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Woody species associated with coffee production systems in southern Colombia

Especies leñosas asociadas a los sistemas productivos de café en el sur de Colombia

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ARTICLE DATA

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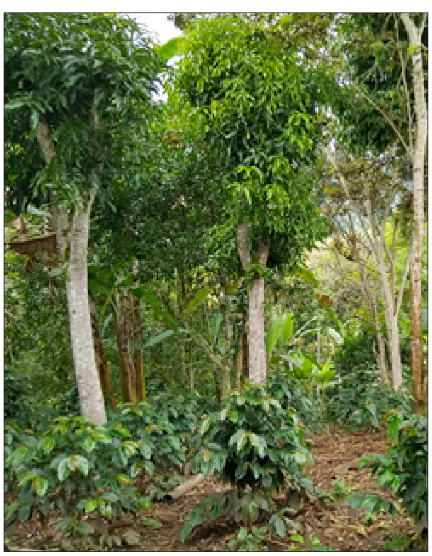

ABSTRACT

In the coffee zone of the town La Unión- Nariño, native or introduced trees are associated with the productive systems of the farms, mainly because they provide shade for coffee crops, where particular aspects such as species biodiversity and silvicultural management are unknown. With the aim of knowing the woody species of common use and the cultural importance, a semi structured survey was applied to 100 coffee growers who were selected at random and aleatorily distributed in three altitudinal ranges: (m a.s.l.): I (<1500), II (1500-1800) and III (> 1800). Species richness was determined for each chosen range; for diversity between ranges, the Jaccard Index (JI) and the Cultural Importance Index (CI) were used. The latter was determined by adding up the intensity of use (IU), frequency of citation (FC), and use value (UV). In the three altitude ranges evaluated, 59 tree species were found. These were distributed in 32 botanical families and 46 genera. The fabaceae family was the most representative, followed by rutaceae, myrtaceae and bignoniaceae; 45.8% of the species were introduced. Among the altitudinal ranges, a low degree similarity was found; ranks I and II shared 24 species, which is equivalent to 33.8% of their floristic composition. As for ranges I and III, they had an even lower degree of similarity: 24.2%; only 17 species were shared. The species *I. densiflora* had the highest percentage of CI, with 32.92%, followed by *C. sinensis* with 31.98%; then the species *T. gigantea* and *P. americana* with 30.49% and 26.27% respectively. These species were of great importance to coffee growers due to the positive impact they have on the family economy and their contribution to the environmental well-being of production systems.

Keywords: tree; biodiversity; wealth; similarity; somber.

RESUMEN

En la zona cafetera del municipio de La Unión Nariño, los árboles nativos o introducidos, se asocian a los sistemas productivos de las fincas, especialmente como sombra del cultivo del café, en donde se desconoce aspectos particulares como la biodiversidad de especies y manejo silvicultural. Con el objetivo de conocer las especies leñosas de uso común y la importancia cultural, se aplicó una encuesta semiestructurada a 100 productores seleccionados aleatoriamente y distribuidas proporcionalmente en tres rangos altitudinales: I (<1500 msnm), II (1500-1800 msnm) y III (> 1800 msnm). Se determinó la riqueza de especies a nivel de rango, para la diversidad entre rangos, se utilizó el Índice de Jaccard (IJ) y el Índice de importancia cultural (IC), el cual se determinó mediante la sumatoria de la intensidad de uso (IU), frecuencia de mención (FM) y valor de uso (VU). En los tres rangos altitudinales evaluados, se encontraron 59 especies arbóreas, distribuidas en 32 familias botánicas y 46 géneros, la familia fabaceae fue la más representativa, seguida por rutaceae, myrtaceae y bignoniaceae; el 45,8% de las especies son introducidas. Entre los rangos altitudinales existe baja similitud, donde los rangos I y II, comparten 24 especies, equivalente al 33,8% de su composición florística; los rangos I y III, presentan una menor similitud con un 24,2%, comparten 17 especies. La especie *I. densiflora* presentó el mayor valor en porcentaje del ICC, con un 3,92%, seguida por *C. sinensis* con 31.98%; a continuación, las especies *T. gigantea*, y *P. americana* con 30,49% y 26,27% respectivamente. Las especies identificadas son de gran importancia para los productores, puesto que genera impactos positivos en la economía familiar, y contribuyen al bienestar ambiental de los sistemas productivos.

