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Nutritional quality of Piptocoma discolor and Cratylia argentea as a non-timber forest products for animal feed in the Caquetá province

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Abstract

The present work determined the nutritional quality of Piptocoma discolor and Cratylia argentea as non-timber forest products used in animal feed in the Amazonian foothills in Caquetá province - Colombia, where the grasses B. decumbens and B. humidicola predominate in the pastures.A random selection of 50 farms was made, identifying that in each of them the shrub species Piptocoma discolor, Cratylia argentea and areas of grasslands for grazing where Brachiarias decumbens and B. humidicola predominate. One sample per species was taken from each farm. The samples were subjected to chemical analysis (CP, ADF, NDF, ADL, cellulose, hemicellulose, EE, ash and IVDDM, OMD, TDN, DE, ME). An analysis of variance was performed for each of the variables evaluated using a linear mixed model, considering the species factor as a fixed effect and municipality was considered a random effect. The model assumptions were evaluated by graphical inspection of residual. A multivariate synthesis to see the interrelation between variables and species was performed using a biplot graphic obtained by principal component analysis. C. argentea and P. discolor presented higher CP levels than the grasses in the pastures (17.7; 13.1; and 6.15%, respectively) with good levels of energy intake, confirming that C. argentea and P. discolor are non-timber forest resources with forage potential.

*Key Words**:** Bromatological composition, forage shrubs, forage woody plants.*

Introduction

Cattle ranching is one of the main economic activities in the Amazon region, where feeding models based on grazing are commonly found, as the area covered by cultivated pastures exceeds 90 million hectares (Silva et al., 2017), with pastures being the main land use after forest in the Amazon biome. The introduction of grasses such as *Andropogon gayanus*, *Brachiaria decumbens*, *Panicum maximum*, *Pennisetum clandestinum* and *Hyparrhenia rufa* are the common denominator and are less frequently associated with legumes such as *Desmodium ovalifolium*, *Leucaena leucocephala*, *Arachis pintoi* and *Centrosema macrocarpum* (Neto et al., 2012; Townsend et al., 2010).

La *Cratylia argentea* is a forage shrub used as a feed alternative in livestock production systems in the tropics (Herrera & Arguedas, 2016), due to its ability to establish on low-fertility acid soils, rapid regrowth, easy propagation and drought resistance (Hess et al., 2006). *Piptocoma discolor* is a native American species that predominates in secondary forest (González et al., 2018), is characterised by being consumed by cattle in paddocks (Guayara, 2010) and by having rapid growth despite being in degraded soils (Hurtado & Suárez, 2013).

The main feed source in livestock production systems are cultivated pastures, mainly of the genus *Brachiaria decumbens*, reporting the presence of up to nine species of this genus (Londoño et al., 2022), which are mainly characterized by having low biomass and low nutritional quality, because of the interaction with low fertility soils (do Nascimento et al., 2018).

Nutritional problems resulting from the dependence on grazing systems are one of the main causes of economic losses for producers (Edson et al., 2018), since these depend on climate incidences, given that in the Amazon the critical seasons can extend up to 6 months. This generates a decrease in forage supply and quality, given that the grasses implemented are characterized by low protein content, low digestibility percentage and high fiber content (Reyes et al., 2006). In addition, the nutritional stress generated due to the energy and protein deficit provided by pastures (Madzimure et al., 2011; Mwendia et al., 2018), forces the animal to mobilize its body reserves for milk synthesis (Reyes et al., 2006), generating a decrease in productive and reproductive parameters, limiting the productive potential of livestock systems (Mwendia et al., 2018).

To mitigate the adverse effects of nutritional deficiencies in forage species implemented in the Amazon region, the paradigm of implementing new promising species in livestock systems has been proposed. The main strategy that has been proposed is supplementation with native species to the region that provide a higher percentage of nutrients to cattle to improve their productive and reproductive performance (Riascos et al., 2020). For this reason, the incorporation of native trees and shrubs with high forage nutritional quality (Jose & Dollinger, 2019) is fundamental for the productive rehabilitation of livestock systems (Murgueitio et al., 2011). However, tree species have a highly variable nutritional quality, therefore, the use of perennial woody species in bovine nutrition for the improvement of production parameters in bovine systems requires the determination of the forage quality of forest resources available in each region and considering the need to use alternative sources for animal feeding in the conditions of the humid tropics (Riascos et al., 2020).

