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Biodiversity

Woody Plants Diversity in Cocoa Farms of Grand Zattry Region Southern Côte D'ivoire

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Abstract | **Original Research Article**

This study was carried out in cocoa plantations of the south-western Côte d'Ivoire. The main objective was to evaluate the richness and diversity of the natural remaining or introduced trees with DBH≥10 cm associated with cocoa in 102 ha plots in so many farms belonging the three main farmers' origins (35 autochthonous, 34 allochthonous and 33 foreign). The flora showed 208 vascular plant species from 153 genera and 51 families among which there are 3 endemics to Côte d'Ivoire, 28 rare and endangered tree species reflecting the potentiality of these cocoa farms for biodiversity conservation. The plot average floristic richness set between19-20 species/ha is not influenced by the origin of cocoa farmers.

Keywords: Native and exotic trees, biodiversity conservation, Cocoa production, farmers' origin, Côte d'Ivoire.

INTRODUCTION

The destruction of natural ecosystems causes in general 70% of global biodiversity [1]. In the tropics, studies have argued that agriculture is one of the main causes of tropical forest cover regression [2, 3] and a threat to biodiversity as the crops take the place of natural plant species [4]. In Côte d'Ivoire, this upheaval is rooted in the rapid growth of populations and the need for land for agriculture which is an intensive use of resources to ensure rapid economic growth and excessive deforestation [5, 6]. However, agricultural activity can be a source of biodiversity by maintaining or creating habitat favorable to its development. Thus, many animals and plants species are subservient in agrosystems. Farmers can be managers of the natural environment and promote biodiversity if they have environmentally friendly practices.

In west Africa, agroforestry systems are often seen as a strategy that benefits to both authorities and farmers in terms of environmental protection, provision of environmental services (ecosystem services) and income diversification [7] to [14]. However, there is a delicate balance between agriculture and biodiversity which can be disrupted by specialization and the intensification of certain production methods. Such as marginalization and/or abandon of traditional land management [15]. If agroforestry is perceived today as a sustainable agro-ecological practice, it remains a very old practice for cocoa cultivation whose main objective was not to maintain the biodiversity but rather the life of cocoa perceived as a tree enjoying shade [16, 17]. Nowadays, cocoa like most perennial crops is grown in farm types from mixed shade or productive shade systems (fruit crops or woody association) to very specialized shade (crops-legumes) and finally to full sun systems [18]. Rustic mixed shade systems still mostly found in Cameroon and Nigeria while in western Africa, cocoa cultivation has been intensified with the removal of shade from the monoculture practice [19]. Although Côte d'Ivoire provides 40% of world cocoa production [20] it is among the lowest performing countries in the world [21]. The causes of the decline in cocoa farms productivity are the dominance of full-sun cropping systems which lead to an increase in yield in the short term [22, 11] and the serious soil degradation and rapid deforestation [23].

In Côte d'Ivoire during the recent decades the increase in cocoa production catalyzed by an environment conducive to culture has attracted a flow of migrants from neighboring countries, leading to the destruction of much of the forest of the upper Guinea, biodiversity hotspot [9, 24]. According to [25], all Côte d'Ivoire regions have been affected by deforestation

mainly in the south-west which accounted for 91% of the country's forest areas in 1996. Additionally, the current Ivorian agricultural policy has had an ecological impact such as degradation of forest resources and unavailability of natural resources. That environmental crisis in Côte d'Ivoire like most tropical countries in the world cannot be dissociated the issues of preservation of natural resources, sustainability and food security. This study in Grand-Zattry region is intended to be a contribution to the knowledge of the associated biodiversity in cocoa farms in Côte d'Ivoire. As the farmers remain or introduce in plantations the plants those they know the uses, we hypothesize to find different plant richness and diversity between the farms of the three ethnic groups.

MATERIALS AND METHODS

Study sites

The study area is located in the southwest of Côte d'Ivoire, at Grand-Zattry in the Administrative Department of Soubré (Figure 1). Its vegetation belongs to the Guinean domain [26] and consists of a moist south-west evergreen forest [27]. The anthropogenic activities on this vegetation led to a new landscape with patches of forest amongst huge plantations of traditional perennial crops (coffee and cocoa) and industrial crops (rubber and palm oil). The climate is of the subequatorial type with two dry seasons and two rainy seasons. The average annual rainfall varies between 1600 and 1800 mm while the mean annual temperature is between 24 and 29 ° C [28]. The soils are highly desaturated ferralitic [29]. The main activity of the region is agriculture.

Data sampling

Data were sampled using ha (100m × 100m) plot method as recommended [30] and [31] that consists of identifying and measuring the circumferences of all individuals of woody plant species (trees, shrubs and lianas) whose DBH were equal to or larger than 10 cm. A total of 102 plots were inventoried as above in so much cocoa plantations that belong to the three local main farmers' ethnic groups as follow 34 plots from Baoulé people (allochthonous), 33 plots from Burnabe people (foreign) and 35 plots from Bété people (autochthonous).

Data analysis

Floristic richness

The richness of a site is the number of species that account this site [32]. It consists of counting all the species listed on the site regardless of their abundance. It has been determined for all plantations and each origin of farmers.

Species with particular status

The numbers of Ivorian endemic species [33-35] and of rare and threatened species to extinction [36] were analyzed and compared according the origin of farmers.

Floristic diversity

The diversity of flora in plantations was analyzed through the commonest indices.

Shannon-Weaner index

The Shannon-Weaner index measures the species composition of a stand considering the wealth. It is used to express the diversity of cocoa farms according to the origins of farmers.

$$H' = -\Sigma Pi \ln Pi$$

With Pi the relative proportion of the average recovery of species i in the community. It varies from 0 (monospecific stand) to NS (equitable distribution of all species).

Simpson index

Simpson's index (D') reports the abundance of one or a few species. It is strongly dependent on the number of rare species.

$$D' = 1 - D = 1 - \Sigma Pi^2$$

With $D = \Sigma Pi^2$ knowing that $Pi = ni/\Sigma ni$ and neither the average recovery of species i and Σni the total recovery of all species. The value of D' tends to a maximum of 1 when the D tends to 0 and therefore there are very few species; D' tends to 0 when D tends to 1.