Palabras clave: árbol; biodiversidad; riqueza; similitud; sombrío.

INTRODUCTION

Colombia is the first soft coffee producer in the world with *Coffea arabica* L., which has different varieties: Typica, Bourbon, Caturra, Maragogipe, Colombia, Cenicafé 1 and Castillo. By 2020, the area used for coffee production was 844.000 ha, and the department of Nariño contributed with 35.760; this represents 4.24% of the national total. According to the National Federation of Coffee Growers of Colombia (FNC for its initials in Spanish) (FNC, 2020; FNC, 2014) and Red de información y comunicación del sector Agropecuario Colombiano (MADR, 2017), about 4 million Colombians depend financially on this crop. The largest coffee growing areas are located in northern municipalities; one of them is La Unión, where one of the best quality coffees is produced. This coffee is highly appreciated internationally due to its denomination of origin (Martínez, 2004; Oberthür *et al*., 2011).

There exists a great number of woody species which can be used to provide direct shade to coffee or as part of the shrubbery in farms. These species, despite their potential, have been deemed to be endangered or at risk of extinction in our country (Farfán, 2012). In Nariño, in most farms, woody species are of primary importance in the structure and function of coffee productive systems. These species are associated with coffee growing, border setting up, living fences, scattered trees, alley cropping, and windbreakers; fruit species are prioritized for self-consumption or for sale, as the fruit may be used for multiple purposes (Ordoñez, 2014; Farfán and Mestre, 2013).

The area selected for this study stands out for its diversity in terms of flora, which is of vital importance for shade-grown coffee and other productive systems under different agroforestry arrangements. Most woody species are native to the region or geographical areas with similar features. The ones that are most commonly used as shade vegetation are Inga and fruit trees such as orange trees *Citrus sinensis* and lemon trees *Citrus limon*. In this sense, coffee growers tend to select native vegetation due to financial, environmental, and usability reasons (Garen *et al*., 2009; Muñoz and Villota 2014; Escobar *et al*., 2016).

Determining the cultural importance of woody species in coffee systems is a priority; as Turner (1988) states, it is necessary to establish the importance value of species unbiasedly. We need to assess their cultural importance based on a score obtained from the addition of the factors that contribute to their importance; the value of tree species is obtained by using the importance value index or use value (Da Silva *et al*., 2006).

This study assessed floral diversity and cultural importance of tree species in coffee systems established in La Unión (Nariño). To meet this purpose, it was necessary to analyze the perceptions and knowledge of local coffee growers regarding the importance of trees in their farms. The data collected provides information that comprises the uses and preservation of woody species as a strategy for sustainable development.

MATERIALS AND METHODS

The study was conducted in the municipality of La Unión, department of Nariño, located at an altitude between 900 and 2200 m a.s.l. The average temperature is 19ºC; annual precipitation is 2116mm; average sunlight 4,9 hours/day. La Unión is located at 1º36' and 06'' North latitude and 77º00' and 15'' West longitude (Alcaldía municipal La Unión, 2012). In this municipality, shallow volcanic soil prevails. This type of soil has a low content of organic matter and medium natural fertility, and it is highly prone to erosion (Gómez *et al*., 1991).

In order to identify the most commonly used woody species, which have cultural importance in coffee production systems, it was necessary to select the farms that would be part of the study. To do so, the information provided by Comité de Cafeteros de Nariño - La Unión (2018) was used. This committee reports 6187 coffee farms, which cover an area of 5087 ha. The sample population is made up of coffee farms that are located in three altitudinal ranges: <1.500, 1.500-1.800 and >1.800 m a.s.l.

In this research, a simple random sampling was used, taking coffee farms as population and each coffee farm as sampling unit. At the same time, each sampling unit was taken as an analysis unit, assuming a margin of error at 10%, and a 95% confidence. To establish the sample size and considering that the study deals with a finite population, Murray and Larry's (2005) formula was used.

$$n = \frac{Z^2_{\alpha} .N .p .q}{i^2 (N-1) + Z^2_{\alpha} . p .q}$$

where:

n: simple size

N: population size

z: value corresponding to gauss distribution, zα= 0.05 =1.96

p: expected prevalence, q: 1 – p (if p = 70%, q = 30%)

i: margin of error 10%, i = 0.1

It was also necessary to collect secondary data related to Plan de Ordenamiento Territorial (POT for its initials in Spanish), a land-use plan; a survey administered to coffee growers; and studies conducted in the area by public and private institutions related to the coffee sector.

