ESCAPEE ORNAMENTAL PLANTS: EFFECT ON SPECIES DIVERSITY IN THE ADJOINING VEGETATION OF THE PARKS AND GARDENS, UNIVERSITY OF LAGOS, NIGERIA

[* 1 & 2]Sanyaolu, V. T., [2]Awodoyin, R. O. [3]Ayodele, A. E. and [2]Ogunyemi, S.
[1]Department of Biological Science (Environmental Biology Unit), School of Pure and Applied Sciences, Lagos State Polytechnic, Ikorodu, Lagos
3Department of Crop Protection and Environmental Biology, Faculty of Agriculture and Forestry, University of Ibadan
[2]Department of Botany, Faculty of Science, University of Ibadan
[*] Corresponding Author: vaksanyaolu@yahoo.com, sanyaolu.v@mylaspotech.edu.ng

ABSTRACT
This study identified invasive species amongst the escapee OPs and determined their effects in the adjoining vegetation (AV) of the Parks and Gardens, University of Lagos, Nigeria. Species enumeration was done across the AV and an uninvaded vegetation located within the garden using systematic sampling technique in two consecutive years during dry (D1, D2) and wet (W1, W2) seasons. Escapee OPs were identified and Relative Importance Value (RIV) of plants were determined. Community structure was established using Shannon-Wiener (H') and Equitability (J) indices. Comparison of species was carried out using Jaccard's similarity coefficient (SC_J). Results obtained revealed more individuals in the dry seasons and more in wet seasons for invaded and uninvaded vegetation respectively. A total of 59 species in 36 families occurred in invaded vegetation and 67 species in 39 families in the uninvaded vegetation. Diffenbachia seguine (Jacq.) Schott was the most important species in the invaded AV in all four seasons with mean RIV of 19.5%. In the uninvaded vegetation, mean RIV were low, ranging between 0.21% - 3.41%. Species diversity indices, H' and J were 2.39 - 3.03 and 0.69-0.71 respectively for invaded vegetation and 3.94-4.04 and 0.97 in all seasons respectively for uninvaded vegetation. SC_J ranged between 40.0-60.0% in the invaded vegetation and 84.4-90.1% in the uninvaded vegetation. Twelve OPs escaped into the AV. Among these, only four; Diffenbachia seguine, Synogonium podophyllum Schott, Heliconia psittacorum L.f. and Epipremnum pinnatum (L.) Engl. were invasive. Their invasion resulted in low species diversity in the adjoining vegetation.

Keywords: Ornamental plants, Invasive plants, Relative Importance Value, Adjoining vegetation, Plant diversity

INTRODUCTION
Man-made introductions in new habitats are responsible for rapid change within the indigenous communities (Ridenour and Callaway, 2001; Razanajatovo *et al.*, 2015). Many exotic plant species worldwide introduced for commercial

exploitation, economic reasons and for ornamental purpose have subsequently become noxious invaders (Mack, 2003). Thus, horticulture is a major pathway for the introduction of alien plants (Razanajatovo *et al*., 2015). Sometimes, under the alien conditions or in new invaded ecosystems, such species become naturalized and expand over native ecosystems (Richardson, 1998; Pyšek *et al*. 2011). It is estimated that as many as 50% of invasive species in general can be classified as ecologically harmful, based on their actual impacts (Richardson *et al*., 2000).

Plants introduced for ornamental purposes, but have become invasive in their new areas with attendant environmental problems have been widely reported (Akobundu and Agyakwa, 1998; Reichard, and White, 2001). *Tithonia diversifolia* (Hemsl.) A. Gray, commonly called Mexican sunflower and native to Central America, Mexico and Cuba (Royal Horticultural Society, 1956), probably introduced into Africa as an ornamental plant (Akobundu and Agyakwa, 1998) is invasive in parts of Kenya, Uganda, Tanzania (Tropical Biology Association, 2010) and in Nigeria (Ayeni *et al*., 1997), where *T. diversifolia* is a widespread species, having colonized roadsides, waste places, fallow land and disturbed open spaces like abandoned construction sites, displacing native species (Adebowale and Olorode, 2005). *Eichhornia crassipes* (Mart.) Solms (Water hyacinth), a native of the Amazon Basin, was brought to Africa, probably to decorate ornamental ponds with its attractive violet coloured flowers (Akobundu and Agyakwa, 1998). Water hyacinth can explode into a floating blanket, affecting shipping, reducing fish catches, hampering electricity generation and human health. *Eichhornia crassipes* is highly invasive in Lagos State, Nigeria (Adekanmbi *et al*., 2009).

Leucaena leucocephala (Lam.) de Wit (Fabaceae) native to Southern Mexico and Northern Central America (Germplasm Resources Information Network (GRIN), 1995), is a fast-growing, multipurpose and beneficial tree, suitable as an ornamental and roadside landscaping species (Orwa *et al*., 2009). It has become an aggressive invader in tropical and subtropical disturbed areas. The plant is reported to be invasive in more than 20 of the more than 105 countries where it was introduced (Walton, 2003). *Dieffenbachia seguine,* an ornamental plant commonly used as an exotic houseplant, has its native range from the Caribbean to Tropical South America (Missouri Botanical Garden, 2016). The plant is reported to have escaped into the wild and has become invasive in many locations including Fiji Island (Smith, 1979), the Pacific Islands (Space and Flynn, 2000), Kosrae Island, Federated States of Micronesia (Space *et al*., 2000) and Nigeria (Bassey and Akpanumun, 2009; Aigbokhan, 2013).

Invasive alien species pose a threat to native plant communities globally, especially where these communities are disturbed (D'Antonio *et al*., 2001). Invasions by non-native plants can alter ecosystem functions and reduce native plant diversity (Levine *et al.*, 2003). Plant invasions dramatically affect the distribution, abundance and reproduction of many native species (Sala *et al.*, 1999). For example, the introduction of pines in the Southern Hemisphere has affected large areas of natural grass and shrub lands, bringing a lot of changes in the dominant life forms, decreasing the species composition and modifying vegetation patterns and nutrient cycles in the region (Richardson *et al*., 1994). A study of the impact of invasive plants on invaded communities revealed that species richness, diversity and evenness were reduced in invaded plots (Hejda *et al.,* 2009). Invasive species exhibiting the greatest impact reduced species numbers per plot and the total number of species recorded in the communities sampled by almost 90%. Furthermore, a strong reduction of species number at the plot scale resulted in a marked reduction in the total species number at the landscape scale and in less similarity between invaded and uninvaded vegetation (Hejda *et al.,* 2009).

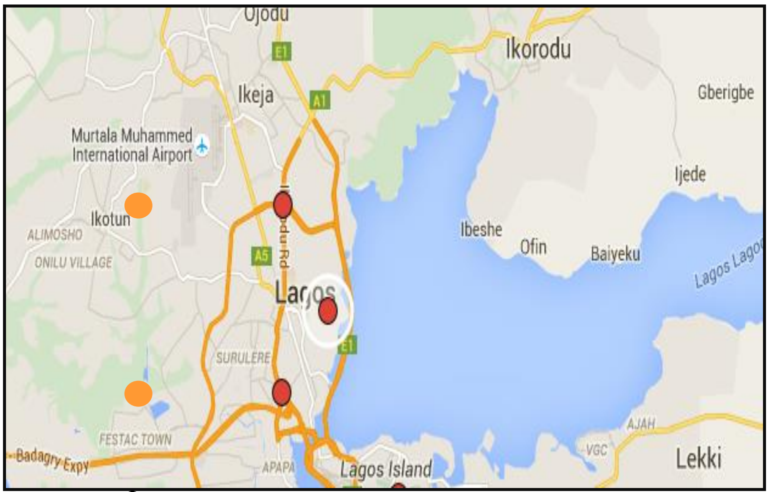
Owing to the devastating impact of invasive plants in the ecosystem, and knowing that ornamental plant introductions are a major pathway of their inlet into a region, there is need for early detection of these species by studying the attributes of ornamental plants in places where they are introduced. Therefore, this study was conducted to identify invasive escapee ornamental plants and determine their effects in the adjoining vegetation of the Parks and Gardens, University of Lagos, Nigeria.