The objective of this study is to determine the nutritional quality of *P. discolor* and *C. argentea* as non-timber forest products for animal feed in the Amazon region where *Brachiaria* sp. grasses predominate in the pastures.

Materials and methods

Study areas

The study was carried out in farms located in the municipalities of San Vicente del Caguán, Puerto Rico, El Doncello, Cartagena del Chaira, and Albania, in the Amazonian foothills in the Caquetá province (Figure 1). The climate and life zones defined by Holdridge, (1987) and characteristics that grant climate type A: Tropical (Tropical Rainforest Climate – Equatorial Climate - Af) in the climatic classification according to Köppen in Colombia (IDEAM, 2017) (Figure 1). Likewise, the diversity of landscapes (Mountain, Knoll and Lowland) also allows for different types of soils corresponding to Entisols, Inceptisols, Ultisols and Oxisols, which are characterized for low fertility with high aluminum and iron saturation (IGAC, 2014).

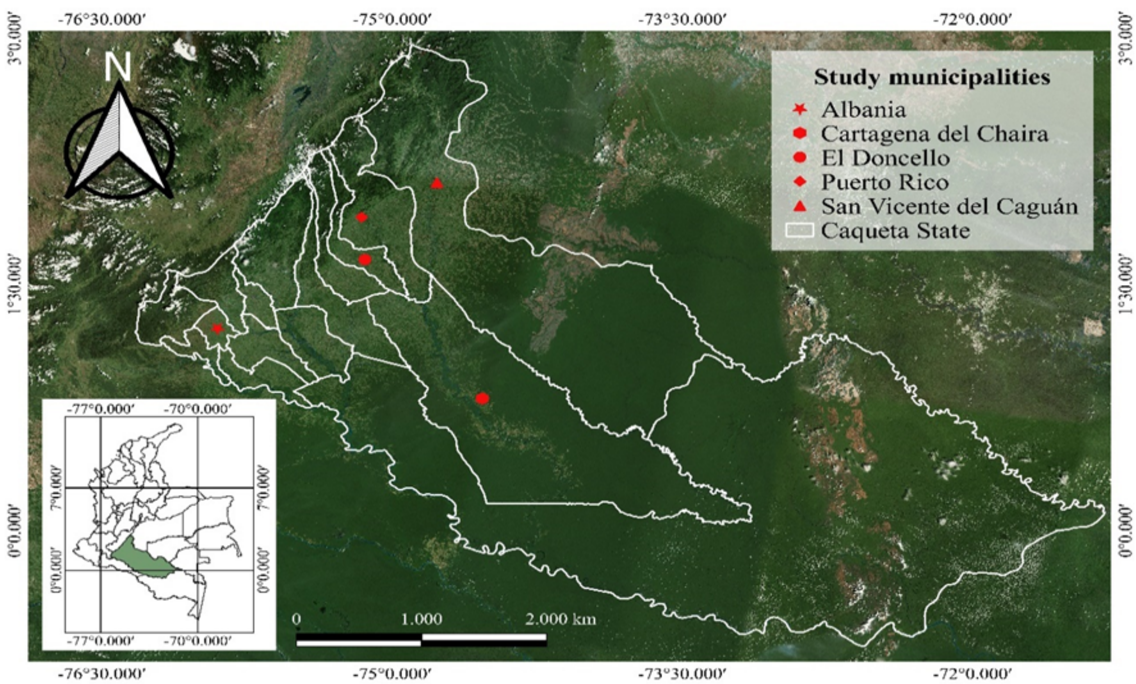

Figure 1. Municipalities involved in the project – ARAINMBA – In Caquetá province

Samples

A random selection of 50 farms was made, identifying that in each of them the shrub species *P. discolor* and *C. argentea* were present in areas of grasslands for cattle grazing. One sample per specie was taken from each farm.

Taking into account the regrowth time for forage shrubs (Lascano et al., 2002) and for grasses (Pérez et al., 2022), samples were taken 42 days after regrowth. In the shrubs, leaves and green stems were taken, and in the grasses, the heart of the plant was cut by hand, simulating the grazing of the cows, performing this process by zigzagging through the grassland padock. An approximate 5 kg sample of each forage was taken in the field, and after homogenizing a 1 kg subsample was taken to the laboratory. The samples were collected during the months of December to March, which corresponds to the dry season or the season of less rainfall.