Pielou equitability index

The Pielou index measures the degree of diversity reached by the population and corresponds to the ratio between the effective diversity H 'and the maximum theoretical diversity H'max.

$$J' = H'/\ln S$$

Where J' is Piélou's equitability index, H' is the Shannon-Weaner index and S represents the total number of species in a plot. According to [37] Piélou's equitability is low when J' is inside [0;0.6[that means presence of dominant species and when J' is included in [0.6; 0.8 [, the equitability is medium and finally the equitability is high, meaning a lack of dominance species when J' is inside [0.8; 1].

Hill index

The index of Hill combines the Shannon-Weaner (H) and Simpson diversity indices. It has been used for analysis of plantation diversity by origin. The formula is:

$$Hill = (\Sigma Pi2) - 11 / \exp [H']$$

With Pi the relative proportion of the average recovery of species i in the community and the Shannon index. The Hill index varies from 1 to α.

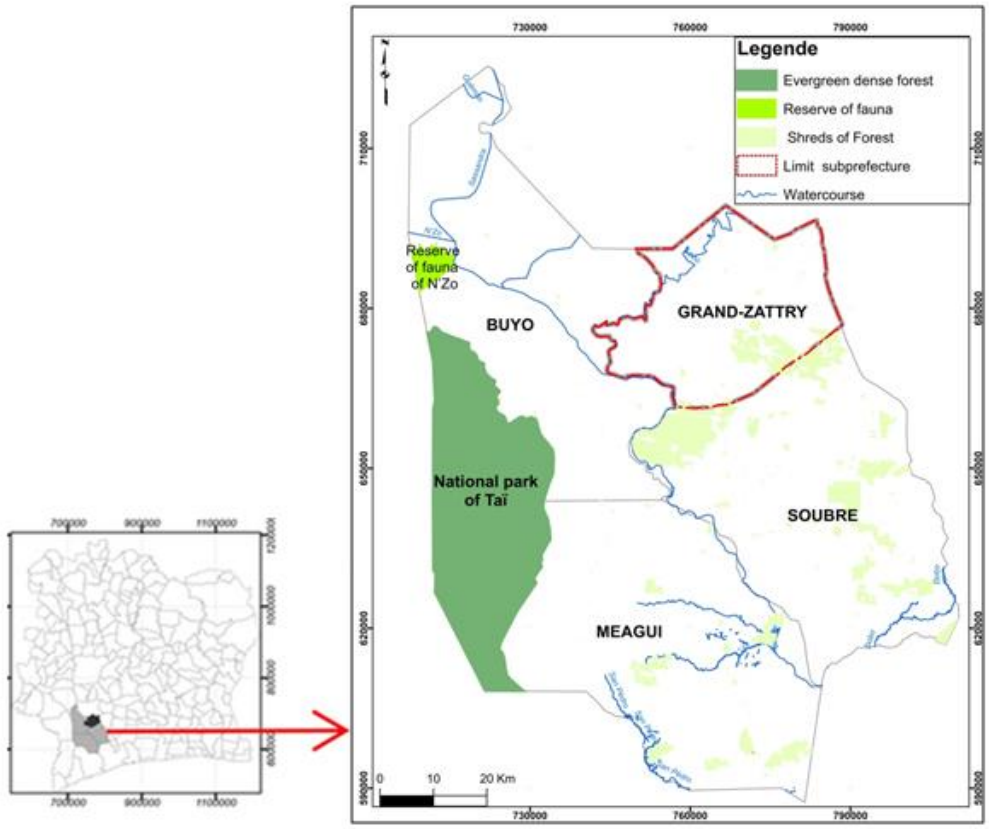

Fig-1: Localization of Grand-Zattry region. On the left the administrative map of Côte d'Ivoire is shown while on the right the locality where the current study was carried out is given on map of the Western Côte d'Ivoire region

Coefficient of similarity

The floristic resemblance between two spaces has been studied through the Morisita-Horn (MH) similarity index that allows ß diversity measurement. This similarity index considers the presence of the species and their abundance to evaluate the floristic resemblance [38].

$$MHij = (\Sigma\ PisPjs) / (\Sigma\ P2is + \Sigma\ P2ij)$$

Where Pis and Pjs respectively represent the probabilities that the species is derived from the records i and j. The values of this index vary from 0 to 100. The more two floristic lists have species in common, the more MH tends to 100.

Analysis of variance

The non-parametric test of Kruskall-Wallis has been used to compare the richness and the diversity indices in the plantations according to the origin of farmers. Then a Dunn post-hoc test with a degree of significance $p < 0.05$ was performed to check the differences between means. Finally, the box-plots method was used for a better visualization of the variations of means according to the origins of farmers.

RESULTS

Floristic richness

The flora recorded in all the 102 plotted plantations is estimated at 208 species of natural or exotic vascular plants that belong to 148 genera and 52 botanical families (Table 1) with 64 species common to the three farmers' origins (Appendix 1). These taxa are Dicotyledonous Angiosperms (97%) and Monocotyledonous Angiosperms. Among these cumulative taxa, 117 species have been accessed in all the cocoa plantations of foreign farmers, 136 species found in all the plantations of allochthonous farmers and 156 species met in all the plantations of autochthonous farmers (Table 1). But, at the individual plantation level, no difference has been found for the richness and the diversity indices in the plantations of these three origins of farmers as their mean values are similar (Table 2, Figure 2).

The similarity coefficient of Moresita-Horn revealed a high (≥79%) floristic similarity between cocoa plantations of any origins of farmers (Table 3).

Species with special status

We found *Baphia bancoensis* Aubrév. (Fabaceae), *Gymnostemon zaizou* Aubrév (Simaroubaceae). & Pellegr. and *Teclea carpopunctifera* A.Chev. (Rutaceae) that have not yet been reported

outside Ivorian territory in the plantations of autochtonous and allochthonous farmers (Table 4).