METHODOLOGY

Sites description

The Parks and Gardens, University of Lagos is situated in Akoka campus of the University of Lagos, Yaba, Lagos, southwestern Nigeria and is located 6^{o} 30' 40.10" N, 3^{o} 23' 54.39" E and 07.01 m above sea level (Figure 1). It was set up in 1981 to perform the main functions of developing and carrying out a landscaping plan for the University campus, perfect general beautification and environmental care of the campus, plant and maintain shade trees and flowers as well as fruit and tree nurseries both for the University and for sale to staff and the public. The

University of Lagos is largely surrounded by the Lagos lagoon and the vegetation in this area is represented by mangrove and riparian type (Nodza *et al*., 2014). The cultivated garden covers an approximate total area of 4,551 m^2. It is adjoined by natural vegetation, which for most parts is waterlogged and experience seasonal flooding. This section is invaded by some ornamental plants. Lying at right angle to this area is well drained soil with rich uninvaded vegetation.



Study site

Figure 1: A Map showing the location of Parks and Gardens, University of Lagos

Sampling procedure

This study was conducted between 2013 and 2015. All ornamental plants grown in the garden (in the soil and in pots) were identified (Table 1). In addition, all herbaceous (weedy) plants in the graden floor were also identified and enumerated (Sanyaolu *et al*., 2018a). Sampling of the the AV was by the belt transect technique (Grant *et al.,* 2004; Ahmed, 2016). A single transect was laid in each across the vegetation five meters away from the edge of the garden and was continuous through the entire length, running parallel to the edge of the garden. Sampling along the transect was at 10 meters intervals using a 2 m x 2 m wooden quadrat. All plants rooted within each quadrat were identified and enumerated. This procedure was also repeated in the uninvaded vegetation located within the garden premises. A total of eight and four quadrats respectively were taken in the invaded and uninvaded vegetation. Data were collected in dry and wet seasons of two consecutive years. These were denoted D1, D2, W1 and W2 for first dry, second dry, first wet and second wet seasons respectively. Identification of plants was done on-site using keys from standard floras and manuals. Samples of unidentified plants were taken to the Herbarium located in the Department of Botany, Obafemi Awolowo University for identification.

Analysis of data

Data obtained for both invaded and uninvaded sections of the garden were analysed to determine Relative Importance Value (RIV) (Curtis, 1959; Barbour *et al.*, 1999; Awodoyin *et al.*, 2013), plant diversity indices and Jaccard similarity coefficient as follows:

$$\boldsymbol{Relative\ Importance\ Value\ RIV}\ (\%) = [Relative\ density + Relative\ frequency]/2$$

$$Relative\ Density\ RD\ (\%) = [density\ of\ a\ species/density\ of\ all\ plant\ species] \times 100$$ ..Eq 1

$$Species\ density\ D\ (m^2) = Total\ no.of\ individuals\ of\ a\ species\ in\ all\ quadrats / total\ no.of\ quadrats\ taken$$ ….Eq 2

$$Relative\ frequency\ of\ a\ species\ RF\ (\%) = [frequency\ of\ that\ species/frequency\ of\ all\ species] \times 10$$ ……Eq 3

$$Species\ frequency\ F\ (\%) = No.of\ quadrats\ species\ occur/total\ no.of\ quadrats \times 100$$ …...Eq 4

Determination of plant community structure

Shannon-Wiener and Equitability indices were obtained using the Paleontological software package (PAST) version 3.10 (Hammer *et al.*, 2015).

Shannon-Wiener Index $H' = -\sum(pi.\ln pi)$ (Shannon and. Wiener, 1949) …Eq 5

Where pi = ni/N, where ni is the no. of individuals of a species in a garden and N is the total number of individuals in the garden.

Equitability index $J = H'/\ln S$ (Whittaker, 197 ……………………Eq 6

Where, S = total number of species enumerated in the garden and In = natural logarithm

Similarity index This was determined using jaccard's similarity coefficient SCJ (Jaccard, 1912) and calculated using the formula: $SCJ = [w/(A + B - w)]\ x\ 100.$ ………………………Eq 7

(Spellberg, 1991; Awodoyin *et al.*, 2013). Where SCJ = Jaccard similarity coefficient, w = number of species common to (or shared by) two seasons/plots, A = number of species in one season/plot and B = number of species in the second season/plot

RESULTS

Species enumeration in the adjoining vegetation

Results obtained for ornamental plants (Ops) composition in the garden unit of the study site revealed a total of 123 species disrtributed in 43 families, among which were the invasive species found in the AV (Table 1). Results for enumerated species revealed that more individual plants were enumerated in the invaded vegetation, occurring in the dry season, compared to the uninvaded vegetation and also where more individuals occurred in the wet season (Tables 1 and 2). Results for species composition of the invaded AV are presented in Tables 1. A total of 296, 297, 292 and 268 individuals were identified in the D1, D2, W1 and W2 respectively. These were distributed among 35 species belonging to 27 families, 42 species in 29 families, 31 species in 24 families and 32 species in 24 families respectively during these seasons (Tables 1). In the uninvaded vegetation, 113, 107, 133 and 129 individuals were enumerated for D1, D2, W1 and W2 respectively. These were distributed in 59, 59, 63 and 65 species and 35, 34, 37 and 37 families respectively for the seasons, signifying that although fewer individuals occurred in the uninvaded sections, these individuals were distributed among more plant species and families compared to the invaded vegetation (Table 2).

Table 1: Ornamental plant composition of the Parks and Gardens, University of Lagos

S/N	Family	S/N	Scientific name
1	Acanthaceae	1.	*Crossandra infundibuliformis* L.
		2.	*Pseuderanthemum carruthersii* (Seem.) Guillaumin
		3.	*Sanchezia speciosa* Ruiz & Pav
2	Agavaceae	4.	*Agave marginata*
		5.	*Yucca sp.*
3	Amaranthaceae	6.	*Alternanthera dentata*
4	Amaryllidaceae	7.	*Crinum jagus* (J.Thomps.) Dandy
		8.	*Crinum mooreii 'alba'*
		9.	*Crinum xanthophyllum*
		10.	*Hymenocallis latifolia* (Mill.) M. Roem
		11.	*Zephyranthes rosea* Lindl.
5	Annonaceae	12.	*Greenwayodendron suaveolens* (Engl. & Diels) Verdc
		13.	*Polyalthia longifolia* (Sonn.) Thwaites
6	Apocynaceae	14.	*Allamanda cathartica* L
		15.	*Amsonia* sp
		16.	*Catharanthus roseus* (L.) G.Don
		17.	*Plumeria rubra* L.
		18.	*Rauvolfia serpentina* (L.) Benth. ex Kurz
		19.	*Tabernaemontana coronaria*
7	Araceae	20.	*Aglaonema commutatum* Schott
		21.	*Caladium bicolor* (Aiton) Vent.
		22.	*Asterix Dieffenbachia seguine* (Jacq.) Schott
		23.	*Asterix Epipremnum pinnatum* (L.) Engl.
		24.	*Peltandra virginica* (L.) Schott
		25.	*Philodendron atabapoense* G.S.Bunting
		26.	*Philodendron hederaceum* (Jacq.) Schott
		27.	*Asterix Syngonium podophyllum* Schott
8	Araliaceae	28.	*Polyscias batfluoriana* (Sander ex André) L.H. Bailey
		29.	*Polyscias filicifolia* (C.Moore ex E.Fourn.) L.H.Bailey
		30.	*Polyscias scutellaria* (Burm.f.) Fosberg
		31.	*Schefflera arboricola* (Hayata) Merr.
9	Arecacea	32.	*Roystonea regia* (Kunth) O.F.Cook
		33.	*Adonidia merrillii* (Becc.) Bec
		34.	*Archontophoenix alexandrae*. (F. Muell.) H. Wendl. & Drude
		35.	*Caryota* sp
		36.	*Dypsis lutescens* (H.Wendl.) Beentje & J.Dransf
		37.	*Licuala* sp.
		38.	*Pritchardia remota* Becc.
10	Asparagaceae	39.	*Asparagus densiflorus 'sprengeri'*
		40.	*Aspidistra elatior* Blume
		41.	*Chlorophytum bichetii*

