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Woody species diversity of *Vitellaria paradoxa* C.F. Gaertn traditional agroforests under different land management regimes in Atacora district (Benin, West Africa)

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Agricultural production in northern Benin is characterized by smallholder traditional agroforestry systems, with on-farm remnant tree species. Among its numerous advantages, agroforestry is known for its valuable contribution to biodiversity conservation. This study quantifies the importance of *Vitellaria paradoxa* C.F. Gaertn agroforests in terms of woody species conservation in Atacora district in Benin. Forest inventories were performed within 50×50 m plots constructed on a net grid map of Atacora district. Diversity indices were computed for both adult and juvenile species in two land management regimes: fields and fallows. Overall 41 woody species were recorded; 28 in fields and 36 in fallows. Taking into account matured and juvenile individuals, the diversity of woody species increased: 86 species in total; 69 species in fields and 78 in fallows. The biodiversity of *V. paradoxa*'s agroforestry parklands increases from fields to fallows, and decreases from bulk species (considering mature and juvenile species) to adult ones. *Leguminosae* and *Combretaceae* were the most abundant families registered. From the Cover Value Index, *V. paradoxa*, *Parkia biglobosa*, *Lannea microcarpa*, *Lannea acida* and *Diospiros mespiliformis* were the most abundant species. Support for maintaining this kind of agricultural system is needed, as this exemplifies the synergy for providing, provisioning and supporting services and biodiversity conservation.

Key words: Agroforestry, conservation, ecosystem services, farmland, shea tree.

INTRODUCTION

Agroforestry, the integration of trees with annual crop cultivation, livestock production and other farm activities, is a series of land management approaches practiced by more than 1.2 billion people worldwide (Jamnadass et al.,

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2013). According to some projections, the area of the world under agroforestry will increase substantially in the near future (Albrecht and Kandji, 2003). Therefore, agroforestry that characterize agricultural areas, appears to be the future landscape in West Africa sub-region, where agricultural land covers more than double of the area covered by forests. The ratio between agricultural land and forests is expected to rise due to population growth inappropriate agricultural production mainly. In order to feed the burgeoning global population, agricultural production has to grow in the coming decades. This makes trees on agricultural land a promising tool to address climate change mitigation and adaptation (Verchot et al., 2007; Henry et al., 2012) while enhancing biodiversity and human populations' livelihood.

The importance of agriculture in sub-Sahara African countries calls for new insights and consideration of agricultural activities not as a source of biodiversity loss but rather as a mean of its conservation considering the area covered by agroforestry. These strategies support the development of plans for ecoagriculture, a new type of agriculture that combines objectives of enhancing rural livelihoods, ensuring food security, and conserving biodiversity in the same landscape. ecoagriculture is advocated by many researchers to complement other conservation methods (McNeely and Scherr, 2003; McNeely and Schroth, 2006; Scherr and McNeely, 2002, 2012).

The integration of trees and crops is an environmentally sound land management conducive to moisture, soil conservation, and thus to high productivity (Traoré, 2003; Tomlinson et al., 1995; Jonsson et al., 1999). Trees in agroforestry systems provide traditional medicines as well as basic food commodities, including a variety of gums, oils, proteins, fruits, and drinks to a large number of people (Atakpama et al., 2012; Avocèvou-Ayisso et al., 2012; Edwige et al., 2012). There is ample evidence of indigenous knowledge and practices involved in enhancing biodiversity at the landscape level (Gadgil et al., 1993). Some food-providing trees and palms, especially fruit-producing ones, have been managed by people in a transition from the wild to cultivation in farmland for millennia, resulting in complex agroforestry systems that contain many different foods (Torquebiau, 1985)

Shea tree, *Vitellaria paradoxa* C.F. Gaertn, a tree belonging to Sapotaceae's family, is the most common species found in most of the traditional agroforestry parklands in West Africa (Breman and Kessler, 2011; Boffa, 2000; Aleza et al., 2015). In Atacora district in Benin, shea agroforests provide to rural households 36 to 46% of their income through the money gained from selling shea-based products (Gnanglé et al., 2009; Dah-Dovonon and Gnangle, 2006).

Previous studies in the region addressed the shea agroforests' population structure, land management and productivity (Djossa et al., 2008; Adissatou and Brice, 2009). Some showed its socio-economic and use values (Agbahungba et al., 2001; Assogbadjo et al., 2012) and its population adaptation along different ecological zones in Benin (Glèlè et al., 2011). Considering its wide distribution, agroforestry has the potential to enhance biodiversity conservation through *in situ* conservation. But the contribution of shea agroforests to the conservation of biodiversity at landscape level lacks scientific evidences.

For this reason, this study (i) examines the diversity of woody species in two land management regimes of Shea agroforests in Atacora district and (ii) compares the state of biodiversity conservation between adult woody species and the overall species taking into account juveniles and adults individuals. Addressing these objectives will show human impact on the agroforestry systems' physiognomy and biodiversity conservation. It is expected that this study will help to improve adoption of agroforestry projects and provide insights for farmers' management practices.

MATERIALS AND METHODS

Study area

Benin is divided into 12 districts which are further subdivided into 77 communes. Atacora district, concerned by the current work, is the northwestern one and covers a surface area of 20 459 km^2 over 112 622 km² of the country's area. Four over nine of Atacora communes have been investigated in the current study. These four communes cover 12,117 km^2 and are the following: Tanguieta, Materi, Cobly and Boukombé (Figure 1), all located in the Sudanian zone. Atacora district is one of the research sites of the WASCAL program (West African Science Service Center on Climate Change and Adapted Land Use) under which this study is enrolled. According to 2013 census, the district has a population of 769,337 inhabitants over 9,983,884 million of the total population (RPG4, 2013). A range of mountains extends along the northwest border and into the northeast Togo. Three major soil types can be found: tropical ferruginous soils, hydromorphic soils, and rough and undeveloped mineral soils. The climate in Atacora is characterized by two seasons: one rainy season from May to September, and one dry season for the rest of the year (Aregheore, 2009). The annual amount of rainfall varies between 900 and 1100 mm (Benin Republic, 1996). Variations in temperature increase when moving north through savannah towards the Sahel. A dry wind from the Sahara called Harmattan blows from December to March. On the social aspect, 70% of the population is rural with agricultural production the main activity. A wide variety of annual crops are grown: cotton, maize, sorghum, groundnut, cowpea, millet etc., associated with scattered multipurpose trees such as *V. paradoxa* and *Parkia biglobosa* Jacq. Dong (Aregheore, 2009; Vissoh et al., 2004).

Sampling design and data collection

Two land management regimes were examined in this study, namely fields and fallows. Fields are areas where annual crops are cultivated, whereas fallows are areas previously cultivated and left for a medium or long period to re-establish its vegetation structure and soil fertility. These are the most important land management regimes in Shea agroforests defined by scholars (Lovett and Haq, 2000; Boffa, 2000; Okiror et al., 2012; Akais Okia et al., 2005).