A total of 28 rare, vulnerable and endangered species has been found in all of the 102 Cocoa farms plotted in the Grand-Zattry region (Table 4). The taxa on the IUCN status categories are about 23 species (Table 4) comprising 20 vulnerable species (VU), four minor risk species (LR/nt) and one endangered species (EN). Those on Aké-Assi threatened category species list are about 09 species according to Aké Assi. For any categories of particular species status except the endangered species, autochthonous farmers protect more species in their farms than the two other origin of famers (Figure 3). Among these two last origins of farmers, foreign farmers protect fewer vulnerable species of IUCN and threatened species of Aké-Assi (Table 3) while similar number of minor risk species have been found in both farmer origins.

Table-1: The main botanical ranks of the flora recorded in cocoa farms foreign farmers are coming from outside of Côte d'Ivoire (Burkinabé), allochthonous farmers are from another region of Côte d'Ivoire (Baoulé) while autochthonous farmers are from the study region (Bété)

Botanical ranks	Origins of cocoa famers			Total
	Foreign	Allochthonous	Autochthonous	
Families number	43	41	46	52
Genera number	93	98	118	148
Species number	117	136	156	208
Dicotyledonous Angiosperms	112	133	151	204
Monocotyledonous Angiosperms	4	4	4	4

Foreign farmers are coming from outside of Côte d'Ivoire (Burkinabé), allochthonous farmers are from another region of Côte d'Ivoire (Baoulé) while autochthonous farmers are from the study region (Bété).

Table-2: Richness and diversity indices of the cocoa plantations according to origins of farmers

Parameters	Variables	Origins of cocoa famers		
		Foreign	Allochthonous	Autochthonous
Richness (Species/ha)	Minimum	11	11	7
	Maximum	36	35	34
	Mean	19[a]	19[a]	20[a]
	Standard deviation	5.91	4.93	5.97
Shannon-Weaner index (bits/ha)	Minimum	1.51	1.71	0.99
	Maximum	3.15	2.93	3.05
	Mean	2.26[a]	2.40[a]	2.33[a]
	Standard deviation	0.36	0.32	0.47
Simpson index (bits/ha)	Minimum	0.60	0.56	0.60
	Maximum	0.93	0.93	0.94
	Mean	0.81[a]	0.85[a]	0.82[a]
	Standard deviation	0.08	0.08	0.11
Hill index (bits/ha)	Minimum	0.45	0.42	0.43
	Maximum	0.84	0.87	0.88
	Mean	0.63[a]	0.69[a]	0.65[a]
	Standard deviation	0.10	0.13	0.12
Pielou index	Minimum	0.54	0.48	0.48
	Maximum	0.91	0.95	0.95
	Mean	0.77[a]	0.82[a]	0.79[a]
	Standard deviation	0.09	0.10	0.13

Foreign farmers are coming from outside of Côte d'Ivoire (Burkinabé), allochthonous farmers are from another region of Côte d'Ivoire (Baoulé) while autochthonous farmers are from the study region (Bété)

Table-3: Matrix of Moresita-Horn's similarity index in the cocoa plantations according to origins of farmers

Origins of cocoa famers	Foreign	Allochthonous	Autochthonous
Foreign	100		
Allochthonous	86	100	
Autochtonous	79	79	100

Foreign farmers are coming from outside of Côte d'Ivoire (Burkinabé), allochthonous farmers are from another region of Côte d'Ivoire (Baoulé) while autochthonous farmers are from the study region (Bété)
Table 4: Species with particular status in the plantations according to the origins of farmers.

