SPATIAL DISTRIBUTION AND ABUNDANCE OF *SOLANECIO BIAFRAE* (OLIVE & HEIRNE) C. JEFFREY AND STRUCTURE OF WEED COMMUNITIES IN SOME COCOA PLOTS IN EKITI, OYO AND CROSS RIVER STATES, NIGERIA

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ABSTRACT

Cocoa plots and cocoa agro-forests have served as sustainable land-use practice that conserve the biological diversity of the original tropical forests and remain the major source of *Solanecio biafrae*, a pot herb, and other useful tropical rainforest plants. The population of *Solanecio biafrae* may be endangered as its common sight in the local markets has been replaced by exotic vegetable species. This study determined the abundance of *Solanecio biafrae* and structure of weed communities in selected cocoa plots in Ekiti, Oyo and Cross-Rivers States with the aim of establishing the threat status and shift in species composition, and identifying possible invasive species. Enumeration of low-growing herbs was conducted in 19 cocoa plots following random sampling technique, with ten $1m^2$ wooden quadrats located within a $50m^2$ area in each plot. The data were used to determine the Relative Importance Value (RIV) as a measure of abundance for each species. The Species Richness (R), Shannon-Wiener (H'), Equitability (J) and Dominance (D) and Jaccard indices were determined as measures of community structure. Seventy six (76) weed species belonging to 36 families were found. The species richness per plot ranged from 5 to 29. Of the 7 common weed species, *Solanecio biafrae* remained the most ubiquitous, being found in 15 plots. The RIV for *S. biafrae* ranged from 0.46 to 14.76 across plots. Most of the ubiquitous species were invasive plants, which included *Chromolaena odorata, Asystasia gangetica, Oplismenus burmannii* and *Adenia cissampeloides*. Across the plots in the three states, diversity indices ranged from 1.390 to 2.938 for Shannon-Wiener, 0.793 to 0.992 for Equitability and 0.057 to 0.271 for Dominance. These implied high species diversity, except in CR plots, and random distribution of the species. Jaccard index of similarity ranged from 0 to 90.91% across plots. The inter-state Jaccard index values ranged from 18.18 to 20.00%. The high values indicate less environmental heterogeneity and low values imply high environmental heterogeneity. The spread of *Adenia cissampeloides* in the cocoa plots may aggravate threat to *S. biafrae* populations.

Keywords: Cocoa plots, Invasive Plants, *Solanecio biafrae*, Species Diversity, Weed Communities.

INTRODUCTION

Biodiversity offers essential environmental services upon which life on earth depends (UNEP, 2007). The tropical rainforests, which is about 7% of global land area, account for about 55% of the plant and animal species on earth (Miller, 1990; Watson *et al.*, 2000). Deforestation for agricultural development has destroyed about 55% of the world's original area of tropical moist forest thus causing declines in global biodiversity (Miller, 1990; Donald, 2004; Green *et al.*, 2005). Plot agriculture has been reported to account for over 130 million hectare worldwide (Cubbage *et al.*, 1996), with cocoa plots replacing original forest ecosystem in more than 50 tropical and semi-tropical developing countries across Asia, Africa and Latin America (Akinbola, 2001; Lass, 2004; Ruf and Schroth, 2004). The heavy concentration of cocoa production is in West Africa (Abbott, 2002), with Nigeria being the fourth largest producer in the world, ranking after Cote d'Ivoire, Brazil and Ghana (Wikipedia, 2010).

Cocoa plots with diverse and structurally complex shade present a land use that may perfectly simulate the forest land use and thus conserving a significant portion of the original tropical forest biodiversity (Alves, 1990; Rice and Greenberg, 2000; Scroth *et al.*, 2004). The biodiversity conservation potential of cocoa plots is well documented for bats, ants and birds (Rice and Greenberg, 2000), but poorly documented for floral diversity. It has been reported that increase in structural diversity of the shade level in cocoa plot and cocoa agro-forests, with varying proportions of shade trees, will increase the biological diversity thus serving as a sustainable land-use practice that complements the conservation of biodiversity (Rice and Greenber, 2000; Scroth *et al.*, 2004). The cocoa agro-forests in particular can create forest-like habitats which harbor tropical biodiversity in rapidly degrading landscapes (Greenberg *et al.*, 2000), while providing an economic crop for small-holder farmers (Perfecto and Vanderneer, 1996), and serving as faunal refuges (Griffith, 2000).