		42.	*Chlorophytum comosum* (Thunb.) Jacques
		43.	*Cordyline fruticosa* (L.) A. Chev
		44.	*Dracaena marginata* Lam
		45.	*Dracaena fragrans (*L.) Ker Gawl
		46.	*Dracaena loureiri* Gagnep.
		47.	*Dracaena surculosa* Lindl.
		48.	*Furcraea foetida* (L.) Haw
		49.	*Sansevieria cylindrica* Bojer ex Hook.
		50.	*Sansevieria liberica* Gérôme & Labroy
		51.	*Sansevieria trifasciata*Prain.
		52.	*Sansevieria zeylanica* (L.) Willd
11	Cactaceae	53.	*Gymnocalycium sp.*
		54.	*Pereskia bleo* (Kunth) DC.
12	Cannaceae	55.	*Canna indica* L.
13	Combretaceae	56.	*Terminalia catappa* L
		57.	*Terminalia mantaly* H. Perrier
14	Commelinaceae	58.	*Tradescantia spathacea* Sw.
		59.	*Tradescantia zebrine* hort. ex Bosse
15	Costaceae	60.	*Costus woodsonii* Maas
16	Crassulaceae	61.	*Bryophyllum pinnatum* (Lam.) Oken.
17	Cupressaceae	62.	*Thuja occidentalis* L.
18	Cycadaceae	63.	*Cycas petrea*
		64.	*Cycas revoluta* Thunb.
		65.	*Acalypha hispida* Burm.f.
19	Euphorbiaceae	66.	*Acalypha wilkesiana* Müll. Arg.
		67.	*Breynia disticha* J.R. Forst. & G. Forst.
		68.	*Codiaeum variegatum* (L.) A. Juss
		69.	*Euphorbia ingens* E.Mey. ex Boiss.
		70.	*Euphorbia milii* L.
		71.	*Jatropha curcas* L.
		72.	*Jatropha integerrima*. Jacq.
		73.	*Jatropha multifidi* L.
20	Fabaceae	74.	*Delonix regia* (Bojer ex Hook.) Raf
		75.	*Poinciana pulcherrima* L. *(Caesalpinia pulcherrima* (L.) Sw.)
		76.	*Senna alata* (L.) Roxb.
		77.	*Senna corymbosa (*Lam.) Irwin & Barneby
21	Gentianaceae	78.	*Anthocleista nobilis* G. Don
22	Heliconiaceae	79.	*Asterix Heliconia psittacorum* L. f.
23	Lythraceae	80.	*Cuphea hyssopifolia* Kunth.
		81.	*Lagastroemia indica* L.
		82.	*Lagerstroemia speciosa* (L.) Pers
24	Malvaceae	83.	*Hibiscus rosa-sinensis* L.
		84.	*Sterculia tragacantha* Lindl.
25	Marantaceae	85.	*Calathea majestica*
		86.	*Calathea orbifolia* (Linden *)* H.Kenn
		87.	*Ctenanthe setosa* (Roscoe) Eichler

		88.	*Thaumatococcus daniellii* (Benn.) Benth.
26	Moraceae	89.	*Ficus benjamina* L
		90.	*Ficus elastica* Roxb. ex Hornem.
		91.	*Ficus lyrata* Warb
		92.	*Ficus microcarpa* L.
		93.	*Ficus pumila L.*
27	Moringaceae	94.	*Moringa oleifera* Lam
28	Myrtaceae	95.	*Eucalyptus sp.*
		96.	*Eugenia uniflora* L.
		97.	*Syzygium jambos* L. (Alston)
29	Nephrolepidaceae	98.	*Nephrolepis exaltata (*L.) Schott
		99.	*Nephrolepis falcata (*Cav.) C. Chr.
30	Nyctaginaceae	100.	*Bougainvillea sp.*
31	Pandanaceae	101.	*Pandanus odoratissimus* L.
32	Phytolaccaceae	102.	*Petiveria alliacea* L.
33	Pinaceae	103.	*Pinus Sp.*
34	Poaceae	104.	*Axonopus compressus* (Swartz) P. Beauv
		105.	*Cymbopogon* citratus (DC. ex Nees)
35	Polypodiaceae	106.	*Phymatosorus sp*
36	Rubiaceae	107.	*Gardenia jasminoides*
		108.	*Gardenia jasminoides variegata*
		109.	*Hamelia patens Jacq.*
		110.	*Ixora coccinea* L
		111.	*Ixora finlaysoniana* Wall. ex G.Don
		112.	*Mussaenda philippica A. Rich*.
		113.	*Pseudomussaenda flava* Verdc.
37	Rutaceaae	114.	*Murraya paniculata* (L.) Jack
38	Solanaceae	115.	*Brunfelsia pauciflora* (Cham. & Schltdl.) Benth.
		116.	*Solanum torvum* Sw.
39	Strelitziaceae	117.	*Ravenola madagascariensis* Sonn
30	Turnaraceae	118.	*Turnera ulmifolia* L
31	Verbenaceae	119.	*Duranta erecta* L.
		120.	*Duranta erecta' variegata'*
42	Xanthorrhoeaceae	121.	*Aloe vera* (L.) Burm.f.
43	Zingiberaceae	122.	*Cucurma* sp.
		123.	*Ethligera eliator* (Jack) R.M. Sm.

*Ornamental plants that invaded the adjoining vegetation of the garden

Table 2: Species composition of invaded Adjoining vegetation of the Parks and Gardens, University of Lagos in two wet and dry seasons