Drying, milling and chemical analysis

The dry matter (DM) of the samples was obtained by A.O.A.C, (2010) methodology. Subsequently, the dried samples were ground on a 1.00 mm sieve. The crude protein (CP) content was determined by the Kjeldahl method (A.O.A.C, 2010; Licitra et al., 1996). Acid detergent fiber (ADF), neutral detergent fiber (NDF) and lignin (A.O.A.C, 2010; P J Van Soest et al., 1991), ethereal extract (EE) and ash (A.O.A.C, 2010), in vitro DM degradability (IVDDM) (Theodorou et al., 1994).

Estimates of nutritional values were made using equations:

Hemicellulose (NDF - ADF) and cellulose (ADF - ADL) estimates were made by difference (Vargas, 2008).

Organic Matter Digestibility (OMD %) = 1,017 × DDM + 1,9

Total Digestible Nutrients (TDN %) = OMD % + (2,25 × digestible ethereal extract DEE %) (Maynard, 1993).

Digestible Energy (DE) (Mcal/kg DM) = 0,04409 × TDN (%).

Metabolizable Energy (ME) = 3,61 × IVDDM (%) (Di Marco, 2011).

Data analysis

An analysis of variance was performed for each of the variables evaluated using a linear mixed model (Di Rienzo et al., 2011), considering the species factor as a fixed effect and municipality and farm effects were considered a random (Casanoves et al., 2005, 2007). Because of the majority of the farms have the two species, farm effect was also considered as random effect nested in municipality effect. The assumptions were evaluated using graphical inspection of residual. A multivariate synthesis to see the interrelation between variables and species was performed using a biplot graphic obtained by principal component analysis. The analysis of variance and principal components was performed using the statistical program InfoStat version 2020 (Di Rienzo et al., 2020).

Results and discussion

The evaluation of the bromatological properties of the non-timber forest products *P. discolor* and the forage woody *C. argentea* and *Braquiaria* sp. grass showed significant differences ($p<0.0001$) in crude protein (CP) levels (Table 1). The one with the highest CP values was *C. argentea* (17.67%), followed by *P. discolor* (13.12%) and *Brachiaria* sp. (6.15%). Durango et al., (2021) also found that *C. argentea* has the greatest potential as a feed resource in livestock production systems that base their feeding systems on pastures that provide a low protein content in their composition. The difference in CP contents in forage woody plants may be attributed to factors such as the maturity stage of the plants or the soil characteristics of the sampling sites; however, more evidence is needed to corroborate this. The CP levels reported in this study for *C. argentea* were lower than those reported by Suárez et al., (2008), which ranged from 17.82% to 18.24%. On the other hand, the values obtained for *P. discolor* are lower than those reported for other perennial woody forages such as *Leucaena leucocephala* and *Gliricidia sepium* (Agbede & Aletor, 2004), *Erythrina poeppigiana* (Jiménez et al., 2015), *Calliandra calothyrsus* y *Morus alba* (Kabi & Bareeba, 2008), but the important thing about the contents of PC in *P. discolor* is that this native shrub presents higher values than those found in the grasses that are traditionally used in the region.

Previously, crude fiber was considered an adverse compound of nutritional quality (Harun et al., 2017; Tucak et al., 2021), as it was related to low digestibility. However, the evaluation of detergent fibers with the methodology of Van Soest, (1994), allowed them to be fractionated into neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Mertens, 2000). In the case of ruminants, NDF is directly related to forage digestibility, especially the fraction that encourages rumination and intake capacity, so NDF is the most reliable method to establish the cellulose and hemicellulose content in the cell wall of forages (Harper & McNeill, 2015). The highest NDF values were for *C. argentea* (61.10%), followed by grasses (48.95%) and *P. discolor* (48.94%) which obtained similar results (Table 1). This suggests that *C. argentea* is related to a higher intake and efficiency of DM digestibility in ruminants, in addition to evidencing a tendency for perennial woody plants to present higher CP levels as NDF levels increase. On the other hand, the contents of NDF are directly related to the levels of lignin, which comprise the indigestible fraction of the cell wall of forages, since ruminal microorganisms are capable of efficiently digesting cellulose and hemicellulose. However, cellulose digestibility is inversely related to lignin content, as forages mature, their lignification increases, which reduces cellulose digestibility by approximately 60%, while the lignin content in younger forages is 5% increasing cellulosic digestibility by up to 80% (McDonald, 2002). Since the lignin levels found for *C. argentea* (13.67%) and *P. discolor* (7.13%) do not exceed 15%, they are considered as good quality forages; similarly, the levels of cellulose and hemicellulose for *C. argentea* (29.05%, 18.47%) and *P. discolor* (21.85%, 19.91%) are indicative of quality, since the contents of these compounds are directly related to the biosynthesis of volatile fatty acids (VFA).