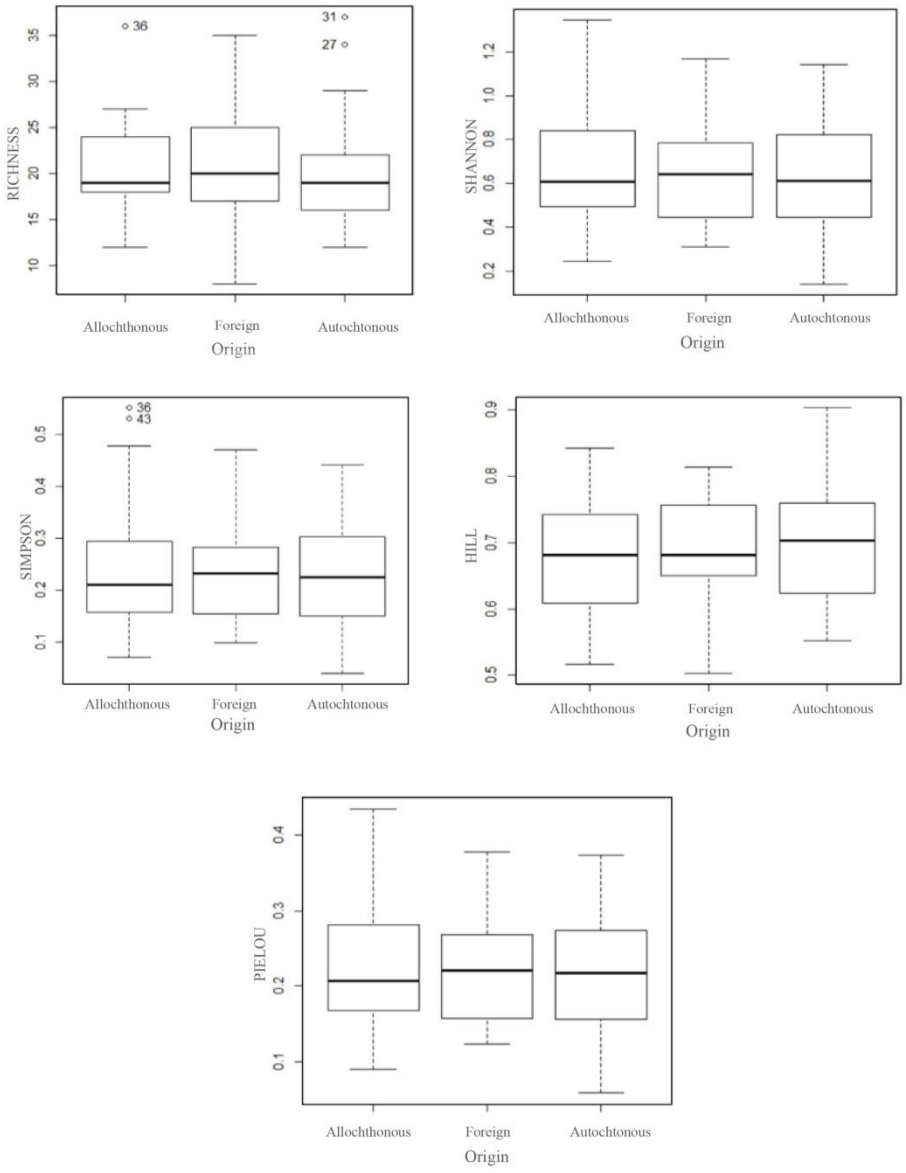

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Fig-2: Richness and diversity indices of the plantations according the origins of farmers

Table-4: Foreign farmers are coming from outside of Côte d'Ivoire (Burkinabè), allochthonous farmers are from another region of Côte d'Ivoire (Baoulé) while autochthonous farmers are from the study region (Bété). For species status according to [36], read endangered species for EN, vulnerable species for VU and minor risk species for LR/nt

Species	Families	Status source		Origins of cocoa famers		
		UICN	Aké-Assi	Foreign	Allochthonous	Autochtonous
Afzelia africana	Fabaceae	VU			x	
Albizia ferruginea	Fabaceae	VU				x
Cleidion gabonicum	Euphorbiaceae		x		x	
Cordia platythyrsa	Boraginaceae	VU		x		x
Entada gigas	Fabaceae		x			x
Entandrophragma angolense	Meliaceae	VU			x	x
Entandrophragma candollei	Meliaceae	VU		x	x	x
Entandrophragma cylindricum	Meliaceae	VU		x	x	x
Entandrophragma utile	Meliaceae	VU		x	x	x
Eribroma oblongum	Malvaceae	VU			x	
Erythrina vogelii	Fabaceae		x		x	x
Garcinia kola	Clusiaceae	VU	x		x	x
Guarea cedrata	Meliaceae	VU				x
Gymnostemon zaizou	Simaroubaceae	VU	x			x
Irvingia gabonensis	Irvingiaceae	LR/nt		x	x	x
Khaya grandifoliola	Meliaceae	VU				x
Lannea nigritana	Anacardiaceae	VU	x	x		
Milicia excelsa	Moraceae	LR/nt	x	x	x	x
Milicia regia	Moraceae	VU	x	x	x	x
Nesogordonia papaverifera	Malvaceae	VU		x	x	x
Oricia suaveolens	Rutaceae	LR/nt				x
Pierreodendron kerstingii	Simaroubaceae	VU				x
Pterygota bequaertii	Sterculiaceae	VU				x
Pterygota macrocarpa	Sterculiaceae	VU		x	x	x
Teclea carpopunctifera	Rutaceae	VU	x			x
Terminalia ivorensis	Combretaceae	VU		x	x	x
Tieghemella heckelii	Sapotaceae	EN		x	-	x
Triplochiton scleroxylon	Malvaceae	LR/nt		x	x	x

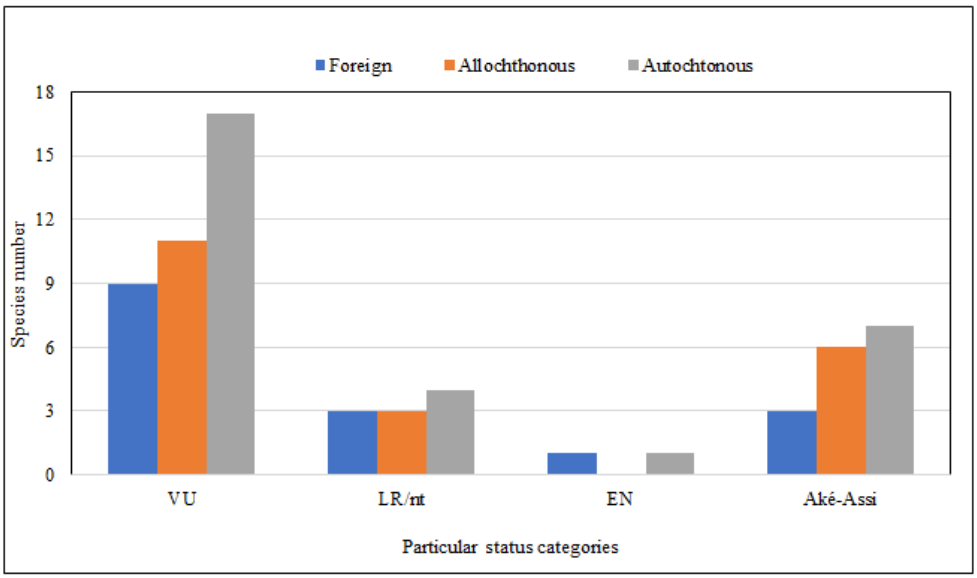

Fig-3: Richness in terms of species with particular status in the plantations according to the origins of farmers

Foreign farmers are coming from outside of Côte d'Ivoire (Burkinabè), allochthonous farmers are from another region of Côte d'Ivoire (Baoulé) while autochthonous farmers are from the study region (Bété). For species status according to [36], read endangered species for EN, vulnerable species for VU and minor risk species for LR/nt.