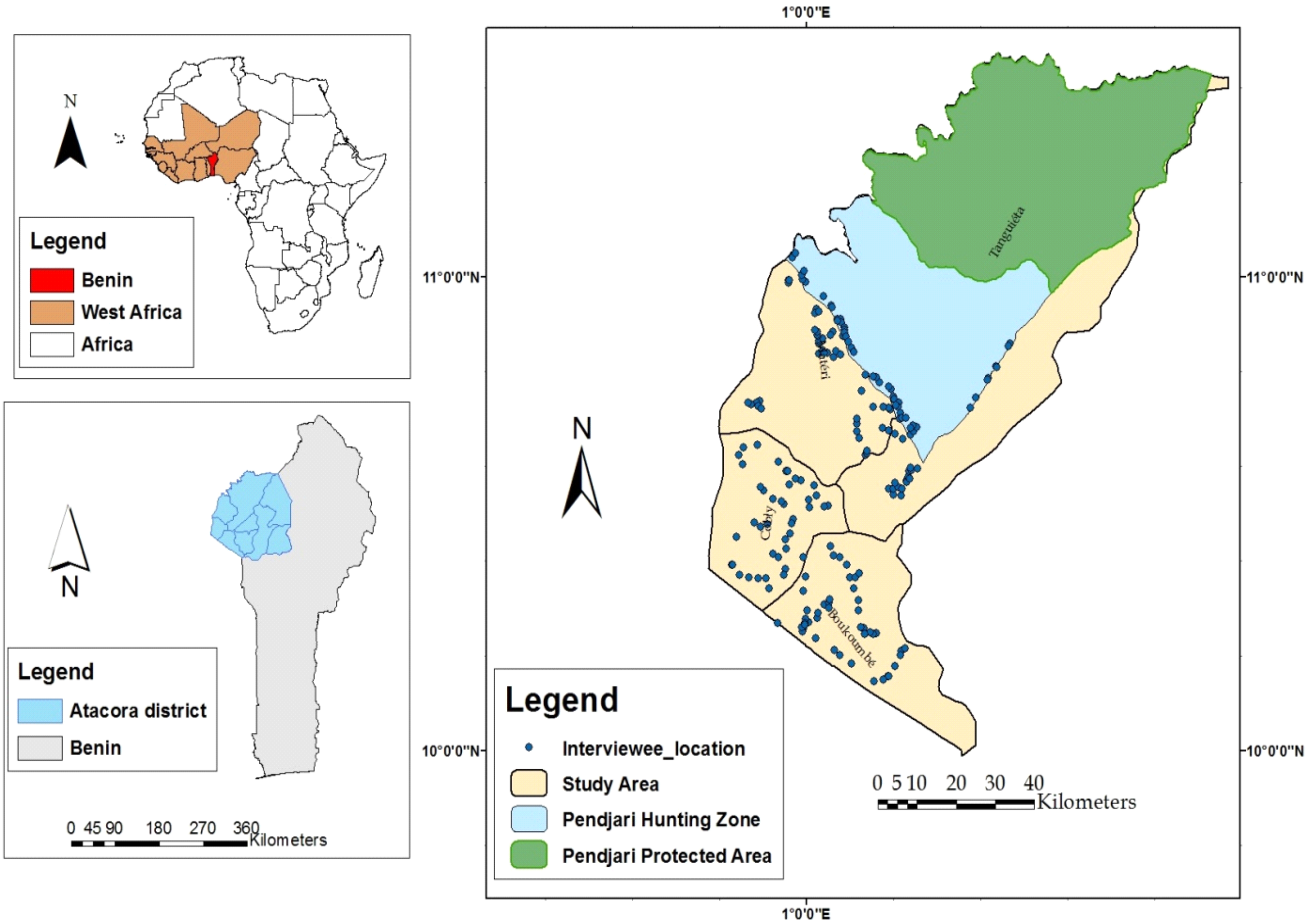

Figure 1. Sample sites within Atacora district in Benin.

The sampling method used is a cluster sampling. First, squares sized 10 x 10 km were chosen on a net grid map of Atacora's district. Within each selected square, one to ten plots sized 50 x 50 m (2500 m^2) were established according to the availability of shea stands and the accessibility of the considered area. Plots size was justified by the fact that they were successfully used in the same region during previous parklands studies (Wala et al., 2005; Byakagaba et al., 2011; Padakale et al., 2015). Overall, data were collected from 213 plots: 50 in Boukombé, 39 in Cobly, 47 in Materi and 76 in Tanguieta (Figure 1). The first plot was located randomly whilst the following ones were established at least at 100 m away from the first one. In each plot, all woody species were recorded and dendrometric parameters (circumference and total height) measured for adult trees species with diameter at breast height (DBH) ≥10 cm while those with DBH <10 cm were considered as juveniles. Species names were further conformed to those set by Brunel et al. (1984) and Akoègninou et al. (2006). Moreover, geographical coordinates of each plot were registered for cartography purposes.

Data analysis

Data collected were processed using Minitab 16, and ArcGIS 10. The first software was used for diversity indices calculation, the second one for statistical analysis where Fisher test was used to verify hypothesis in the difference of variables. The third one was used for mapping.

Alpha diversity indices of all species

All species encountered in this study were categorised into their respective families and genera according to those set by (Brunel et al., 1984; Akoègninou et al., 2006). Alpha diversity indices were computed for bulk species (both adult and juveniles). Each land management regime was characterized by alpha diversity indices: species richness (*S*), Shannon-Wiener diversity index (*H*) and Pielou evenness index (E) (Brower and Zar, 1984). The Pielou's evenness measures the similarity of the abundance of the different woody species sampled. Its value varies between 0 and 1. The value tends to 0 when one or few species had high abundance than others and 1 in the situation where all species had equal abundance (Magurran, 2004).

The species richness *S* is the total number of species recorded in a given land management regime. Shannon diversity index (*H*) was expressed as:

$$H = -\sum_{i=1}^{S}\left(\frac{Ni}{N}\right)\log\left(\frac{Ni}{N}\right) \quad (1)$$

Where *Ni* is the number of species *i*, *N* the total number of individuals sampled in a considered land management regime and *S* the total number of species encountered.

Whereas, Pielou evenness index (E) is computed as follows:

$$E = -\frac{\sum_{i=1}^{S}\left(\frac{Ni}{N}\right)\times\log_2\left(\frac{Ni}{N}\right)}{\log_2(S)} \quad (2)$$

Diversity indices of adult woody species

In addition to alpha diversity indices, woody species diversity indices were computed for adult woody species and also for the two distinguished land management regimes. Target indices are the cover value index (CVI), which was defined by Förster (Bailey and Dell, 1973) and used by de Olivera-Filho et al. (1989), the importance value index (IVI), (Curtis and McIntosh, 1950; Cottam and Curtis, 1956; Pereki et al., 2013) and the Sorenson-Dice coefficient (β) to compare the similarity of fields and fallows biodiversity.

CVI is used to evaluate the importance of the species within each of the land management regime. It gives equal weights to the species density through the number of individuals and equal size through the total basal area of the individual. CVI is expressed as:

$$CVI = RDe + RDo \quad (3)$$

where, RDe, the relative density is computed as follows:

RDe = (number of individuals of species *i* / total number of individuals) × 100

RDo, the relative basal area is obtained by using the following formula:

RDo = (total basal area for species *i* / total basal area of all species) × 100

$$RDo = \frac{g_i}{\sum_{i=1}^{n} g_i} \quad (4)$$

g, the basal area is computed as follows:

$$g_i = \frac{\pi}{4} d_i^2 \quad (5)$$

Where, d_i is the DBH of species *i*

The importance value index (IVI) is calculated as a sum of relative frequency, relative density and relative basal area of each species. The following formula was used:

$$IVI = CVI + RF \quad (6)$$

where RF, the relative frequency is calculated as follows:

RF = (frequency of species i / sum frequencies of all species) × 100 (6)

Sorenson-dice coefficient is expressed as follows:

$$\beta = \frac{2C}{A+B} \quad (7)$$

where, C is the number of species common to the two land management regimes, A is the number of species recorded in fields and B is the number of species registered in fallows.

