LOCAL TREE PREFERENCES IN THE CACAO-CABRUCA SYSTEM IN THE SOUTHEAST OF BAHIA, BRAZIL[1]

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Introduction

Biodiversity is essential to human life on our planet. The destruction of tropical forests is one of the main causes of biodiversity loss in the world (AYRES, 2005). In Brazil, the degree of conversion of forest ecosystems to other uses is of great concern (AYRES, 2005; IRIGARAY, 2007). The Atlantic Rainforest ecosystem is one of the richest on the planet. It is also one of the most threatened (GALINDO LEAL e CÂMARA, 2003). For instance, it is currently restricted to a fraction of its original extension (8%). Nevertheless, it is estimated that the remnant forest shelters between 1% and 8% of the world's biodiversity (SILVA e CASTELETI, 2003).

The Southeastern region of the State of Bahia has one of the largest concentrations of Atlantic Rainforest remnants in the Northeastern region of Brazil (LANDAU, 2003; SAMBUICHI e HARIDASAN, 2007). A large part of these remnants are found in cocoa (*Theobroma cacao*) cultivation areas in the so-called cocoa-*cabruca* or *cabruca* agroforestry system (AFS) (AGUIAR *et al.*, 2003). During the implementation of this system, trees native to the Atlantic Rainforest were maintained so as to provide shade, essential for the good development of cocoa trees (CASSANO *et al.*, 2009). Studies have shown that

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AFSs can serve as *habitat and corridor* for a number of endemic species, increasing their chances of long-term survival (CI and IESB; RABOY *et al.*, 2004; SAMBUICHI and HARIDASAN, 2007; CASSANO *et al.*, 2009). Field surveys have demonstrated that *cabruca*s vary in density - between 35 and 355 shade trees per hectare, and in variety - between 16 and 60 different tree species per hectare sampled (SAMBUICHI, 2006; SAMBUICHI *et al.*, 2012).

In the recent years, with the drastic drop in cocoa production, mainly linked to the infestation of the cultivation by witches' broom disease (*Moniliophthora perniciosa*), *cabruca*s have undergone a gradual process of simplification (ROLIM e CHIARELLO, 2004; SAMBUICHI and HARIDASAN, 2007). Loss in the diversity of species in the *cabruca*s is the result of the type of management adopted by farmers (ROLIM e CHIARELLO, 2004). In this process, farmers tend to substitute native shade trees by a smaller number of exotic species which have a higher market value (CASSANO *et al.*, 2009). Another threat to *cabruca* areas is their substitution by more profitable crops which are less sustainable from a socio-environmental point of view (AGUIAR *et al.*, 2003).

Despite greater productivity, cocoa crops cultivated under full-sun or low shade are less sustainable. There are greater risks and higher production costs, as they require greater amounts of water, nutrients and insecticides (ARÉVALO *et al.*, 2007). Furthermore, studies have shown that the productive advantages of full-sun cocoa cultivation diminish over time, being as productive as shade systems in the long-term (AHENKORAH *et al.*, 1974). This occurs because the soil becomes increasingly exhausted and plants more stressed in full-sun systems (ALVIM, 1976; KNIGHT, 1976; AHENKORAH *et al.*, 1974).

Despite the recognized role of agricultural preferences regarding shade in AFSs, affecting the conservation of biodiversity (SAMBUICHI e HARIDASAN, 2007; SOTO-PINTO *et al.*, 2007; MOURA, 2008; CASSANO *et al.*, 2009), little attention has been paid to studying these preferences in *cabruca* areas in the southeastern region of the state of Bahia, Brazil. This knowledge may be a valuable resource in moving towards a type of management, which is not only compatible with environmental criteria, but also with local priorities (SOTO-PINTO *et al.*, 2007). Furthermore, knowing individual preferences regarding tree species can assist us in understanding farmers' tendency to adopt particular management practices and their implications for the conservation of biodiversity.

The study of individual farmers' preferences with regard to *cabruca* trees highlights the utilitarian, anthropocentric and instrumental values associated to biodiversity (RANDALL, 1997). This is because, in general, species become important when they are desired by people, have market value, are useful or are seen as a means to achieve human satisfaction. In contrast to utilitarian values, the existence value of biodiversity does not depend on its usefulness for human beings (NOGUEIRA e MEDEIROS, 1999). The existence value attributed to environmental assets originates from the willingness of individuals to guarantee the survival of plants and animals due to a feeling of affection for them and not because of their current or future utility (Ibid.), thus, recognizing the "right of non-human beings and other things to exist", regardless of their current use and of what they could provide humans in the future (NOGUEIRA e MEDEIROS, 1999: 64).

The aim of this study is to identify the preferences of small farmers with regard to shade trees in *cabruca*s, as well as the main uses and methods employed in their management. In order to do so, questionnaires were completed by individuals in charge of 160 rural holdings, where *cabruca*s had been identified, in the traditional cocoa-growing area in the Southeastern region of Bahia. Data collected with the use of questionnaires were analyzed and compared with the results of a survey of tree species carried out in farms in the Southeastern region of Bahia.

Following this introduction we describe the methods used during the research. We subsequently present and discuss the findings and consider their implications for the conservation of tree diversity in *cabruca* areas and make some recommendations.

Methodology

During this research, 160 rural holdings were visited. They are situated in 14 municipalities in an economic region known as Litoral Sul (Southern Coast), in Southeastern Bahia. This region was chosen because it contains the largest area occupied by the *cabruca* system in the state of Bahia, according to a survey conducted in 2007 by CEPLAC [Executive Planning Commission for Cocoa Cultivation Education Centre], the main governmental institution dedicated to research and education in cocoa cultivation in the region. Questionnaires were completed by the individuals in charge of the farms at the time of the visits. They contained questions related to the individuals' socio-economic profile (age, number of years of experience in cocoa cultivation, level of education and income); their perception on cultivation (shade intensity, factors affecting productivity, ideal distance between shade trees and the benefits of shade, as well as questions on which trees are becoming more prominent and which are in a process of decline); local uses of tree species; management practices regarding these species; and the sale of alternative products to cocoa. Interviewees were classified according to their position in the farm as landowner, settler, farm manager, sharecropper or farm worker.

