Evaluation of five shrubby legumes in comparison with *Centrosem*a *acutifolium*, Carimagua, Colombia

D. THOMAS AND R. SCHULTZE-KRAFT
*Tropical Pastures Programme, CIAT, Cali, Colombia*

Abstract

A small-plot grazing trial was conducted to assess selection by oesophageal-fistulated steers of 5 shrubby legumes adapted to acid, low-fertility soils (*Centrosem*a *arenarium*, *Desmodium strigillosum*, *D. velutinum*, *Flemingia macrophylla*, and *Tadehagi triquetrum*) and the herbaceous *Centrosem*a *acutifolium*, associated with native pasture. There was marked variation between seasons in legume consumption. In the first dry season the proportion of legume in the diet selected by fistulated steers was greater than the legume available in the pastures for all shrub species. In the second dry season, when there was significant off-season rainfall, legume consumption in 4 of the 5 shrub species was lower and appreciably less than the legume on offer. In the wet season legume selection was low, except for the herbaceous *C. acutifolium*.

The N concentrations for legume leaf were high in the dry and wet seasons but digestibility (IVDMD) was low, especially in *F. macrophylla*. It was concluded that the shrubby species tested have a potential as dry-season forage when associated with native pastures but that in the light of apparently low IVDMD this potential needs to be assessed in terms of animal production.

Resumen

*Con el fin de determinar el consumo animal de 5 leguminosas arbustivas adaptadas a suelos ácidos y de baja fertilidad (Centrosem*a arenarium, Desmodium strigillosum, D. velutinum, Flemingia macrophylla y Tadehagi triquetrum) y de la especie herbácea Centrosem*a acutifolium, asociadas con especies da sabana nativa, se realizó un experimento de pastoreo en parcelas pequeñas, usando novillos fistulados en el esófago. El consumo de las leguminosas varió considerablemente entre una estación y otra. En la época seca del primer año, la proporción de leguminosa en la dieta seleccionada por los novillos fue, para todas las especies arbustivas consumidas, más alta que la proporción de la leguminosa disponible en la pastura. En la segunda época seca se registraron lluvias extraordinarias; en ella el consumo de leguminosa de 4 de las 5 especies arbustivas fue notoriamente más bajo que la cantidad de leguminosa en oferta. En la época lluviosa, la selección que los animales hicieron de las leguminosas fue baja, a excepción de la especie herbácea C. acutifolium.*

La concentración de N en las hojas de las leguminosas fue alta durante las épocas seca y lluviosa, aunque la digestibilidad (DIVMS) fue baja, especialmente la de F. macrophylla. Se concluyó que las especies arbustivas evaluadas, cuando están asociadas con especies de sabana nativa, tienen potencial como forraje para la época seca. Sin embargo, en vista de que la DIVMS es aparentemente baja, este potencial debe determinarse en términos de producción animal.

Introduction

Leguminous shrubs and trees have been used for livestock feed in many tropical countries. Such plants offer potential advantages over herbaceous species in terms of superior persistence, higher yields, better resistance to mismanagement and a capacity to retain high quality forage under moisture stress conditions (Maasdorp and Gutteridge 1986). The more commonly used shrubs, *Leucaena leucocephala* and *Gliricidia sepium*, have performed poorly in tropical South...
America where soils are extremely acid with a high aluminium saturation and a low calcium content (R. Schultz-Kraft and P. Perdomo, unpublished data). In recent years, the Centro Internacional de Agricultura Tropical (CIAT) has initiated a search for shrubs adapted to such soils, and germplasm collections have been made in tropical America and south-east Asia (Schultz-Kraft et al. 1989a).

Agronomic trials at the Quilichao Experiment Station of CIAT in the Cauca Valley, Colombia have identified a number of productive shrubby legumes tolerant of acid soils (R. Schultz-Kraft and P. Perdomo, unpublished data). However, small-plot grazing trials in Quilichao and observations elsewhere with these species have indicated that palatability is often low and variable (Asare et al. 1984, Asare 1985, Lascano et al. 1985, Schultz-Kraft et al. 1989b). No data on diet selection were available under savanna conditions in Colombia where the quality of native grasses is poor for much of the year and where shrub legumes are of potential value in protein-banks to supplement the natural vegetation. Accordingly, a trial was conducted to measure animal preference of 5 selected, acid soil-tolerant shrub legumes, in comparison with the herbaceous legume Centrostepa acutifolium cv. Vichada, grown in savanna in the eastern plains ("Llanos Orientales") of Colombia.