Weed diversity is often related to local conditions, most especially habitat heterogeneity, with high weed species richness in complex landscape (Olubode *et al.*, 2011). Also, the crop grown strongly affects the weed species richness and composition. The openness in a young cocoa plot promotes dominance by light-loving annual weeds (heliophytes) that poses serious threat to the survival of cocoa seedlings. The nurse plants in a cocoa agro-forest provide shade that reduces the impact of the annual heliophytic weeds. However, the close canopy of mature cocoa trees creates a microclimate for shade-loving herbs (sciophytes), both annuals and perennials, to establish. Thus cocoa plot continues to serve as the land use where some useful pot herbs like *Solanacio biafrae* are collected for consumption (Adebooye, 2004). *Solanacio biafrae* (Oliv. & Hiern) C. Jeffrey (Syn. *Senecio biafrae* Oliv. & Hiern, *Crassocephalum biafrae* (Oliv. & Hiern) S. Moore) belongs to the plant family Asteraceae. It is an understorey, scrambling, sub-succulent and glabrous herb growing in the rainforest of Africa, Madagascar and Yemen. It occurs naturally in the forest zone from Guinea to Uganda (Adebooye, 2004). It is found in the rainforest zone of West Central Africa where annual rainfall is up to 1500 mm and at altitude up to 1800 m asl. It has medical and cultural uses in Nigeria, Cameroun, Sierra Leone, Liberia, Ghana, Cote d'Ivoire and Congo where it is used to treat bleeding from cuts and injury, and in treating sore eyes (Schippers, 2000; Adebooye, 2004). Though 'worowo' (as it is called in Nigeria) is cultivated and staked on trellis about 1 m tall in few homestead gardens, much of the plant consumed as pot herb is collected from the wild and in cocoa and kolanut plots where they are spared during weed control, which is mainly by manual method. The plant is available all year round because high humidity and moist conditions under the canopy in cocoa plots support its growth, even in the dry seasons. The 100 g dry matter of leaves of the green-stemmed and purple-stemmed types of *S. biafrae* is reported to contain respectively 12.3 g and 11.6 g of crude protein; 11.8 g and 10.5 g of crude fibre; 342 mg and 320 mg of Ca; 39 mg and 46 mg of P; and 52 mg and 53 mg of Fe (Adebooye, 2000).

As a result of massive exploitation without replacement, wild stands of 'worowo' might have been decimated and the species is becoming endangered. Its common sight in the local market has been replaced by exotic vegetable species like *Amaranthus hybridus* and *Celosia argentea* that do not require staking and shade. This study enumerated the low-growing plant species in selected cocoa plots in Ekiti, Oyo and Cross-Rivers States, three of the 14 cocoa-growing states in Nigeria, to determine the distribution and abundance of *Solanecio biafrae* relative to other understorey herbs as they determine structure of weed communities, and to identify the invasive weed species.

MATERIALS AND METHODS

The Study Locations

The enumeration was carried out in February/March 2010 in Ise Local Government area of Ekiti State; in November/December 2010 in Afijio and Ona Ara Local Government areas of Oyo State; and in April 2012 in Etung Local Government area, Ikom in Cross River State. Ten, three and six cocoa plots were found in Ekiti, Oyo and Cross River States respectively. The coordinate points and elevation of the 19 study sites in the three states (Table 1) were taken with the aid of Global Positioning System (GPS model Extrex Legend Garmin) (Figure 1). Also, the light intensity within each cocoa plot was recorded with a digital light meter (model HP88IA). The plots studied in Ekiti State and Oyo plots 2 and 3 are located in the lowland rainforest: drier type; the Afijio plot in Oyo State is northernmost and located within derived savanna; and the plots in Cross River State are southerly within the lowland rainforest: wet type (White, 1983). The Afijio plot (OY1) is young (5 years) with much open canopy, the Ekiti plots and Ona Ara (OY2 and OY3) are mature (15-20 years) with patches of opening in the canopy while Cross River plots are quite old (40-50 years with ownership mainly by inheritance) with fairly close canopy and heavy coverage of leaf litter.

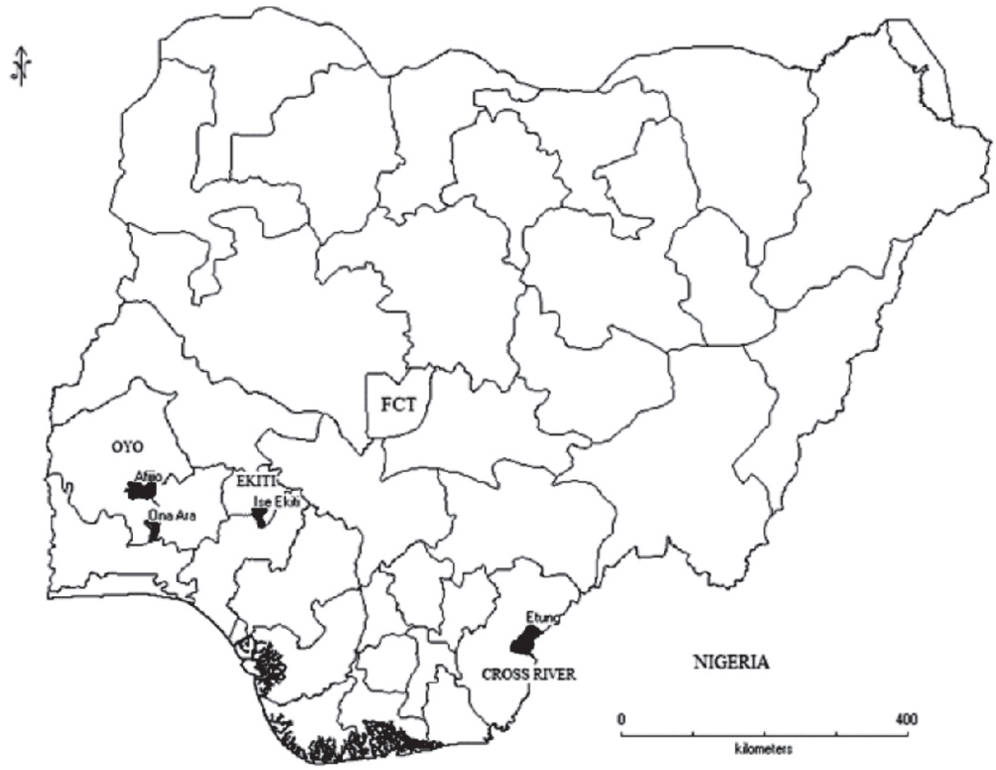

Figure 1. Map of Nigeria Showing the Study Areas.