The basis of this study is the analysis of the preferences of individual interviewees with regard to tree species, both native and exotic, found in *cabruca* areas. The preference of interviewees with regard to tree species was assessed by asking individuals to list in descending order of preference three species they would like to keep in the cocoa plantations, in the hypothetical case that all trees had to be eliminated from their areas. In order to identify which species have the highest rejection rate, interviewees were asked to list in order of descending importance the three species they would, in theory, like to eliminate from the cocoa plantation, given that Brazilian environmental legislation prohibits the suppression of native vegetation. In both cases, we sought to identify the criteria used by farmers in their choice of species. In addition, the main uses of these species were also analyzed (human consumption, food for wild and domestic animals, timber, firewood, and medicinal use), as well as their management, and more specifically, the practices involving the selective cutting of seedlings during weeding (selective weeding), thinning of shade trees and planting of trees. Questionnaires were completed between December 2007 and March 2009.

The data collected was codified and analyzed both qualitatively and quantitatively. It was then compared with the results of a survey of tree species conducted in 2008 in 16 rural holdings situated in 13 municipalities in the Litoral Sul economic region in Southeastern Bahia (SAMBUICHI *et al.*, 2012). A hectare of *cabruca* was sampled from each farm. During this survey, the following parameters were calculated for each species: density, basal area and frequency. An importance value was obtained for each species by adding the relative values of density, basal area and frequency. This study also used information gathered from a survey carried out by Alvim e Pereira in 1965 and described by Sambuichi *et al.* (2012). Data from this older survey, which encompassed 61 hectares in different cultivations of cocoa-*cabruca* in the region, was used to compare the densities of some species identified in the survey conducted in 2008 by Sambuichi *et al.* (2012).

We compared the local criteria employed for choosing tree species with the requirements for the composition of a shade cover compatible with the conservation of biodiversity. It is recommended that in the composition of shade cover priority is given to the diversity of native species, which should preferably be non-deciduous (evergreen) and provide food and shelter to native and endemic animal species (PARRISH *et al.*, 1999).

Results and Discussion

Profile of interviewees

Five categories of interviewees were identified according to their position in the farm: 61 (38%) were managers, 48 (30%) owners, 35 (22%) partners, 9 (5.6%) employees and 7 (4.4%) settlers. Just over half of the interviewees (52%) were between 26 and 50 years old. Approximately 53% had over thirty years of experience in cocoa cultivation. In terms of their educational level, 26% of interviewees were illiterate and 39% had not finished primary education. Out of the 69 interviewees who provided information on their income, 71% earned between one and two minimum salaries and 20% earned less than a minimum salary per month.

Perceptions on shade levels

Despite the fact that most interviewees (54%) thought the level of shade in their cultivations to be adequate, a significant number (46%) considered it to be too high. Excessive shade levels were seen by interviewees as the cause for a higher incidence of black pod disease (*Phytophthora palmivora*) and witches' broom disease, as well as a reduction in production. Interviewees also believed that excessive shade levels stimulated the longitudinal development of plants, making them too tall and more difficult to harvest.

In the literature, a reduction in the productivity of cocoa trees in areas with high levels of shade is explained by a lower rate of photosynthesis due to lower amounts of sun radiation, an increase in the incidence of diseases and the competition between shade trees and cocoa for water, sunlight and nutrients (BEER *et al.*, 1998; ZUIDEMA *et al.*,

2005). In addition to the high levels of shade, low productivity was attributed to other factors such as a deficient genetic material (clones which are self-incompatible and have low productivity and disease-susceptible varieties), low soil fertility, water stress and lack of adoption of cultivation practices in general.

On the other hand, interviewees cited a number of benefits associated to shading of the cocoa cultivation: protection against strong winds; reduction in the number of weeds; a lower incidence of the fungal disease "verticillium wilt", caused by *Verticillium dahliae* which proliferates when there is scarcity of water (PEREIRA *et al.*, 2008), occurring more commonly in areas with low shade levels; lower incidence of pests; and protection against the drying out of the soil. Another important benefit of shade mentioned by interviewees was the protection of cocoa trees against sunlight intensity.

According to a settler interviewee:

> "if (you) take away the shade, it (the cocoa tree) resents it... without shade, the strong sun will kill a large part... cocoa shrivels and even dies, the leaves dry out... it's like when we go to the (drought-ridden) *sertão*".

Furthermore, interviewees also reported that the maintenance of a higher number of shade trees contributes to greater availability of water in their farms. There is, therefore, recognition of the role of shade in conserving the water regime. As one of the farmer states, "there used to be more shade and more water, with deforestation there is less water".

Other benefits of shade cover reported in the literature include: protecting soil against erosion; enhancing pollination (YOUNG, 1982); maintaining air humidity levels; regulating air and soil temperature; enhancing nutrient cycling; producing organic matter (BONDAR, 1938); preserving the soil's natural fertility; lower incidences of epiphytes; more stable production; increased crop longevity (AHENKORAH *et al.*, 1974); as well as providing agroforestry products with market and subsistence value (such as timber, firewood and fruit) [DIAS, 2001; BEER *et al.*, 1998]. In addition, this type of AFS maintains environmental services such as carbon sequestration and the conservation of biodiversity (RICE and GREENBERG, 2003; SOMARRIBA and BEER, 2010).

