Ranking Twenty-Two Tropical Browse Species from Guanacaste, Costa Rica[1]

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ABSTRACT

Twenty-two species of tropical trees and shrubs were sampled, chemically analyzed and ranked according to mean values for crude protein (CP) and *in vitro* true digestibity (IVTD) of leaves. A simple statistical formula was used to combine the two criterion values, and rank the species. From this ranking and additional information the species were grouped according to their fodder potential. The first group includes *Acacia farnesiana, Caesalpinia eriostachys, Cassia bicapsularis* ("candelillo") and *Myrospermum frutescens* with the highest folder potential based on chemical analysis, but have either physical or chemical factors inhibiting consumption. The second group, with more immediate fodder potential includes *Gliricidia sepium, Pithecellobium saman, Tabebuia ochracea, Spondias purpurea, Lysiloma divaricata, Cajanus cajan* and *Enterolobium cyclocarpum.* The third group with species whose protein content generally ranks much higher than most range grasses, but lower compared to the above eleven species, includes *Bauhinia ungulata, Cordia alliodora, Hemiangium excelsum* ("guachero"), *Piscidia carthagenensis, Lonchocarpus minimiflorus, Tamarindus indica, Ficus* sp. ("higueron"), *Guazuma ulmifolia, Mangifera indica, Hymenaea courbaril* and *Andira inermis.* Crude protein and IVTD values are also given for the fruits or pods of some of the above species and three additional ones: *Acrocomia vinifera, Cassia grandis,* and *Crescentia alata.*

COMPENDIO

Veintidós especies de árboles y arbustos tropicales fueron muestreadas, analizadas químicamente y clasificadas según los valores promedios de proteína cruda (CP) y digestibilidad verdadera *in vitro* (IVTD) de las hojas. Se usó una fórmula estadística para combinar los dos valores criterios y clasificar las especies. Con base en esta clasificación y otra información citada en la literatura consultada, las especies se agruparon de acuerdo con su potencialidad como árboles forrajeros. En el primer grupo se incluyen: *Acacia farnesiana, Caesalpinia eriostachys, Cassia bicapsularis* (candelillo) y *Myrospermum frutescens.* En el segundo grupo aparecen *Gliricidia sepium, Pithecellobium saman, Tabebuia ochracea, Spondias purpurea, Lysiloma divaricata, Cajanus cajan* y *Enterolobium cyclocarpum.* El tercer grupo está conformado por *Bauhinia ungulata, Cordia alliodora, Hemiangium excelsum* (guáchero), (*Piscidia carthagenensis, Lonchocarpus minimiflorus, Tamarindus indica, Ficus* sp. (higuerón), *Guazuma ulmifolia, Mangifera indica, Hymenaea courbaril* y *Andira inermis.* Los valores de proteína cruda e IVTD también están dados para las frutas o vainas de algunas de las especies ya mencionadas y tres especies adicionales: *Acronomia vinifera, Cassia grandis* y *Crescentia alata.*

INTRODUCTION

Browse or fodder trees are frequently included as components of agroforestry systems but more information is required on the nutritional value of most of them. Central America in rich in plant life and the source of two widely-used fodder trees, *Leucaena* and *Gliricidia*. *Leucaena* plantings around the tropical world have been suffering from insect and disease attack (13). Farmers need to be able to choose from a greater number of fodder tree species. Small or subsistence farms in particular, need to protect themselves by planting a variety of species.

This paper presents nutritional information on some of the less-utilized tree species from the same climatic zone as *Leucaena*, that may have fodder potential. Standard forage analysis techniques are used to evaluate potential browse (3). Some of the results are presented from a survey of 22 tree and shrub species growing on man-made savanna in Guanacaste Province, Costa Rica. Most of the species sampled are deciduous, including *Gliricidia sepium*, but with irrigation can be made evergreen artificially during the dry season. Nutritional values for fruits or pods of some trees are also included, these often being as valuable as the foliage, especially if the species is deciduous (15).

