on DM yield.

Table 1. Mean dry matter on offer (t DM/ha) and the proportions (% DW) of *Brachiaria brizantha (Bb)*, *Arachis pintoi (Ap)* and other species (OS) measured before grazing on *Bb* monoculture and in association with *Ap* at 2 stocking rates (LSR = 3.0 hd/ha; HSR = 6.0 hd/ha).

Pasture	SR	DM on offer	% DW		
			Bb	*Ap*	OS
		(t/ha)			
Bb	LSR	6.0a[1]	95.4a	0c	4.6b
Bb	HSR	3.5c	91.3b	0c	8.7a
Bb + *Ap*	LSR	6.2a	90.0b	5.9b	4.1b
Bb + *Ap*	HSR	4.0b	60.6c	34.0a	5.4b

[1]Values within the same column with different letters are significantly ($P<0.05$) different.

Mean dry weight proportion (DW%) of *Ap* over the 2.8 years of grazing was significantly ($P<0.001$) higher at the HSR than at the LSR. The pasture was relatively free of weeds (other species), with only the HSR of *Bb* showing a significantly ($P<0.05$) higher proportion of other species than the other treatments.

Diet selection

At the 2 sampling dates, the mean DW% of *Bb* in the pasture varied from 75–90%, with the exception of *Bb*+*Ap* at the HSR, which averaged 48%. The mean DW% of *Ap* over the 2 samplings was 44% at the HSR, which was significantly ($P<0.001$) higher than the 8% at the LSR.

On the first day of the grazing cycle, *Bb* leaf comprised 85–95% of the diet in all treatments except *Bb*+*Ap* at the HSR in which the animals selected *Bb* leaf (42%) and *Ap* (50%) (Figure 1). Grass leaf content of the diet at the LSR remained high but decreased slightly during the grazing week, and there was no significant difference between *Bb* and *Bb*+*Ap*. At the HSR, there was a steep decline in the grass leaf content of the diet during the week of grazing, with corresponding significant ($P<0.01$) increases in the content of stem, dead material and volunteer species in the diet. The legume content of the diet was not affected by grazing time, but mean legume content in the diet at the HSR was 6-fold that at the LSR.