There is no consensus among interviewees regarding the optimum distance of shade trees in *cabruca* areas. However, most interviewees (59% or 80 out of 136) thought that the ideal spacing between shade trees should be between 20 and 40 metres. This spacing is obtained with between 25 and 6 shade trees per hectare (ALVIM, 1976; MANDARINO, 1979). These distances either fall within or are greater than the distance recommended by cocoa cultivation manuals produced by CEPLAC, specified as 24 metres (MANDARINO, 1979; GRAMACHO *et al.*, 1992). In the past, the spacing between shade trees recommended by agronomists was lower, between 8 and 16 metres, depending on the species (MIRANDA, 1938). Spacing distances lower than 20 metres were assessed as being ideal by 29% (36 out of 136) interviewees. On the other hand, a minority (13% or 17 out of 136) stated that spacing distances should be greater than 40 metres, equivalent to a density lower than 6 trees per hectare.

The average density of shade trees found in the survey conducted in 2008 by Sambuichi *et al.* (2012) was of 121 trees per hectare. This shows that spacing between shade trees in the *cabruca*s of the region is around 9 metres, a figure considered to be lower than that thought to be ideal by most interviewees. The gap between the average density found in practice and the density considered ideal by most farmers may explain why almost 50% of the interviewees believed their own cultivations to be excessively shaded.

Interviewees pointed out that the distance between shade trees should vary according to factors such as fertility and soil depth (less fertile and shallow soils require more shade), topography (hilltop areas require more shade than lower areas), the age of cocoa trees (older plants require less shade), the density of the cultivation (denser cultivations require less shade) and the type of canopy (depending on how much it branches out).

Various interviewees reported a loss in production due to the higher incidence of witches' broom disease in low-lying areas close to water courses, generally more fertile and humid, than in higher slopes and hilltops. Indeed, the combination of high air humidity levels and temperatures between 20 °C and 25 °C are known to stimulate the dissemination of this pathogen (RUDGARD *et al.*, 1993; LUZ *et al.*, 2006). Consequently, many interviewees reported cutting shade trees in these areas, so as to increase the amount of sunlight and improve air circulation. This practice goes against recommendations for a type of management, which promotes biodiversity conservation. For example, Parrish *et al.* (1999) recommend preserving native vegetation within at least ten metres from water sources on both banks so as to protect water resources and aquatic biodiversity, and contribute to the creation of riparian forest corridors. Cutting down the riparian forest is a source of conflict among environmentalists and cocoa farmers, given that traditionally many cocoa plantations were established in fertile valleys alongside rivers. According to Brazilian legislation, these areas are assigned as Permanent Preservation Areas (APPs), comprising native vegetation. However, recent amendments made to the Forestry Code have meant that, as an exception, agroforestry is allowed in APPs in case of family smallholdings.

Preferences of interviewees

Most preferred species

Interviewees cited a total of 45 species as their most preferred. Among these, most were native species (31 or 69%). The survey carried out in 2008 (SAMBUICHI *et al.*, 2012) identified that native trees made up the majority of individuals (78%) and species (93%), surpassing, therefore, the number of exotic species in the composition of the shade canopy within *cabruca* areas.

The main use of most species reported was as timber, followed by human consumption. The 16 most cited species among the most preferred and their uses are listed in Table 1. Out of the 16 species cited as being most preferred by interviewees, seven were attractive to wild fauna and six had medicinal use.

According to interviewees, the three most preferred species were native timber-producing species. These were in decreasing order: rose-colored jequitibá (*Cariniana legalis*) (40% of interviewees or 58 out of 146), rose-colored cedar *(Cedrela odorata*) (36% of interviewees or 53 out of 146) and "vinhático" (*Plathymenia foliolosa*) (26% of interviewees or 38 out of 146). These were followed by some exotic species, "cajazeira" *(Spondias mombin*), species of the erythrina genus (*Erythrina spp.*) and jackfruit tree (*Artocarpus heterophyllus*).

The reason given by most interviewees for choosing these three species was because they produced good quality timber (hard and resistant, so-called hardwoods), which can be employed in the manufacture of furniture and in civil construction. Others added that these species have "greater market value", "they are the most sought after in terms of sales" and increase the value of the property. The survey also found that interviewees consider "good" quality shade to be generally provided by large trees, with a high, wide canopy, which is not too dense. According to Bondar (1956:14), a high canopy is desirable because "the higher the shade, the thicker the layer of stable humid air, which benefits the cocoa tree".

It is interesting to note that despite the fact that "louro-sabão" (*Nectandra* sp.) was mentioned, together with "vinhático", as being one of the most popular trees used for timber in rural holdings, it was listed only in seventh position in terms of interviewee preference (Table 1). This shows that farmers tend to prefer timber species with a high market value rather than a high utility value.

The three most preferred species were also those interviewees perceived as being in decline in cocoa cultivation areas, rose-colored jequitibá (mentioned by 17% or by 16 out of 95 interviewees), rose-colored cedar (14% or 13 out of 95) and "vinhático" (13% or 12 out of 95), respectively. This seems to relate to the fact that these species have been most affected by illegal logging in the past. They are also, currently, the most sought after for commercial purposes. Farmers' statements confirmed that the exploitation of these species, in particular "vinhático", increased due to the crisis in cocoa cultivation.

However, a smaller number of interviewees claimed that there has been an increase in these species within the *cabrucas* (rose-colored cedar, 11% or 11 out of 98 mentions; rose-colored jequitibá and "vinhático", both 9%, or 9 out of 98 mentions). This perception may be due to the fact that most farmers (78% or 120 out of 154) have been encouraging the natural regeneration of the seedlings of these three species during selective weeding. Therefore, it can be observed that although native species have been prioritized, regeneration has been mainly focused on three native species. This may not be sufficient to ensure the continuity of shade canopy diversity in the long-term.

Table 1 - Main uses, besides shade, of the 16 species cited as the most preferred by the interviewees. Only species cited at least five times were considered.