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MATERIALS AND METHODS

Selection of the species for study was based on farmer recommendations and field observations of browsing range cattle at two sites. Sixteen frequently-browsed species were chosen for leaf sampling, with some preference given to leguminous trees. An additional six species that were extremely common but avoided by cattle were also included in the leaf sampling in an attempt to identify factors leading to their rejection. Three more species were chosen for evaluation only of their fruits; the leaves were not significantly browsed. The individual trees sampled were chosen at random according to standard plant ecology sampling methods (14) by placing line transects up hedgerows or selecting coordinates in forest quadrates on Hacienda La Pacífica, Cañas. Leaves were harvested according to how the cattle harvested them; some trees with very large leaflets and their petioles were avoided by the cattle. These petioles were placed in the twig category, contrary to their botanical classification.

Of the 22 species sampled for their leaves, eight were sampled three times, at the beginning, middle and end of the rainy season; and eight were sampled twice, at the beginning and end of the rainy season. Single samplings were taken of six additional species when observations indicated the importance of these in the diet of the free-ranging animal. Most of the single samples were collected half way through the rainy season.

Each seasonal sample of a species was a composite sample from ten trees. Twigs were cut at 1 cm diameter and all leaves were pulled off and placed in a plastic bag. The twigs were then cut up and placed in a second plastic bag. The two fractions were analyzed separately. This twig size was selected as the twigs can be chopped by a small stationary chopper without damaging the machine (3). The percentage of leaf was determined by establishing the leaf: twig ratio by weight.

The laboratory procedures performed on the samples were: Kjeldahl crude protein (CP) and *in vitro* true digestibility (IVTD) (7). The following equation was used to determine the final composite ranking:

$$\frac{\text{total mean IVTD\% - species IVTD\% +}}{\text{standard deviation}}$$

$$\frac{\text{total mean CP\% - species CP\% = ranking \#}}{\text{standard deviation}}$$

Total mean refers to the mean of all 22 species, and the standard deviation is of the total mean. The total means and standard deviations were calculated from different trees of the same species. Since samples of each period were pooled per species, values for each tree were not considered. Each pooling included different trees. This formula is crude but considered adequate in this instance as the species being evaluated are wild, and the aim is to simply indicate species worthy of further and more controlled research. A t-test was used to compare the 16 species with early- and late-rainy-season collection periods and check the validity of combined values obtained from different periods. The IVTD or CP of the species is the mean value for each individual for each individual species. Crude protein and IVDT are two different characteristics of feed and are measured by different methods. This formula allows the combining of two parameters that cannot be logically averaged by simply adding the values and dividing by two.

Sequential cell wall extractions were performed to obtain an approximate tannin fraction using a neutral-detergent followed by acid-detergent (NAD) on one sub-sample, and then on acid-detergent followed by neutral-detergent (AND) on a second sub-sample, as described by Horvath (9). This value was calculated as NAD minus AND but the number is used only to indicate a range of tannin levels. This procedure needs further verification.

Palatability was assessed by observing cattle selectivity; if the cattle browsed the especies frequently, it was considered palatable. It was identified as unpalatable if it was avoided or never seen to be browsed by the cattle. A qualitative ranking from zero to four was assigned each species.

RESULTS

The t-test showed IVTD not be significantly different ($p \geq 0.05$) from early to late rainy season. The first plant collection was made when the leaves were about one month old, while the late rainy season leaves were six to eight months old. In fact, nine of the species actually increased their digestibility with age, but most of the differences were within the two percentage units considered as an acceptable error for the methods used, so cannot be said to have significantly increased their digestibility. Crude protein, however, was significantly different ($p \geq 0.05$) with the average for the one-month-old leaves at 19.7 % and the six to eight- month-old leaves at 16.8 % CP, a very small but significant difference.

To test whether the "top eleven/bottom eleven" groupings were affected by this CP difference, the leaves were first ranked from most to least nutritious according to sampling period, and then by combining

all periods for one ranking. The same species fell into the same "top eleven/bottom eleven" groupings regardless of the ranking method used, and the results are thus given from the combined ranking instead of by individual sample period. It should be noted, however, that the orders of the species within the top group varied slightly depending on which ranking method was used. Nevertheless, since these are wild populations being evaluated, with the aim of prioritizing species most worthy of additional research, the combined rankings are adequate.

In vitro true digestibility is an estimate of total digestible nutrients (TDN). The mean value for IVTD for all species evaluated was 52.7 % (Table 1). It was decided that for a tree leaf to be considered as potential maintenance fodder it must have a digesbility greater than 50 % for sheep or 40 % for cattle (17).