To collect primary information, a semi-structured interview was designed. The questions included some related to the woody species that prevail in the area, emphasizing their local name, uses, and importance in a farm.

These are telltale indicators of the possible management strategies coffee growers employ. The survey was administered to 1000 coffee growers who were randomly selected. This instrument was proportionally applied in the three altitudinal ranges.

The information gathered through the surveys was analyzed to later create a database; useless or redundant information was eliminated. The databases of the herbarium of Universidad de Nariño, the online herbarium of Tropicos (2021), and that of the Universidad Nacional de Colombia (2020) were used to identify the woody species present in coffee farms.

The number of species was established to have a clear idea of the richness of species in each altitudinal range. Additionally, the Jaccard Index (JI), which measures similarities across ecosystems, was used to determine the degree of diversity across altitudinal ranges (Finol, 1971).

$$JI = j / a + b - j$$

Where: (a): number of species present in ecosystem A; (b): number of species present in ecosystem B; (j) number of species shared by the communities.

The Cultural Importance Index (CI) was calculated by adding up the intensity of use (IU), the frequency of citation (FC), and use value (UV) (Sánchez et al., 2017). The equations used were as follows:

$$IU = \frac{\text{Number of uses of Sp. x}}{\text{Overall number of uses for all species}} * 100$$

$$FC = \frac{\text{Number of citations of sp. x for all the uses}}{\text{Overall number of citations of all the species for all the uses}} * 100$$

$$UV = \frac{\text{Number of citations of sp. x for one use}}{\text{Overall number of citations of all the species for one use}} * 100$$

$$UVt = \sum(UVx + UVy + UVz + \cdots \dots UVn)$$

$$CI = \frac{(IUz + FCz + UVtz)}{300}$$

Where: Intensity of use (IU): percentage of uses in which one species appears; frequency of citation (FC): sum of citations of one species, all the uses, and all the informants; use value (UV): percentage of uses in which a species appears for a given use according to the categorical classification of use.

In determining the cultural importance index, the following categories of use were found: Wood, firewood, charcoal, poles, protective reforestation, erosion control, soil protection, ornamental uses , fruit, green manure, rituals, medicine, domestic animal and wildlife food, living fence, silvopasture, animal protein (Pp), association with crops, food, handicrafts, sawmilling, coloring, construction, housing construction, treatment and prevention of psychotropic diseases, toxins, and others including species with specific uses.
The primary information and that obtained through surveys was processed using Microsoft Excel 2010.

RESULTS AND DISCUSSION

Fifty-nine tree species of common use that interact with coffee crops were found in the three altitudinal ranges chosen for this study. These species were distributed into 32 plan families and 46 genera (Table 1). The fabaceae family was the one that stood out the most with 11 species. This was followed by rutaceae with 7, then by myrtaceae and bignoniaceae with 4 species each, and lauraceae with 3 species (Table 1).

Table 1. Species identified in three altitudinal ranges in the municipality of La Unión - Nariño.