DISCUSSION

In Grand-Zattry region, cocoa is cultivated mainly by the three main ethnic groups (Bété, Baoulé, Burkinabè) that are essential components of their riparian population. The flora associated with the cocoa in plantations varies qualitatively and quantitatively according to the origin of the farmers explaining the differences at several botanical ranks (Table 1, Appendix) and at the level of the particular status species (Table 4, Figure 3) between the plantations of autochthonous farmers and the plantations of the two others origins. In fact, in West Africa and specifically in Côte d'Ivoire, cocoa farms are mostly established following a similar model referred to as short-term ''boom-and-bust cycles'' [39]; primary or secondary forests are selectively cleared, burned and cocoa is planted along with understory food crops [40, 41]. And due to their cultural knowledge of plants, farmers preserve and/or introduce some woody plants for their primary needs [42, 43]. The highest richness for all plants and those of particular status in the all plantations of autochthonous farmers (Tables 1, 2, Figure 3) can be attributed to the deeper knowledge of the autochthonous farmers to the local plants and their uses. Our results are supported by those of [44] who have shown that in a general way, the diversity of trees in cocoa systems is variable depending on cultural differences, location and history of exploitation [44]. Showed that although all non-native and non-native farmers conserve useful plants in their plantations although the natives conserve and even plant a greater density and diversity of trees other than cocoa.

At the ha plot level, the lack of influence of the farmers' origins on the richness and the diversity indices (Table 2) indicates that in Grand-Zattry region, all the farmers from any of the three origins preserve or introduce around 20 woody species with DBH ≥10 cm in a ha of plantation. This α diversity within the plantations of different socio-cultural groups in Grand-Zattry region (Table 2) is poorer than the cocoa plantations of Duekoué region and of Scio region with respectively 32 species/ha and 40 species/ha [42] although both regions are only around 50 km from Grand-Zattry (Figure 1). It is as far poorer than the 112-64 species/ha found respectively in young and old cocoa farms in the centre Côte d'Ivoire [45].

Part of the difference of richness and diversity of woody and non-cocoa trees between cocoa plantations of Grand-Zattry region and, those of Duekoué and Scio regions [42] and centre Côte d'Ivoire [45] can be due to the difference in the forest landscape between Grand-Zattry, Duekoué, Scio and centre Côte d'Ivoire. The original vegetation of Grand-Zattry and Scio belongs to the rain evergreen forest while those of Duekoué and centre Côte d'Ivoire includes the rain semi-deciduous forest [27]. Therefore, the natural trees to be preserved in cocoa farms can vary qualitatively from Duekoué to the two other regions.

The other part of the difference in richness and diversity of woody plants from Grand-Zattry's region cocoa farms in comparison to the cocoa farms from other regions in Côte d'Ivoire [42, 43, 45] is tributary of the difference of social and cultural knowledges and rituals of the farmers mainly the autochthonous. Foreign and allochthonous farmers are taught first by autochthonous farmers the native plants needed for local uses (medicinal, foods, craft etc.). Gradually, foreign and allochthonous farmers introduce their own knowledge useful plants in their farms thus sharing with autochthonous farmers their knowledges. Finally, the same useful native and non-native plants live in the cocoa farms independently of the origins of the farmers as found in Grand-Zattry region (Tables 2 & 3, Figure 2). According to [44], traditional cocoa farms seem to harbor advantages of forest species if they are located in landscapes with high forest cover, suggesting that forests constitute an important source of species in agroforestry landscapes. Furthermore, our results are in accordance with the standards required by the certification programs which recommends 18 to 25 trees to be maintained in a plantation for a significant involvement of certification programs in the management of cocoa farms in the study area [54]. However, this management of plantations by the cocoa industry seems to be incomplete because it considers the preference of the farmers which is constantly variable according to ecological and climatic hazards.

The weak and similar values of Shannon, Simpson, Pielou and Hill diversity indices in cocoa plantations of Grand-Zattry. Region according to the origins of farmers (Table 2) indicate that this cocoa cultivation has an impact on the vegetation whatever the management of the different farmers' origins as have shown by some studies [43, 46, 47]. The similarity coefficient of Moresita-Horn (Table 3) reveals a resemblance of more than 50% between cocoa trees of different farmers' origins which reflect a floristic similarity between these cocoa farms due the similarity farming practices. However, this similarity is higher between the plantations form foreign farmers and those from allochthonous farmers (Table 3). The presence of some species with particular status in all the cocoa farms of Grand-Zattry region (Table 4) confirms the results of [48- 53] who have shown that cocoa farming offers options for conserving biodiversity.

CONCLUSION

This study reveals the presence of several woody tree species (208 species for 102 ha) in the cocoa farms of Grand-Zattry region comprising native and non-native species (Appendix). This flora is also diverse in terms of botanical subdivisions but belongs fully to Angiosperms group with 97% of Dicotyledonous. In terms of total flora of woody trees in plantations according to the origin of the farmers, our hypothesis to find different plant richness and diversity between the farms of the three ethnic groups is confirmed. In fact, autochthonous farmers' cocoa plantations showed higher total richness while the foreign farmers' cocoa plantations expressed the lower total richness. But at the plot level, plantations from all the three farmers' origins showed similar richness and diversity indices of woody trees comprising native and non-native species. It means that a hectare plantation is too small to detect difference of flora of woody trees between cocoa farms from the three main farmers' origins in Grand-Zattry region as their socio-cultural habits became similar along time. The high values of Morisita-Horn similarity index between these cocoa farms from the three main farmers' origins confirm the proximity of the socio-cultural practices of these farmers. The presence of 3 Ivorian woody endemic species, 28 rare and endangered woody species in the cocoa farms and more especially in autochthonous farmers' plantations let to suggest the implementation of the agroforestry management system as a better solution for plants conservation in a context of African tropical forest rapid deforestation and loss of its flora. But many questions regarding which species are more suitable in cocoa plantations for better incomes to farmers, what is the interval of trees density in plantations that will not have negative impacts on cocoa production, why farmers conserve or introduce these trees in their farms etc. need to be answered to improved the behavior of cocoa farmers and preserve tropical forest and its biodiversity.