Table 1. Average *in vitro* true digestibility (IVTD), crude protein (CP), and leaf percentages for the leaves of 22 tropical browse species, in Guanacaste, Costa Rica.

Chemical fraction	(%)	
	$\bar{X}$	S
IVTD	52.7	15.1
CP	18.3	4.5
proportion of sample that is leaf per 1 cm diameter twig:	57.5	12.5

For maintenance, CP must be above 7-8 %. Browse is frequently considered as a protein supplement because it is normally not high in total digestible nutrients. When ranking these species preference is therefore given to leaves with the highest CP values, that is, above the 18.3 % mean obtained for this group.

The species data are presented in Tables 2 and 3, starting with those showing the highest potential nutritional value, based on laboratory analysis. Some of the leaf samples were single, composite samplings, as were all of the fruit samples, and therefore have no standard deviation. Values for four species (*Acacia farnesiana, Spondias purpurea, Lonchocarpus minimiflorus*, and *Guazuma ulmifolia*) from a previous study (13) are included for comparison with the results of this study.

Two thirds of the species in the top ranking group (Table 2) are in the lowest tannin level category. Interestingly, while most of the apparently more nutritious species also rank high on the selectivity scale, three of them were never seen to be consumed, even though they were plentiful. The average percentage of leaf for the top ranking group is 59.1, while for the second group it is 55.5 (Table 3).

In Table 4, the fruit fraction consumed by cattle for *Acrocomia vinifera* is the hull and for *Crescentia alata* is the pulp. *Cassia grandis* was not observed as eaten by livestock, even though it is readily available.

DISCUSSION

The following seven species represent the group with the most practical potential as cultivated browse. The numbers refer to each species' ranking from Tables 2 and 3:

5. *Gliricidia sepium* (Jacq.) Steud., syn. *G. maculata*, family Leguminosae, subfamily Papilionoideae (or Fabaceae), common names: "madero negro" or "madre cacao". This species is currently being used in some tropical countries as cattle fodder. As it is highly palatable, it is also the subject of a fair amount of research (16). These results show that it has an IVTD above the cut-off point for both sheep and cattle and an above average crude protein. Its percentage leaf is the second highest of those species sampled here. It contains rotanone in the roots and variable levels of an alkaloid in the leaves (5) but these do not appear to bother livestock. The anti-coagulant dicoumerol is formed when the leaves are fermented. This chemical is used as a raticide but no information is available on the effect of fermented leaves on ruminants (6).

6. *Pithecellobium saman* (Jacq.) Benth., syn. *Samanea saman* (Jacq.) (Merrill) or *Pithecolobium saman*, family Leguminosae, sub-family Mimosoideae, common names: "genízaro", "cenízaro", or "raintree". It has an above average CP value but its IVTD is unacceptable for sheep, which may be due to the presence of alkaloids (12). Since the trees sampled for this project came from wild populations, they are likely to be highly variable genetically, so it may be possible to find individuals with higher levels of digestibility that could be used to breed more acceptable varieties of the species. The leaf is palatable and the tree produces a palatable and digestible fruit for cattle, which has an unconfirmed reputation in Guanacaste for abortion-producing properties. Venezuelan literature indicates it can be used as feed without problems (4).

7. *Tabebuia ochracea* (Cham.) Standl., syn. *T. neochrysantha* A. Gentry or *T. neochrysantha* (Jacq.)

Table 2. ***In vitro*** **true digestibility (IVTD), crude protein (CP), leaf percentages and tannin levels for the eleven higher-ranking species, in Guanacaste, Costa Rica.**