Common name	Scientific name	Family
Acacia negra	*Acacia melanoxylon* R. Br.	Fabaceae
Achiote	*Bixa orellana*; L	Bixaceae
Aguacate	*Persea americana*; Mill	Lauraceae
Aguacatillo	*Persea caerulea*; (Ruiz & Pav.) Mez	Lauraceae
Arrayan	*Myrcianthes rhopaloides* (Kunth) McVaugh	Myrtaceae
Balso	*Ochroma pyramidale*; (Cav. ex Lam.) Urb.	Malvaceae
Cacao	*Theobroma cacao* L.	Malvaceae
Cachimbo	*Erythrina poeppigiana* (Walp.) O.F. Cook.	Fabaceae
Cajeto or crecedor	*Delostoma integrifolium* D. Don	Bignoniaceae
Carambolo	*Averrhoa carambola*; L	Oxalidaceae
Carbonero gigante	*Albizia carbonaria* Britton	Fabaceae
Cascarillo	*Cinchona pubescens* Vahl	Rubiaceae
Cedro	*Cedrela odorata* L.	Meliaceae
Chachafruto	*Erythrina edulis* Triana ex Micheli.	Fabaceae
Chilco	*Escallonia paniculata* (Ruiz & Pav)	Escalloniaceae
Chirimoya	*Annona cherimola*; Mill., Gard	Annonaceae
Ciprés	*Cupressus lusitanica*; Miller	Cupressaceae
Cordoncillo	*Piper aduncum* L.	Piperaceae
Cucharo	*Myrsine guianensis* (Aubl.) Kuntze	Myrsinaceae
Eucalipto	*Eucalyptus globulus;* Labill	Myrtaceae
Gualanday	*Jacaranda caucana;*	Bignoniaceae
Guamo churimba	*Inga marginata* Wild.	Fabaceae
Guamo macheto	*Inga densiflora;* L	Fabaceae
Guamo rabo mono	*Inga codonantha* Pittier	Fabaceae
Guanabana	*Annona muricata* L.	Annonaceae
Guayaba	*Psidium guajava;* L	Myrtaceae
Guayacan	*Lafoensia acuminata* (Ruiz & Pav.) DC.	Lythraceae
Jigua	*Nectandra acutifolia k* (Ruiz & Pav.)	Lauraceae
Leucaena	*Leucaena leucocephala*; (Lam.) de Wit,	Fabaceae
Limón Común	*Citrus limon;* L	Rutaceae
Limón Mandarino	*Citrus limonia;* L	Rutaceae
Limón rugoso	*Citrus medica;* L	Rutaceae
Limón taiti	*Citrus x latifolia*; Tanaka ex Q.Jiménez	Rutaceae
Mandarina	*Citrus reticulata*; Blanco	Rutaceae

Continuation Table 1.

Mango	*Mangifera indica;* L	Anacardiaceae
Mano de oso	*Oreopanax incisus* (Willd. ex Schult.) D. & P.	Araliaceae
Matarratón	*Gliricida sepium* (Jacq.) Kunth ex Walp	Fabaceae
Moringa	*Moringa oleifera*; Lam	Moringaceae
Nacedero	*Thichanthera gigantea* (Humboldt & Bonpland)	Acanthaceae
Naranja	*Citrus x sinensis* (L.) Osb.	Rutaceae
Níspero	*Eriobotrya japonica* (Thunb.) Lindl	Rosaceae
Nogal cafetero	*Cordia alliodora* (Ruiz & Pav.)	Boraginaceae
Ovo	*Spondias purpurea;* L	Anacardiaceae
Pelotillo	*Viburnum pichinchense* Benth.	Caprifoliaceae
Pichuelo	*Senna pistaciifolia* (Kunth) H.S. Irwin & Barneby	Fabaceae
Pino	*Pinus patula* Schltdl. & Cham.	Pinaceae
Pomo	*Syzygium jambos* L.	Myrtaceae
Quillotocto	*Tecoma stans* (L.) Juss. ex Kunth	Bignoniaceae
Roble	*Quercus humboldtii* Kotschy ex A. DC.	Fagaceae
Samán	*Samanea saman; (Jacq.) Merr.*	Fabaceae
Sauce llorón	*Salix humboldtiana;* Willd	Salicaceae
Sauco	*Sambucus nigra* L.	Caprifoliaceae
Tomate de árbol	*Solanum betaceum;* Cav. Anales Hist	Solanaceae
Toronja	*Citrus maxima* (Burm. ex Rumph.) Merr.	Rutaceae
Tulipan	*Spathodea campanulata;* P. Beauv	Bignoniaceae
Urapan	*Fraxinus chinensis*; Roxb	Oleaceae
Vainillo (velero)	*Senna spectabilis* (DC.) H.S. Irwin & Barneby	Caesalpiniaceae
Yarumo	*Cecropia peltata*; L	Urticaceae
Zapote	*Pouteria sapota;* L	Sapotaceae

In the three altitudinal ranges, a great similarity was found in the number of species, but not in the shared species; the range < 1500 presented a value of 36 species; the range between 1500-1800, 35 species; and > 1800, 34 species. Of the woody species used in coffee farms, 32 are native and 27 are introduced; many of them have been naturalized, i.e. 45.8% are introduced woody species. These are used for different purposes; additionally, they have a number of ecosystemic functions such as: coffee shade, wood energy, soil protection, fodder, human food, and conservation of areas with environmental significance.