Scientific name	Common name	Main use	Supplementary uses	N. of citations	%
Cariniana legalis	Jequitibá	Timber	firewood, medicinal	58	17.0
Cedrela fissilis	Cedro	Timber	firewood, medicinal	53	15.4
Plathymenia foliosa Benth	Vinhático	Timber	firewood, medicinal	38	11.1
Spondias mombin	Cajazeira	Consumption (fruit)	Attractive to wildlife	33	9.6
Erythrina spp.	Eritrina	Firewood		19	5.5
Artocarpus heterophyllus	Jackfruit tree	Consumption (fruit)	attractive to wildlife, firewood and timber	17	4.9
Nectandra sp.	Louro-sabão	Timber	Attractive to wildlife, medicinal	14	4.1
Caesalpinia echinata	Pau brasil	Timber		11	3.2
Tabebuia spp.	Pau d'arco	Timber	Firewood, medicinal	11	3.2
Hevea brasiliensis	Rubber tree	Product with market value (latex)	Firewood, timber	9	2.6
Centrolobium robustum	Putumuju	Timber	Firewood	8	2.3
Dalbergia nigra	Jacarandá	Timber		8	2.3
Genipa americana	Genipap	Consumption (fruit)	Attractive to wildlife, firewood and timber	7	2.0
Lecythis pisonis	Sapucaia	Timber	Consumption (nut), attractive to wildlife, craft, ornamental	6	1.7
Caryocar edule	Pequi	Timber	Attractive to wildlife, medicinal	6	1.7
Sloanea obtusifolia	Gindiba	Timber	Attractive to wildlife, firewood and timber	5	1.5

In the species' survey conducted in 16 rural holdings in the region (SAMBUICHI *et al.*, 2012), these three species were among the 13 most important. "Vinhático" and rose-colored cedar were found to be the second and fourth most important species respectively. A comparison of the densities found in the survey carried out by Alvim and Pereira in 1965 with that conducted in 2008 (SAMBUICHI *et al.*, 2012) showed that the density of "vinhático" increased 7.7 times during this period, whilst the densities of "jequitibá" and rose-colored cedar, whose timbers are also valued by interviewees, saw smaller increases, 2.7 and 2.5 times respectively.

The fourth species cited in terms of preference was "cajazeira" (*Spondias mombin*). It appeared as the third most important in the survey. Its high density may be due to the fact that it is the preferred choice of interviewees for planting in the *cabruca*s. The main attributes of this tree are its fruits, often sold to the region's agribusinesses for pulp production, generating additional income to owners and/or rural workers. Other attributes of this species appreciated by interviewees include "good shade", having slim leaves and wind resistance.

Erythrina genus species were mentioned in fifth place. The only use reported for these species, besides providing shade to the cocoa trees, was as firewood, which in general is not well-appreciated by interviewees. These species were cited in second place as those chosen for planting, followed by rubber trees (*Hevea brasiliensis*) and "pau-brasil" (*Caeslapinia echinata)*. Preference for these species can be understood, by the fact that during the 1930s they were promoted by research and education institutions as the best shade trees (MIRANDA, 1938). These species have been more widely disseminated since the 1960s, by means of incentives to cocoa planting using the total-cut ("derruba total") method, when these species were used in exclusivity as shade trees (JOHNS, 1999). Agronomists valued these species for the following reasons: they are nitrogen-fixing legumes; grow fast; lose their leaves in winter; produce low density shade; are tall; can be easily propagated by seeds and cuttings; and are well-adapted to both humid and dry soils (BONDAR, 1938; GRAMACHO *et al.*, 1992). However, *Erythrina* spp. were also present in the list of least preferred species.

The exotic jackfruit tree was also found among the species most preferred by interviewees. Their main advantage is fruit production, an important source of food for rural workers. Among shade species, it was the most important source of food (fruit), followed by "cajazeira" and genipap tree. It was also cited as having the greatest number of uses (food, timber and firewood).

According to interviewees, there has been an increase in the density of jackfruit trees in the farms. It is interesting to note that in the survey, this species appeared as the most important, presenting the greatest number of individuals (269), the greatest frequency (72% of parcels) and the largest basal area (26.5 m^2) (SAMBUICHI *et al.*, 2012]. The number of jackfruit trees found in the studied areas was three times that of the second most numerous species, "vinhático". It is worth emphasizing, however, that this species was also classified among the most rejected, where it received a higher proportion of mentions in this case.

Data analysis revealed that the criteria most used by interviewees to choose their preferred species were: timber quality (36.9% or 87 of 236 mentions); fruit and/or nut for household consumption (18.2%); shade quality (15.3%) and the provision of products for sale (12.7%) (Table 2). Most of the criteria cited could be described as utilitarian, where only 4.7% (origin and density/aesthetic values) could be referred to as existence or non-utilitarian values (NOGUEIRA e MEDEIROS, 1999).

Table 2. Criteria used by interviewees for choosing their most preferred tree species in the *cabrucas*. (N= 130 interviewees answered this question)

Choice criteria	N. of citations	%
Timber quality (resistant/hardwood)	87	36.9
Food production (fruits and/or nuts) for human and animal Consumption (yes)	43	18.2
Shade quality (good)	36	15.3
Providing products for sale (such as "*cajá" fruit*, latex and oil)	30	12.7
Competing for water with cocoa trees (low)	10	4.3
Height of canopy and tree (high)	9	3.8
Origin and density (native and rare or endangered)	7	3.0
Size of leaf (small or slim)	5	2.1
Aesthetic value (high)	4	1.7
Rate of leaf decomposition/contribution to soil nutrients (high/yes)	3	1.3
Soil protection (high)	2	0.9
Total	236	100

Two criteria associated to the tree's capacity to provide additional income to farmers from products such as timber and fruits appeared in approximately half of the citations, (49.6%), either together or separately. This shows that criteria associated to income generation are important in the selection of *cabruca* tree species. They predominate over criteria associated to effects on the development of cocoa trees and the provision of subsistence goods. This finding is associated to the crisis in cocoa cultivation, which meant that alternative activities became crucial for recovering the economic viability of farms comprising *cabruca* AFSs. Nevertheless, agricultural diversification in the rural farms studied is still low.