RESULTS

Alpha diversity of woody species in fields and fallows

Overall, 1622 adult trees were measured over a total of 53.25 ha of land. Within this area, 86 woody species were recorded: 69 in fields and 78 in fallows (Table 1). The two land management regimes have many species in common. This is shown by Sorenson-Dice coefficient values: 0.72 for adult species and 0.79 for both juveniles and adult. Fisher test showed a significant difference in species richness between fields and fallows (p = 0.000). An average of 8±4 and 11±6 species per plot was counted for fields and fallows, respectively.

The 69 woody species in fields belonged to 57 genera and 30 families. Among the dominant species recorded are *V. paradoxa* (found 115 times within 115 plots), *Combretum collinum* Fresen. (55), *Parkia biglobosa* (53), *Stereospermum kunthianum* Cham. (47) and *Annona senegalensis* Pers. ssp. *oulotrieha* Le Thomas (45). The most represented families are Leguminosae (12 species), Combretaceae and Rubiaceae (7 species), Moraceae (6 species) and Anacardiaceae (4 species). The alpha diversity estimated by Shannon is 1.56 and Pielou evenness index is 0.85 (Table 1).

In fallow areas, a total of 78 species belonging to 65 genera, and 32 families were recorded. Among the dominant species recorded are *V. paradoxa* (found 97 time within 97 plots), *C. collinum* Fresen. (59), *S. kunthianum* Cham. (49), *A. senegalensis* Pers. ssp. *oulotrieha* Le Thomas (48), and *Acacia polyacantha* Willd. ssp. *campylacantha (*Hochst.ex A.Rich.*)* (44). The most well represented families were Leguminosae (15 species), Combretaceae (8 species), Anacardiaceae (7 species), Rubiaceae (6 species) and Meliaceae (4 species). The Shannon diversity index is estimated to 1.63 and Pielou eveness index to 0.86 (Table 1).

Though fallows appear to be more diversified, Fischer test showed that land management regime does not influence species richness (p = 0.112). However, Fisher test showed significant differences between adult species diversity and bulk ones in fields (p = 0.00) and fallows (p = 0.00) (Appendix 1b).

Diversity of adult woody species

Overall, *V. paradoxa* agroforests registered 41 woody species. Among 69 species found in fields, 28 were adults belonging to 24 genera, and 14 families. Table 2 shows adults woody species vegetation indices. According to the importance value index (Table 2), the

Table 1. Alpha diversity of woody species within *V. paradoxa* agroforestry parklands of Atacora in Benin. Values in parentheses are overall species' indices.

Parameter	Fields	Fallows
Species richness	28 (69)	36 (78)
Shannon diversity index	0.46 (1.56)	0.59(1.63)
Pielou evenness index	0.32 (0.85)	0.38 (0.86)

Table 2. Vegetation indices of adult woody species within *V. paradoxa* parklands in Atacora (Benin, West Africa); bold fonts denote the five most important agroforestry species.

Family	Fields Species name	Ni	Rde	Rdo	CVI	Rn	RF	IVI
Anacardiaceae	***Lannea acida* A.Rich. s.l.**	**21**	**2.57**	**1.58**	**4.15**	**10**	**4.22**	**8.37**
Anacardiaceae	***Lannea microcarpa* Engl. & Krause**	**8**	**0.98**	**1.46**	**2.44**	**7**	**2.95**	**5.39**
Anacardiaceae	*Mangifera indica* L.	4	0.49	1.58	2.07	4	1.69	3.76
Anacardiaceae	*Anacardium occidentale* L.	1	0.12	0.02	0.14	1	0.42	0.56
Arecaceae	*Borassus aethiopum* Mart.	1	0.12	0.27	0.40	1	0.42	0.82
Bombacaceae	*Adansonia digitata* L.	2	0.24	4.04	4.28	2	0.84	5.12
Bombacaceae	*Bombax costatum* Pellegr. & Vuillet	2	0.24	0.95	1.19	2	0.84	2.04
Chrysobalanaceae	*Parinari curatellifolia* Planch. ex Benth.	5	0.61	0.29	0.90	2	0.84	1.75
Combretaceae	*Anogeissus leiocarpa* (De.) Guill. & Perr.	6	0.73	0.27	1.00	5	2.11	3.11
Combretaceae	*Combretum collinum* Fresen.	3	0.37	0.10	0.46	1	0.42	0.89
Combretaceae	*Terminalia laxijlora* Engl.	1	0.12	0.13	0.26	1	0.42	0.68
Combretaceae	*Terminalia macroptera* Guill. & Perr.	1	0.12	0.02	0.14	1	0.42	0.56
Ebenaceae	***Diospyros mespiliformis* Hochst. Ex A. De.**	**13**	**1.59**	**1.49**	**3.09**	**9**	**3.80**	**6.88**
Leguminosae	***Parkia biglobosa* (Jacq.) R.Br. ex Benth.**	**90**	**11.02**	**20.41**	**31.43**	**48**	**20.25**	**51.68**
Leguminosae	*Prosopis africana* (Guill. & Perr.) Taub.	3	0.37	0.32	0.68	3	1.27	1.95
Leguminosae	*Pterocarpus erinaceus* Poir.	3	0.37	0.34	0.71	3	1.27	1.97
Leguminosae	*Tamarindus indica* L.	1	0.12	0.11	0.23	1	0.42	0.65
Meliaceae	*Azadirachta indica* A.Juss.	11	1.35	0.46	1.81	5	2.11	3.92
Meliaceae	*Ficus sycomorus* L.	4	0.49	0.52	1.01	3	1.27	2.28
Meliaceae	*Khaya senegalensis* (Desr.) A.Juss.	3	0.37	2.97	3.34	3	1.27	4.61
Meliaceae	*Ficus exasperata* Vahl	2	0.24	1.68	1.92	2	0.84	2.77
Meliaceae	*Ficus platyphylla* Delile	1	0.12	0.14	0.27	1	0.42	0.69
Ochnaceae	*Lophira lanceolata* Tiegh. ex Keay	1	0.12	0.16	0.28	1	0.42	0.71
Rubiaceae	*Mitragyna inermis* (Willd.) Kuntze	1	0.12	0.03	0.15	1	0.42	0.57
Sapotaceae	***Vitellaria paradoxa* C.F.Gaertn. ssp. *Paradoxa***	**623**	**76.25**	**59.90**	**136.15**	**115**	**48.52**	**184.68**
Sterculiaceae	*Sterculia setigera* Delile	1	0.12	0.07	0.19	1	0.42	0.61
Tiliaceae	*Grewia carpinifolia* Juss.	1	0.12	0.02	0.15	1	0.42	0.57

Table 2. Vegetation indices of adult woody species within *V. paradoxa* parklands in Atacora (Benin, West Africa); bold fonts denote the five most important agroforestry species.