		IVTD (%)		CP (%)		Leaf (%)		Tannin	Selection rank
Rank	Species	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S		
1	*Acacia farnesiana*	65.1	0.3	25.5	0.9	n.a.		***	4
+	*Acacia farnesiana*	75.2		25.3					
2	*Caesalpinia eriostachys*	66.5		24.4		72.3		*	0
3	*Cassia bicapsularis*	71.4		21.0		61.7		*	0
	whole pods	47.8		9.0					
4	*Myrospermum frutescens*	79.8	3.7	19.1	2.4	54.9	8.8	*	0
5	*Gliricidia sepium*	60.9	10.3	20.7	1.0	73.7	3.0	**	4
6	*Pithecellobium saman*	47.3	1.5	23.8	0.3	67.0	9.3	*	4
	whole pods	72.2		16.2					
	pod without seeds	71.0		14.2					
	seeds	88.9		37.3					
7	*Tabebuia ochracea*	52.2	8.6	22.2	6.0	61.4	11.4	**	4
8	*Spondias purpurea*	68.8	1.6	16.5	0.5	71.5	7.5	*	4
+	*Spondias purpurea*	79.6		16.3					
	fruit pulp	95.6		3.2					
9	*Lysiloma divaricata*	67.0	4.8	16.8	2.4	43.0	7.5	*	3
10	*Cajanus cajan*	49.0		20.5		23.5		***	3
	whole pods	83.9		14.1					
11	*Enterolobium cyclocarpum*	39.7	4.5	22.8	7.9	62.0	1.6	***	3
	whole pods	79.0		16.2					
	pod without seeds	74.7		10.6					
	seeds	90.2		24.4					

n.a. = not available

* = NAD-AND < 10; ** = NAD-AND 10-15; *** = NAD-AND > 15

+ = McCammon-Feldman, 1980

Selection ranking: 0 = not selected, 1 = occasionally, 2 = frequently, 3 = very frequently, 4 = always selected when present.

Nichol, family Bignoniaceae, common name: "cortéz amarillo" or "corteza". It is the first non-legume to appear in this ranking; the IVTD level is acceptable and that for CP is high for a non-legume; it is fairly low in tannin content and is palatable. The leaves, however, are highly pubescent, causing some skin irritation in people collecting samples, but livestock appeared not to be affected.

Tannins are polyphenolic compounds frequently found in trees and chemically related to lignin. As with lignin, they have a depressing effect on digestibility (1, 2). Tannins, in particular, affect the availability of protein, but while the effect is considerable it is not consistent and much research remains to be undertaken on this relationship.

8. *Spondias purpurea* L., family Anacardiaceae, common names: "jocote" or "ciruela". It is the second non-legume in this ranking; it is also palatable to cattle, has a high IVTD value but slightly below average CP; and its percentage leaf is quite high. This species produces a fruit commonly consumed by humans as well as livestock. The Anacardiacea family includes mango, poison ivy, and poison oak. Some people have strong allergic reactions to certain or all members of this family but cattle seem to be unaffected.

9. *Lysiloma divaricata* (Jacq.), formerly *L. seemannii* Britt. & Rose, family Leguminosae, subfamily Mimosoideae, common name: "quebracho". This species is chemically similar to *Spondias* but its percentage leaf is below average; cattle browse it, but its poor leaf to stem ratio would require modification

Table 3. ***In vitro*** **true digestibility (IVTD), crude protein (CP), leaf percentages and tannin levels for the eleven lower-ranking species, in Guanacaste, Costa Rica.**

Rank	Species	IVTD (%) $\bar{X}$	S	CP (%) $\bar{X}$	S	Leaf (%) $\bar{X}$	S	Tannin	Selection rank
12	*Bauhinia ungulata*	48.2	4.5	19.5	3.8	50.1	7.4	**	3
13	*Cordia alliodora*	45 7	1.0	19.6	0.9	48.0	10.5	***	3
14	*Hemiangium excelsum*	66.8		12.5		n.a		***	2
15	*Piscidia carthagenensis*	43 0	3.2	19.5	2.0	68.1	5.6	*	3
16	*Lonchocarpus minimiflorus*	33 3	2.9	20.1	3.0	53.2	5.1	***	1
+	*Lonchocarpus minimiflorus*	60.1		18.4					
17	*Tamarindus indica*	50.9	0.8	14.6	1.2	45.8	1.3	***	2
	whole pods	59.0		5.9					
	pods without seeds	58.6		4.2					
	seeds	71.4		14.7					
18	*Ficus* sp	49.4	1.8	13.3	1.1	60.4	2.8	*	2
19	*Guazuma ulmifolia*	48.1	3.3	12.4	2.1	56.8	9.0	*	4
+	*Guazuma ulmifolia*			72.6		13.7			
	whole fruit	65.2		5.7					
20	*Mangifera indica*	58.0	3.2	8.6	0.6	73.9	2.3	**	3
	fruit pulp	95.4		1.8					
21	*Hymenaea courbaril*	33.4		13.6		46.1		**	0
	whole pods	44.5		3.7					
22	*Andira inermis*	14.8		15.5		52.8		**	1

n.a. = not available
* = NAD-AND < 10; ** = NAD-AND 10-15; *** = NAD-AND > 15
+ = McCammon-Feldman, 1980
Selection ranking: 0 = not selected, 1 = occasionally, 2 = frequently, 3 = very frequently, 4 = always selected when present.