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Appendix. Occurrences and individual number of the woody plant species in the cococa farms according to the farmers' origins

		Allochthonou farmers (Baoulé)		Autochthonous farmers (Bété)		Foreign farmers (Burkinabé)	
Species	Families	Occurrence	Individual Number	Occurrence	Individual Number	Occurrence	Individual Number
Acioa barteri (Hook. ex Oliv) Engl.	Chrysobalanaceae			2	4	1	1
Adansonia digitata Linn.	Malvaceae					1	1
Afzelia africana Sm.	Apocynaceae			1	2		
Afzelia bella Harms var. gracilior Keay	Fabaceae	1	1				
Alafia barteri Oliv.	Apocynaceae			1	1		
Albizia adianthifolia (Schumach.) W.F.Wright	Fabaceae	3	3	2	2	2	2
Albizia ferruginea (Guill. & Perr.) Benth.	Fabaceae	3	4	2	2	1	1
Albizia zygia (DC.) J.F.Macbr.	Fabaceae	20	73	22	53	14	51
Alchornea cordifolia (Schum. & Thonn.) Müll.Arg.	Euphorbiaceae	4	10	8	21	14	42
Allophylus africanus P.Beauv.	Sapindaceae	3	3				
Alstonia boonei De Wild.	Apocynacea e	5	5	8	15	8	9
Amphimas pterocarpoides Harms	Fabaceae	3	4	2	3	3	3
Anacardium occidentalis Linn.	Anacardiaceae	3	3			2	2
Angylocalyx oligophyllus (Bak.) Bak.	Fabaceae			4	5		
Annona muricata Linn.	Annonaceae	1	1				
Anthocleista djalonensis A.Chev.	Gentianacea e	2	2			1	2
Anthocleista nobilis G.Don	Gentianaceae					2	3
Anthonotha macrophylla P.Beauv.	Fabaceae	1	4	1	2		
Anthostema aubryanum Baill.	Euphorbiaceae			1	1		
Antiaris toxicaria Lesch. var. africana (Engl.) C.C.Berg	Moraceae	4	10	8	12	4	5
Artocarpus heterophyllus Lam.	Moraceae	3	6	8	12	11	16

Atroxima liberica Stapf	Polygalaceae			1	1		
Aubrevillea platycarpa Pellegr.	Fabaceae					1	2
Baphia bancoensis Aubrév.	Fabaceae	3	6	4	10		
Baphia nitida Lodd.	Fabaceae	5	10	2	2	2	2
Berlinia grandiflora (Vahl) Hutch. & DaIz.	Fabaceae			1	1		
Blighia sapida K.D.Koenig	Sapindaceae	3	3			2	2
Blighia unijugata Baker	Sapindaceae			2	2	1	4
Blighia welwitschii (Hiern) Radlk.	Sapindaceae	1	1				
Bombax brevicuspe Sprague	Malvaceae	1	1				
Bombax buonopozense P.Beauv.	Malvaceae	7	10	4	6	2	2
Bridelia ferruginea Benth.	Phyllanthaceae					1	2
Bridelia grandis Pierre ex Hutch.	Phyllanthaceae	1	1	5	10	1	4
Bridelia micrantha (Hochst.) Baill.	Phyllanthaceae	1	1	1	1		
Buchholzia coriacea EngI.	Capparidaceae	1	1	1	1		
Campylospermum glaberrimum (P.Beauv.) Farron	Ochnaceae					1	1
Canarium schweinfutii Engl.	Burseraceae	1	1	1	1	2	2
Carapa procera (DC.) De Wilde	Meliaceae			1	1		
Carica papaya Linn. var. papaya	Caricaceae	20	74	19	74	22	109
Carpolobia lutea G.Don	Polygalaceae	1	2				
Casearia calodendron Gilg	Salicaceae					2	3
Ceiba pentandra (Linn.) Gaertn.	Malvaceae	20	45	22	45	17	45
Celtis adolfi-fridericii Engl.	Ulmaceae	1	3	4	7	1	2
Celtis mildbraedii Engl.	Ulmaceae	1	1	2	3	6	10
Celtis philippensis.Blanco	Ulmaceae	2	2			3	3
Celtis zenkeri EngI.	Ulmaceae			4	6		
Chassalia kolly (Schumach.) Hepper	Rubiaceae	1	1				
Christiana afrïcana DC.	Malvaceae	1	1			1	4
Chrysophyllum perpulchrum Mildbr. ex Hutch. & Dalz.	Sapotaceae	1	1	2	3		
Chrysophyllum pruniforme Engl.	Sapotaceae	2	2	1	1	1	1
Chrysophyllum ubanguiense (De Wild.) D.J.Harris	Sapotaceae			1	1		
Citrus aurantifolia (Christm.) Swingle	Rutaceae			1	1		
Citrus grandis Osbeck	Rutaceae	1	1	1	1	3	6
Citrus reticulata Blanco	Rutaceae	5	9	3	3		
Citrus sinensis (L.) Osbeck	Rutaceae	21	84	7	9	18	33
Cleidion gabonicum Baill.	Euphorbiaceae	1	2				
Cleistopholis patens (Benth.) Engl. & Diels	Annonaceae			1	1		
Cnestis corniculata Lam.	Connaraceae					1	2
Cocos nucifera Linn.	Arecaceae	4	7	6	7	3	4
Coffea arabica L.	Rubiaceae	15	213	4	20	24	448
Cola caricaefolia (G.Don) Schumann	Malvaceae	1	3				
Cola lateritia Schumann var. maclaudi Brenan & Keay	Malvaceae			1	1		
Cola nitida (Vent.) Schott & Endl.	Malvaceae	13	34	21	96	15	72
Cordia guineensis Schum. & Thonn.	Boraginaceae			1	2		