Verbenaceae	*Vitex doniana* Sweet	4	0.49	0.68	1.17	3	1.27	2.43
Anacardiaceae	*Anacardium occidentale* L.	3	0.37	0.14	0.51	1	0.45	0.96
Anacardiaceae	*Haematostaphis barteri* Hook.F.	3	0.12	0.02	0.15	2	0.45	0.6
Anacardiaceae	*Lannea barteri* (Oliv.) Engl.	1	0.12	0.86	0.99	1	0.45	1.44
Anacardiaceae	***Lannea acida* A.Rich. s.i.**	**32**	**3.98**	**3.9**	**7.87**	**15**	**6.73**	**14.6**
Anacardiaceae	***Lannea microcarpa* Engl. & Krause**	**20**	**2.48**	**1.24**	**3.73**	**7**	**3.14**	**6.86**
Anacardiaceae	*Mangifera indica* L.	1	0.12	0.15	0.27	1	0.45	0.72
Anacardiaceae	*Sclerocarya birrea* (A.Rich.) Hochst.	2	0.37	0.45	0.82	2	1.35	2.17
Araliaceae	*Cussonia arborea* Hoehst. ex A. Rich.	1	0.12	0.24	0.36	1	0.45	0.81
Bignoniaceae	*Stereospermum kunthianum* Cham.	9	0.75	1.41	2.16	4	2.69	4.85
Bombacaceae	*Bombax costatum* Pellegr. & Vuillet	7	0.87	0.93	1.8	3	1.35	3.14
Combretaceae	*Anogeissus leiocarpa* (De.) Guill. & Perr.	9	1.12	0.5	1.62	6	2.69	4.31
Combretaceae	*Combretum collinum* Fresen.	6	0.75	0.19	0.94	3	1.35	2.28
Combretaceae	*Pteleopsis suberosa* Engl. & Diels	1	0.25	0.49	0.74	1	0.9	1.63
Combretaceae	*Terminalia laxiflora* Engl.	4	0.12	0.74	0.86	3	0.45	1.31
Combretaceae	*Terminalia macroptera* Guill. & Perr.	2	0.25	0.05	0.3	2	0.45	0.75
Ebenaceae	*Diospyros mespiliformis* Hochst. Ex A. De.	4	0.5	0.22	0.72	2	0.9	1.62
Euphorbiaceae	*Brideliaferruginea* Benth.	1	0.12	0.02	0.14	1	0.45	0.59
Leguminosae	*Acacia gourmaensis* A.Chev.	2	0.25	0.05	0.3	2	0.9	1.2
Leguminosae	*Acacia polyacantha* Willd. ssp. *campylacantha* (Hochst. ex A.Rich.)	1	0.12	0.03	0.15	1	0.45	0.6
Leguminosae	***Daniellia oliveri* (Rolfe) Hutch. & Dalziel**	**14**	**1.74**	**0.92**	**2.65**	**6**	**2.69**	**5.35**
Leguminosae	*Entada africana* Guill. & Perr.	4	0.5	0.15	0.65	2	0.9	1.54
Leguminosae	***Parkia biglobosa* (Jacq.) R.Br. ex Benth.**	**66**	**8.2**	**13.04**	**21.24**	**32**	**14.35**	**35.59**
Leguminosae	*Prosopis africana* (Guill. & Perr.) Taub.	2	0.12	0.21	0.34	2	0.45	0.79
Leguminosae	*Pterocarpus erinaceus* Poir.	3	0.12	0.09	0.21	3	0.45	0.66
Leguminosae	*Tamarindus indica* L.	2	1.12	1.21	2.33	1	1.79	4.13
Meliaceae	*Azadirachta indica* A.Juss.	4	0.5	0.25	0.74	2	0.9	1.64
Meliaceae	*Khaya senegalensis* (Desr.) A.Juss.	1	0.37	0.47	0.84	1	0.45	1.29
Moraceae	*Ficus exasperata* Vahl	2	0.5	0.28	0.78	2	1.35	2.12
Moraceae	*Ficus sycomorus* L.	3	0.25	0.23	0.48	1	0.9	1.38
Ochnaceae	*Lophira lanceolata* Tiegh. ex Keay	1	0.12	0.32	0.45	1	0.45	0.9
Polygalaceae	*Securidaca longepedunculata* Fresen.	1	0.25	0.19	0.43	1	0.9	1.33
Sapotaceae	***Vitellaria paradoxa* C.F.Gaertn. *ssp. Paradoxa***	**579**	**71.93**	**69.41**	**141.34**	**97**	**43.5**	**184.83**
Sterculiaceae	*Sterculia setigera* Delile	6	0.12	0.03	0.15	6	0.45	0.6
Tiliaceae	*Grewia carpinifolia* Juss.	1	0.37	0.11	0.49	1	0.45	0.93
Verbenaceae	*Vitex doniana* Sweet	5	0.62	0.98	1.6	5	2.24	3.84
Zygophyllaceae	*Balanites aegyptiaca* (L.) Delile	3	0.37	0.49	0.87	2	0.9	1.76

Ni = Overall number of individuals of specie i, RDe = relative density, RDo = relative basal area, Rn = richness number, RF = relative frequency, CVI = cover value index, IVI = importance value index.

five most abundant species are *V. paradoxa* (184.27%), *P. biglobosa* (51.51%), *L. acida* (8.33 %), *Diospiros mespiliformis* Hochst. Ex A. De. (6.86%) and *L. microcarpa* (5.37%). In terms of families' representation, Meliaceae, Anacardiaceae, Combretaceae and Leguminosae are the most represented families. In fields, the Shannon diversity index is 0.46 and the Pielou eveness index is 0.32. The complete list of woody species registered in Atacora and their frequency is found in appendix 1a.

On the other hand, fallow areas registered a total of 36 adult species representing about 22% more species than that of fields. These species belonged to 31 genera and 17 families. The IVI showed that, the five most abundant species found in fallows were: *V. paradoxa* (184.75%), *P. biglobosa* (35.58%), *L. acida* (14.6%), *L. microcarpa* (6.86%) and *D. oliveri* (5.35%) (Table 2). The most represented families in fallows are Leguminosae (8 species), Anacardiaceae (7 species) and Combretaceae (5 species). The Shannon diversity index is 0.59 and Pielou evenness index is 0.39.

DISCUSSION

Adult woody species richness was estimated to be 41 tree species in Atacora. Comparable to our findings is report by Augusseau et al. (2006) and Ouinsavi and Sokpon (2008) who recorded respectively, 50 tree species in agroforestry parklands of the sub-humid part of Burkina Faso, and 45 species in *Milicia excelsa* (Welw.) C.C.Berg agroforesty parklands in Benin. On the other hand, our findings are higher than Fifanou et al. (2011) findings with 21 species in Pendjari Biosphere Reserve in Benin. Wala et al. (2005) recorded 25 species in Doufelgou's parklands in northern Togo and Folega et al. (2011) found 29 species under fallow in protected areas of Northern Togo. Cline-Cole et al. (1988) also found less species (22) in Kano's farmed parklands in northern Nigeria with almost the same agroecological zone. The differences in species richness could be explained by factors such as sampling design, sampling effort or both. In eastern and central Africa, Kindt et al. (2005) found 127 tree species in western Kenya's farms. The difference in woody species diversity between our study and that of Kindt et al. (2005) could be due to the study area's ecoregion, which in Kenyan case belongs to the Victoria Basin forest-savanna mosaic ecoregion (Kindt et al., 2005). Indeed, the later is known for its high species diversity and endemism which results from the mixture of habitat types. Wala et al. (2009) reported that woody species diversity in parkland varied according to the latitudinal gradient in Togo. Moreover, conservation of woody species in agricultural areas is directed by the use and knowledge of local communities and the traditional management practices (Ræbild et al., 2011).