Table 4. ***In vitro*** **true digestibility (IVTD) and crude protein (CP), fruits from three species sampled only for their fruits, in Guanacaste, Costa Rica.**

Species	IVTD (%)	CP (%)
Acrocomia vinifera		
whole fruit	44.7	4.0
nut without hull	17.5	4.1
hull	64.7	3.3
Cassia grandis		
whole pod	46.4	4.1
Crescentia alata		
whole fruit	60.6	5.8
pulp	89.0	12.2

through selection to create a more productive variety. "Quebracho" is a commercial name frequently used to indicate a number of tree species high in tannins, which are extracted and used in leather work. This particular species, however, has a below average tannin content.

10. *Cajanus cajan* (L.) Millsp., family Leguminosae, sub-family Papilionoideae, common names: "pigeon pea", "gandul" or "guandul". This a domesticated species included for reference purposes, and this particular variety does not rank well. It was being grown for fodder on the same ranch where the rest of the trees were found; its IVTD level is a little low for sheep; its CP is above average but its percentage leaf is the lowest of the species sampled; it is reasonably palatable; and its pod is quite digestible. In many countries the seeds are used for human consumption.

11. *Enterolobium cyclocarpum* (Jacq.) Griseb., family Leguminosae, sub-family Mimosoideae, common name: "guanacaste". This species is palatable to cattle but its IVTD value is a little below that required; its tannin level is above average, which probably explains the low IVTD; other secondary plant compounds may also influence digestibility. This species is renowned as a feed source due to its fruit crop, which is palatable to cattle, as well as being quite digestible.

The following four species are those that rank chemically as having the highest potential nutritional value, but they have other problems requiring additional research:

1. *Acacia farnesiana* (L.) Willd., family Leguminosae, sub-family Mimosoideae, common names: "aromo" or "espino blanco". The leaves of this species rank highest; it has the highest CP level and its IVTD is fairly high in spite of a high tannin level; it is however, a thorny, weedy shrub, which makes it unrecommendable for cultivation. This species is browsed by cattle and constitutes a feed resource on the range but should not be introduced as it is almost impossible to eradicate.

The next three species are interesting as they rank high chemically but are not browsed by cattle. The reason appears to be a strong odor, probably terpenes in the lipid fraction (Conklin, unpub. data). If this odor problem can be solved, these browses could have good potential.

2. *Caesalpinia eriostachys* Benth., family Leguminosae, sub-family Caesalpinioideae, common name: "saino". This is large shrub or treelet that commonly grows in natural monoculture.

3. *Cassia bicapsularis* L. (tentative identification) (syn. *C. indecora* H.B.K.) family Leguminosae, subfamily Caesalpinioideae, common name: "candelillo". This species' odor is similar to that of *Ceasalpinia*; its digestibility and CP are fairly high and it is also low in tannins; it produces a fruit that livestock consume but its nutritional value does not appear high.

4. *Myrospermum frutescens* Jacq., family Leguminosae, sub-family Papilionoidae (Fabaceae), common name: "arco". This plant has the highest IVTD levels and leaf percentage of any of the tested species. It has a similar odor to the previous two, but chemically it would appear to be a good fodder, if the cattle would eat it.

If the aroma of an essential oil is the problem with these three species, perhaps the leaves would be consumed dry. It was observed that the cattle were somewhat reluctant to eat fresh peanut plants, which have a very similar but more mild aroma, whereas dried peanut plants were consumed readily.

The remainder of the sampled species do no show as much promise as exploitable species (Table 3) but they should not be discarded. Most of them provide valuable fodder under range conditions and having a mix of trees available to the animals during the dry season is important. Some of the species that are not browsed but are evergreen, provide valuable shade. The numbers refer to each species ranking from Tables 2 and 3.