Table 1. Location and Light Intensity of the Cocoa Plots Enumerated in Ekiti, Oyo and Cross River States

Cocoa Plot	**Latitude (N)**	**Longitude (E)**	**Elevation (m asl)**	**Light Intensity (lux)**
	EKITI STATE: Ise Local Government Area			
EK1	°27.407’	5°20.867’	356	1810
EK2	7°27.394’	5°20.833’	358	1830
EK3	7°27.355’	5°20.876’	355	1870
EK4	7°27.331’	5°20.821’	353	1980
EK5	7°27.312’	5°20.841’	370	1790
EK6	7°27.297’	5°20.858’	371	1870
EK7	7°27.256’	5°20.835’	378	1930
EK8	7°27.228’	5°20.849’	374	1860
EK9	7°27.199’	5°20.868’	354	1880
EK10	7°27.175’	5°20.845’	355	1940
	OYO STATE			
OY1 - Afijio LGA	7°40.148’	3°58.211’	332	2180
OY2 - Ona Ara LGA	7°20.024’	4°00.179’	142	1930
OY3 - Ona Ara LGA	7°19.852’	4°00.157’	149	1610
	CROSS RIVER STATE: Etung Local Government Area			
CR1	5°53.235’	8°46.117’	129	1410
CR2	5°53.234’	8°46.118’	131	1650
CR3	5°53.234’	8°46.120’	138	1510
CR4	5°53.363’	8°46.363’	134	1610
CR5	5°52.473’	8°46.082’	135	1560
CR6	5°52.467’	8°46.120’	138	1500

Sampling and measures of Importance

At the centre of each cocoa plot a 50 x 50 m area was marked out and, using x- and y- ordinate random sampling technique, ten points were located for the placement of wooden quadrat (1 x 1 m) for weed species enumeration. All weeds and other low-growing plants (including saplings of tree plants) that rooted within each quadrat were identified and counted. Weed identification and naming were done using flora (Johnson, 1997; Akobundu and Agyakwa, 1998; Gbile, 1999). The species that cannot be identified immediately on the field were preserved in wooden press and identified in the University of Ibadan Herbarium (UIH) located in Department of Botany.

From the data, measure of importance for each species in each plot was determined as mean of relative density and relative frequency for each species:

RIV (%) = [(Relative Density + Relative Frequency)/2] - Barbour *et al.*, 1999.

Density = Number of individual of a species/Area sampled

Relative Density (%) = [Density of a species/Total Density for all species] x 100

Frequency (%) = [Number of quadrat in which a species occurred/Total Number of quadrat]x100

Relative Frequency (%) = [Frequency of a species/Total Frequency for all species] x 100

Measures of Community Structure

A structure of community is a function of species composition and the distribution of each species (Harper and Hawksworth, 1995). The biological community structure as informed by the ecological diversity of the weed species was determined by alpha diversity and beta diversity. The alpha diversity, which is the diversity of species within a particular community, was determined by Species Richness (R), Shannon-Wiener (H'), Equitability (J) and Dominance (D) indices using PAST software version 2.08 (Whittaker, 1975; Hammer, 2011). The beta diversity, which is the expression of between-habitat diversity was determined by Jaccard index (Spellerberg, 1993).

Species Richness is the total number of species occurring within a specified area of the community; Equitability index is a measure of evenness with which individuals are distributed among all species present; Shannon-Wiener is a function of species richness and the evenness with which individuals are distributed among the species; and Dominance seeks to show if the community is dominated by a particular species (Whittaker, 1975; Kent and Coker, 1992; Spellerberg, 1993; Barbour *et al.*, 1999; Elle, 2009; Hammer, 2011). Jaccard index of community similarity (SCj) determines community similarity, and it is based on the presence-absence relationship between the number of species in each community and the number of common species (Spellerberg, 1993).

The Shannon-Wiener index of species diversity (H') is calculated as;

$H' = -\sum pi.\mathit{In}pi$; where $pi = n/N$ - (Kent and Coker, 1992);

where pi is proportion which is the number of individuals in a species (n) in relation to the total number of all individuals in the community (N), *In* = naperian logarithm = 2.303 x $\log_{10}$. The value ranges from 0 to 4.6. Value 0 indicates dominance by a single species as obtained in monocrop situation while high values indicate that there are many species, each with few individuals.

The species Equitability index (J) is calculated as: $J = H'/\mathit{In}S$; (Whittaker, 1975);

where H' is Shannon-wiener index and S is total number of species in the community. The value may range from 0 to 1. When individuals are evenly distributed among all species (random distribution) the value tends toward one (1) and toward 0 when one or few species have most individuals in the community (patterned distribution: regular or contagious) (Whittaker, 1975; Hammer, 2011).

The Dominance index (D) is calculated as: $D = \sum (pi^2) = \sum (n/N)^2$ - (Hammer, 2011);

where n is number of individuals of a particular species and N is total number of individuals of all species found in the community. It is 1-Simpson index and ranges from 0 when all species are equally present and 1 when one species dominates the community as it is the situation in a monocrop community.

The Jaccard index of community similarity (SCj) is calculated as;

SCj = [w/(A+B-w) x 100] % - (Spellerberg, 1993);

where w is the number of common species; A is the number of species in community A; and B is the number of species in community B. The values range from zero percent (no similarity) to 100% (maximum similarity) (Spellerberg, 1993). The 19 plots were compared pairwise and a matrix of values of index of community similarity established.