		RIV (%)				
Family	**Scientific name**	**D1**	**D2**	**W1**	**W2**	**Mean**
1.Acanthaceae	1. *Asystasia gangetica* (L.) T.Anderson	0.00	0.00	1.04	2.61	0.91
2. Amaranthaceae (2)	2. *Alternanthera brasiliana* (L.) Kuntze	0.00	0.73	0.00	0.00	0.18
	3. *Cyathula prostrata* (L.) Blume	10.23	6.21	7.17	2.70	6.58
3. Amaryllidaceae	4. *Crinum jagus* (J.Thomps.) Dandy	2.93	0.00	0.00	0.00	0.73
4. Annonaceae	5. *Greenwayodendron suaveolens* (Engl. & Diels) Verdc	0.00	0.00	0.78	0.00	0.20
	6. *Alstonia boonei* De Wild.	0.87	0.00	0.00	0.84	0.43
5. Apocynaceae (3)	7. *Alstonia congensis* Engl.	0.87	0.73	2.32	0.00	0.98
	8. *Holarrhena floribunda* (G.Don) T.Durand & Schinz	0.87	0.00	0.00	0.00	0.23
	9. *Rauvolfia vomitoria* Afzel	0.00	2.17	1.04	1.68	1.22
6. Araceae (6)	10. *Caladium bicolor* (Aiton) Vent.	0.00	0.00	0.00	0.84	0.21
	11. *Asterix Dieffenbachia seguine* (Jacq.) Schott	17.36	14.11	22.54	24.04	19.51
	12. *Epipremnum pinnatum* (L.) Engl.)	3.76	6.09	4.89	3.35	4.52
	13. *Peltandra virginica* (L.) Schott	3.27	5.54	0.91	2.05	2.94
	14. *Philodendron atabapoense* G.S.Bunting	0.00	1.40	0.00	0.00	0.35
	15. *Asterix synogonium podophyllum* Schott	10.57	2.58	4.89	4.09	5.53
7. Arecaceae	16. *Elaeis guineensis* Jacq.	2.93	5.48	0.78	1.68	2.72
8. Asparagaceae	17. *Dracaena arborea* (Willd.) Link	0.87	0.89	1.56	0.00	0.83
9. Bignoniaceae (2)	18. *Crescentia cujete* L.	0.00	1.45	0.00	0.00	0.36
	19. *Newbouldia laevis* (P. Beauv.) Seem. ex Bureau	2.93	2.29	1.56	2.89	2.42
10. Bixaceae	20. *Bixa orellana* L	0.87	1.95	0.00	0.00	0.71
11. Combretaceae	21. *Terminalia catappa* L	0.87	1.79	0.00	0.00	0.67
12. Commelinaceae (2)	22. *Aneilema aequinoctiale* P.Beauv.	0.00	1.40	0.00	0.00	0.35
	23. *Commelina erecta* L	0.00	0.00	0.00	0.84	0.21
13. Connaraceae (2)	24. *Byrsocarpus coccineus* Thonn. ex Schumach.	0.00	0.73	1.56	0.00	0.57
	25. *Cnestis ferruginea* Vahl ex DC	0.00	0.00	1.04	0.00	0.26
14. Convolvulaceae	26. *Ipomoea involucrata* P. Beauv.	0.00	0.73	0.00	0.00	0.18
15. Dioscoreaceae (2)	27. *Dioscorea bulbiferia* L	0.00	0.73	1.69	3.34	1.44
	28. *Dioscorea dumetorum* (Kunth) Pax	0.00	0.00	0.00	0.84	0.21
16. Ebanaceae	29. *Diospyros mobutensis* Gurke	0.00	0.73	0.00	0.00	0.18
17. Euphorbiaceae	30. *Alchornea cordifolia* (Schumach. & Thonn.) Müll.Arg.	3.46	4.35	3.89	8.10	4.95
18. Fabaceae (3)	31. *Albizia ferruginea* (Guill. & Perr.) Benth.	0.00	0.73	0.00	0.00	0.18
	32. *Albizia lebbeck* (L.) Benth.	0.87	0.73	0.00	0.84	0.61
	33. *Leptoderris micrantha* Dunn	0.00	0.73	0.00	0.00	0.18
19. Gentianaceae	34. *Anthocleista nobilis* G. Don	0.87	2.17	0.78	2.05	1.47
20. Heliconiaceae	35. *Asterix heliconia psittacorum* L. f.	4.58	1.74	6.16	5.03	4.38
21. Hypericaceae	36. *Harungana madagascariensis* Poir.	3.44	7.48	4.52	4.93	5.09
22. Icacinaceae	37. *Icacina trichantha* Oliver.	2.59	1.62	2.34	2.70	2.31

23. Lecythidaceae	38. *Napoleonaea vogelii* Hook. & Planch	0.87	0.73	2.32	0.84	1.19
24. Malvaceae	39. *Glyphaea brevis* (Spreng.) Monachino	0.00	1.79	0.00	0.00	0.45
25. Menispermaceae	40. *Cissampelos owariensis* Beauv. ex DC	0.87	1.45	0.78	0.84	0.99
26. Moraceae (6)	41. *Antiaris toxicaria* (Pers.) Lesch.	0.87	1.57	0.00	1.68	1.03
	42. *Trilepisium madagascariense* DC. (*Bosqueia angolensis* Ficalho)	0.00	0.73	0.00	0.00	0.18
	43. *Ficus capensis* Thunb.	0.87	1.4	1.56	2.51	1.59
	44. *Ficus exaasperat* Roxb. ex Hornem.	0.00	0.00	0.78	0.00	0.20
	45. *Ficus vogelii* (Miq.) Miq	0.00	0.73	0.00	0.84	0.39
27. Musaceae	46. *Musa* sp.	2.59	0.00	2.34	1.86	1.70
28. Myrtaceae	47. *Syzygium samarangense* (Blume) Merr. & L.M.Perry	0.87	0.00	0.00	0.00	0.22
29. Passifloraceae	48. *Adenia lobata* (Jacq.) Engl	2.07	1.45	5.81	1.68	2.75
30. Phyllanthaceae	49. *Phyllanthus niruri* L	0.00	0.00	0.00	0.84	0.21
31. Poaceae	50. *Bambusa vulgaris* Schrad. ex J.C. Wendl.	6.99	5.14	8.99	9.40	7.63
32. Polygonaceae	51. *Antigonon leptopus* Hook. & Arn	0.00	0.00	0.00	0.84	0.21
33. Rubiaceae (2)	52. *Chassalia kolly* (Schumach.) Hepper	1.73	1.23	0.00	0.00	0.74
	53. *Leptodermis* sp.	0.87	0.00	0.00	0.00	0.22
34. Sapindaceae (2)	54. *Blighia sapida* K.D.Koenig	0.87	0.89	0.00	0.00	0.44
	55. *Paullinia pinnata* L	2.41	2.90	2.97	2.51	2.70
35. Vitaceae (3)	56. *Cissus aralioides* (Welw. ex Baker) Planch	0.00	0.00	0.78	0.00	0.20
	57. *Cissus populnea Guill.*& Perr	0.00	0.00	0.00	0.84	0.21
	58. *Cissus quadrangularis* L.	0.87	1.45	0.78	0.00	0.78
36. Zingiberaceae	59. *Etlingera elatior* (Jack) R.M. Sm	1.04	1.40	1.56	0.00	1.00
		100.2	100.1	100.1	100.1	99.8
	Total individual plants enumerated	296	297	292	268	
	No of species	35	42	31	32	
	Families	27	29	24	24	

D1: 1st dry season D2: 2nd dry season W1: 1st wet season W2: 2nd wet season

*Invasive ornamental plants with high mean RIV in the adjoining vegetation

Table 3: Species composition of uninvaded vegetation of the Parks and Gardens, University of Lagos in two wet and dry seasons