Cordia platythyrsa Bak.	Boraginaceae	1	2			1	12
Cordia senegalensis Juss.	Boraginaceae	1	2				
Crescentia cujete L.	Bignoniaceae	1	1				
Croton penduliflorus Hutch.	Euphorbiaceae	1	1				
Dacryodes klaineana (Pierre) H.J.Lam,	Burseraceae			1	1		
Dalbergia oblongifolia G.Don	Fabaceae	9	13	1	2	3	9
Daniellia ogea (Harms) Rolfe ex Holland	Fabaceae	1	1	2	2		
Dasylepis brevipedicellata Chipp	Flacourtiaceae			1	1		
Deinbollia pinnata (Poir.) Schum. & Thonn.	Sapindaceae	2	2				
Dialium dinklagei Harms	Fabaceae	1	1	1	1		
Dichapetalum madagascariense Poir.	Dichapetalaceae			3	16		
Diospyros abyssinica (Hiern) F.White	Ebenaceae	2	2	3	4		
Diospyros heudelotii Hiern	Ebenaceae					1	2
Diospyros kamerunensis Gurke	Ebenaceae			1	1		
Diospyros soubreana F.White	Ebenaceae			2	2		
Discoglyprernna caloneura (Pax) Prain	Euphorbiaceae			3	5	4	5
Distemonanthus benthamianus Baill.	Fabaceae	1	3	2	4		
Dracaena arborea (Willd.) Link.	Dracaenaceae	2	11	3	5	1	2
Dracaena mannii Baker	Dracaenaceae			1	1		
Elaeis guineensis Jacq.	Arecaceae	23	140	21	115	30	138
Entada gigas (Linn.) Fawcet & Rendle	Fabaceae	1	1				
Entandrophragma angolense (Welw.) C.DC.	Meliaceae	2	2	5	9		
Entandrophragma candollei Harms	Meliaceae	2	4	2	2	2	2
Entandrophragma cylindricum (Sprague) Sprague	Meliaceae	8	16	12	35	5	10
Entandrophragma utile (Dawe & Sprague) Sprague	Meliaceae	5	5	3	6	4	4
Erythrina senegalensis DC.	Fabaceae	2	4			2	2
Erythrina vogelii Hook.f.	Fabaceae			1	2		
Ficus barteri Sprague	Moraceae	1	1				
Ficus bubu Warb.	Moraceae	1	1	2	3	3	5
Ficus exasperata M.Vahl	Moraceae	29	142	22	73	27	107
Ficus kamerunensis Warb. ex Mildbr. & Burret	Moraceae	2	6			1	2
Ficus lutea M.Vahl	Moraceae			1	1	1	1
Ficus mucuso Welw. ex Ficalho	Moraceae			7	10	3	5
Ficus polita M.Vahl.	Moraceae	1	1	1	1		
Ficus scott-elliotii Mildbr. & Burret	Moraceae			3	6		
Ficus sur Forssk..	Moraceae	17	54	6	11	20	45
Ficus thonningii Blume	Moraceae	1	5			1	2
Ficus umbellata M.Vahl	Moraceae			3	3	2	2
Ficus vogeliana (Miq.) Miq.	Moraceae	4	8	4	4	8	13
Flabellaria paniculata Cav.	Malpighiaceae			2	2		
Funtumia africana (Benth.) Stapf	Apocynaceae	3	5	1	1		
Funtumia elastica (P.Preuss) Stapf	Apocynaceae			1	1		

Garcinia gnetoides Hutch. & Dalz.	Clusiaceae	1	7			2	2
Garcinia kola Heckel	Clusiaceae	3	4			1	1
Glyphaea brevis (Spreng.) Monachino	Malvaceae	2	5	1	1	2	2
Grossera vignei Hoyle	Euphorbiaceae	1	1			1	2
Guarea cedrata (A.Chev.) Pellegr.	Meliaceae			5	8		
Gymnostemon zaizou Aubrév. & Pellegr.	Simaroubaceae			1	1		
Hannoa klaineana Pierre & Engl.	Simaroubaceae			3	5		
Harungana madagascariensis Lam. ex Poir.	Hypericaceae	8	17	4	6	4	6
Hevea brasiliensis (Kunth) Müll.Arg	Euphorbiaceae	10	342	16	358	14	115
Holarrhena floribunda (G.Don) Dur. & Schinz	Apocynaceae	14	27	8	16	9	21
Holoptelea grandis (Hutch.) Mildbr.	Ulmaceae			4	7	1	1
Homalium africanum (Hook f) Stapf	Salicaceae	3	3	1	1		
Homalium le-testui Pellegr.	Salicaceae			2	2		
Homalium lastoursvillense Pellegr.	Salicaceae	1	2				
Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill.	Irvingiaceae	2	4	11	18	2	3
Khaya grandifoliola C.DC.	Meliaceae			1	2		
Kigelia africana (Lam.) Benth.	Bignoniaceae	2	2	1	2		
Klainedoxa gabonensis Pierre	Irvingiaceae	3	3	4	6		
Lannea nigritana (Sc.Elliot) Keay var. nigritana	Anacardiaceae					1	2
Lecaniodiscus cupanioides Planch.	Sapindaceae			2	2	1	3
Leptoderris fasciculata (Benth.) Dunn	Fabaceae	1	1	1	3		
Macaranga heudelotii Baill.	Euphorbiaceae	1	1	1	1	1	1
Maesobotrya barteri Hutch. var. sparsiflora Keay	Phyllanthaceae	1	1				
Mangifera indica L.	Anacardiacea e	22	132	19	39	25	80
Mansonia altissima (A.Chev.) A.Chev var. altissima	Malvaceae			7	7		
Mareya micrantha (Benth.)Müll.Arg.	Euphorbiaceae	1	1	4	4		
Margaritaria discoidea (Baill.) Webster	Phyllanthaceae	2	3	6	8	3	4
Markhamia lutea (Benth.) Schumann	Bignoniaceae			1	3		
Markhamia tomentosa (Benth.) Schumann.	Bignoniaceae			1	2		
Milicia excelsa (Welw.) Benth.	Moraceae	14	30	8	11	10	15
Milicia regia A.Chev.	Moraceae	3	5	3	4	4	4
Millettia griffoniana Baill.	Fabaceae					1	1
Millettia zechiana Harms	Fabaceae	11	54	9	18	17	69
Monodora myristica (Gaertn.) Dunal	Annonaceae			1	1	1	1
Morelia senegalensis A.Rich. ex DC.	Rubiaceae	1	2	1	1	1	1
Morinda lucida Benth.	Rubiaceae	5	9	2	2	4	4