RESULTS AND DISCUSSION

Combining the three cocoa producing zones, 76 weed species belonging to 36 families were found, with 42, 35 and 22 species found in Ekiti, Oyo and Cross River (CR) States respectively (Table 2). The families Acanthaceae (5), Asteraceae (5), Euphorbiaceae (7) and Fabaceae (7) had highest number of species. Only seven species were common to the three states. They are *Asystasia gangetica, Chromolaena odorata, Solanecio biafrae, Combretum hispidum, Ficus exasperata, Oplismenus burmannii and Talinum fruticosum*. *Solanecio biafrae* was found in all plots in Ekiti and Oyo States but in 33% of plots in Cross River State (Table 2).

Table 2. Weeds and Low-growing Plant Species Found in Cocoa Plots in Three Cocoa-Growing States of Nigeria

S/No	Family (No. of Species)	Species composition	% Occurrence Ekiti	Oyo	Cross River
1	Acanthaceae (5)	*Acanthus montanus* (Nees) T. Anders.	100		
		Asystasia gangetica (L.) T. Anders.	100	33	50
		*Hypoestes forskalei (*Vahl.) Soland ex Roem. & Schult		33	
		Justicea flava (Forsk) Vahl.		33	
		Monechma ciliatum (Jacq.) Milne-Redhead		67	17
2	Amaranthaceae (3)	*Achyranthes aspera* L.		100	
		Alternanthera sessilis (L.) DC.		33	33
		Celosia laxa Schum. & Thonn.	90		
3	Anarcadiaceae (1)	*Spondias mombin* L.		33	
4	Arecaceae (1)	*Elaeis guineensis* Jacq.		67	
5	Asclepiadaceae (2)	*Gongronema latifolium* Benth.	60		
		Pergularia daemia (Forsk.) Choiv.	40		
6	Asteraceae (5)	*Ageratum conyzoides* L.		33	
		Chromolaena odorata (L.). R.M. King & Robinson	100	100	50
		Solanecio biafrae (Olive and Hiern) C. Jeffrey	100	100	33
		Acmella brachyglossa Cass. (Syn. *Spilanthes filicaulis* (Schum & Thonn.) C.D. Adams		33	
		Synedrella nodiflora Gaertn.		33	
7	Bignoniaceae (1)	*Newbouldia laevis* (P. Beauv.) Seemann ex Bureau		33	

Table 2. Contd

S/No	Family (No. of Species)	Species composition	% Occurrence Ekiti	Oyo	Cross River
8	Capparaceae (1)	*Ritchiea capparoides* (Andrews) Britten	100		
9	Cochlospermaceae (1)	*Cochlospermum planchoni* Hook f.	30		
10	Combretaceae (3)	*Combretum hispidum* Laws.	80	33	17
		Combretum racemosum P. Beauv.	70		
		Combretum zenkeri Engl. & Diels.	90		
11	Commelinaceae (4)	*Aneilema aequinoctiale* (P. Beauv.) Kunth.	80	67	
		Commelina benghalensis L.		67	33
		Commelina erecta L.		33	
		Floscopa africana (P. Beauv.) C.B. Clarke	50		
12	Connaraceae (1)	*Cnestis ferruginea* DC	10		
13	Convulvulaceae (1)	*Ipomoea triloba* Linn.			33
14	Cyperaceae (1)	*Cyperus esculentus* Linn.			33
15	Dennstaedtiaceae (1)	*Pteridum aquilinum* (L.) Kuhn.		33	
16	Dilleniaceae (1)	*Tetracera alnifolia* Willd.	60		
17	Euphorbiaceae (7)	*Alchornea cordifolia* (Schum & Thonn.) Mull. Arg.	80		17
		Anthonotha macrophylla P. Beauv.	40		
		Croton hirtus L'Herit	100		
		Euphorbia hirta Linn			50
		Euphorbia lateriflora Schum. & Thonn.	20		
		Manihot esculanta Linn.			17
		Phyllanthus amarus Schum. & Thonn.	60		
18	Fabaceae (7)	*Acacia ataxacantha* DC	20		
		Albizia zygia (DC.) J.F. Macbr.	20	33	
		Centrosema pubescens D.C. Benth.		33	17
		Desmodium adscendes	100		
		Desmodium tortuosum Sw. DC.		33	
		Gliricidia sepium (Jacq.) Walp.	40		
		Tephrosia pedicellata Bak.			17
19	Icacinaceae (1)	*Icacina tricantha* Oliv.	70		33
20	Loganiaceae (2)	*Anthocleista liebrechtsiana* De Wild. & Th. Dur.	10		
		Spigelia anthemia Linn.	100		
21	Malvaceae (4)	*Malvastrum cormandelianum* (Linn.) Garcke			17
		Sida acuta Burm. f.			33
		Sida corymbosa R.E. Fries	30		
		Sida rhombifolia L.			17
22	Melastomataceae (1)	*Heterotis rotundifolia* (Sm) Jac. Fel.		33	
23	Menispermaceae (3)	*Chasmanthera dependens* Hochst.	30		
		Sphenocentrum jollyanum Pierre	100		
		Triclisia subcordata Oliv.	40		