Trees that are acceptable for rangeland browsing are:

12. *Bauhinia ungulata* L., family Leguminosae, sub-family Caesalpinioideae, common names: "casco de venado" or "pata de cabra". This species is voluntarily browsed and palatable in spite of a very strong terpenoid smell, similar to that of pine trees.

14. *Hemiangium excelsum*, family Hippocrateaceae, common name: "guachero". It is the first evergreen shrub in this ranking and is non-leguminous; its digestibility is acceptable for sheep or cattle, in spite of its tannin level, being the highest of any species measured; cattle browsed this species during the dry season.

15. *Piscidia carthagenensis* Jacq., family Leguminosae, sub-family Papilionoideae (Fabaceae), common name: "pellejo de toro" or "siete cueros". It is palatable to cattle but may not be nutritious enough to justify further research.

19. *Guazuma ulmifolia* Lam., more correctly identified as *G. tomentosa* H.B.K., family Sterculiaceae, common name: "guácimo". It is a non-leguminous tree that is traditionally considered very palatable to cattle for the leaves and fruit, but both are of low nutritional value; although McCammon-Feldman (13), studying goats, obtained an IVTD 24.5 percentage units higher than those obtained in this study. Animals can increase the digestibility of a plant through selectivity.

Trees more suited for uses other than browse are:

13. *Cordia alliodora* (R. & P:) Cham. family Boraginaceae, common name: "laurel". It was browsed by the cattle but is probably more important as a lumber tree than for fodder.

17. *Tamarindus indica* L., family Leguminosae, sub-family Caesalpinioideae, common name: "tamarindo". It is commercially important for its fruit production for human consumption, though in India its leaves are used as fodder.

20. *Mangifera indica* L., family Anacardiaceae, common name: "mango". It is frequently planted for shade, being evergreen and its fruit is important for human consumption.

The following trees are evergreen and useful as shade:

18. *Ficus* sp., family Moraceae, common names: "higueron" or "chilemate". It is a non-leguminous, evergreen tree, and browsed by cattle.

21. *Hymenaea courbaril* L., family Leguminosae, sub-family Caesalpinioideae, common name: "guapinol". It is an evergreen legume with leaves that appear plastic. This species is not browsed by cattle. Its pod has a very thick husk, which makes it inaccessible to ruminants, though rodents can subsist on the inside pulp (10).

22. *Andira inermis*, (Swartz.) H.B.K., family Leguminosae, sub-family Papilionoideae (Fabaceae), common names: "carne asada" or "almendro de monte". This is another evergreen legume with low digestibility, which is probably due to an antimicrobial compound. The leaves are high in an alkaloid that makes humans and monkeys sick and which is fatal in large doses (5).

16. *Lonchocarpus minimiflorus* Donn-Smith, sometimes mistakenly referred to as *L. orotinus* Pittier, family Leguminosae, sub-family Papilionoideae (Fabaceae), common name: "chaperno negro", McCammon-Feldman (13) obtained an IVTD 26.8 percentage units higher than that obtained in this study. It is a extremely common, small, fast-growing, deciduous tree.

It is important to note that the values obtained by McCammon-Feldman (13) give CP values about equal to those obtained here but IVTD values 10.1 to 26.8 % higher. There are three possible reasons for this: 1) In the McCammon-Feldman study goat rumen fluid, on a browse diet, was used as the inoculum; whereas in this study the inoculum source was a Holstein cow fed a timothy grass diet; and some studies have shown that the inoculum source can affect the IVTD obtained (8). 2) The McCammon-Feldman study sampled the trees to mimic the selectivity of individual leaves used by the goats when browsing. The sampling undertaken in this study assumed the leaves would be fed in troughs and there would be less opportunity for selectivity. 3) The geographical location may have had some effect on the nutritional value of the tree leaves. The McCammon-Feldman study was undertaken in a slightly drier environment.

Of the following three trees, two produce a fruit of good nutritional value and could aid the nutritional status of livestock on the range.

Acrocomia vivifera Oerst., family Palmae, common name "coyol". Cattle ruminate only the hull or husk, spitting out or passing the nut, which is eaten by pigs. Results show that the cattle are consuming the more nutritious part of the fruit, though it is only an energy source, its CP level being too low even for maintenance.

Cassia grandis L.F., family Leguminosae, subfamily Caesalpinioideae, common name: "carao" or "sandal". It has been extensively planted as an ornamental in Guanacaste. The large pods are conspicuous but untouched by cattle, possibly because of the thick, woody pod.