The Honduras Foundation for Agricultural Research - FHIA (for its initials in Spanish) (2004) indicates that the greatest number of species is found in low areas since coffee growers seek to control the high temperatures present in the production system. Farfán and Jaramillo (2009) mention that the presence of species for coffee shade decreases as the altitude increases. This fact is due to the increase in cloudiness, natural shade, since excess shade generates a decrease in production. In the present research, the number of species does not fluctuate depending on altitude; this study took into consideration the cultural importance of the species, and in addition to the species used as shade for coffee, trees in the different agro-ecosystems of the coffee farm were also considered.

The similarity of tree species found in the three altitudinal ranges in coffee production systems (Table 2) was evaluated using the Jaccard Index (JI); a low similarity was found between the altitudinal ranges. The highest value was found in ranges I and II because they shared 24 species, equivalent to 33.8% of their floristic composition. On the other hand, ranges I and III had a lower similarity level of 24.2%, sharing 17 species.

The low similarity between altitudinal ranges can be attributed to climatic conditions and management; DaMatta and Rodriguez (2007) indicate that the variability of species diversity is due to climatic and edaphic conditions. The values found in the present study are considered low in comparison to those recorded by Villavicencio and Valdez (2003) for the rustic coffee agroforestry system (SAF for its initials in Spanish) and the medium sub evergreen forest (SMSP for its initials in Spanish) in San Miguel, Veracruz, (Mexico), which shared 58% of the woody species.

The dissimilarity found is possibly due to the specific way in which coffee growers manage the crop depending on the zone. How they handle the crop depends on the knowledge they have on the matter, which is largely empirical and based on customs (Escobar *et al*., 2016). Therefore, it is considered that each altitudinal range displays different customs, and all of these elements are evident in the management of the coffee farm.

Muñoz and Villota (2014) indicate that similarity is high when the species are native to the region, or the areas where they are located have similar geographical features. This research confirms what Muñoz and Villota (2014) state, as it showed that 45.8% of the woody species used in coffee farms are introduced, with a predominance of fruit trees.

To determine the Cultural Importance Index (CI), the following variables were considered: intensity of use, frequency of citation, and use value of each of the species found within the altitudinal ranges assessed in this study.

Table 2. Jaccard Index (JI) for three species in three altitudinal ranges in coffee production systems, municipality of La Unión, Nariño.

Jacard Index			
Ranges (m a.s.l)	**I (<1500)**	**II (1500-1800)**	**III (>1800)**
I (<1500)	1		
II (1500-1800)	33.8%	1	
III (>1800)	24.2%	26%	1

The assessment of woody species concerning altitudinal ranges (Table 3) showed that at altitudes <1500 m a.s.l., *I. densiflora* and *T. gigantea* are the species with the highest values of intensity of use (4.41%). In terms of frequency and use value, *C. sinensis* and *T. gigantea* stand out with percentages of 12.87 and 22.73%, respectively. In range II (1500-1800 m a.s.l.), the species *I. densiflora* and *C. reticulata* stand out with 4.08% of intensity of use. Likewise, the species *C. sinensis* is the most important regarding use value and frequency of citation. At altitudes >1800 m a.s.l., *I. densiflora* stands out for having the highest intensity of use (5.45%) and use value (24.95%). On the other hand, the species P. americana is the most mentioned in this altitudinal range.

Based on the perception of coffee growers, the woody species above are of particular interest due to their multiple uses; they can be used as firewood, erosion regulators, remedies, and human and animal food. The findings are in line with those reported by Paz and Torres (2017), who state that among the useful flora of coffee plantations, edible and medicinal plants stand out; these contribute to satisfy the primary needs of man such as food and health.