Table 2. Contd

S/No	Family (No. of Species)	Species composition	% Occurrence Ekiti	Oyo	Cross River
24	Moraceae (2)	*Ficus exasperata* Vahl.	10	67	17
		Melicia excelsa (Welw.) C.C. Berg.	20		
25	Passifloraceae (1)	*Adenia cissampeloides* (Planch. ex Hook) Harns	100	67	
26	Periplocaceae (1)	*Parquetina nigrescens* (Afzel.) Bullock	100		
27	Piperaceae (1)	*Peperomia pellucida* (L.) H.B. & K.		33	
28	Poaceae (4)	*Acrocera zizanoides* Dandy		33	
		Axonopus compressus (Sw.) P. Beauv.			17
		Digitaria longiflora (Ret.) Pers.	80		
		Oplismenus burmannii (Retz.) P. Beauv.	100	100	17
29	Portulacaceae (1)	*Talinum fruticosum* (L.) Juss.	40	33	33
30	Smilacaceae (1)	*Smilax anceps* Willd.		33	
31	Solanaceae (2)	*Solanum erianthum*	20		
		Solanum nigrum L.	10		
32	Sterculiacea (1)	*Cola millenii* K. Schum.		33	
33	Thelypteridaceae (1)	*Pneumatopteris afra* (Christ) Holttum	10		
34	Tiliaceae (1)	*Triumfetta cordifolia* A. Rich.		33	
35	Urticaceae (2)	*Laportea aestuans* (L.) Chew.		100	
		Laportea ovalifolia (Schum.) Chew		100	
36	Verbanaceae (1)	*Stachytarpheta jamaicensis* (L.) Vahl.		33	
	Total (76)	**Number of Species**	**42**	**35**	**22**

The species richness (R) per plot ranged from 20 to 29 in Ekiti, 13 to 24 in Oyo and 5 to 9 in CR (Table 3). The generally high species richness in Ekiti and Oyo plots may be attributed to their location in the lowland rainforest ecosystem with complex landscape and habitat heterogeneity (Miller, 1990). Also, the high species richness conforms to the species richness of 15 to 26 reported for cocoa plots in Cameroun (Sonwal *et al.*, 2007). However, the species richness values deviated from Adenikinju (1975) who reported 148 weed species belonging to 49 families in some cocoa plots in Western Nigeria, and with 35 ubiquitous species. The declining trend of weed species richness was also reported in rubber plantations by Ohikhena and Awodoyin (2012). They reported 92 weed species in 40 families compared to 197 species in 59 families reported by Gill and Onyinbe (1990). However, Odiwe *et al.* (2012) reported similar composition of understorey species between a ten-year old forest tree (*Tectona grandis*) plantation and a nearby re-growth secondary forest in Ile-Ife, but reduction in percentage importance of each species in the tree plantation.

The fairly openness of Afijio cocoa plot might have excluded the obligate sciophytes and the oldness and quite close canopy of CR cocoa plots might have excluded the obligate heliophytes, thus accounting for the low species richness. However, Ekiti that have mature cocoa plots with some open patches might present the peculiar diverse and structurally complex shade of cocoa plots and cocoa agro-forest (Scroth *et al.*, 2004) that supported both sciophytes and heliophytes, thus the relatively high species richness.

Table 3. Relative Importance Value (%) of Weed and Low-Growing Plant Species Enumerated in Cocoa Plantations in Ekiti, Oyo and Cross River States,

S/No	Binomial	EK1	EK2	EK3	EK4	EK5	EK6	EK7	EK8	EK9	EK10	OY1	OY2	OY3	CR1	CR2	CR3	CR4	CR5	CR6
1	*Acacia ataxacantha*	0.46		1.05																
2	*Acanthus montanus*	9.78	8.88	8.72	12.75	13.11	12.21	10.49	11.09	8.98	9.33									
3	*Achyranthes aspera*											9.36	12.45	9.62						
4	*Acmella brachyglossa*											2.91								
5	*Acrocera zizanoides*											4.91								
6	*Adenia cissampeloides*	1.11	1.5	1.13	0.85	2.71	2.09	2.04	1.96	1.94	2.24	2.91	5.32							
7	*Ageratum conyzoides*											28.5								
8	*Albizia zygia*							1.32	0.57					1.57						
9	*Alchornea cordifolia*	1.33	1.72	1.05	0.76			1.42	2.32	3.09	3.45				11.11					
10	*Alternanthera sessilis*											1.65				16.2	14.21			
11	*Aneilema aequinoctiale*	1.95	1.08	2.09	1.52	2.61	2.75	0.76	0.77				3.81	5.46						
12	*Anthocleista liebrechtsiana*			2.11																
13	*Anthonotha macrophylla*							1.78	1.71	1.34	1.41									
14	*Asystasia gangetica*	5.75	6.12	1.74	1.45	4.77	5.19	3.31	4.32	0.78	0.84	2.98	4.57	5.73	23.35		19.19			8.45
15	*Axonopus compressus*																			12
16	*Celosia laxa*	16.1	15.9	7.22	5.96	9.62	10.22	9.92		7.12	7.83									
17	*Centrosema pubescens*													3.49			13.79			
18	*Chasmanthera dependens*					0.94	0.91		10.34											
19	*Chromolaena odorata*	3.59	3.53	8.11	9.27	4.95	3.83	4.47	3.66	6.18	6.71	12.1	3.81	2.87		27.6	23.3		36	
20	*Cnestis ferruginea*					12.58														
21	*Cochlospermum planchoni*			1.05	0.76			0.66												
22	*Cola milleni*													0.79						
23	*Combretum hispidum*	3.33	3.71			1.52	0.91	1.32	2.12	14.6	12.4			1.57					2	
24	*Combretum racemosum*	0.46	0.51			1.52	1.68	1.98	2.12	0.78										

Table 3. Contd.