Crescentia alata H.B.K. family Bignoniaceae, common name: "jícaro", or "calabash". In Costa Rica this pulp is not traditionally fed to cattle, though it is palatable to horses (11) and in Nicaragua it is cracked open and fed to cattle. Its nutritional value is quite good but it has a strong, fetid odor when ripe.

Fruit can be important on rangelands where mature trees are growing, and as part of different management systems that involve fodder tree leaves. Two possible management schemes are involved. One maintains secondary regrowth species at a height where cattle can directly browse the trees or small enough for the trees to be cut with a machete and chopped. The other system involves rangeland management where trees grow to maturity, and when the trees mature, the fruit crop becomes more important than the leaf crop.

The standard deviations given in the tables are from samples, thus reflecting differences among sampling periods, in this case mostly seasonal and age differences, rather than differences among individual trees. Individual variation among trees of the same species is much greater (5,3), therefore the genetic variability needed to select and develop more nutritious varieties from a given wild species is present.

One aspect that may have affected the ranking is that of tree age, rather that season or sampling period. The *Caesalpinia, Myrospermum*, and *Lonchocarpus* are invader species and frequently the first individual encountered near the randomly-selected point was a sapling. *Enterolobium* and *Pithecellobium* were mostly mature trees, because the seedlings and saplings are so palatable they could not escape destruction by the cattle. *Gliricidia* was a 50:50 mix of adults and saplings because it was protected from the cattle. Including the percentage leaf in the ranking formula may also have changed the order. Additional factors involved in fodder tree choices are evergreen habit, tolerance to defoliation, sprouting capacity and biomass production. We recommend that all of the species in the high ranking group receive further study as well as a few from the lower group, such as *Bauhinia ungulata, Guazuma tomentosa, Tamarindus indica*, and *Piscidia carthagenensis*. Farmers interviewed also recommended additional species that could not be included in this study.