Family	S/N	Scientific name	RIV (%) D1	D2	W1	W2	Mean RIV
1. Acanthaceae (1)		*Asystasia gangetica* (L.) T.Anderson	1.96	2.36	2.78	2.08	2.30
2. Amaranthaceae (2)		*Alternanthera brasiliana* (L.) Kuntze	1.96	2.87	1.60	1.69	2.03
		Cyathula prostrata (L.) Blume	2.93	1.40	2.4	2.93	2.42
3. Anacardiaceae (1)		*Mangifera indica* L.	1.96	0.96	1.18	1.69	1.45
4. Apocynaceae (4)		*Alstonia boonei* De Wild.	0.98	0.96	0.80	0.85	0.90
		Alstonia congensis Engl.	1.96	1.40	2.40	2.08	1.96
		Holarrhena floribunda (G.Don) T.Durand & Schinz	1.96	1.92	1.60	1.69	1.80
		Rauvolfia vomitoria Afzel	1.45	1.40	1.60	2.08	1.63
5. Araceae (2)		*Caladium bicolor* (Aiton) Vent.	1.96	2.36	1.98	1.69	2.00
		Peltandra virginica (L.) Schott	0.00	0.96	0.80	0.85	0.65
6. Arecaceae (2)		*Cocos nucifera* L.	0.98	0.96	0.80	0.85	0.90
		Elaeis guineensis Jacq.	2.93	2.87	1.60	1.69	2.27
7 Asteraceae (1)		*Emilia praetermissa* Milne-Redh	0.00	0.00	0.00	1.24	0.31
8. Bignonaceae (2)		*Newbouldia laevis* (P. Beauv.) Seem. ex Bureau	3.40	2.87	2.40	2.54	2.80
		*Tabebuia rosea (*Bertol) DC	0.98	0.00	0.80	0.85	0.66
9. Bixaceae (1)		*Bixa orellana* L	0.98	0.00	0.80	0.85	0.66
10. Combretaceae (2)		*Terminalia catappa* L	2.42	3.12	2.40	2.08	2.51
		Terminalia superba	0.98	0.96	1.60	0.85	1.10
11. Commelinaceae (2)		*Aneilema aequinoctiale* P.Beauv.	1.96	2.36	3.18	1.69	2.30
		Commelina erecta L	1.96	0.96	2.78	2.54	2.06
12. Connaraceae (2)		*Byrsocarpus coccineus* Thonn. ex Schumach.	0.98	0.96	0.80	0.85	0.90
		Cnestis ferruginea Vahl ex DC	1.96	1.92	1.60	1.69	1.79
13. Convolvulaceae (1)		*Ipomoea involucrata* P. Beauv.	0.00	0.96	1.60	0.00	0.64
14. Cyperaceae (2)		*Cyperus tenuis Sw.*	2.42	2.36	1.98	2.93	2.42
		Cyperus cyperoides	0.98	0.96	0.80	0.85	0.90
15. Dioscoreaceae (2)		*Dioscorea bulbiferia* L	1.96	0.96	1.60	1.24	1.44
		Dioscorea dumetorum (Kunth) Pax	0.98	0.96	0.80	0.85	0.90
16. Ebanaceae (1)		*Diospyros mobutensis* Gurke	1.96	0.96	1.60	1.24	1.44
17. Euphorbiaceae (1)		*Alchornea cordifolia* (Schumach. & Thonn.) Müll.Arg.	0.98	1.92	0.80	0.85	1.14
18. Fabaceae (3)		*Albizia ferruginea* (Guill. & Perr.) Benth.	1.45	0.96	1.18	1.24	1.21
		Albizia lebbeck (L.) Benth.	0.98	0.96	0.80	0.85	0.90
		Leptoderris micrantha Dunn	0.00	1.92	1.98	0.85	1.19
19 Gentianaceae (1)		*Anthocleista nobilis* G. Don	0.98	1.92	1.60	0.85	1.34
20. Hypericaceae (1)		*Harungana madagascariensis* Poir.	3.40	3.76	3.53	2.93	3.41
21. Icacinaceae (1)		*Icacina trichantha* Oliver.	3.40	3.32	2.40	2.93	3.01
22. Irvinginaceae (1)		Irvinginia gabonensis	0.98	0.96	0.80	0.85	0.90
23. Lauraceae (1)		*Presea Americana Mill*	0.98	0.96	0.80	0.00	0.69

24. Lecythidaceae (1)	*Napoleonaea vogelii* Hook. & Planch	1.96	1.92	1.60	1.69	1.79
25. Malvaceae (2)	*Glyphaea brevis* (Spreng.) Monachino	0.98	0.96	0.80	0.85	0.90
	Sida acuta Burm. f.	1.96	0.00	1.98	2.54	1.62
26. Meleaceae (1)	*Azadirachta indica*	0.98	3.32	2.78	2.08	2.29
27. Menispermaceae (1)	*Cissampelos owariensis* Beauv. ex DC	0.98	0.00	1.60	1.69	1.07
28. Moraceae (7)	*Antiaris toxicaria* (Pers.) Lesch.	2.93	3.32	3.58	2.54	3.09
	Artocarpus heterophyllus	0.98	0.96	1.22	1.69	1.21
	Trilepisium madagascariense DC.	1.96	1.92	1.60	2.08	1.89
	Ficus capensis Thunb.	1.45	1.40	0.80	1.69	1.34
	Ficus exasperata Roxb. ex Hornem.	1.96	1.92	1.60	1.69	1.79
	Ficus Thonningii Blume	1.96	1.92	0.00	0.85	1.18
	Ficus vogelii (Miq.) Miq	1.96	1.92	1.60	1.69	1.79
29. Musaceae (1)	*Musa* sp.	2.42	2.36	1.60	2.54	2.23
30. Myrtaceae (1)	*Syzygium samarangense* (Blume) Merr. & L.M.Perry	0.98	0.96	0.80	0.85	0.90
31. Passifloraceae (1)	*Adenia lobata* (Jacq.) Engl	0.98	0.96	1.60	0.85	1.10
32. Phyllanthaceae (2)	*Phyllanthus niruri* L	0.98	0.96	1.60	1.24	1.20
	Phyllanthus amarus Schum & Thonn.	0.00	0.96	0.00	2.47	0.86
33. Poaceae (2)	*Bambusa vulgaris* Schrad. ex J.C. Wendl.	2.93	2.87	1.18	2.08	2.27
	Setaria barbata (Lam.) Kunth	0.00	0.96	1.60	0.85	0.85
34. Polygonaceae (1)	*Antigonon leptopus* Hook. & Arn	1.96	1.92	1.60	0.85	1.58
35. Pyroiodea (1)	*Morinda lucida* Benth	0.00	0.00	0.80	0.85	0.41
36. Rubiaceae (3)	*Chassalia kolly* (Schumach.) Hepper	2.93	2.36	2.40	2.93	2.66
	Leptodermis sp.	1.96	1.92	2.40	1.69	1.99
	Oldenlandia corymbosa (L.)	1.96	1.92	1.60	2.08	1.89
37. Sapindaceae (2)	*Blighia sapida* K.D.Koenig	0.98	0.96	0.80	0.85	0.90
	Paullinia pinnata L	0.98	0.96	2.40	0.85	1.30
38. Vitaceae (3)	*Cissus aralioides* (Welw. ex Baker) Planch	0.00	0.00	0.00	0.85	0.21
	Cissus populnea Guill.& Perr	0.98	0.00	0.80	0.85	0.66
	Cissus quadrangularis L.	0.98	0.96	0.80	0.85	0.90
39. Zingiberaceae (1)	*Etlingera elatior* (Jack) R.M. Sm	0.98	1.92	0.80	1.69	1.35
		100.2	99.9	100.1	100.1	100.15
	Total individuals	113	107	133	129	
	No of species	59	59	63	65	
	Families	35	34	37	37	

D1: 1st dry season D2: 2nd dry season W1: 1st wet season W2: 2nd wet season

Escapee and invasive ornamental plants identified in the adjoining vegetation

Table 1 shows the Relative importance values of all plants enumerated in the AV during the study period. *Dieffenbachia seguine*, an introduced ornamental plant grown in the garden, remained the most important species in all four seasons of study with mean RIV of 19.5% (Table 1). Result also revealed that *D. seguine* had higher RIV in the wet seasons (22.5% and 24.0% for W1 and W2 respectively), when the total number of species appeared lower compared to dry season (17.4% and 14.1% for D2 and D2 respectively), when number of species were higher. Highest RIV for *D. seguine* (24.0%) occurred in the last season of study (W2).