According to the data obtained, only 29% of farmers traded products other than cacao from their farms. Bananas were the most frequently sold products. In relation to shade trees, the products of 14 species, all exotic and mainly producing fruits, were mentioned. The most sold products were "cajá" (42%) and jack fruit (16%).

Species with the highest rejection rates

A total of 44 species were mentioned as the most rejected by interviewees (Table 3). In descending order, the most mentioned were "embaúba" (*Cecropia* spp.) (41% or 57 out of 138 farmers); "gameleira" (*Ficus* spp.) (38% or 52 out of 138 farmers); species of the erythrina genus (29% or 40 out of 138 farmers); and jackfruit tree (15% 21 out of 138 farmers). These were the main species removed from the cultivation during the thinning of shade [jackfruit tree (20%), species of the erythrina genus (13%), "gameleira" (13%), "fidalgo" (*Aegiphila sellowiana*) (9%) and "embaúba" (8.5%)] and whose seedlings were cut during manual selective weeding ["gameleira" (42%), jacktree (35%), erythrina genus species (26%) and "embaúba" (21%)].

The main use reported by interviewees for most of these species was firewood. The first two species were also cited as having medicinal uses. Therefore, it can be observed that interviewees valued species, which main uses were cited as being either for timber or human consumption in detriment of species whose main use was firewood.

The main reason for farmers to reject "embaúba" related to the fact that its large and rough leaves, which are also resistant to decomposition, frequently fall on the cocoa crop, "dirtying the cocoa" by forming layers over its canopies, blocking sunlight and thus, affecting its development. Other negative attributes mentioned were its high density, very dense shade and low utility value. The last attribute related to the fact that this tree does not provide high quality timber or edible fruits for human consumption. This species is only used as firewood or for medicinal purposes, less valued attributes. The main shade species cited as having medicinal uses were the native species "jatobá" (*Hymenaea oblongifolia*) (23%), "buranhém" (*Pradosia glaziovii*) (14%) and "pau-d'alho" (*Gallesia integrifolia*) (8%).

Table 3. Main uses, other than shade, of the 16 species most cited as the least preferred. Only species cited at least five times were considered.

Scientific name	Common name	Main use	Supplementary uses	N. of citations	%
Cecropia spp.	Embaúba	Firewood	Medicine	57	19.2
Ficus spp.	Gameleira	Firewood	Medicine	52	17.5
Erythrina spp.	Eritrina	Firewood		40	13.5
Artocarpus heterophyllus	Jacktree	Consumption	Timber, attractive to fauna, timber	21	7.1
Schefflera morototoni (Aubl.) Maguirre, Steyerm&Frodin.	Matataúba	Firewood		18	6.1
Trema micrantha (L.) Blume	Corindiba	Firewood		13	4.4
Inga spp.	Ingazeira	Firewood		13	4.4
Aegiphila sellowiana Cham.	Fidalgo	Firewood		11	3.7
Cestrum laevigatum Schlecht	Coarana	Firewood	Medicine	8	2.7
Aparisthmium cordatum (A. Juss) Baill	Pau-frieira	Firewood		7	2.4
Croton urucurana Baill.	Lava-prato	Firewood		6	2.0
Tapirira guianensis	Pau-pombo	Firewood	Attractive to wildlife	5	1.7

The high number of "embaúba" individuals noticed by interviewees is confirmed in the species survey (SAMBUICHI *et al.*, 2012). As a whole, these species were found to be in seventh position in terms of density. Furthermore, "embaúba" have also seen the largest expansion in terms of numbers in the *cabruca*s between 1964 and 2008, equivalent to 8.5 times. One explanation for the increase in the density of this species is that despite the fact that farmers reject them, they reproduce very easily and grow quickly, readily

regenerating within the *cabruca* environment. The drop in the frequency of weeding in cocoa plantations during this period, due to the economic crisis, benefitted this species.

Despite the fact that interviewees did not associate any positive value to this species, according to the literature, "embaúba" has a number of attributes which can play an important role within AFSs, such as its initial rapid growth potential (MACIEL *et al.*, 2012) and the structure of its canopy which allows light into the undergrowth, stimulating photosynthesis of species lying underneath the canopy (OLIVEIRA e CARVALHO, 2008). These characteristics make this species desirable within AFSs such as the cacao-*-cabruca* system. However, data from this survey suggest that farmers in the region do not recognize the benefits this species can bring to the system, either because they are unaware of or do not value them.

Interviewees' rejection of "gameleira" (*Ficus* spp.) was associated to the quality of its shade, which is considered too dense, its tendency to strangle other shade species, causing them to die, and its high density in the *cabruca*s.

According to interviewees, the least appreciated attribute of the erythrina species was the frequent fall of branches onto the cocoa crop, which causes serious damage. In addition, these species have thorns, compete with cocoa trees for water, nutrients and sunlight and do not provide any marketable products (MARQUES *et al.*, 2007). Recognizing these inconveniences, CEPLAC agronomists have stimulated the substitution of erythrinas for other species, which generate products with a market value, such as rubber trees (Ibid).

Among the most rejected species, jackfruit tree was the only one cited as being used mainly as food for human consumption. According to interviewees, this species is also the one most frequently used as food by wild animals. Among the main negative attributes cited were its excessively dense shade, which reduces the production of cocoa crops, and its high density. It was referred to as the species most removed from the cocoa plantations during shade-thinning activities.