Materials and methods

The trial was undertaken at the Carimagua Research Station, Meta, Colombia, South America at latitude 4°30'N, longitude 71°19'W and 150 m altitude. Rainfall is usually distributed from April to December inclusive and during the experimental period was 2872 mm (1986), 2743 mm (1987) and 2033 mm (1988). Mean maximum and mean minimum temperatures were 32°C and 23°C, respectively. The soil type was an Oxisol (Tropersic Haplustox Isohyperthermic) with pH 4.9 (1:1, water), 86% A1 saturation and low in available P (1.3 ppm Bray II), exchangeable K (0.04 me/100 g), Ca (0.09 me/100 g) and Mg (0.05 me/100 g).

Six legume treatments were arranged in a randomized complete block design with 2 replications. There were 5 shrubby legumes Centrostepa arenarium, Desmodium strigilosum, D. velutinum, Flemingia macrophylla and Tadehagi triquetrum, and the herbaceous legume Centrostepa acutifolium cv. Vichada.

Centrostepa arenarium: Of the agronomically known Centrostepa species, this is the only one that is erect-growing, non-trailing and non-climbing. On acid, low-fertility soils, adult plants are little-branching and not very leafy when uncut, attaining a height of 1.20-1.60 m. Accession CIAT 5236 originates from the state of Bahia, Brazil.

Desmodium strigilosum is a rather small, freely branching, remarkably leafy, semierect subshrub with trifoliate leaves and is in its growth habit quite similar to the common form of D. heterocarpus as represented by the US cultivar 'Florida carporn'. A mixture of 2 (probably identical) accessions from Thailand, CIAT 13155 and 13158, was used.

Desmodium velutinum: A mixture of 3 similar accessions (CIAT 13204, 13213 and 13215) from Thailand was used; they represent a semierect-growing shrub type with unifoliolate leaves. Adult, uncut plants have been observed to grow on acid, low-fertility soils up to a height of 1.20 m; their leafiness is intermediate.

Flemingia macrophylla (syn. F. congesta): Of the shrubby species tested, this is probably best known agronomically. The accession used, CIAT 17403, was collected in Thailand and represents an erect-growing (1.50-2.50 m), leafy bush with a remarkable potential to branch at the stem base.

Tadehagi triquetrum (syn. Desmodium triquetrum) is an erect subshrub. On acid, low-fertility soils it grows up to 1.50 m high and is of intermediate to low leafiness. Leaves are unifoliolate, lanceolate and have winged petioles. The accession used also originates from Thailand.

Centrostepa acutifolium cv. Vichada was included as a herbaceous control. Morphologically, this species is quite similar to C. pubescens; cv. Vichada was collected in the Comisaria del Vichada, Colombia.

Inoculated seed was sown in "Jiffy" pots in the screenhouse in mid-March 1986 and transplanted in the field 4 weeks later. Each plot consisted of 12 rows of legumes 20 m long with 1.5 m of Trachypogon-dominated savanna between rows. The distance between plants within a row was 50 cm. Fertilizer was applied in the rows at establishment at rates equivalent to 5, 5, 3 and 3 kg/ha of P, K, Mg and S, respectively. The sources of fertilizer were triple super-
phosphate, potassium chloride, magnesium sulphate and elemental sulphur. In subsequent years, fertilizer was given at 50% of establishment rates. A standardization cut to 15 cm above ground level was made in early May 1987 at the start of the wet season.