Twelve ornamental plants grown in the garden (Table 1) escaped into the AV. These were *Crinum jagus, Dieffenbachia seguine, Epipremnum pinnatum, Peltandra virginica, Caladium bicolor, Synogonium podophyllum, Heliconia psittacorum, Polyalthia suaveolens* (formerly *Greenwayodendron suaveolens*) *Dracaena arbore, Syzygium samarangense, Philodendron atabapoense* and *Terminalia catappa*. Of these, only *Dieffenbachia seguine (*Araceae), *Synogonium podophyllum (*Araceae), *Epipremnum pinnatum (*Araceae) *and Heliconia psittacorum* (Heliconiaceae), (Plate 1 A, B. C and D respectively) with mean RIV 19.51%, 5.53%, 4.52% and 4.38% respectively, were invasive the AV. Five of the garden ornamental plants were found in the uninvaded vegetation located within the garden premises. These include *Peltandra virginica, Caladium bicolor, Syzygium samarangense, Terminalia catappa* and *Synogonium podophyllum.* However, they only occurred in insignificant numbers compared to other species in the vegetation, thus showing no invasion (Table 2).

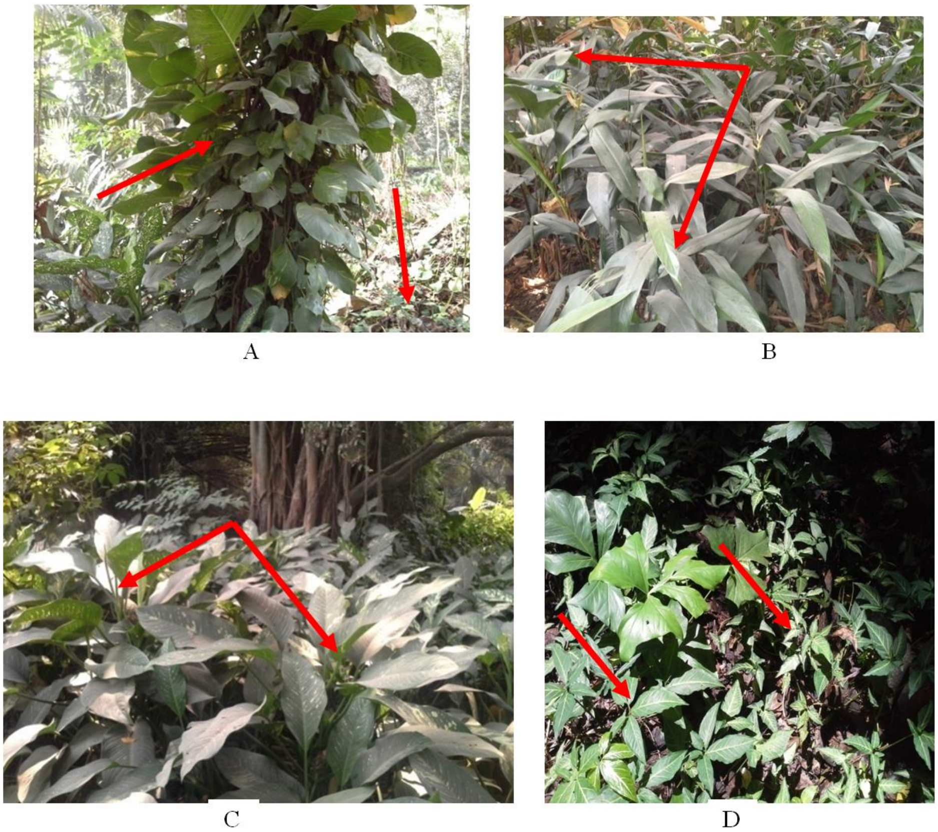


Plate 1: Invasive ornamental plants in the study site (all arrowed); *Epipremnum pinnatum* as a climber and creeper (A) *Heliconia psittacorum* (B) *Dieffenbachia seguine* (C) and *Synogonium podophyllum* (D)

Plant species diversity and similarity indices

Results obtained revealed that species diversity were higher in uninvaded vegetation compared to invaded vegetation. The Result as presented in Table 3 shows that species lower diversity and similarity in the invaded vegetation compared to the uninvaded vegetation. In the invaded vegetation, species diversity indices were generally higher in the dry compared to the wet seasons. Shannon diversity index ranged between 2.39 and 3.03, the highesr values occurring in the dry seasons. Equitability index ranged between 0.69 and 0.81, with the higher values also observes in the dry seasons (Table 4). In the uninvaded vegetation, species diversity indices were higher in the wet compared to the dry seasons (Table 2). Shannon diversity index ranged between 3.94 – 4.04, the higher values occurring in the wet seasons, whereas, equitability was 0.97 in all four seasons (Table 3). Similarity index between vegetation of the study sites is shown in Table 4. In the invaded section of the AV, lowest similarity was 40% occurring between D1 and W1 whereas, highest similarity values of 60% occurred between W1 and W2. In the uninvaded section of the garden, similarity index ranged between 84.4% and 91.0%, with highest values also occurring between W1 and W2. Similarity index between invaded and uninvaded sections of AV was 61.5%.

Table 4: Diversity index of species in four seasons in invaded and uninvaded sections of the AV

	Invaded section				Uninvaded section			
Diversity index\Season	D1	D2	W1	W2	D1	D2	W1	W2
Shannon	2.54	3.03	2.39	2.41	3.97	3.94	4.02	4.04
Equitability	0.73	0.81	0.70	0.69	0.97	0.97	0.97	0.97

D1-First dry season W1- First wet season D2- second dry W2 – Second wet season

Table 5: Jaccard's similarity index (%) comparing species in four seasons in the study site

Seasons	Invaded section				Uninvaded section			
	D1	D2	W1	W2	D1	D2	W1	W2
D1	-				-			
D2	50.98				84.38	-		
W1	40.00	46.00			90.63	87.69	-	
W2	45.65	45.10	60.00	-	90.77	85.07	91.04	-

D1-First dry season W1- First wet season D2- second dry W2 – Second wet season

DISCUSSION

The University of Lagos is largely surrounded by the Lagos lagoon (Nodza *et al.*, 2014) and the study site, the Parks and Gardens of the University, is located by a swamp that leaves a larger section of the AV soil waterlogged, particularly during the wet seasons. Since most plants require a well drained soil for optimal growth and reproduction, this may have partially accounted for lower species number in the wet season in the AV, when only water-logged soil tolerant plants could thrive. However, during the dry season, the adjoining soil conditions improved, allowing more species to emerge, hence, higher number of species recorded in dry seasons. This seasonal fluctuation in soil water content may have also created the necessary disturbance required by invasive escapees to thrive (D'Antonio *et al.*, 2001). Thus, moist soil conditions and seasonal flooding as well as fewer plants in the wet seasons in the AV may have presented the opportunity for aggressive invasion by these species. However, in the uninvaded vegetation, relatively higher individual plants, species number and families were enumerated in the wet compared to dry seasons as is generally observed in well drained tropical soils

(Peters *et al.*, 2014). The vegetation in this area was observed to be very stable with regards to the number and type of species as indicated by higher similarity index between species in the four seasons of study. It could be inferred that there is a direct correlation between soil moisture content and type and abundance of plant species in the vegetation as earlier reported by Peters *et al.* (2014).

Although many OPs escaped into the adjoining vegetation, only a few of these species were invasive. This validates earlier report that only a few among the species that escaped into the landscapes may become invasive (Masterson, 2007). Fountain (2016) stated some characteristic of an invasive plant to include; plants that may have ornamental characteristics making it highly desirable to gardeners and enhances spread to new areas, adaptation to a variety of cultural conditions, very rapid growth, reproduction by vegetative means, flowers and fruits at a young age, produces large numbers of seeds and seeds to have a high percent germination or the species is already known to be invasive in other regions. All or some of these characteristics were observed in each of the species listed as invasive escapees in this study. All four invasive escapees were listed among the commonly grown non native OPs in Southwestern Nigeria (Sanyaolu *et al*., 2018b). Therefore, their widespread usage in the region may further enhance their spread into other native landscapes, where they may continue their invasions, thus posing serious threat to the region.