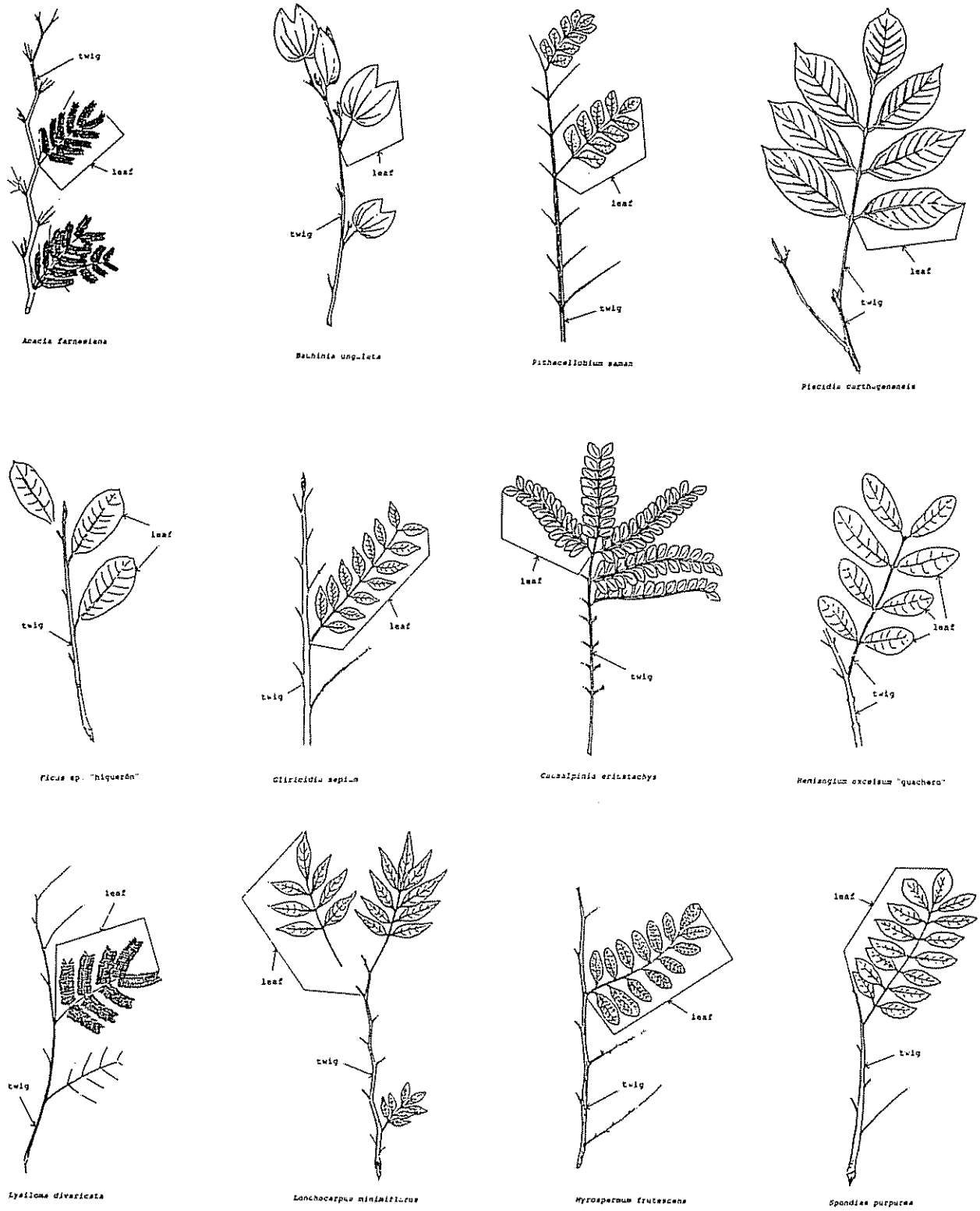

Fig 1. Twenty-two species of tropical trees and shrubs.

Nota: Drawings of the tree and shrub species sampled.
Drawings are not to scale. Some of the leaves are drawn five to ten times larger than the natural size. The designations of "twig" and "leaf" are not necessarily botanically correct, but indicate how the species were analyzed in this study and the cows' treatment of them when browsing. Some of the species have leaflets that are so large they are consumed one at a time, whereas some of the pètioles are so woody, they are treated as twig. In the case of other species, the whole compound leaf is small enough for consumption in a single bite.


leaf
twig
Andira inermis
Cassia biscapsularis
Tamarindus indica
Tabebuia ochracea
Cordia alliodora
Enterolobium cyclocarpum
Hymenaea courbaril
Guazuma ulmifolia
Mangifera indica
Cajanus cajan

Fig. 1. (Cont.)

The values for the leaves are presented here, but in some cases value for twigs should also be considered in making practical management decisions. Twigs with their respective leaves can be chopped and fed to cattle in troughs, but to provide balanced rations it would be necessary to know how much the inclusion of twigs dilutes the nutritional value of the leaves.

This type of species survey gives initial screening information, but so few feeding trials have been carried out on different browses that it is still difficult to interpret chemical data. Recent studies in Ethiopia indicate that there are great species differences among browses regarding types of tannins present and the extent to which they reduce protein digestibility (19). Future research must focus on feeding trials and tannin chemistry of individual browse species. Once digestibility problems are better understood, superior varieties of browse can be selected.

CONCLUSIONS

A formal hypothesis was not offered at the beginning of this study because of its survey format. However, if one were to be suggested, it would be to test whether or not any of the trees and shrubs native to Guanacaste, Costa Rica could be used as cattle fodder. *Gliricidia* is being used in many tropical countries for that purpose. The results of this study indicate that several other species have browse or fodder potential.

Three high ranking species: *Caesalpinia eriostachys*, *Cassia bicapsularis*, and *Myrospermum frutescens* need further chemical tests to determine the basis for their rejection by cattle.

Within the group of seven species with the most potential as fodder trees, *Pithecellobium saman*, *Tabebuia ochracea*, *Spondias purpurea*, *Lysiloma divaricata*, and *Enterolobium cyclocarpum* merit immediate attention in experimental plantings to quantify productivity and for livestock feeding trials.

The remainder of the species evaluated in this survey provide valuable protein and/or shade on the range, even though they did not rank so highly. A range animal needs all of the resources possible at its disposal, especially during the dry season. Forested areas along permanent waterways can supplement the diet with additional protein from trees and shrubs.

The fruits and pods of several of the trees native to Guanacaste would be interesting to investigate. Very little is know about fruit production levels from these wild tree populations.

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