The trial was grazed at the beginning (mid-December), in the middle (mid-February) and at the end (mid-April) of the dry seasons of 1987-88 and 1988-89, and also in the middle of the wet season in mid-August 1988. At each grazing, different animals were used for a given treatment. Each plot was fenced and grazed by a single oesophageal-fistulated steer (approx. 200 kg liveweight) for 5 days. Animals were rotated around the 2 replicates with a given steer allocated to the same treatment in both replicates. When not in the experiment the steers grazed native pasture supplemented with minerals. Consequently, the experimental animals were on a low plane of nutrition for most of the year in contrast to those used in palatability grazing trials at the Quilichao Experiment Station.

Samples of forage on offer and diet selected were taken at each grazing cycle. Native pasture, which comprised dominantly grass species, and *C. acutifolium* were sampled from 8 random 0.5 m² quadrats cut 10 cm above ground level in each plot. For all shrub legume species samples of green leaf only were taken from two areas in every plot, each containing 8 plants. Samples of forage on offer were oven-dried at 60°C for 48 h and the dry weight recorded. Samples taken in the middle of both dry seasons (mid-February) and in the middle of the wet season (mid-August) were ground in a Wiley mill using a 1 mm screen. Samples were analysed for N (microKjeldahl method) and subjected to a two-stage *in vitro* digestion (IVMD) (Tilley and Terry, 1963 as modified by Moore and Mott, 1974). Dietary samples from oesophageal-fistulated steers were collected only in the second replicate on the third and fifth days of grazing, to ensure a period of animal adaptation to the legume. After collection the extrusa samples were slightly squeezed and frozen for subsequent analysis. Botanical composition of the forage selected was determined by the microscope point-hit technique (Harker et al. 1964). As there were no major differences in leaf thickness between the tested species, no adjustment for weight per unit area was made in the estimation of the extrusa botanical composition.

Data were subjected to conventional analysis of variance and least significant differences between means are reported.

**Results**

*Plant growth, pests and diseases*

All legumes grew well, were well nodulated and did not show any nutrient deficiency nor toxicity symptoms. *C. acutifolium* showed a particular ability to spread into the native pasture.*

*C. acutifolium* was attacked slightly by the fungal disease *Cylindrocladium Leaf Spot*. In the final year of the trial, *D. strigillosum* and *D. velutinum* were affected by the stem-gall nematode *Pterostylenchus cecidogenus*, which has caused problems in *Desmodium ovalifolium* at Carimagua. The nematode was detected in all replicates and infestation varied from slight to heavy. Although there was some mortality most plants recovered. Both *D. strigillosum* and *D. velutinum* produced large quantities of seed and seedling recruitment between rows was high. Young plants did not appear affected by the nematode.

*Forage availability and quality*

The forage on offer sampled in both the dry and wet seasons in the associations of 5 shrubby legumes and *C. acutifolium* with native pasture is presented in Table 1. Yields of native pasture were low, and in both dry seasons were highest in the *C. arenarium* treatment, and lowest in the *C. acutifolium* treatment. Legume-leaf yields were also low. The highest yields were recorded for *C. acutifolium* and *F. macrophylla* in both dry seasons, and for *D. strigillosum* and *F. macrophylla* in the wet season.

The N concentration values for native pasture were very low in both the mid-wet and dry seasons (Table 2). Those of the legume leaves were appreciably higher; more than 1.5% in the dry season and above 2.3% in the wet season. The highest values were noted in *C. arenarium* and *D. velutinum*, and, in the 1988 wet season, in *C. acutifolium*. With the exception of *C. arenarium* and *D. velutinum* in the first dry season and in the wet season (*D. velutinum* also during the second dry season), IVMD values for green leaf were very low. It is noteworthy that the percentages for *F. macrophylla* were even lower than those for native pasture.
Table 1. Forage availability in associations of five shrubby legumes and Centrosema acutifolium with native pasture during the dry and wet seasons