Invasion or potential invasion by all four species has been previously reported. *Dieffenbachia seguine*, a plant native to North and South America (Cuartas-Hernandez and Nunez-Farfan, 2006), the most invasive species in the AV, has been reported to be invasive in many locations especially in the Pacific Islands (American Samoa) and elsewhere in Nigeria. In Akwa Ibom and Delta states of Nigeria, *D. segune* forms extensive mats and appear to be displacing native and naturalized flora at the location (Bassey and Akpanumun, 2009). In this study, invasion by these ornamental plants was largely restricted to the section of the AV with moist, water logged soils. This agrees with previous reports that *D. seguine* can be invasive and difficult to remove in moist areas (Space and Imada, 2004; Bassey and Akpanumun, 2009). Moreover, in this study, the RIV of *D. segune*, was highest in the last season of study compared to the previous seasons, signifying increased population as time progressed. This indicates a gradual invasion, which may probably be accompanied by gradual elimination of native plants. This agrees with earlier report that *D. seguine* can thrive in dense shade, crowding out other species (Space and Imada, 2004). Aigbokhanei (2013) stated that *D. seguine* infested sites were relatively sparsely and poorly vegetated when compared with adjoining non-infested sites, signifying that the plant probably was out-competing native plants with which it exists in the community.

Epipremnum pinnatum (commonly called pothos), native to Mo'orea, French Polynesia is listed as invasive in the Galápagos Islands, Tanzania, St. Lucia and islands in the Pacific including Hawaii, French Polynesia, and Micronesi (Graveson, 2012). *Syngonium podophyllum* indigenous to South and Central America from Mexico to Panama (Global Invasive Species Database (GISD), 2015), has established invasive populations in the United States, South Africa, Singapore, the Caribbean, and on several Pacific islands, where it establishes dense populations that displace native plants and grow over native trees and surrounding vegetation (Ferriter *et al*., 2005; Morgan and Overholt, 2005; GISD, 2010. *Heliconia* species native to South America (National Tropical Botanical Garden (NTBG), 2016), is reported to have escaped from gardens, becoming naturalized along roadsides in Hawaii, although it is yet to be listed as serious invasive species.

Invasions by non-native plants can reduce native plant diversity (Sala *et al.*, 1999; Levine *et al.*, 2003; Hejda *et al.,* 2009), species richness and evenness (Hejda *et al.,* 2009) in invaded plots. These reports validate the results obtained from the present study where plant diversity indices appeared low in all seasons, with much lower values in wet seasons, when *D. seguine* invasion was particularly highest. In addition, species diversity values were higher in invaded vegetation of the AV compared to nearby uninvaded vegetation. Higher similarity index between species in the wet seasons in the invaded vegetation was probably due to large population of *D. seguine* and low species diversity recorded during these seasons. Overall, species diversity in the unvaded vegetation remained higher in all season compared to invaded vegetation indicating stability in the uninvaded vegetation. Thus, this study confirms earlier report that the conventional approach of introduction and landscaping with exotic ornamental plants in urban centres may affects biodiversity, as it limits the diversity of native species in areas dominated by these plants and can affect surrounding natural environments (Hostetler and Main, 2010).

CONCLUSION

Data from the present study revealed that twelve ornamental plants cultivated in the garden unit escaped into the adjoining vegetation of the garden. Four of these; *Dieffenbachia seguine, Synogonium podophyllum, Heliconia psittacorum* and *Epipremnum pinnatum* were invasive and their invasion resulted in low species diversity in invaded compared to uninvaded vegetation. Findings from this study bring to the fore the need to regulate the introduction of exotic ornamental plants into the country. Development as well as use of native ornamental plant is therefore advocated.

REFERENCES

Adebowale, A. and Olorode, O. (2005). An overview of the invasive potential of *Tithonia* species (Asteraceae) in Nigeria. *Science Focus*, **10**(3): 65-69.

Adekanmbi, H. O., Ogundipe, O. T. and Olowokudejo, J. D. (2009). Flora Diversity of South-western Nigeria Coastal Environments. *Journal of Science Resources and Development*, **11**: 9-20.

Ahmed, S. B. (2016). Bilogical techniques and skill.Retrieved Accessed 16, 2016, retrieved from http://www.slideshare.net/anasuhaimi/chapter-1-bio-300

Aigbokhan, E. (2013). *Dieffenbachia seguine* (Jacq.) Schott (Araceae) – a potential invasive threat to rainforest ecosystems in Nigeria. *Nigerian Journal of Botany*. Accessed May 5, 2016, retrieved from http://nijbot.org/?p=355

Akobundu, I. O. and Agyakwa, C. W. (1987). *A Handbook of West African Weeds*.International Institute of Tropical Agriculture, Ibadan, Nigeria.

Awodoyin, R.O., Akinyemi, C.Y., Bolanle, O.O. and Antiabong, I.C. (2013). Spartial distribution and abundance of *Solanecio boafrae* (Olive & Heirne) C. Jeffery and structure of weed communities in some cocoa plots in Ekiti, Oyo and Cross River States, Nigeria. *Ife journal of Science*, **15**(3): 661-676.

Ayeni, A. O., Lordbanjou, D. T. and Majek, B. A. (1997). *Tithonia diversifolia* (Mexican sunflower) in south-western Nigeria: occurrence and growth habit. *Weed Research*, **37**: 443–449.

Babour, M. G., Bunk, J. H. and Pitts, W. D. (1999). *Terrestrial Plant Ecology*.Benjamin\Cummings Publishing Company, Menio Park, Califonia.

Bassey, M. and Akpanumun, I. V. (2009). Identification and distribution of invasive plants in Akwa Ibom State. *Nigerian Journal of Botany*, **22**(2): 349 – 358

Cuartas-Hernandez, S and Nunez-Farfan, J. (2006). The genetic structure of the tropical understory herb Dieffenbachia seguine before and after forest fragmentation. *Evolutionary Ecology Research*, **8**(6): 1061-1075.

Curtis, J. T. (1959). *The vegetation of Wisconsin; An Ordination of Plant Communities*, University of Wisconsin Press, Madison, Wisconsin.

D'Antonio, C.M., Levine, J.M and Thomson, M. (2001). Ecosystem resistance to invasion and the role of propagule supply: A California perspective. *J. Mediterr*. *Ecol*,. **27**: 233-245.

Ferriter, A., Thayer, D., Goodyear, C. Doren, B., Langeland, K and Lane, J. (2005). Chapter9: Invasive Exotic Species in the South Florida

Environment. South Florida Environmental Report (SFER) vol.1. Accessed Aug. 24, 2016, retrieved from http://www.sfwmd.gov/portal/page/portal/pg_grp_sfwmd_sfer/portlet_prevreport/2005/volume1/chapters/V1_Ch9.pdf

Fountain, W. M. (2016). *Invasive Species: Understanding the Characteristics*. College of Agriculture Food and Environment, University of Kentucky, Academic Research Extension. Accessed May 12, 2016, retrieved from https://ukntrees.ca.uky.edu/Treetalk/ invasive-characteristics.

Global invasive species database (GISD) (2010). *Syngonium podophyllum* Accessed Aug, 24, 2016, retrieved from http://www.iucngisd.org/gisd/species.php?sc=1562 24/8/2016

Global Invasive Species Database (GISD) (2015). Species profile *Syngonium podophyllum.* Accessed Feb. 20, 2016, retrieved from http://www.iucngisd.org/gisd/species.php? sc=1562]

Grant, T. A., Madden E. M., Murphy R. K., and Nenneman, M. P. (2004). Monitoring Native Prairie Vegetation: The Belt Transect Method. *Ecological Restoration*, **22**(2):106-111.