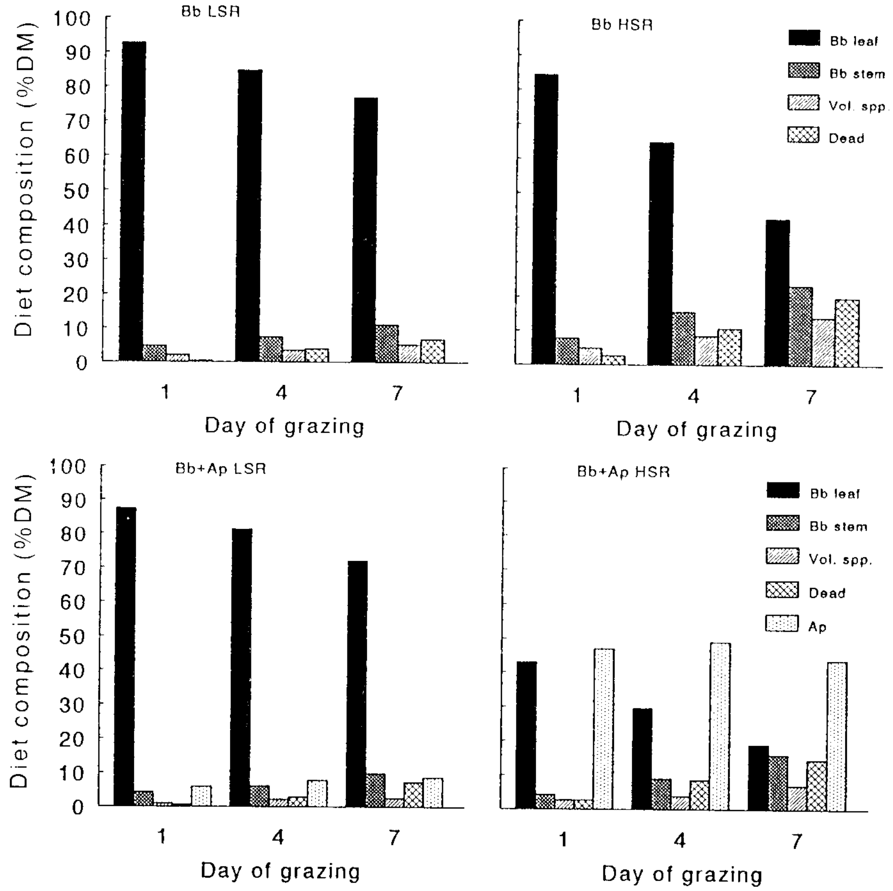

Figure 1. Changes during the week of grazing in composition (%DM) of the diet of steers — *Brachiaria brizantha* (Bb) leaf, Bb stem, dead material, *Arachis pintoi* (Ap) and volunteer spp. — on Bb alone and Bb + Ap grazed at 2 stocking rates [3.0 (LSR) and 6.0 (HSR) hd/ha].

The crude protein (CP) concentration and IVDMD of the diet significantly ($P<0.05$) decreased with progressive grazing, but CP% of the diet from *Bb + Ap* stayed above 15% at the HSR (Table 2). There were no significant differences between *Bb* and *Bb + Ap* in the quality of diet selected at the LSR although CP% and IVDMD of the diet were slightly higher for *Bb + Ap*. However, at the HSR, *Ap* had a significant ($P<0.01$) positive effect on the CP% and IVDMD of the diet selected. On the *Bb + Ap* pasture, the mean CP% and IVDMD of the diet at the HSR were, respectively, 8.5 and 4.3 units higher than that selected from *Bb* pasture.

Table 2. Changes during the week of grazing in the crude protein concentration (%CP) and *in vitro* dry matter digestibility (%IVDMD) of the diet of steers grazing *Brachiaria brizantha (Bb)* in monoculture or with *Arachis pintoi (Bb + Ap)* at 2 stocking rates (LSR = 3.0 hd/ha; HSR = 6.0 hd/ha).

	LSR		HSR	
	Bb	*Bb + Ap*	*Bb*	*Bb + Ap*
Day	%CP			
1	9.6a[1]	10.4a	9.5a	17.8a
4	8.7a	9.4b	8.0b	16.7b
7	8.1b	8.5c	7.0c	15.2c
Mean	8.8	9.4	8.1	16.6
Day	%IVDMD			
1	66.2a	66.0a	62.9a	64.1a
4	63.9b	64.6a	58.2b	63.1a
7	60.5c	61.8b	54.1c	60.9b
Mean	63.5	64.1	58.4	62.7

[1]Values within the same column and within parameters with different letters are significantly ($P<0.05$) different according to Duncan's multiple range test.

Liveweight changes

During the first grazing period, there were no significant differences in ADG (Table 3).

Table 3. Average daily liveweight gain (ADG) (g/d) of steers grazing *Brachiaria brizantha* alone *(Bb)* or with *Arachis pintoi (Bb + Ap)* at 2 stocking rates (LSR = 3.0 hd/ha; HSR = 6.0 hd/ha).

	LSR		HSR	
Period	*Bb*	*Bb + Ap*	*Bb*	*Bb + Ap*
22.6.90–27.2.91	396a[1]	452a	291a	308a
27.2.91–29.1.92	511a	551a	377b	476ab
29.1.92–24.2.93	449b	515a	345c	501ab

[1]Values within the same row with different letters are significantly ($P < 0.05$) different according to Duncan's multiple range test.