25	*Combretum zenkeri*	0.46		1.22	0.93	1.88	2.47	7.63	7.71	5.41	3.83									
26	*Commelina benghalensis*											4.98	5.69					26.33		11.2
27	*Commelina erecta*												9.1							
28	*Croton hirtus*	1.95	1.72	2.36	1.71	4.92	11.83	3.19	3.36	1.75	2.05									
29	*Cyperus esculentus*																	12.87		9.32
30	*Desmodium adscendes*	19.6	19.9	12	21.19	0.23	5.02	7.56	7.37	9.11	9.34									
31	*Desmodium tortuosum*													3.13						
32	*Digitaria longiflora*	5.37	5.63	6.06	6.38	11.88	10.81	5.66	5.69											
33	*Elaeis guineensis*											0.82	2.29							
34	*Euphorbia hirta*														19.86	20	16.07			
35	*Euphorbia laterifolia*	0.46	0.51																	
36	*Ficus exasperata*	0.46										1.65		0.79						15.5
37	*Floscopa africana*	1.86	1.85			1.16	1.62	0.56												
38	*Gliricidia sepium*			0.17	0.76			0.76	0.77											
39	*Gongronema latifolium*	2.94	2.69	1.13	0.85	1.64	2.57													
40	*Heterotis rotundifolia*													6.77						
41	*Hypoestes forskalia*													6						
42	*Icacina tricantha*	1.43	1.65	1.13				0.76	1.55	1.78	1.03				12.72			18.77		
43	*Ipomoea triloba*														18.25				22	
44	*Justicea flava*													10.4						
45	*Laportea aestuans*											2.24	8.7	4.95						
46	*Laportea ovalifolia*											5.35	16.26	5.47						
47	*Malvastrum cormandelianum*																			7.57
48	*Manihot esculanta*																	14.94		
49	*Melicia excelsa*	0.46				0.69														
50	*Monechma ciliatum*											6.4	6.81						12	
51	*Newbouldia laevis*													0.79						

Table 3. Contd.

52	*Oplismenus burmannii*	7.09	8.63	21.8	18.68	3.41	5.49	12.49	12.35	8.42	10.7	3.43	8.72	4.95						8.57
53	*Parquetina nigrescens*	1.51	1.53	4.28	2.37	3.39	1.56	1.4	1.58	2.94	2.24									
54	*Peperomia pellucida*											3.13								
55	*Pergularia daemia*					2.43	1.99	1.88	2.22											
56	*Phyllanthus amarus*	0.91	1.08					0.96	1.07	2.13	2.24									
57	*Pneumatopteris afra*			1.22																
58	*Pteridum aquilinum*													3.14						
59	*Ritchiea capparoides*	1.95	1.72	3.91	4.24	5.49	7.04	6.69	6.92	9.43	10.1									
60	*Sida acuta*															23.8			28	
61	*Sida corymbosa*			1.05	0.85			0.76												
62	*Sida rhombifolia*																			9.32
63	*Smilax anceps*													1.57						
64	*Solanecio biafrae*	0.46	0.58	1.22	1.52	1.76	1.91	0.66	0.77	0.97	1.03	5.89	12.52	9.11	14.76		13.46			
65	*Solanum erianthum*	0.46								0.97										
66	*Solanum nigrum*					0.69														
67	*Sphenocentrum jollyanum*	0.53	0.58	1.31	1.42	2.21	2.45	5.89	5.41	7.93	8.76									
68	*Spigelia anthemia*	7.74	8.39	4.69	3.91	2.25	2.51	0.97	1.48	2.48	2.81									
69	*Spondia mombin*													1.57						
70	*Stachytarpheta jamaicensis*													4.95						
71	*Synedrella nodiflora*													2.68						
72	*Talinum fruticosum*	0.53	0.58	1.13	0.94							0.9				12.4		27.06		
73	*Tephrosia pedicellata*																			18.2
74	*Tetracera alnifolia*			1.13	0.93	0.82	1.91	2.71	0.77											
75	*Triclisia subcordata*					0.82	1.02			1.84	1.66									
76	*Triumfetta cordifolia*													2.61						
	Number of Species	**29**	**24**	**27**	**23**	**27**	**24**	**29**	**26**	**22**	**20**	**18**	**13**	**24**	**6**	**5**	**6**	**5**	**5**	**9**