The evaluation showed that the levels of ethereal extract (EE) are within acceptable ranges for inclusion in ruminant diets, where *P. discolor* (4.01%) presented the highest values, followed by *C. argentea* (2.98%) and grasses (1.15%) (Table 1). Previous studies show that the results obtained for *P. discolor* were higher than those reported for the same species (3.94%) by Riascos et al., (2020), while *C. argentea* obtained higher values than *Trichanthera gigantea* (2.5%) Sarwatt et al., (2003). The higher EE contents in *P. discolor* are due to its lower fiber content Díaz et al., (2003). The amounts of EE found in forages meet the lipid requirements of ruminants, since the inclusion of high concentrations of fat in the diet can suppress rumen microbial activity and decrease fiber digestion and DM intake in ruminants (Faichney et al., 2002).

The determination of the amount of total ash (ASH) is fundamental in the characterization of feeds, as they contain different types and amounts of micro, macro and trace minerals that are indispensable for animal homeostasis (Harun et al., 2017). Knowing the amount of minerals contained in forages is of vital importance for selecting appropriate raw materials in animal diets and whether mineral supplementation is necessary to meet animal requirements. The supply of high amounts of minerals in the diet can affect digestibility and health conditions such as infections or urinary restrictions due to mineral accumulation and crystallization. In the current study, mean ASH and organic matter (OM) contents were found to be within satisfactory limits (Table 1). The ASH results for *C. argentea* (8.30%) and *P. discolor* (7.60%) are lower than those reported in previous studies by Celis et al., (2004) and Riascos et al., (2020) respectively. The variation in the results may be influenced by characteristics such as habitat and soil conditions where sampling was conducted (Hussain & Durrani, 2009).

As mentioned above, different nutritional parameters can indicate the potential nutritional quality values of a feed, however, the actual feeding value for ruminants can be determined by finding the digestibility ratio of those nutrients. Kallah et al., (2000) and Megersa et al., (2017) suggested that the average digestibility of 45% for forages is sufficient to maintain optimal animal performance, while Van Soest & Robertson, (1985) findings report that digestibility of forages in tropical and subtropical zones range from 40 to 70%. Nogueira et al., (2000) establishes a range of 40 to 52.7% digestibility for grasses, and the values obtained for *C. argentea* (56.07%), *P. discolor* (55.57%) and grasses (68.06%) are within the ranges reported in previous studies (Table 1).

The PCA analysis allowed visualizing the main associations between forage species and the different variables. The C. argentea species presented the highest contents of CP, Lignin and ASH, while *P. discolor* showed a direct relationship with EE; on the other hand, grasses are related to high values of DE, TDN, OMD, ME and IVVDM, and to a lesser extent with FDN, FDA and Cellulose, which are components of the cell wall. Tropical grasses, especially those that predominate in the Amazonian piedmont, are characterized by being fibrous foods that provide high energy and low protein (Riascos et al., 2020) (Figure 2).

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Table 1. Chemical characteristics of Cratilya argentea, Pictocoma discolor and predominant grasses in the pastures of five municipalities of the Caquetá province

Variables	Species												P-value
	Cratilya argentea (%)				*Piptocoma discolor* (%)				*Grasses (%)*				
	Media		S.E.		Media		S.E.		Media		S.E.		
C.P.	17.67	±	0.32	a	13.12	±	0.33	b	6.15	±	0.26	c	<0.0001
N. D. F.	61.10	±	0.46	a	48.94	±	0.46	b	48.95	±	0.47	c	<0.0001
A. D. F.	42.50	±	1.01	a	28.75	±	1.02	b	42,87	±	0.93	a	<0.0001
Lignin	13.67	±	0.41	a	7.13	±	0.41	b	5.49	±	0.37	c	<0.0001
Hemicellulose	18,47	±	1.10	b	19.91	±	1.11	a	23.90	±	1.10	a	0.0001
Celullose	29.05	±	1.12	a	21.85	±	1.13	b	37.39	±	1.12	a	<0.0001
E.E.	2.98	±	0.21	b	4.01	±	0.22	a	1.15	±	0.05	c	<0.0001
Ash	8.30	±	0.37	a	7.60	±	0.38	b	8.22	±	0.47	a	0.0190
IVDDM	56.07	±	1.58	b	55.57	±	1.58	b	68.06	±	2.85	a	0.0003
TDN	54.79	±	1.73	a	53.11	±	0.75	a	59.04	±	2.41	a	0.0580
OMD	60.24	±	1.70	b	58.43	±	0.85	b	71.12	±	2.90	a	0.0003
DE	2415.57	±	76.33	a	2341.44	±	32.84	a	2602.63	±	106.52	a	0.0585
ME	2070.66	±	60.53	b	2006.16	±	30.25	b	2456.98	±	102.92	a	0.0003