Shannon diversity index and Pielou eveness index recorded in fields are similar to that of fallows. This can be explained by the interconnectivity existing between the two land management regimes. Species that are conserved in fields are selected among those that grow in natural areas. The selected species are conserved and managed until the depletion of soil fertility and shifting from field to fallow.

Leguminosae and Combretaceae were the most important families registered in Atacora district. Previous studies found similar results in northern Togo's agroforestry systems (Wala et al., 2005, 2009; Folega et al., 2011; Kebezikato et al., 2015). The current study site and the above ones are located in Sudanian tropical climate, which vegetation is dominated by families mentioned earlier. Indeed, Combretaceae and Leguminosae are part of the most dominant families in the Sudanian tropical zones (Aubreville, 1950). In addition, Leguminosae trees are known for their importance in agroforestry and silvo-pastoral systems, which function primarily in restoring and maintaining soil fertility through their ability to establish in nitrogen-deficient soils and the benefits of the nitrogen fixed to associated crops (Dommergues, 1987; Danso et al., 1992; Sprent, 1999).

Abundance of *V. paradoxa*, *P. biglobosa*, *L. microcarpa, L. acida* and *D. mespiliformis* is the result of farmers willingness to conserve trees in agricultural areas. Many researchers mentioned the above species as the most dominant one in agroforestry systems of the Sudanian zone (Wala et al., 2005; Folega et al., 2011; Aleza et al., 2015). Species listed in annex 1 are conserved in fields and fallows by local farming communities. Their presence and abundance confirm their importance for local communities (Agbahungba et al., 2001; Dah-Dovonon and Gnanglé, 2006; Gnanglé et al., 2009; Assogbadjo et al., 2012).

The woody species diversity associated with shea agroforestry parklands increases from fields to fallows, and decreases from bulk species to adult ones. This aspect reflects the selective character of conservation when it comes to species associate with crops. Many tree species grow naturally in lands allocated to agriculture, but not all of them reach the adult stage within the study area. Only those that are important for farmers and pastoralists are conserved and managed until their adult stage. Undesirable and unwanted species are removed during agricultural activities such as tillage, weeding, pruning, etc.

On-farm trees are integrally part of agricultural systems in Atacora as well as in other places in West Africa for their multiple uses. Nowadays, in addition to the uses and importance of trees in farmlands, they play a major role in the context of climate change. Indeed, some researchers have proposed agroforestry as a potential strategy for helping subsistence farmers reduce their vulnerability to climate change (Challinor et al., 2007; Verchot et al. 2007). Agroforestry among the land uses analyzed in the land-use, land-use change and forestry report of the IPCC (Intergovernmental Panel on Climate Change) offered the highest potential for carbon sequestration in non-Annex I countries (they are countries that have ratified or acceded to the UNFCCC but are not included in Annex I which means they are not required to reduce their greenhouse gas emissions)

Agricultural land use affects large parts of terrestrial area, so its contribution to biodiversity is critical for successful conservation projects. Lands used for agricultural activities are estimated to 28.31% of Benin surface area and are expected to rise in the future (FAO, 2010). There is possibility to simultaneously conserve biodiversity while reducing farmers' vulnerability to climate change. Agroforestry has such a high potential because there is a large area that is susceptible for land use change (Verchot et al., 2007). Traditional agroforestry systems, practiced by the majority of farmers in Atacora, are known to be more supportive of biodiversity than mono-cropping (Schroth, 2004), even though they are not substitute for natural habitat.

Conclusion

Through *in situ* conservation, *V. paradoxa*, agroforests has the potential to contribute to biodiversity conservation in agricultural areas. A total of 41 adult woody species were recorded in *V. paradoxa*'s agroforest, whereas according to land management regimes, 28 species are found in fields and 36 species in fallows. The composition of woody species in Atacora parklands reflects the needs of local communities and their implication in people's livelihood. The results shown in this study suggest the possibility to conserve part of the biodiversity while nourishing the population and reducing its vulnerability to climate change. There is a need to support and maintain this kind of agricultural system, as this exemplifies the synergy for providing, provisioning and supporting services and biodiversity conservation. Moreover, a good understanding of how agroforestry parklands are managed could give insight into sustainable development.

Conflict of interests

The authors did not declare any conflict of interests.

REFERENCES

Agbahungba G, Sokpon N, Gaoué O (2001). Situation des ressources génétiques forestières du Bénin. Atelier sous-régional FAO/IPGRI/ICRAF sur la conservation, la gestion, l'utilisation durable et la mise en valeur des ressources génétiques forestières de la zone sahélienne (Ouagadougou, 22–24 Sept. 1998). Note thématique sur les ressources génétiques forestières. Document FGR F, 12.

Akais OC, Obua J, Agea JG, Agaro E (2005). Natural regeneration, population structure and traditional management of Vitellaria paradoxa subspecies nilotica in the shea parklands of northern and eastern Uganda. African Crop Science Society, 7, 5.

Akoègninou A, Van Der Burg W, Van Der Maesen L (2006). Flore analytique du Bénin, Backhuys Publishers.

Albrecht A, Kandji ST (2003). Carbon sequestration in tropical agroforestry systems. Agriculture, ecosystems environment, 99: 15-27. http://dx.doi.org/10.1016/S0167-8809(03)00138-5

Aleza K, Wala K, Bayala J, Villamor GB, Dourma M, Atakpama W, Akpagana K (2015). Population structure and regeneration status of Vitellaria Paradoxa (C. F. Gaertner) under different land management regimes in Atacora department, Benin. Agroforestry Systems, 1-13. http://dx.doi.org/10.1007/s10457-015-9787-9

Aregheore EM (2009). The Republic of Benin.

Assogbadjo A, Glèlè Kakaï R, Vodouhê F, Djagoun C, Codjia J, Sinsin B (2012). Biodiversity and socioeconomic factors supporting farmers' choice of wild edible trees in the agroforestry systems of Benin (West Africa). Forest Policy and Economics, 14: 41-49. http://dx.doi.org/10.1016/j.forpol.2011.07.013

Atakpama W, Batawila K, Dourma M, Pereki H, Wala K, Dimobe K, Akpagana K, Gbeassor M (2012). Ethnobotanical knowledge of Sterculia setigera Del. in the Sudanian zone of Togo (West Africa). ISRN Botany, 2012.

Aubreville A (1950). Flore Forestiere Soudano-guinéenne, Afrique Occidental Française-Cameroun-Afrique Equatorial Française. Societé d'Edition Geographiques Maritimes et Coloniales, Paris.

Augusseau X, Nikiéma P, Torquebiau E (2006). Tree biodiversity, land dynamics and farmers' strategies on the agricultural frontier of southwestern Burkina Faso. Biodiversity Conservation, 15, 613-630. http://dx.doi.org/10.1007/s10531-005-2090-8

Avocèvou-Ayisso C, Avohou T, Omorou M, Dessou G, Sinsin B (2012). Ethnobotany of Pentadesma butyracea in Benin: A quantitative approach. Ethnobot. Res Applications.