Comparing the present result with the report by Adenikinju (1975), it is evidenced that there was shift in the population with many weed species lost. Of the 35 ubiquitous weed species that he listed, only 11 were encountered in the present study and most of them with low Relative Important Value (RIV) and found in 15 of the 19 plots studied. Those found include *Ageratum conyzoides* (RIV 28.53; 1 plot), *Synedrella nodiflora* (RIV 2.68; 1 plot), *Newbouldia laevis* (RIV 0.79; 1 plot), *Aneilema acquinoctiale* (RIV 0.76-5.46; 10 plots), *Commelina* sp. (RIV 4.98-26.33; 5 plots), *Solanecio biafrae* (RIV 0.46-14.76; 15 plots), *Albizia zygia* (RIV 0.57-1.57; 3 plots), *Melicia excelsa* (RIV 0.46-0.69; 2 plots), *Parquetina nigrescens* (RIV 1.40-4.28; 10 plots), *Talinum fruticosum* (RIV 0.53-27.06; 7 plots) and *Solanum* sp. (RIV 0.46-0.97; 3 plots) (Table 3). *Solanecio biafrae* remained the most ubiquitous, especially in Ekiti and Oyo plots, and this may be due to deliberate protection and little uncoordinated cultivation because of its culinary importance as a pot herb (Adebooye, 2004). Actually, the farmers in Cross River State did not identify *S. biafrae* as having any ethnobotanical function, hence no attention was given to it. The maturity of CR cocoa plots may further explain the reduction in number of ubiquitous species because only those that are obligate sciophytes will survive under the relatively close canopy. Also, incursion of invasive weed species into the cocoa plots may account for the reduction. For example, *Chromolaena odorata* that was not listed as ubiquitous species by Adenikinju (1975) was identified as one of the major weed species in cocoa plot by Adeyemi (1986) and it is one of the ubiquitous species identified in the present study. The RIV of the weed species ranged from 0.17 to 21.75 in Ekiti cocoa plots; 0.79 to 28.53 in Oyo plots and 2 to 27.58 in CR plots (Table 3). Heliophytes like *Acrocera zizanoides* (RIV 4.91), *A. conyzoides* (RIV 28.53), and *Acmella brachyglossa* (RIV 2.91) were peculiar to Afijio plot (OY1) that is quite young. The RIV for *S. biafrae r*anged from 0.46 to 1.91 in Ekiti; 5.89 to 12.52 in Oyo and 13.46 to 14.76 in CR cocoa plots (Table 3). In Ekiti plots the low RIV might be due to harvesting without concerted efforts at replacing. For Oyo State, *S. biafrae* had lowest RIV in Afijio plot, probably because there was no deliberate cultivation of the plant. However, in OY2 and OY3 plots the RIVs for *S. biafrae* were relatively high because the farmers spared stands during weed control and deliberately introduced some stands through propagation by cuttings to increase the stock. The low species richness in CR plots projected the RIV of each species, hence the high value for *S. biafrae* compared to Ekiti and Oyo plots. Considering the CR plots only, *S. biafrae* had relatively low RIV (13.46-14.76; 2 plots), which may be strongly due to lack of use for it by the people, and therefore, the farmers do not have cause to spare its stands during weed control. *Acmella brachyglossa* (RIV:2.91) was found in only OY1 plot. It is a recently spreading invasive weed species and a heliophyte. Its population is becoming disturbing on maize and soyabean fields across Oyo and Osun States (Ogunjobi, 2010). The plant was mistakenly identified as *Spilanthis filicaulis* but now properly classified (Chung et al., 2008). The openness of OY1 plot might have encouraged incursion of *A. brachyglossa* into the cocoa field. *Adenia cissampiloides* (RIV:0.85-5.32; 12 plots) is another invasive weed species that is recently taking over tree crop plots. It survives under the close canopy of tree crops like *Citrus sinensis* (citrus), *Mangifera indica* (mango) and tree fallows, being a sciophyte. However, it was not found in the CR plots and OY3 plot that have quite close canopy (light intensity: 1410-1650 Lux).

The weeds that were ubiquitous in cocoa plots across the three states include *Adenia cissampeloides* (RIV: 0.85-5.32; 12 plots), *Asystasia gangetica* (RIV: 0.78-23.35; 16 plots); *Chromolaena odorata* (RIV: 3.53-36.00; 16 plots); *Oplismenus burmannii* (RIV: 3.41-21.75; 13 plots) and *Solanecio biafrae* (RIV: 0.46-14.76; 15 plots) (Table 3). It is clear from the enumeration that *C. odorata* that was the first invasive weed species on Nigerian fields is still present across the three localities. However, *A. cissampeloides* is becoming important in cocoa plantations. The implication of invasive weed species is suppression and ousting of indigenous species and vulnerability to fire outbreak (Popoola et al., 2000; Ohikhena and Awodoyin, 2012). *Acanthus montanus* that was reported to occur frequently with high abundance in cocoa plots (CSTS, 2009) was found in only Ekiti plots, though with consistently high RIV (8.72-13.11).

In Ekiti plots the Shannon-Wiener indices ranged from 2.486 to 2.938, Equitability indices from

0.793 to 0.909 and Dominance indices from 0.065 to 0.116. The indices in Oyo plots ranged from 2.423 to 2.923 for Shannon-Wiener, 0.854 to 0.945 for Equitability and 0.057 to 0.126 for Dominance. In CR plots the indices ranged from 1.390 to 2.167 for Shannon-Wiener, 0.864 to 0.992 for Equitability and 0.124 to 0.271 for Dominance (Table 4). The high Shannon-Wiener indices in Ekiti and Oyo indicated high diversity and that no one species was dominant. Also, the equitability indices that tended towards one indicated random distribution of all species. The low Dominance indices confirmed the random distribution of all species. In CR plots the relatively low Shannon-Wiener indices implied low species diversity. However, the high Equitability indices implied that no particular species was dominant. The enumeration showed clearly that no particular species was ubiquitous in all the CR plots. The relatively high Dominance indices in plots CR2 (0.215), CR4 (0.217) and CR5 (0.271) can be accounted for by the high RIV for *Chromolaena odorata* (27.58), *Tephrosia pedicellata* (27.06) and *Sida acuta* (28.00) in the plots respectively.