The preference for certain woody species, especially those associated with coffee farming, is in line with research conducted in different coffee regions. Salamanca (2017) reported that coffee growers prefer the genus Inga as shade species, including *C. sinensis*, *C. odorata*, P. americana, *P. guajava*. These species provide suitable conditions for the crop; they generate higher productivity and provide food for wildlife and humans. In addition, they generate external products to be used as wood, firewood, green manure, and fruit, among others.

Table 3. Cultural importance of woody species in the three coffee altitudinal ranges, municipality of La Unión, Nariño.

Ranges (m a.s.l.)	Species	IU%	FC%	UV%	CI%
I (<1500)	*Thichanthera gigantea*	4.41	11.06	22.73	12.73
	Citrus x sinensis	3.52	12.87	14.86	10.42
	Inga densiflora	4.41	9.12	11.48	8.33
	Cordia alliodora	2.64	0.77	19.54	7.65
	Persea americana	3.96	8.84	9.48	7.43
II (1500-1800)	*Citrus sinensis*	3.27	13.97	14.30	10.51
	Inga densiflora	4.08	11.00	12.27	9.12
	Thichanthera gigantea	3.27	7.14	11.33	7.24
	Citrus reticulata	4.08	6.64	6.87	5.86
	Lafoensia acuminata	3.67	2.48	11.38	5.84
III (>1800)	*Inga densiflora*	5.45	16.02	24.95	15.47
	Persea americana	4.46	17.18	17.73	13.12
	Citrus sinensis	4.46	13.80	14.89	11.05
	Trichanthera gigantea	4.46	7.80	19.29	10.51
	Eucalyptus globulus	2.48	2.00	20.20	8.23

On the other hand, Zapata (2019) mentions that species *C. sinensis*, *I. edulis* and *C. alliodora* were the most ecologically significant species in the coffee plantations of the municipalities of Pacho, Rioseco and Tibacuy in Cundinamarca. This importance would be related to the preferences of coffee growers regarding the use and characteristics of the species that have beneficial interactions with coffee, in addition to the fact that the most important uses of these species are as firewood and shade.

Regional studies on biodiversity in coffee growing areas of Colombia (Sánchez *et al*., 2013) indicate that the species most frequently used as shade in conventional coffee plantations in Santander was *I. edulis* with 28%; as for the Cairo region, it was *I. codonantha* with 73%, with the genus Inga predominating in the areas assessed.

In the coffee landscape of the municipality of La Unión, the use of woody species as shade for coffee farming is commonplace. As stated by Martinez *et al*. (2007), in some of the coffee farms of this municipality, shade is provided by commercially important species such as *C. sinensis, C. reticulata* and *P. americana* (avocado). One of the reasons that accounts for this is the fact that they generate additional income for the grower. However, other species such as *Inga sp*, *G. sepium* and *A. acuminata*, which are not considered commercially important, are also used to provide shade.

The cultural importance of the woody species present in the coffee farms was determined by the sum of the intensity of use (IU), frequency of citation (FC) and use value (UV) as indicated in Table 4. In the municipality of La Unión, the species *I. densiflora* had the highest percentage in relation to the sum of cultural importance in the three altitudinal ranges, with 32.92%, followed by *C. sinensis* with 31.98%, and *T. gigantea* and *P. americana* with 30.49% and 26.27% respectively. These findings reflect the importance of the use of woody species, especially as shade for coffee cultivation, land delimitation, soil protection, and human and animal food, which contributes to food security of the populations.

Studies carried out in different coffee growing regions validate the above, especially when it comes to species of the genus Inga. These species are particularly relevant due to their usefulness as shade for coffee farming and the fact that they provide organic matter to the soil, about 2.5 times more than in crops with free sun exposure. This contributes to the improvement of the physical characteristics of the soil, such as humidity and bulk density, which favor the development of coffee (Cardona and Sadeghian, 2005).

Cardona *et al*. (2013) and Farfán *et al*. (2013) state that guamo has been widely used as a shade tree for perennial crops, especially alongside coffee. The species *I. densiflora* and *I. edulis* are the most commonly used due to the multiple services they offer such as acting as a windbreak barrier, regulating solar radiation, controlling temperature, and reducing water demand. In addition, guamo is planted for its socioeconomic and ecological value; its wood is a source of firewood, which can be used in construction and carpentry, and its fruits are suitable for human and wildlife consumption.