<table>
<thead>
<tr>
<th>Native pasture-legume association</th>
<th>Native pasture</th>
<th>Seasonal forage availability</th>
<th>Legume leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrosema arenarium</td>
<td>2220</td>
<td>1370</td>
<td>1390</td>
</tr>
<tr>
<td>Desmodium strigillosum</td>
<td>1450</td>
<td>1100</td>
<td>910</td>
</tr>
<tr>
<td>Desmodium velutinum</td>
<td>1290</td>
<td>840</td>
<td>1050</td>
</tr>
<tr>
<td>Flemingia macrophylla</td>
<td>1300</td>
<td>1160</td>
<td>1020</td>
</tr>
<tr>
<td>Tadehagi triquetrum</td>
<td>1680</td>
<td>1340</td>
<td>980</td>
</tr>
<tr>
<td>Centrosema acutifolium</td>
<td>650</td>
<td>1120</td>
<td>720</td>
</tr>
<tr>
<td>cv. Vichada</td>
<td>840</td>
<td>1410</td>
<td>500</td>
</tr>
<tr>
<td>LSD (P = 0.05)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Dry season values are means of three samplings, early-December, mid-February and late-April.
² Sampled in mid-wet season (August).

Legume selection

The proportions of legume on offer in the associations are shown in Table 3. For the 5 shrub species, values varied from 13 to 49% in the dry seasons and from 12 to 42% in the wet season (Table 3). The highest legume contents were found in the treatments containing F. macrophylla and D. strigillosum. Corresponding values for C. acutifolium cv. Vichada ranged from 35 to 66%.

In the first dry season, for the 5 shrub species, the proportion of legume in the diet selected by fistulated steers was greater than the legume available in the pastures (Table 3). A high proportion (>38%, i.e. as high as or higher than in the C. acutifolium treatment) of F. macrophylla, D. strigillosum and D. velutinum was selected. In the second dry season, with the exception of C. arenarium, legume selection was lower and appreciably less than the legume on offer in the pastures. The selection of C. arenarium was not significantly different from that of the control C. acutifolium. In the first dry season, the off-season rainfall was only 33 mm compared to 220 mm in the 1988-89 season. This higher off-season rain in the second dry season stimulated the growth of new shoots in the native grasses which were grazed in preference to most of the legumes. In the wet season, legume selection was low for all legumes, particularly for the shrubby species.

Discussion

Cutting trials have indicated that a number of shrubby legumes are adapted to acid, low-fertility soils. However, since legumes are often un-

Table 2. Nitrogen (N) concentration and in vitro dry matter digestibility (IVDMD) of leaves of five shrubby legumes and Centrosema acutifolium, and whole tops of native pasture during the dry and wet seasons.

<table>
<thead>
<tr>
<th>Legume/native pasture</th>
<th>N¹ (%)</th>
<th>IVDMD¹ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrosema arenarium</td>
<td>2.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Desmodium strigillosum</td>
<td>1.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Desmodium velutinum</td>
<td>2.7</td>
<td>3.2</td>
</tr>
<tr>
<td>Flemingia macrophylla</td>
<td>1.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Tadehagi triquetrum</td>
<td>2.1</td>
<td>2.3</td>
</tr>
<tr>
<td>Centrosema acutifolium</td>
<td>1.9</td>
<td>3.2</td>
</tr>
<tr>
<td>cv. Vichada</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native pasture</td>
<td>0.6</td>
<td>1.0</td>
</tr>
</tbody>
</table>

¹ Samples for N and IVDMD were taken in the mid-dry season (February) and the mid-wet season (August).
² Data not available (loss of sample); wet-season IVDMD of this variety ranges at Carimagua between 45% and 55% (C. Lascano, pers. comm.).
Table 3. Proportion of legume leaf in the forage on offer and selected by oesophageal-fistulated steers in associations of five shrubby legumes and Centrosema acutifolium with native pasture during the dry and wet seasons.