However, during the second grazing period, there was a significantly ($P < 0.05$) lower ADG on *Bb* at the HSR than at the LSR, and during the last period, there were significant benefits of *Ap* at both SRs. Mean ADG of steers was 0.05 kg higher than that of heifers which was significant ($P < 0.05$).

Cumulative LWG/animal over the 3 grazing periods combined (Figure 2) clearly shows the positive effects of decreasing the SR and of including *Ap*. Particularly at the HSR, the effect of *Ap* on cumulative LWG/hd was more pronounced in the second and third grazing years, and this was associated with a significant increase in dry matter yields of *Ap*.

The cumulative LWG/ha over the 3 grazing periods combined (Figure 3) shows that including *Ap* in the mixture increased LWG by 29.6% at HSR and by 11.9% at LSR.

The LWGs over the whole period of 975 days (Figures 2 and 3) have been converted to an annual basis (Table 4). Only at the HSRs were the differences between *Bb* and *Bb + Ap* significant ($P < 0.05$).

Table 4. Annual liveweight gain (kg) per animal and per ha on *Brachiaria brizantha* alone or grown with *Arachis pintoi* at 2 stocking rates (LSR = 3.0 hd/ha; HSR = 6.0 hd/ha), calculated from the data in Figures 2 and 3.

	Per animal		Per hectare	
Stocking rate	LSR	HSR	LSR	HSR
Pasture				
B. brizantha	159	119	478	716
B. brizantha + A. pintoi	178	154	534	937
LSD ($P = 0.05$)	NS[1]	27.4	NS	145

[1]Not significant.

Discussion

Pasture DM production was high (Table 1) and during the 2.8 years of the experiment the pastures maintained a low weed content. The

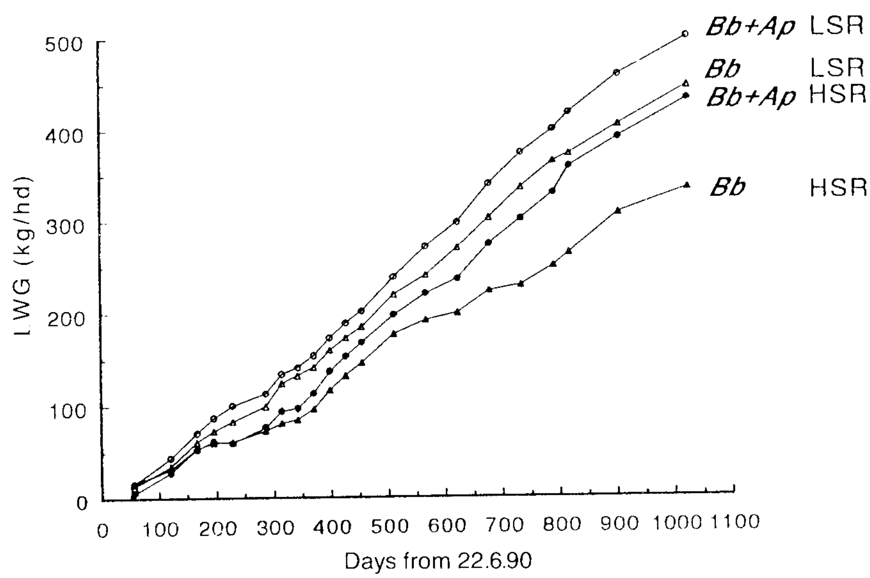

Figure 2. Cumulative liveweight gain per animal of cattle grazing *Brachiaria brizantha* (Bb) alone or with *Arachis pintoi* (Bb + Ap) grazed at 2 stocking rates [3.0 (LSR) and 6.0 (HSR) hd/ha] from 22.6.90 to 24.2.93.