Table 4. Community Structure of Weed Community in the Cocoa Plots in Ekiti, Oyo and Cross River States, Nigeria

Plots	Taxa	Diversity Indices		
		Shannon- Wiener (H')	**Equitability (J)**	**Dominance (D)**
Ek1	29	2.751	0.817	0.101
Ek2	24	2.559	0.805	0.091
Ek3	27	2.798	0.849	0.098
Ek4	23	2.486	0.793	0.116
Ek5	27	2.850	0.865	0.071
Ek6	24	2.849	0.897	0.070
Ek7	29	2.938	0.873	0.065
Ek8	26	2.905	0.892	0.069
Ek9	22	2.785	0.901	0.078
Ek10	20	2.722	0.909	0.080
Oy1	18	2.468	0.854	0.126
Oy2	13	2.423	0.945	0.095
Oy3	24	2.923	0.920	0.057
CR1	6	1.76	0.982	0.178
CR 2	5	1.573	0.977	0.215
CR 3	6	1.778	0.992	0.178
CR4	5	1.567	0.974	0.217
CR5	5	1.390	0.864	0.271
CR6	9	2.167	0.986	0.124

Table 5. Jaccard Similarity Index Values Comparing Some Cocoa Plantations in Ekiti, Oyo and Cross River States, Nigeria Based on Weed Species Composition

	EK1	EK2	EK3	EK4	EK5	EK6	EK7	EK8	EK9	EK10	OY1	OY2	OY3	CR1	CR2	CR3	CR4	CR5	CR6
EK1																			
EK2	89.29																		
EK3	60	59.38																	
EK4	57.58	62.07	85.19																
EK5	60	59.38	50	56.25															
EK6	60.61	65.52	54.55	62.07	88.89														
EK7	61.11	65.63	64.71	67.74	60	65.63													
EK8	57.14	61.29	55.88	58.06	60.61	66.67	83.33												
EK9	64.52	64.29	48.48	50	53.13	58.62	64.52	65.52											
EK10	58.06	62.96	51.61	53.57	51.61	57.14	63.33	64.29	90.91										
OY1	14.63	16.67	15.38	17.14	12.5	13.51	11.9	12.82	14.29	15.15									
OY2	16.67	19.35	17.65	20	17.65	19.35	16.67	18.18	16.67	17.86	55								
OY3	15.22	14.29	10.87	11.9	13.33	14.29	15.22	16.28	12.2	12.82	23.53	27.59							
CR1	12.9	15.38	13.79	16	6.44	7.14	12.9	14.29	16.67	18.18	9.09	11.76	7.14						
CR2	6.25	7.41	6.67	7.69	3.23	3.57	3.03	3.33	3.85	4.17	9.52	5.88	0	10					
CR3	9.38	11.11	10	11.54	10	11.11	9.38	10.34	12	13.04	20	18.75	15.38	33.33	37.5				
CR4	6.25	7.41	6.67	3.7	0	0	3.03	3.33	3.85	4.17	9.52	5.88	0	10	11.11	0			
CR5	6.25	7.41	3.23	3.7	3.23	3.57	11.76	6.9	8	0	9.52	12.5	7.41	10	25	10	0		
CR6	5.56	6.45	5.88	6.67	5.88	6.45	5.56	6.06	6.9	7.41	17.39	15.79	6.45	7.14	0	7.14	16.7	0	

Jaccard (SCj) indices of similarity based on weed species composition between pairs of plot ranged from 50 to 90.91% within Ekiti plots, 23.53 to 55% within Oyo plots and 0 to 37.5% within CR plots (Table 5). The high values within Ekiti plots may indicate less environmental heterogeneity among the plots, and low values within Oyo and CR may imply high environmental heterogeneity. Among the Ekiti plots, EK9 and EK10 were the closest (SCj:90.91%) followed by EK1 and EK2 (SCj:89.29%), EK5 and EK6 (SCj:88.89%) and EK7 and EK8 (SCj:83.33%). EK3 and EK9 had the least similarity (SCj:48.48%). The closest plots in Ekiti and Oyo were EK4 and OY2 (SCj: 20.00%), in Ekiti and CR plots they were EK10 and CR1 (SCj:18.18%) and in Oyo and CR they were OY1 and CR3 (SCj:20.00%) (Table 5). These low values are indicative of high spatial variations among the localities. Olubode *et al.* (2011), working on three quite close wetlands in Ibadan, Nigeria, reported high variation in species composition and density. It was severally reported that plant species composition and abundances within tropical forest landscapes respond to local conditions, especially heterogeneity in soil properties, topography, and level of inter- and intra-specific competition (Tuosnusto and Poulsen, 2000; Harms *et al.*, 2001; Cannon and Leighton, 2004; Udoh *et al.*, 2007). The pattern of distribution may also be attributed to differences in the amount of light reaching the plot floor (Kumar Sit *et al.*, 2007) and weed management practices (Cardina *et al.*, 1997; Hyvonen, 2004).

CONCLUSION

The recent spread of *Adenia cissampeloides* (a sciophyte) in the cocoa plots may aggravate the threat to *S. biafrae* population and the few ubiquitous species, which will result in the loss of the culinary, environmental, social and cultural services and functions of the species. The fast evolving herbicidal weed control in cocoa plot may exacerbate the threat. Therefore, cultivation of *S. biafrae* outside cocoa plantation will ensure steady availability of less chemical-contaminated stocks to consumers, more so that many agrochemicals are used in the production of cocoa. Also, understanding the agronomic requirements for field cultivation of *S. biafrae* will ensure its sustainable production.

It is clear from the study that cocoa plots may no longer strictly serve the purpose for conservation of tropical rainforest plant diversity. Establishment of botanical gardens for *ex-situ* conservation may conserve the weed species with ethnobotanical potentials.

Early detection of incursion of invasive weed species and immediate control will curb their spread and suppression of endemic weed species. Setting up of protected areas and putting in place legislations against unauthorized trespass and other anthropogenic activities will conserve the original native plant species and reduce threats to biodiversity sustenance.

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