<table>
<thead>
<tr>
<th>Native pasture-legume association</th>
<th>Legume on offer</th>
<th>Legume in extrusa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrosema arenarium</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Desmodium strictilobus</td>
<td>20</td>
<td>42</td>
</tr>
<tr>
<td>Desmodium velutinum</td>
<td>18</td>
<td>40</td>
</tr>
<tr>
<td>Flemingia macrophylla</td>
<td>25</td>
<td>39</td>
</tr>
<tr>
<td>Tadegahi triquetrum</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Centrosema acutifolium cv. Vichada</td>
<td>55</td>
<td>35</td>
</tr>
<tr>
<td>LSD (P = 0.05)</td>
<td>26</td>
<td>25</td>
</tr>
</tbody>
</table>

<sup>1</sup> Dry season values are means of three samplings, early-December, mid-February and late-April.

palatable to livestock, early evaluation of these plants with animals is essential. The present experiment has shown that, at certain times, animals actively selected for the 5 shrubby legumes and the proportion consumed was greater than the proportion on offer in the pastures. Nevertheless, there was marked variation between seasons, and this appeared to be related to rainfall. For 4 of the 5 shrubby species, selection was highest in the first dry season and lowest in the wet season and second dry season when there was significant off-season rainfall. A seasonal pattern of legume selection by grazing animals has often been observed in tropical grass-legume mixtures. Studies carried out in Australia have indicated that cattle grazing native grasses with Stylosanthes humilis (Hunter et al. 1976), S. hamata (Gardener 1980) and Stylosanthes species (McLean et al. 1981) have selected more legumes during the dry periods of the year when the quality of the companion grasses has declined. Similarly, Böhnert et al. (1985) reported that in the savannas of the eastern plains of Colombia, cattle exhibited a higher preference for Pueraria phaseoloides and Stylosanthes capitata during the dry season. An exception, in the same environment, appears to be the high-quality legume Arachis pintoi where Lascano and Thomas (1988) found that selection by animals was highest in the wet season. No seasonal legume selection effect was found in southeastern Queensland, Australia, with cattle grazing Leucaena leucocephala (Jones and Jones 1984).

Low wet-season legume selection as in the case of the 5 shrubby legumes tested in this trial can be advantageous, particularly in extensive pasture utilization systems with no major legume management opportunities: It prevents plants from being overgrazed during the growing period and enables accumulation of, in general, high-quality forage for the dry season. As a recent grazing experiment in Carimagua has shown, a palatable legume such as C. acutifolium, when associated with the native Trachypogon savanna, is easily overgrazed (C. Lascano, personal communication).

All species tested in this trial have the capacity to supply high levels of crude protein especially in the dry season when protein is limiting. In the Colombian savannas, N concentrations below 1% result in severe weight losses in cattle (Böhnert et al. 1986). However, this capacity to supply protein would appear to be discounted due to low digestibility. IVDMD values were low, particularly for the most productive species F. macrophylla. This could be partially due to the presence of phenolic compounds known to inhibit digestion of forage by ruminal microorganisms (Boneman et al. 1986; Varel and Jung 1986). For F. macrophylla, such an inhibitory effect on microorganisms is substantiated by the finding of Budelman (1988) that leaf mulch of this species had a particularly slow decomposition in the soil (and was, therefore, considered as promising in retarding weed development). The method of drying the leaf tissues used for the in vitro digestion could also have contributed to a reduced digestibility. Recent results with a number of tropical legumes with variable contents of tannins clearly indicate that oven-drying samples at 60°C can result in considerably lower IVDMD than freeze-drying (Mahyuddin et al. 1988; Narváez...
and Lascano 1989). Therefore, the digestibility of *F. macrophylla* in this trial might have been underestimated. However, there seems to be no doubt that this legume has low digestibility compared with the other legumes included in the trial.

In conclusion, the 5 shrubby species evaluated in this trial, particularly the most productive species, *F. macrophylla*, due to their edaphic adaptation, low wet-season acceptance and high crude-protein levels during the dry season, have a potential as dry-season forage legumes for acid, low-fertility soils, when associated with low-quality grasses such as native savanna pasture. This potential, however, is limited by low digestibility. The extent to which this affects animal performance is about to be studied in a grazing trial. The magnitude of genetic variation within individual species also merits assessment in relation to forage quality. Consequently, all available germplasm of *C. arenarium*, *D. strigillosum*, *D. velutinum*, *F. macrophylla* and *T. triquetrum* (6, 10, 107, 65 and 40 accessions, respectively) is at present under evaluation at Carimagua.

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**References**


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