Bailey RL, Dell T (1973). Quantifying diameter distributions with the Weibull function. Forest Science, 19: 97-104.

Boffa J-M (2000). Les parcs agroforestiers en Afrique subsaharienne, FAO.

Breman H, Kessler JJ (2011). Woody Plants in Agro-Ecosystems of Semi-Arid Regions: With an Emphasis on the Sahelian Countries, Springer London, Limited.

Brower J, Zar J (1984). Community similarity. BROWER, JE; ZAR, JH Field Laboratory for General Ecology. Dubuque: Win C. Brown Publishers, 161-164.

Brunel J, Hiepko P, Scholz H (1984). Flore analytique du Togo: Phanérogames. GTZ éd., Eschborn. http://dx.doi.org/10.2307/3776742

Byakagaba P, Eilu G, Okullo JBL, Tumwebaze SB, Mwavu EN (2011). Population structure and regeneration status of Vitellaria paradoxa (CF Gaertn.) under different land management regimes in Uganda. Agric. J. 6:14-22. http://dx.doi.org/10.3923/aj.2011.14.22

Challinor A, Wheeler T, Garforth C, Craufurd P, Kassam A (2007). Assessing the vulnerability of food crop systems in Africa to climate change. Climatic change, 83: 381-399. http://dx.doi.org/10.1007/s10584-007-9249-0

Cline-Cole R, Falola J, Main H, Mortimore M, Nichol J, O'reilly F (1988). Wood fuel in Kano, Nigeria: the urban-rural conflict, ODI, Agricultural Administration Unit.

Cottam G, Curtis J (1956). The Use of Distance Measures in Phytosociological Sampling. Ecology, 37, 451-460. http://dx.doi.org/10.2307/1930167

Curtis JT, Mcintosh RP (1950). The Interrelations of Certain Analytic and Synthetic Phytosociological Characters. Ecology, 31: 434-455. http://dx.doi.org/10.2307/1931497

Dah-Dovonon J, Gnangle C (2006). Evaluation des potentialités de développement de la filière karité dans les départements de l'Atacora et de la Donga: Rapport définitif. ProCGRN, GTZ, Natitingou, Benin.

Danso S, Bowen G, Sanginga N (1992). Biological nitrogen fixation in trees in agro-ecosystems. Plant and Soil, 141:177-196.
http://dx.doi.org/10.1007/BF00011316

Djossa BA, Fahr J, Wiegand T, Ayihouénou B, Kalko E, Sinsin B (2008). Land use impact on Vitellaria paradoxa CF Gaerten. stand structure and distribution patterns: a comparison of Biosphere Reserve of Pendjari in Atacora district in Benin. Agroforestry systems, 72: 205-220. http://dx.doi.org/10.1007/s10457-007-9097-y

Dommergues Y (1987). The role of biological nitrogen fixation in agroforestry. In: Agroforestry.

Edwige DN, Lamien N, Dibong DS, Boussim IJ, Belem B (2012). Le rôle

des especes ligneuses dans la gestion de la soudure alimentaire au Burkina Faso.
FAO (2010). Evaluation des resources forestières mondiales 2010, Rapport national, Bénin FAO, Rome.
Fifanou V, Ousmane C, Gauthier B, Brice S (2011). Traditional agroforestry systems and biodiversity conservation in Benin (West Africa). Agroforestry Systems, 82: 1-13. http://dx.doi.org/10.1007/s10457-011-9377-4
Folega F, Zhang C, Samake G, Kperkouma W, Batawila K, Zhao X, Koffi A (2011). Evaluation of agroforestry species in potential fallows of areas gazetted as protected areas in North-Togo. Afr. J. Agric. Res. 6:2828-2834.
Glèlè K, Romain, Akpona T, Assogbadjo AE, Gaoué OG, Chakeredza S, Gnanglè PC, Mensah GA, Sinsin B (2011). Ecological adaptation of the shea butter tree (Vitellaria paradoxa CF Gaertn.) along climatic gradient in Bénin, West Africa. Afri. J. Ecol. 49, 440-449. http://dx.doi.org/10.1111/j.1365-2028.2011.01279.x
Gnanglé C, Yabi J, Glélé KR, Sokpon N (2009). Changements climatiques : Perceptions et stratégies d'adaptations des paysans face à la gestion des parcs à karité au Centre-Bénin. INNOVKAR-ACC / FSP / RIPIECSA. 19 p.
Henry N, Ian KD, Eike L, Oluyede CA, Tracy B, Aster G, Ramni HJ, Konstantin K, Gudeta WS, Elisabeth S, Carmen Sotelo m, John CW (2012). Carbon sequestration potential of parkland agroforestry in the Sahel. Climatic Change, 115, 443-461. http://dx.doi.org/10.1007/s10584-012-0438-0
Jamnadass R, Place F, Torquebiau E, Malézieux E, Iiyama M, Sileshi G, Kehlenbeck K, Masters E, Mcmullin S, Dawson I (2013). L'agroforesterie pour la sécurité alimentaire et nutritionnelle. unasylva, 64, 241.
Jonsson K, Ong C, Odongo J (1999). Influence of scattered nere and karite trees on microclimate, soil fertility and millet yield in Burkina Faso. Experimental Agriculture, 35, 39-53. http://dx.doi.org/10.1017/S0014479799001039
Kebezikato A.B., Kpérkouma W, Dourma M, Atakpama W, Dimobe K, Pereki H, Batawila K, Akpagana K (2015). Distribution et structure des parcs à Adansonia digitata L.(baobab) au Togo. Numéros, 11.
Kindt R, Noordin Q, Njui A (2005). Biodiversity conservation through agroforestry.
Lovett P, Haq N (2000). Evidence for anthropic selection of the Sheanut tree (Vitellaria paradoxa). Agroforest Syst. 48:273-288. http://dx.doi.org/10.1023/A:1006379217851
Magurran A (Ed.) (2004) Measurement biological diversity, Blackwell Science Ltd.
Mcneely JA, Scherr SJ (2003). Ecoagriculture: strategies to feed the world and save wild biodiversity, Island Press.
Mcneely JA, Schroth G (2006). Agroforestry and biodiversity conservation–traditional practices, present dynamics, and lessons for the future. Biodiv. Conserv., 15:549-554. http://dx.doi.org/10.1007/s10531-005-2087-3
Okiror P, Agea JG, Okia CA, Okullo JBL (2012). On-Farm Management of Vitellaria paradoxa CF Gaertn. in Amuria District, Eastern Uganda. Intl. J. Forestry Res. 2012.
Ouinsavi C, Sokpon N (2008). Traditional agroforestry systems as tools for conservation of genetic resources of Milicia excelsa Welw. C.C. Berg in Benin. Agroforestry Systems, 74:17-26. http://dx.doi.org/10.1007/s10457-008-9109-6
Padakale E, Atakpama W, Dourma M, Dimobe K, Wala K, Akpagagana K (2015). Woody species diversity and structure of parkia biglobosa jacq. Dong parklands in the sudanian zone of Togo (west africa). Annual Rev. Res. Biol. 6:103-114. http://dx.doi.org/10.9734/ARRB/2015/14105
Pereki H, Wala K, Thiel-Clemen T, Bessike MPB, Zida M, Dourma M, Batawila K, Akpagana K (2013). Woody species diversity and important value indices in dense dry forests in Abdoulaye Wildlife Reserve (Togo, West Africa) . Int. J. Biodivers. Conserv., 5: 358-366.
Ræbild A, Larsen AS, Jensen JS, Ouedraogo M, De Groote S, Van Damme P, Bayala J, Diallo BO, Sanou H, Kalinganire A (2011). Advances in domestication of indigenous fruit trees in the West African Sahel. New Forests, 41:297-315. http://dx.doi.org/10.1007/s11056-010-9237-5
Scherr SJ, Mcneely JA (2002). Reconciling agriculture and biodiversity: policy and research challenges of 'ecoagriculture'. Equator Initiative, UNDP.
Scherr SJ, Mcneely JA (2012). Farming with nature: the science and practice of ecoagriculture, Island Press.
Schroth G (2004). Agroforestry and biodiversity conservation in tropical landscapes, Island Press.
Tomlinson H, Teklehaimanot Z, Traore A, Olapade E (1995). Soil amelioration and root symbioses ofParkia biglobosa (Jacq.) Benth. in West Africa. Agroforestry systems, 30, 145-159. http://dx.doi.org/10.1007/BF00708918
Torquebiau E (1985). Man-made dipterocarp forest in Sumatra. Agroforestry Systems, 2:103-127. http://dx.doi.org/10.1007/BF00131269
Traoré K (2003). Le parc à Karité: sa contribution à la durabilité de l'agrosystème. Cas d'une toposéquence à Konobougou (Mali-Sud). Thèse, école nationale supérieure agronomique de Montpellier (Ensam).
Verchot LV, Van Noordwijk M, Kandji S, Tomich T, Ong C, Albrecht A, Mackensen J, Bantilan C, Anupama K, Palm C (2007). Climate change: linking adaptation and mitigation through agroforestry. Mitigation and Adaptation Strategies for Global Change, 12: 901-918. http://dx.doi.org/10.1007/s11027-007-9105-6
Vissoh P, Gbèhounou G, Ahanchédé A, Kuyper TW, Röling NG (2004). Weeds as agricultural constraint to farmers in Benin: results of a diagnostic study. NJAS-Wageningen J. Life Sci., 52, 305-329. http://dx.doi.org/10.1016/S1573-5214(04)80019-8
Wala K, Sinsin B, Guelly KA, Kokou K, Akpagana K (2005). Typologie et structure des parcs agroforestiers dans la préfecture de Doufelgou (Togo). Science et changements planétaires/Sécheresse, 16:209-216.
Wala K, Guelly AK, Batawila K, Dourma M, Sinsin B, Akpagana K (2009). Traditional agroforestry systems in Togo: Variability according to lattitude and local communities In: Traditional Forest-Related Knowledge and Sustainable Forest Management in Africa,IUFRO World Serives, Accra.