Jackfruit tree was also cited as the second most cut species during selective weeding. It was observed that in the *cabruca*s more actions were taken to contain (thinning and selective cutting) this species than to promote it (natural regeneration and cultivation). In relation to this, the high density of this species in the *cabruca*s, detected in the survey conducted in 2008, may be associated to its high capacity of propagation and its inhibitory effect on the germination of other native species, via allelopathic action (CEPAN, 2009). Its dissemination may also be facilitated more as a result of rural employees and wild animals eating its fruits, thus dispersing its seeds, than to a conscious effort to promote it, on the part of farmers. A greater preference for this species was also observed among employees (30%) than owners (11%). This is probably due to the fact that employees value its use as a foodstuff more in comparison to its negative effects on the cocoa production, more important to owners.

The main criteria adopted by farmers to choose the most rejected species were: frequency of falling branches (17% or 34 out of 200 mentions); shade quality (13%); competing for water with cocoa trees (12%); loss of leaves (10%); parasitic relationship with other trees (8%), timber resistance (7.5%), density (7%) and utility (5.5%) (Table

4). The frequent fall of branches, associated to species with "soft" or "white" wood, with lower levels of wind-resistance, was reported in the 1960s as one of the main problems in managing *cabruca*s (MANDARINO, 1979). Indeed, most of the species rejected are softwood trees, in contrast to the most preferred species, which in general are hardwoods. Thus, the criterion associated to wood quality was a determining factor in choosing species in both cases, although for different reasons.

It can be seen that criteria associated to the effect species have on the development and production of cocoa have priority over their utility for human beings (such as the production of timber and fruits) when choosing species with high rejection rates in relation to those with high preference rates.

In the survey, the high density and frequency of pioneer native species such as "embaúba", "pau-frieira" (*Aparisthmium cordatum*), "fidalgo" (*Aegiphila sellowiana*) and "pau-pombo" (*Tapirira guianensis*) was observed, despite high rejection rates among farmers. This shows that farmers tolerate these species in cocoa cultivation areas, in particular when considering that the regeneration of shade through the planting and growth of other more desirable species, usually of slower growth rates, require a longer time. These species may be prioritized particularly in places where there is an urgent need for shade, since they grow fast and do not need to be planted, as they are readily self-propagating. The high densities of these species may also be linked to a reduction in the frequency of weeding in many rural holdings in the region, as a result of the crisis.

Table 4 - Criteria used by interviewees to choose species they least preferred (N= 108 interviewees answered this question)

Choice criteria	N. of citations	%
Frequency of falling branches (high)	34	17
Shade quality (excessively dense)	26	13
Competing for water with cocoa trees (high)	23	12
Loss of leaves (high)	20	10
Negative relationship with other shade trees	16	8
Quality of wood (low)	15	7.5
Density (high)	14	7
Utility (none)	11	5.5
Height and size of canopy (low and large)	10	5
Effect on the production of cocoa near the tree (negative)	8	4
Thorny branches (yes)	7	3.5
Type and quantity of leaves (large, dry, difficult to decompose and/or abundant)	7	3.5
Attracts pests and diseases (yes)	4	2
Dangerous or causes allergy (yes)	2	1
Type of root (buttress)	1	0.5
Effect on the soil (negative)	1	0.5
Shelters epiphytes (bromeliads) (yes)	1	0.5
Total	200	100

Interviewees demonstrated their knowledge of the various characteristics of shade trees and their effect on the development and production of cocoa. The characteristics attributed to the 12 most cited species among those that have the largest preference and rejection rates are listed in Table 5. Species were also classified according to their frequencies in the 2008 survey and their density variation in the *cabruca* areas. Variation was calculated based on a comparison of densities found in surveys conducted in 1964 by Alvim e Pereira (1965) and in 2008 by Sambuichi *et al.* (2012).

Final considerations

The analysis of farmers' perceptions and preferences with regard to shade tree species, their local uses, and management along with a comparison of data from surveys in the *cabruca*s have shown that:

– Farmers tend to reduce shade density in *cabruca* areas, given that there was a large proportion of interviewees who considered their cultivation to be excessively shaded.
– The criteria adopted for selecting trees reveals that preference is given to species that may increase the income of farmers, either through timber exploitation, or food production, regardless of its origin (native or exotic). Thus, utilitarian criteria were prevalent in the selection of species and there was little interest in conserving species, which do not have known uses, even if rare or endangered.
– Most of the species preferred by farmers were also found to be the most important species in the tree survey conducted in the *cabruca*s in the region. This seems to show that, for certain species, there is a strong relationship between farmer preferences, the management practices adopted and the composition of dominant species in the *cabrucas*. Thus, farmers tend to favour the natural regeneration and promote the planting of species with high preference rates in detriment of rejected species. In the case of jackfruit trees and other species less appreciated by interviewees, their predominance in the shade canopy relates more to factors such as its easy multiplication by seed, rapid growth and the low frequency of weeding than to deliberate actions on the part of farmers.

From these results, it can be concluded that in order to maintain native tree species in *cabruca* areas, and consequently conserve biological diversity, it is important to disseminate and improve the knowledge farmers have on the potential uses of these species, their management and intrinsic values. In view of the above, the following recommendations are proposed:

– Research studies could be promoted in order to better understand what are the highest shade levels compatible with the sustainable production of cocoa, considering that the long-term productivity and stability of the crop is favoured by an increase in the biodiversity of the system (SOMARRIBA e HARVEY, 2004; CASSANO *et al.*, 2009).