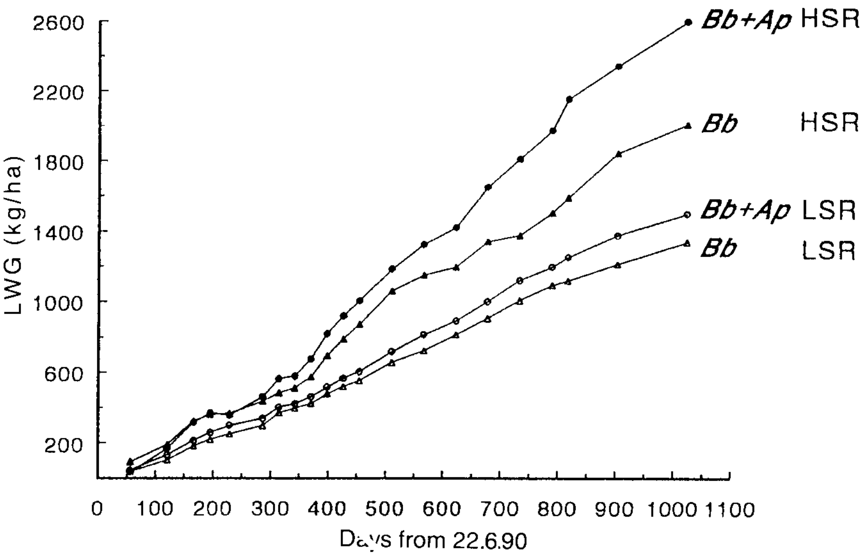

Figure 3. Cumulative liveweight gain per unit area (kg/ha) of cattle grazing *Brachiaria brizantha* (Bb) alone or with *Arachis pintoi* (Bb + Ap) grazed at 2 stocking rates [3.0 (LSR) and 6.0 (HSR) hd/ha] between 22.6.90 and 24.2.93.

mean legume content at the HSR was 5.7 times higher than at the LSR. This is in keeping with other findings on *Ap* at "Los Diamantes" (Ibrahim *et al.* 1993; Ibrahim 1994). It is rare in tropical grasslands that legume content is increased by increasing SR, although it was also shown by Shaw (1978) with *Stylosanthes humilis* oversown into native pasture in central coastal Queensland, Australia. Practically all reports in the literature show the opposite effect and most herbaceous legumes are in danger of disappearing with increased stocking rates.

There are few data available on the LWG of cattle on unimproved pastures in the Atlantic Zone of Costa Rica. Gutierrez (1983) reported a liveweight gain of 158 kg/ha/annum at a stocking rate of 1.7 hd/ha, which is regarded as about the optimum stocking rate on unimproved pastures in this zone. The data in Table 4 show that *Bb* at the LSR, double that for native pasture, produced 200% more LWG/ha/yr than reported for native pasture. The annual LWG/animal of *Bb* at the LSR (159 kg) is comparable with data reported from grass-legume pastures in Queensland, Australia, grazed at about half the SR (e.g. Mannetje and Jones 1990). However, observations in the Atlantic Zone indicate that grass-only pastures deteriorate in time due to the lack of N input and resultant weed invasion. In a region in north-east Queensland with similar total annual rainfall, but with a distinct dry season, grass-legume pastures grazed at 3.0 hd/ha produced similar LWG (550 kg/ha/yr) to the *Bb + Ap* pasture at the LSR (Teitzel *et al.* 1991).

The inclusion of *Ap* reduced the effect of stocking rate on LWG/animal. Doubling the stocking rate caused a reduction in LWG/animal of 25% in the *Bb* pasture compared with 13% in the *Bb + Ap* pasture.

When *Arachis pintoi* was grown with *Brachiaria dictyoneura* and *Brachiaria humidicola* on the acid soils of Carimagua, Colombia, there was a significant improvement in animal production over the grass monocultures (Lascano 1993). With these mixtures stocked at 3–4 animals/ha, daily liveweight gains in the rainy season were 400–520 g/day which was 35–50% higher than on the grass monocultures. Annual LWG of *Ap* with *B. dictyoneura* was 400 kg/ha (Lascano 1993), 30–40% higher than the maximum LWG reported on *Andropogon gayanus-Stylosanthes capitata* and *Brachiaria decumbens-Pueraria phaseoloides* mixtures in Carimagua (Lascano and Estrada 1989; Lascano and Thomas 1990).