Appendix 1a. List of woody (fields) species registered in Atacora and their frequency.

Family	Fields species	Richness
Anacardiaceae	*Anacardium occidentale* L.	3
Anacardiaceae	*Lannea acida* A.Rich. s.l.	18
Anacardiaceae	*Lannea microcarpa* Engl. & Krause	11
Anacardiaceae	*Mangifera indica* L.	7
Annonaceae	*Annona senegalensis* Pers. ssp. *oulotrieha* Le Thomas ex Le Thomas	45
Arecaceae	*Borassus aethiopum* Mart.	8
Asclepiadaceae	*Calotropis procera* (Aiton) W.T.Aiton	5
Bignoniaceae	*Stereospermum kunthianum* Cham.	47
Bombacaceae	*Adansonia digitata* L.	6
Bombacaceae	*Bombax costatum* Pellegr. & Vuillet	7
Bombacaceae	*Ceiba pentandra* (L.) Gaertn.	1
Capparaceae	*Crateva adansonii* DC. ssp. *adansonii*	1
Celastraceae	*Maytenus senegalensis* (Lam.)	18
Chrysobalanaceae	*Parinari curatellifolia* Planch. ex Benth.	9
Combretaceae	*Anogeissus leiocarpa* (De.) Guill. & Perr.	16
Combretaceae	*Combretum collinum* Fresen.	55
Combretaceae	*Combretum glutinosum* Perr. ex De.	14
Combretaceae	*Combretum micranthum* G.Don	17
Combretaceae	*Guiera senegalensis* J.F.Gmel.	2
Combretaceae	*Pteleopsis suberosa* Engl. & Diels	15
Combretaceae	*Terminalia laxijlora* Engl.	31
Connaraceae	*Terminalia macroptera* Guill. & Perr.	7
Ebenaceae	*Diospyros mespiliformis* Hochst. Ex A. De.	31
Euphorbiaceae	*Brideliaferruginea* Benth.	3
Euphorbiaceae	*Flueggea virosa* (Roxb. ex Willd.) Voigt	43
Euphorbiaceae	*Hymenocardia acida* Tul.	2
Leguminosae	*Daniellia oliveri* (Rolfe) Hutch. & Dalziel	13
Leguminosae	*Detarium microcarpum* Guill. & Perr.	6
Leguminosae	*Piliostigma thonningii* (Schumach.) Milne-Redh.	29
Leguminosae	*Tamarindus indica* L.	1
Leguminosae	*Acacia gourmaensis* A.Chev.	3
Leguminosae	*Acacia polyacanth*a Willd. ssp. *campylacantha* (Hochst. ex A.Rich.)	39
Leguminosae	*Entada africana* Guill. & Perr.	1
Leguminosae	*Parkia biglobosa* (Jacq.) R.Br. ex Benth.	53
Leguminosae	*Prosopis africana* (Guill. & Perr.) Taub.	7
Leguminosae	*Desmodium velutinum* (Willd.) De.	4
Leguminosae	*Pericopsis laxiflora* (Benth. ex Baker) Meeuwen	3
Leguminosae	*Pterocarpus erinaceus* Poir.	12
Loganiaceae	*Strychnos spinosa* Lam.	8
Meliaceae	*Azadirachta indica* A.Juss.	27
Meliaceae	*Khaya senegalensis* (Desr.) A.Juss.	4
Meliaceae	*Pseudocedrela kotschyi* (Schweinf.) Harms.	4
Meliaceae	*Trichilia emetica* Vahl	2
Moraceae	*Ficus exasperata* Vahl	8
Moraceae	*Ficus ingens* (Miq.) Miq.	4
Moraceae	*Ficus platyphylla* Delile	4
Moraceae	*Ficus sycomorus* L.	23
Moraceae	*Ficus thonningii* Blume	1
Moraceae	*Ficus vallis-choudae* Delile	1
Ochnaceae	*Lophira lanceolata* Tiegh. ex Keay	2
Polygalaceae	*Securidaca longepedunculata* Fresen.	1

Appendix 1a. Contd.