– More investment in research could be done on the local medicinal uses of native species cited in this study, in particular those which are less appreciated by the interviewees and which could have a phytotherapeutic potential;
– Studies could be promoted on the suitability of a larger number of native species that respond to the local criteria of farmers to be used as shade for cocoa crops in substitution of species of the erythrina genus;
– There is a timely need for environmental education interventions in order to foster awareness about the intrinsic values of biodiversity, focusing on endemic native species that favour the wild fauna, and the understanding of the impact of invasive exotic species on the agro-ecosystem;
– It is essential to conduct research and monitor the dynamics of the expansion of exotic invasive species in *cabruca* areas;
– The implementation of a certified timber management system could add value to the timber from shade trees in *cabruca* areas, thus discouraging its illegal trade and ensuring its future conservation.

Table 5 - Characteristics attributed to 12 tree species presenting the highest and lowest levels of preference among interviewees, in their own words. Erythrina and Jackfruit tree were included among the least preferred species

Most preferred species	Characteristics attributed to the species	Frequency*	Density variation **
Cariniana legalis (rose-colored jequitibá)	Hardwood, good wood, resistant, strong, it is used for furniture-making and crafts, a tall tree, has the highest market value, high shade, closes up quickly, allows cocoa to develop, a tree that grows considerably but does not damage the cocoa crop, it does not break easily, beautiful plant, small leaves, its canopy is not very "closed" (meaning dense), it is good for the cocoa crop, it can be removed in the future in order to make money, an endangered Atlantic Rainforest tree	+ (14.1)	+ + (2.7)
Cedrela odorata (rose-colored cedar)	Market demand, we can make money later by selling it, can be removed in the future, high canopy, hardwood, good shade, closes quickly, improves the value of the property, market value, it is rare in the region, it does not fall down easily, it is endangered, small leaves, its canopy is not very closed, resistant, does not break easily, beautiful plant, important for nature preservation, can be used in furniture-making, does not affect the cocoa crop	+ + + (39.1)	+ + (2.5)
Plathymenia foliolosa ("Vinhático")	There is market demand, hardwood, grows quickly, improves the value of the property, hardwood, tall tree, small leaves, less shade, does not fall down easily, endangered, dries the soil, dries the land, has a large canopy, an endangered Atlantic Rainforest tree, sells well, has a market value, high shade	+ + + (39.1)	+ + ++ (7.7)
Spondias mombin ("Cajazeira'')	Good shade, small leaves, wind-resistant, does not fall on the cocoa crop, brings in additional income, fruit can be sold, income source, has a market value, does not make a mess, good fruit, brings water, leaves fall in winter.	+ + (35.9)	+ (1.2)
Nectrandra spp. ("Louro")	Hardwood, can be used in construction, good shade and no dirt, good canopy, dries the land, lots of leaves	+ (28.1)	+ (1.4)
Caeslapinia echinata ("Pau-brasil")	Tall, resistant, hardwood, allows cocoa crop to develop, does not affect cocoa crop, endangered species, this tree has the highest market value, beautiful, native, good shade	n.a.	n.a.
Tabebuia spp. ("Pau d'arco")	Hardwood, grows quickly, good shade, low amount of shade, high canopy, small leaves, canopy not very closed, smells good, endangered species, good wood for furniture-making and crafts.	n.a.	n.a.
Hevea brasiliensis (Rubber tree)	Good shade, produces income (rubber latex), leaves fall in winter, high germination rate per seed, good canopy, large tree	n.a.	n.a.
Centrolobium rubustum ("Putumuju")	Hardwood, good shade, good canopy shape, resistant, improves the value of the property, develops quickly, high and airy shade, does not affect the cocoa crop	+ (15.6)	n.a.
Dalbergia nigra (Jacaranda)	Hardwood and survives for many years, tall tree, small leaves, low amount of shade, high canopy allowing cocoa crop to develop, endangered species, does not fall down easily, crafts, furniture-making, very valuable, market value	n.a.	n.a.
Genipaba americana (Genipap)	Fruit for making liqueur for sale, fruit, good wood, good shade	n.a.	+ (1.4)
Lecythis pisonis ("Sapucaia")	Hardwood, good and beautiful wood, used in construction, resistant to woodworm, seed is very rich in oil used to make flour and sweets, tasty fruit, good canopy, good shade, beautiful tree, endangered native tree, tree with highest market value, resistant, does not fall on the cocoa crop, high shade, sucks in water, branches break and fall on the cocoa crop, can be used for making fences	+ (15.6)	+ (1.5)

Table 5 - Characteristics attributed to 12 tree species presenting the highest and lowest levels of preference among interviewees, in their own words. Erythrina and Jackfruit tree were included among the least preferred species