S.E.= standard error, CP= Crude protein, DM= Dry matter, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, EE= Ethereal extract, IVDDM= In vitro digestibility of dry matter, TDN= Total digestible nutrients, OMD= Organic matter digestibility, DE= Digestible energy Kcal/kg of dry matter, ME= Metabolizable energy Kcal/kg of dry matter. Means with a common letter are not different (p>0.05).

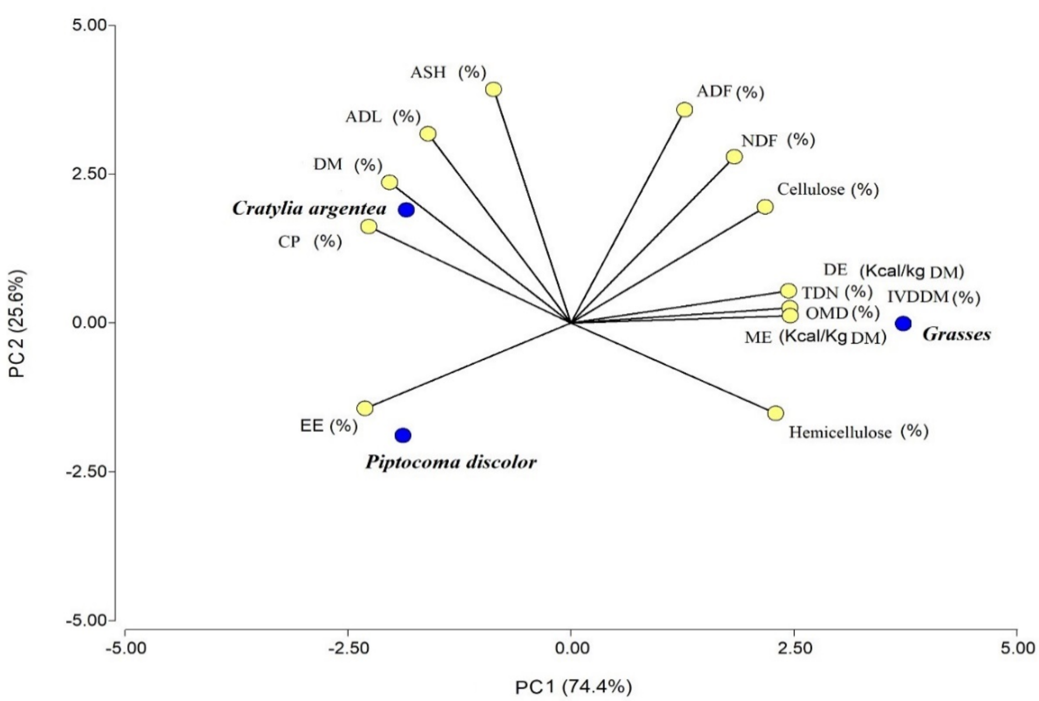

Figure 2. Association of the variables evaluated with the species C. argentea, P. discolor and grasses predominant in the pastures in five municipalities of Caquetá province.

CP= Crude protein, DM= Dry matter, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, ADL= Acid detergent lignin, EE= Ethereal extract, IVDDM= In vitro digestibility of dry matter, TDN= Total digestible nutrients, OMD= Organic matter digestibility, DE= Digestible energy Kcal/kg of dry matter, ME= Metabolizable energy Kcal/kg of dry matter

Conclusions

Taking into account the estimates of IVDDM, TDN, OMD, DE and ME of the grasses of the Amazon region, where *B. decumbens* and *B. humidicola* predominate, it is found that they are a great source of energy, superior to what is offered by the leaves and green stems of *C. argentea and P. discolor*. Because of the low contents of CP of grasses, the supplementation whit *C. argentea* or *P. discolor* have the potential to improve cattle nutrition. *Mainly P. discolor* because it is a native forage resource readily available in the region, which can be used by producers to implement it in productions as silvopastoril models of free browsing or protein banks.

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