Rhamnaceae	*Ziziphus abyssinica* A.Rich.	3
Rubiaceae	*Crossopteryxfebrifuga* (G.Don) Benth.	6
Rubiaceae	*Feretia apodanthera* Delile ssp. *Apodanthera*	15
Rubiaceae	*Gardenia erubescens* Stapf & Huteh.	11
Rubiaceae	*Gardenia ternifolia* Sehumaeh. & Thonn. ssp. *jovis-tonantis* (Welw.) Verde. var. goetzei (Stapf & Huteh.) Verde.	1
Rubiaceae	*Mitragyna inermis* (Willd.) Kuntze	1
Rubiaceae	*Sarcocephalus latifolius* (Sm.) E.A.Bruce	20
Rutaceae	*Zanthoxylum zanthoxyloides* (Lam.) Zepernick & Timler	3
Sapotaceae	*Vitellaria paradoxa* C.F.Gaertn. ssp. *Paradoxa*	115
Simaroubaceae	*Hannoa undulata* Planch.	1
Sterculiaceae	*Sterculia setigera* Delile	7
Tiliaceae	*Grewia carpinifolia* Juss.	23
Tiliaceae	*Grewia puhescens* P. Beauv.	10
Verbenaceae	*Tectona grandis* L.f.	1
Verbenaceae	*Vitex doniana* Sweet	20
Verbenaceae	*Vitex madiensis* Olïv. subsp. *madiensis*	1
Vitaceae	*Cissus cornifolia* (Baker) Planeh.	1
Zygophyllaceae	*Balanites aegyptiaca* (L.) Delile	2

Appendix 1b. List of woody (fallows) species registered in Atacora and their frequency.

Family	Species fallows	Ni
Anacardiaceae	*Anacardium occidentale* L.	4
Anacardiaceae	*Haematostaphis barteri* Hook.f.	2
Anacardiaceae	*Lannea acida* A.Rich. s.l.	21
Anacardiaceae	*Lannea barteri* (Olïv.) Engl.	1
Anacardiaceae	*Lannea microcarpa* Engl. & Krause	11
Anacardiaceae	*Mangifera indica* L.	2
Anacardiaceae	*Sclerocarya birrea* (A.Rich.) Hochst.	5
Annonaceae	*Annona senegalensis* Pers. ssp. *oulotrieha* Le Thomas ex Le Thomas	48
Apiaceae	*Steganotaenia araliacea* Hochst.	2
Araliaceae	*Cussonia arborea* Hoehst. ex A. Rich.	1
Arecaceae	*Borassus aethiopum* Mart.	3
Bignoniaceae	*Stereospermum kunthianum* Cham.	49
Bombacaceae	*Adansonia digitata* L.	1
Bombacaceae	*Bombax costatum* Pellegr. & Vuillet	5
Capparaceae	*Crateva adansonii* DC. ssp. *adansonii*	1
Celastraceae	*Gymnosporia buchananii* Loes.	7
Celastraceae	*Maytenus senegalensis* (Lam.)	20
Chrysobalanaceae	*Parinari curatellifolia* Planch. ex Benth.	6
Combretaceae	*Anogeissus leiocarpa* (De.) Guill. & Perr.	20
Combretaceae	*Cochlospermum planchoni* Hook.f., J.	7
Combretaceae	*Combretum collinum* Fresen.	59
Combretaceae	*Combretum glutinosum* Perr. ex De.	7
Combretaceae	*Combretum micranthum* G.Don	27
Combretaceae	*Guiera senegalensis* J.F.Gmel.	3
Combretaceae	*Pteleopsis suberosa* Engl. & Diels	21
Combretaceae	*Terminalia laxijlora* Engl.	36
Connaraceae	*Terminalia macroptera* Guill. & Perr.	9
Ebenaceae	*Diospyros mespiliformis* Hochst. Ex A. De.	35

Appendix 1b. Contd.

Euphorbiaceae	*Brideliaferruginea* Benth.	9
Euphorbiaceae	*Hymenocardia acida* Tul.	2
Euphorbiaceae	*Flueggea virosa* (Roxb. ex Willd.) Voigt	42
Leguminosae	*Daniellia oliveri* (Rolfe) Hutch. & Dalziel	20
Leguminosae	*Piliostigma thonningii* (Schumach.) Milne-Redh.	41
Leguminosae	*Tamarindus indica* L.	1
Leguminosae	*Acacia amythethophylla* Steud. ex A. Rich.	7
Leguminosae	*Acacia gerrardii* Benth., Trans. Linn.	2
Leguminosae	*Acacia gourmaensis* A.Chev.	8
Leguminosae	*Acacia polyacantha* Willd. ssp. *campylacantha* (Hochst. ex A.Rich.)	44
Leguminosae	*Entada africana* Guill. & Perr.	6
Leguminosae	*Parkia biglobosa* (Jacq.) R.Br. ex Benth.	36
Leguminosae	*Prosopis africana* (Guill. & Perr.) Taub.	6
Leguminosae	*Erythrina sigmoidea* Hua	1
Leguminosae	*Pericopsis laxiflora* (Benth. ex Baker) Meeuwen	2
Leguminosae	*Pterocarpus erinaceus* Poir.	18
Leguminosae	*Aganope stuhlmannii* (Taub.) Adema	1
Loganiaceae	*Strychnos spinosa* Lam.	18
Meliaceae	*Azadirachta indica* A.Juss.	21
Meliaceae	*Khaya senegalensis* (Desr.) A.Juss.	3
Meliaceae	*Pseudocedrela kotschyi* (Schweinf.) Harms.	4
Meliaceae	*Trichilia emetica* Vahl	7
Moraceae	*Antiaris toxicaria* Lesch. ssp. *Welwitschii* (Engl.) C.C.Berg	1
Moraceae	*Ficus exasperata* Vahl	8
Moraceae	*Ficus ingens* (Miq.) Miq.	3
Moraceae	*Ficus sycomorus* L.	13
Myrtaceae	*Eucalyptus camaldulensis* Dehn.	1
Myrtaceae	*Psidium guajava* L	1
Myrtaceae	*Syzygium guineense* (Willd.) DC.	1
Ochnaceae	*Lophira lanceolata* Tiegh. ex Keay	2
Polygalaceae	*Securidaca longepedunculata* Fresen.	3
Rhamnaceae	*Ziziphus abyssinica* A.Rich.	10
Rubiaceae	*Crossopteryxfebrifuga* (G.Don) Benth.	17
Rubiaceae	*Feretia apodanthera* Delile ssp. Apodanthera	21
Rubiaceae	*Gardenia aqualla* Stapf & Huteh.	1
Rubiaceae	*Gardenia erubescens* Stapf & Huteh.	20
Rubiaceae	*Gardenia ternifolia* Sehumaeh. & Thonn. ssp.*jovis-tonantis* (Welw.) Verde. var. goetzei (Stapf & Huteh.) Verde.	2
Rubiaceae	*Sarcocephalus latifolius* (Sm.) E.A.Bruce	8
Rutaceae	*Zanthoxylum zanthoxyloides* (Lam.) Zepernick & Timler	1
Sapotaceae	*Vitellaria paradoxa* C.F.Gaertn. ssp. *Paradoxa*	97
Simaroubaceae	*Hannoa undulata* Planch.	1
Sterculiaceae	*Sterculia setigera* Delile	16
Tiliaceae	*Grewia carpinifolia* Juss.	30
Tiliaceae	*Grewia puhescens* P. Beauv.	22
Verbenaceae	*Gmelina arborea* Roxb.	1
Verbenaceae	*Tectona grandis* L.f.	1
Verbenaceae	*Vitex doniana* Sweet	17
Verbenaceae	*Vitex madiensis* Olïv. ssp. *madiensis*	5
Zygophyllaceae	*Balanites aegyptiaca* (L.) Delile	2
Leguminosae	*Detarium microcarpum* Guill. & Perr.	11