Graveson R, 2012. Plants of Saint Lucia. Accessed April 16, 2016, retrieved from http://www.saintlucianplants.com

GRIN (1995). *Leucaena leucocephala* (Lam) de Wit. United States Department of Agriculture
Retrieved April 18, 2016 from https://npgsweb.ars-grin.gov/Gringlobal/taxon/taxonomysearch.aspx

Hammer, O., Harper, D. A. T. and Ryan, P. D. (2001). PAST: Paleontological Statistics software pakage for Education and data analysis. *Paleontologia electronic*, 4(1): 9.

Hejda, M., Pysek, P. and Jarosík, V. (2009). Impact of invasive plants on the species in: Responses of Plants and Invertebrate Trophic Groups to Contrasting Herbicide Regimes in the Farm Scale Evaluations of Genetically Modified Herbicide-tolerant Crops. *Philosophical Transactions of the Royal Society London B.* **358**: 1899-1915.

Hostetler, M. E. and Main, M. B. (2010**).** Native Landscaping vs. Exotic Landscaping: What Should We Recommend? *Journal of Extension* 48(5) Accessed May 10, 2016, retrieved from https://www.joe.org/joe/2010october/comm1.php

Jaccard, P. (1912). The distribution of the flora in the alpine zone. *New Phytologist* **11**: 37–50

Levine, J. M., Vilà, M., D'Antonio, C.M., Dukes, J.S., Grigulis, K. and Lavorel, S. (2003). Review Mechanisms underlying the impacts of exotic plant invasions. *Proc Biol Sci.*, **270**(1517):775-781

Mack, R.N. (2003). Global plant dispersal, naturalization, and invasion: pathways, modes, and circumstances. *Invasive species: vectors and management strategies* (ed. by G.M. Ruiz and J.T. Carlton), Island Press, Washington. pp 3–30.

Masterson, J. (2007). Indian River Lagoon Species Inventory: Non-Native and Invasive Species Smithsonian Marine Station. Accessed Jan. 10, 2018, retrieved from https://www.sms.si.edu/irlspec/Nonnatives.htm

Missouri Botanical Garden (2016). *Dieffenbachia seguine*. Accessed Aug 14, 2016, retrieved from http://www.missouribotanicalgarden.org/PlantFinder/PlantFinder Details.aspx? kempercode=b589

Morgan, E. C. and Overholt, W. A. (2005). New Records of Invasive Exotic Plant Species in St. Lucie County, Florida. Castanea **70**(1): 59-62

National Tropical Botanical Garden (2016). Meet the plant. Taxonomy: Heliconia psittacorum (Heliconiaceae). Accessed Feb. 20, 2016, retrieved from http://ntbg.org/plants/plant_details.php?plantid=5957

Nodza, I.G., Onuminya, T.O. and Ogundipe, O.T. (2014). Checklist of tree species growing on akoka campus of university of Lagos, Nigeria. *International Journal of Science, Environment and Technology* **3**(3): 1021 – 1034.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. (2009). Agroforestry Database: a tree reference and selection guide version 4.0 1-4pp. Accessed February 19, 2016, retrieved from http://www.worldagroforestry.org/af/treedb

Peters, K., Breitsameter, L. and Gerowitt, B. (2014). Impact of climate change on weeds in agriculture: a review. *Agron. Sustain. Dev.* **34**: 707

Pyšek P., Jarošík V. and Pergl J. (2011). Alien plants introduced by different pathways differ in invasion success: unintentional introductions as greater threat to natural areas? *PLoS ONE*, **6**: e24890.

Razanajatovo, M., Fohr, C., Fischer, M., Prati, D. and van Kleunen, M. (2015). Non-naturalized alien plants receive fewer flower visits than naturalized and native plants in a Swiss botanical garden. *Biol. Conserv*., **182**: 109–116.

Reichard, S. H. and White, P. (2001). Horticulture as a Pathway of Invasive Plant Introductions in the United States. *BioScience* **51**(2): 103–113.

Richardson, D.M., Williams, P. A. and Hobbs, R.J. (1994). Pine invasions in the Southern Hemisphere: Determinants of spread and invadability. *J. Biogeogr.*, **21**: 511-727.

Richardson, D.M. (1998). Forestry trees as invasive aliens. *Conser. Biol*. **12**: 18-26.

Richardson D. M., Pyšek P., Rejmánek M., Barbour M. G., Panetta F. D. and West C. J. (2000). Naturalizationand invasion of alien plants: concepts and definitions. *Diversity Distrib.* **6**: 93–107.

Ridenour, W.M. and Callaway, R.M. (2001). The relative importance of allelopathy in interference: The effects of an invasive weed on a native bunchgrass. *Oecologia* **126**: 444-450.

Royal Horticultural Society (1956). Dictionary of Gardening: *A Practical and Scientific Encyclopedia of Horticulture.* 2nd Edn. The Clarendon Press, Oxford.

Sala, O.E., Chapin, F.S., Gardner, R.H., Lauenroth, W.K., Mooney, H.A. and Ramakrishnan, P.S. (1999). Global change, biodiversity and ecological complexity. In: *The Terrestrial Biosphere and Global Change: Implications for Natural and Managed Ecosystems* (Walker, B., Steffen. W., Canadell, J. and Ingram, J. Eds.). Cambridge University Press, Cambridge, UK, pp. 304-328

Sanyaolu, V. Tom, Awodoyin, R. Olufemi and Ogunyemi, Sola (2018a) Effect of Ornamental Gardening on the Composition and Diversity of Low-growing Plants Species (LPS) in Selected Gardens in Southwestern Nigeria. *Nigerian Journal of Ecology,* **17**(2): 26-46

Sanyaolu, V.T., Awodoyin R. O. and Ogunyemi, S. (2018b). A Survey of the Most Common Ornamental Plants in Southwest Nigeria. *Pacific Journal of Science and Technology* **19**(1): 334-343.

Shannon, C. E. and. Wiener, W. (1949). *The mathematical theory of communication.*Urbana University of Illinois Press, pp 177.

Smith, A. C. (1979). Flora Vitiensis nova: a new flora of Fiji. National Tropical Botanical Garden, Lawai, Kauai, Hawaii.Volume 1. 494 pp In: *Pacific Island Ecosystems at Risk* (PIER) Dieffenbachia seguine (N. Jacquin) Schott, Araceae. Accessed May 14, 2016, retrieved from http://www.hear.org/pier/species/Dieffenbachia_seguine.htm.

Space, J. C. and Flynn, T. (2000). *Report to the Government of Niue on Invasive Plant Species of Environmental Concern.* U.S. Department of Agriculture, Forest Service, Honolulu, Hawaii

Space, J. C., Waterhouse, B., Denslow, J. S., Nelson, D. Waguk, E. E. (2000). *Invasive plant species on Kosrae, Federated States of Micronesia*. USDA Forest Service, Honolulu. Accessed on Aug 15, 2016, retrieved from http://www.hear.org/pier/species/acacia_auriculiformis.htm

Space, J.C. and Imada, C.T. (2004). *Report to the Republic of Kiribati on Invasive Plant Species on the Islands of Tarawa*, Abemama, Butaritari and Maiana.

Spellberg, I.F. (1993). Monitoring Ecological Change. Cambridge University press pp 334. Tropical Biology Association, (2010). Usambara Invasive Plants - Amani Nature Reserve. Accessed on April 6, 2016, retrieved from www.tropical-biology.org/research/dipspecies.htm

Walton, C. S. (2003). *Leucaena* (*Leucaena leucocephala*) in Queensland. Department of Natural Resources and Mines, Queensland. Pest Status Review Series. Accessed May 6, 2016, retrieved from https://www.researchgate.net/profile/Craig_Walton/Publication/237650048

Whittaker, R. H. (1975). Communities and Ecologies. Macmillan Publishing Co. Inc. New York: Collier Macmillan Publishers, London. pp 385