On the *Bb* monoculture, the animals selected forage of a higher quality at LSR than at HSR and this is reflected in higher LWG/animal at LSR. The dietary *Bb* leaf levels at LSR were very high and grazing studies with dairy cows in Australia showed that milk yields from *Panicum maximum* pasture were increased as the leaf content in the diet was increased (Stobbs 1978; Cowan *et al.* 1986). Green leaf fractions are usually of a better quality than stem fractions (Chacon and Stobbs 1976), and a high leaf content in the diet is responsible for high dry matter intake (Poppi *et al.* 1981). Mannetje (1974) and Mannetje and Ebersohn (1980) noted that pasture intake and LWG/animal are related asymptotically to green herbage allowance on a DM basis and this may partially explain the difference in LWG between SRs on the grass monoculture, since dry matter yield at the HSR was only 58% that at the LSR.

The results showed unequivocally that *Ap* has a high nutritive value, which was evident from the high quality of diet selected at the HSR. Animals grazing *Bb*+*Ap* at the HSR selected 45–48% of *Ap* in the diet which was similar to the percentage of *Ap* on offer. This is supported by findings of other grazing experiments in which *Ap* was grown with *Bb* and *B. humidicola* in Los Diamantes (Ibrahim 1994) and in other experiments in which *Ap* was associated with various *Brachiaria* spp. in Carimagua, Colombia (Lascano and Thomas 1988; Lascano 1993). The results of these authors demonstrated that the proportion of *Ap* in the diet was always similar to that on offer even though there were high variations in the proportion of *Ap* in the different mixtures. At the HSR, *Ap* had a positive effect on the N concentration of the diet, which contributes to increased microbial activity and cellulose digestion in the rumen (Weston and Hogan 1973; Humphreys 1991), leading to improved animal performance. Results derived from various experiments with native and grass–legume pastures in Australia showed that there was a positive linear increase in LWG per animal over a wide range of N concentrations in the extrusa (Siebert and Hunter 1977). The IVDMD of the diet selected from *Bb*+*Ap* at the HSR was also higher than that on the pure grass pasture. This and other studies with *Ap* revealed that IVDMD was higher than or similar to the majority of improved grasses and legumes in the Atlantic zone (Roig 1989; Heurck 1990; Ibrahim 1994).

It is too early to conclude that *Ap* will persist for a long time and that *Bb*+*Ap* will prove to be a sustainable pasture mixture, but results from this experiment over 2.8 years and from an adjacent experiment (Ibrahim *et al.* 1993) over 4 years are promising. Farmers in the region are also beginning to see the benefits, and a few have successfully planted *Bb* and *Ap* for dairy cows in the Atlantic Zone. With a 6-fold increase in animal productivity per ha over native pastures obtained in this experiment, the present total beef production of the Atlantic Zone could be more than doubled by establishing similarly productive grass-legume pastures on 25% of the area (Mannetje 1978). It would therefore be possible to both increase beef and milk production in the Atlantic Zone and at the same time make a very large area of land available for other purposes, including reforestation.

Further research is required to find a wider range of grass species to be combined with *Ap* on different soil types. It has been found that *Bb* is subject to a fungal disease on poorly drained soils in the Atlantic Zone of Costa Rica. It is also necessary to investigate SR effects on both the grass–legume balance and the productivity of these pastures.

It can be concluded that *Ap* was very grazing tolerant and capable of high animal production, which is related to higher quality of diet selected in the mixture, compared with the grass monoculture. Taking into account the results of other experiments in Costa Rica (Ibrahim *et al.* 1993), which included other legumes, it may be concluded that *Ap* is at present the best herbaceous legume available for the humid tropics of Costa Rica.

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