Species with the highest rejection rates			
Cecropia spp. ("Embaúba")	Dirties the cocoa crop, too many leaves fall down and gather on top of the crop, there are too many, large leaves, leaves do no decompose easily and attracts snakes, attracts insects to the crop, damages the cocoa production, has a very short life-cycle, makes the soil acidic, produces too much shade, low shade, softwood, no good for anything, dries out the soil	+ + (34.4)	+ + ++ (8.5)
Ficus spp. ("Gameleira")	Provides too much shade, no production under too much shade, in excess, tree is too big, its canopy is huge and tree is difficult to bring down, damages the cocoa plant, no good for anything, kills the trees shading the cocoa crop, branches break and destroy the crop, roots damage the cocoa crop, brings lots of brown rot, dries the soil, sucks water, brings bad luck to the farm, takes up too much space, too many leaves, softwood, low canopy	+ + (21.9)	+ (1.9)
Erythina spp. ("Eritrina")	Branches fall and break cocoa plant, takes in water at night and produces water in the day, provides too much shade, there are too many, too many thorns, soft/bad wood, leaves can be used as organic fertilizer, encourages brown rot, pollutes the water, attracts too many bromeliads, attracts snakes and ants, has no uses, provides good shade, leaves the earth humid, grows fast	+ + (21.9)	+ + + (5.4)
Artocarpus heterophyllis (Jackfruit tree)	Too much shade and cocoa does produce fruit underneath it, fruits, animal fodder, there are too many, provides good shade with no mess, good shade, dries out the soil, covers the cocoa crop, produces brown rot, large leaves, big leaves, damages the soil and affects the production of cocoa fruits, low canopy, it's no good	+ + + + (71.9)	+ + + (5.1)
Schefflera morototoni ("Matataúba")	Too much shade, low quality shade, large leaves, too many leaves fall, closes the cocoa crop, softwood, short life-cycle, bad for the cocoa, dirties the soil too much, damages the cocoa, there are too many, affects the cocoa production, dries out the land, it is worthless	n.a.	n.a.
Trema micrantha ("Corindiba or Candiúba")	Shelters lizards, brings woodworm to the cocoa crop, too much shade, good shade, low shade, softwood, its branches break and fall on the crop, there are too many, dries out the soil, only good as firewood and for cultivating cocoa, its shade is no good, leaves do not decompose easily, short life-cycle	+ + (23.4)	n.a.
Inga spp. ("Ingazeira")	Dries up the soil, too much shade, too many seedlings and closes the area, its branches break and fall on the cocoa crop, softwood, does not allow the crop to develop and produce fruits, food, used for drying, low canopy, fruit can be eaten and sold	n.a.	+ (0.76)
Aegiphila sellowiana ("Fidalgo")	There are too many, loses too many leaves, damages the cocoa production, low shade, too much shade, softwood, no good for anything, only good for firewood, short life-cycle, large leaves prevent the rain from wetting the ground	+ + (23.4)	n.a.
Cestrum laevigatum ("Coarana")	Produces too much shade for the cocoa crops, its shade puts pressure on the cocoa plant and suffocates the plant below, low quality shade, the cocoa cannot develop and produce fruit, low shade, branches fall and damage the crop, there are too many, no good, too many leaves, dries out the land, softwood	n.a.	n.a.
Croton urucurana ("Lava-prato")	Softwood, dries out the soil, produces too many seeds, its leaves are too big, too much shade, low shade, falls on the crop	+ (17.2)	+ (0.3)
Tapriria guianensis ("Pau-pombo")	There are too many, too much shade, closes in on the crop, weak wood and damages the crop, falls on the crop, shade too low, produces too many seeds, dries out the soil, it is no good	+ + (18.8)	+ + + (5.6)

* Frequency results in the species survey conducted in 2008 by Sambuichi *et al.* (2012): + = 1-18%, ++ = >18-36%, +++ = >36-54%, ++++ = >54%.
** Density variation (number of individuals of a species per hectare) - calculation based on comparison between densities found in the species survey carried out in 1964 by Alvim and Pereira (1965) and Sambuichi *et al.* (2012): + = 0-2; + += >2-4; + + += >4-6; + + ++ += >6
n.a.: not available

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LOCAL TREE PREFERENCES IN THE CACAO-CABRUCA SYSTEM IN THE SOUTHEAST OF BAHIA, BRAZIL

Abstract: The areas occupied by cocoa crops shaded with native species (*cabruca*) have an important environmental role. However, studies show that the diversity of native tree species in these areas has been gradually diminishing. The aim of this study is to identify the perceptions and preferences of farmers with regard to tree species which provide shading in *cabruca* areas and how these local species are employed and managed. The species most preferred by farmers were mainly made up of native timber species with high economic value, followed by fruit species, which were mainly exotic. These species have stood out among the dominant species in *cabruca*s in the region, as shown by a survey of species carried out in 2008. This is mainly due to the shade management adopted by farmers who tend to favour the cultivation and natural regeneration of preferred species in detriment of less popular species.

Key-words: Tree species; Atlantic Forest; Cacao region of southern Bahia; Perception.

Resumo: As áreas ocupadas pelo cultivo de cacau sombreado com espécies nativas (cabruca) desempenham uma importante função ambiental. No entanto, estudos mostram que a diversidade em espécies arbóreas nativas nessas áreas vem sendo reduzida gradualmente. Este estudo teve como objetivo identificar as percepções e preferências dos agricultores em relação às espécies arbóreas que compõem o sombreamento nas cabrucas assim como os usos locais dessas espécies e o seu manejo. As espécies de maior preferência dos agricultores foram compostas majoritariamente por espécies nativas madeireiras de elevado valor econômico, seguidas de espécies frutíferas, principalmente formada por exóticas. Essas espécies se destacaram entre as espécies dominantes nas cabrucas da região, conforme os resultados de um levantamento de espécies realizado em 2008. Isso se deve em grande parte ao manejo da sombra adotado pelos agricultores, que tende a favorecer o plantio e a regeneração natural das espécies preferidas em detrimento daquelas pouco apreciadas.

Palavras-chave: Espécies arbóreas; Mata Atlântica; Região cacaueira do Sul da Bahia; Percepção.

Resumen: Las zonas ocupadas por el cultivo de cacao sombreado con especies nativas (cabruca) tienen un importante papel ambiental. Sin embargo, los estudios muestran que la diversidad en especies de árboles nativos en estas áreas se reduce gradualmente. Este estudio pretende identificar las percepciones y preferencias de los agricultores en relación

con especies de árboles de sombra, así como sus usos locales y su gestión. Las especies de mayor preferencia de los agricultores fueron compuestas principalmente por especies maderables de alto valor económico, seguidas de especies frutales, compuestas principalmente de árboles exóticos. Estas especies se destacaron entre las especies dominantes en la región, como se muestra en un estudio de especies hecho en 2008. Esto es debido en gran parte a la gestión de sombra adoptada por los agricultores, que tiende a favorecer la regeneración natural y siembra de las especies preferidas en detrimento de las especies poco apreciadas.

Palabras clave: Espécies de árboles; Mata Atlantica; Región del cacao del sur de Bahia; Percepción.