Table 4. Cultural Importance Index (CI) of woody species in coffee farms in three altitudinal ranges, municipality of La Unión (Nariño).

Species	Altitudinal range (m a.s.l.)			% CI	Ranking CI
Scientific name	(I) <1500	(II)1500-1800	(III) >1800		
Inga densiflora	8.33	9.12	15.47	32.92	1
Citrus sinensis	10.42	10.51	11.05	31.98	2
Thichanthera gigantea	12.73	7.24	10.51	30.49	3
Persea americana	7.43	5.72	13.12	26.27	4
Citrus reticulata	6.82	5.86	5.14	17,81	5
Psidium guajava	6.00	5.37	5.07	16.44	6
Cordia alliodora	7.65	4,59	2.94	15.8	7
Mangifera indica	6.93	5.56	1.79	14.27	8
Citrus limon	3.85	7.37	2.62	13.84	9
Eucalyptus globulus		2.96	8.23	11.19	10
Ochroma pyramidale	3.51	3.47	3.95	10.93	11
Lafoensia acuminata	2.09	5.84	2.52	10.45	12
Erythrina edulis	0.70	5.21	2.98	8.89	13
Inga codonantha	4.18	3.63		7.81	14
Cecropia peltata	1.60	3.31	2.55	7.46	15
Citrus x latifolia	2.28	4.38		6.66	16
Erythrina poeppigiana	5.58	0.71		6.29	17
Citrus medica L.	2.51	3.57		6.08	18
Eriobotrya japonica		3.45	2.61	6.05	19
Inga marginata	2.91	2.97		5.88	20

Similarly, the coffee growers surveyed in this study mentioned that *C. sinensis* is a fruit species intentionally planted in coffee farms; it has been one of the crops with the highest production in this area for many years due to family tradition and also the well-established production system. This fruit is regularly consumed by the inhabitants of the region, and it is also traded in the local markets, constituting a strategy for the diversification of the farms. In this sense, Rice and Ward (1997) indicate that the diversification of the coffee farms plays an important economic and social role; on one hand, it represents an additional income for the families, and it is used for self-consumption as well. On the other, it contributes to the improvement of the quality of the coffee (Saito, 2004; Sosa *et al*., 2004).

Based on the perceptions and local knowledge of the coffee growers, the tree species *T. gigantea* is culturally important for several reasons: It is used as animal fodder, especially for smaller species; it protects and controls erosion; it has medicinal uses; it improves coffee cultivation when grown alongside this crop. Ricaurte *et al*. (2014) mention other uses;

the authors consider that this species maintains soil moisture, provides insulation through the natural fall of foliage, and reduces the loss of eroded soil (Garzón and Libreros, 1999).

Finally, Rice (2008) and Vargas *et al*. (2012) mention that farmers have a preference for trees because they are important for the livelihoods of rural populations. Trees can be used as firewood, wood, and food. In short, they have a positive impact on the family economy and help mitigate the negative effects of global climate change, offering greater resilience to the changes generated and mitigating their negative effects on the environment.

CONCLUSIONS

There exists a variation in the presence of woody species commonly used in coffee agroecosystems, especially as shade for coffee cultivation, between altitudinal ranges. This variation is due to the characteristics of each location; these include climate, temperature, type of system and soil fertility, moisture content, and other environmental factors such as solar brightness, cloudiness. In addition to the above, empirical or traditional knowledge of coffee growers regarding the implementation of woody species associated with the coffee systems of the region also influence such variation.

The richness of species found was high for each altitudinal range. This finding indicates that coffee growers handle diverse species, preferably for coffee shade in order to improve the quality of the product and the durability of the crop. Without the shade provided by these species, there is a risk that the coffee will burn due to the high temperatures present in the region; besides, the life cycle of the crop will be shorter and the input used for production will also increase.

When studying the cultural importance of woody species, considering the intensity of use, frequency of citation, and use value, the results showed that *I. densiflora*, *C. sinensis*, *T. gigantea*, and *P. americana* were the most important species for coffee growers in the region. The reasons that account for these findings are their ecological and socioeconomic value, since they provide additional income through the production of fruit and wood and are also fundamental to the sustainability of the production system.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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