Moringa oleifera Lam	Moringaceae	1	1			1	1
Morus mesozygia Stapf ex A.Chev.	Moraceae	4	8	1	2	4	7
Musanga cecropioides R. Br.	Moraceae	2	6	1	3	2	3
Myrianthus libericus Rendle	Moraceae			7	11	3	3
Napoleonaea vogelii (Hook.f.) Planch.	Napoleonaeaceae			1	1	1	1
Nesogordonia papaverifera (A.Chev.) R.Capuron	Malvaceae	5	8	7	10	5	8
Musa paradisiaca Linn.	Musaceae	32	449	27	499	29	616
Newbouldia laevis (P.Beauv.) Seemann ex Bureau	Bignoniaceae	7	41	3	8	3	4
Oricia suaveolens (Engl.) I.Verdc.	Rutaceae			1	2		
Parkia bicolor A.Chev.	Fabaceae	2	2	4	4	3	3
Pentaclethra macrophylla Benth.	Fabaceae			1	1		
Persea americana Mill.	Lauraceae	29	137	16	34	20	75
Petersianthus macrocarpus (P.Beauv.) Liben	Barringtoniaceae			4	4	5	7
Pierreodendron kerstingii (Engl.) Little	Simaroubaceae			1	1		
Piptadeniastrum africanum (Hook.f.) Brenan	Fabaceae	1	1	1	1		
Pleioceras barteri Baill. var. barteri	Apocynaceae	1	2			1	1
Pouteria aningeri Baehni	Sapotaceae			1	1		
Pseudospondias microcarpa (A.Rich.) Engl.	Anacardiaceae	3	3	13	61	5	10
Psidium guajava Linn.	Myrtaceae	6	18	5	6	18	31
Psychotria guineensis E.M.A.Petit	Rubiaceae					1	1
Psychotria psychotrioides (DC.) Roberty	Rubiaceae			1	1	1	1
Psydrax horizontalis (Schum. & Thonn.) Bridson	Rubiaceae	1	1	1	1	1	1
Psydrax subcordata (DC.) Bridson	Rubiaceae			1	1		
Pterygota bequaertii De Wild.	Malvaceae			1	1		
Pterygota macrocarpa Schumann	Sterculiaceae	5	5	5	7	1	1
Pycnanthus angolensis (Welw.) Warbis	Myristicaceae	10	14	9	10	4	4
Raphia hookeri G.Mann & H.Wendl.	Arecaceae	4	33	6	27	4	33
Rauvolfia vomitoria Afzel.	Apocynaceae	5	8	5	6	3	4
Ricinodendron heudelotii (Baill.) Pierre ex Pax	Euphorbiaceae	8	10	15	22	3	3
Rinorea eiliotii Engl.	Violaceae					2	3
Rinorea kibbiensis Chipp	Violaceae	1	2	1	1		
Scottellia klaineana Pierre var. klaineana	Salicaceae			2	2		
Senna siamea (Lam) H.S.Irwin & Barneby	Fabaceae					1	4
Solanum erianthum D.Don	Solanaceae			1	8	1	2
Solanum rugosum Dun.	Solanaceae	9	27			3	8
Spathodea campanulata P.Beauv.	Bignoniaceae	17	63	15	38	10	38
Rinorea oblongifolia (C.H. Wright) Marquand ex Chipp	Violaceae			1	1		
Samanea dinklagei (Harrns) Keay	Fabaceae					1	1
Spondianthus preussii Engl. var. preussii	Euphorbiaceae					1	1
Spondias mombin Linn.	Anacardiaceae	13	43	19	268	17	45

Sterculia oblonga Mast.	Malvaceae	1	2	1	1		
Sterculia rhinopetala Schumann	Malvaceae	3	4	3	4		
Sterculia tragacantha Lindl.	Malvaceae	16	42	15	55	18	40
Stereospermum acuminatissimum Schumann	Bignoniaceae	1	1	1	1		
Synsepalum brevipes (Baker) T.D.Penn.	Sapotaceae			2	2		
Tabernaemontana crassa Benth.	Apocynaceae	2	3			1	2
Tamarindus indica Linn.	Fabaceae	1	1				
Teclea carpopunctifera A.Chev.	Rutaceae			1	1		
Terminalia ivorensis A.Chev.	Combretacea e	2	5	6	9	1	19
Terminalia superba Engl. & Diels	Combretacea e	10	28	11	19	9	21
Theobroma cacao Linn.	Malvaceae	34	19094	35	18340	33	18385
Tieghemella heckelii Pierre ex A.Chev.	Sapotaceae			1	2	1	1
Treculia africana Decne.var.africana	Moraceae	1	1	1	1		
Trema guineensis (Schum. & Thonn.) Ficalho	Ulmaceae	9	13	3	3	9	19
Trichilia martineaui Aubrév. & Pellegr.	Meliaceae	2	3	1	1		
Trichilia monadelpha (Thonn.) J.J.DeWilde	Meliaceae	1	1	2	2	2	2
Trichilia prieureana A.Juss. subsp. prieureana	Meliaceae	1	2				
Triplochiton scleroxylon Schumann.	Malvaceae	1	1	11	19	6	12
Uapaca guineensis Müll Arg.	Euphorbiaceae			2	3		
Vernonia colorata (Willd.) Drake	Asteraceae	3	4	1	1	1	2
Vismia guineensis (Linn.) Chcisy	Hypericaceae	1	2	1	1		
Vitex fosteri C.H.Wright	Verbenaceae	4	7	3	4	3	4
Xylopia aethiopica (Dunal) A.Rich.	Annonaceae	4	10	6	12	7	31
Xylopia quintasii Engl. & Diels	Annonaceae	1	1				
General total		34	21846	35	20845	33	21065