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Taxonomic Values of Secondary Metabolites (Hydrocarbons and Flavonoids) in the Genus *Euphorbia* L. from Niger Delta, Nigeria

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ABSTRACT

Taxonomic value of secondary metabolites in the *Euphorbia* L. has been carried out. This study aimed at using hydrocarbon skeletons and flavonoids in improving the classification of the genus in Nigeria. Eleven species of this genus occurring in Niger Delta, Nigeria were identified based on field collection and herbarium specimens deposited in Forestry Herbarium Ibadan (FHI). Fresh plant specimens from these species of *Euphorbia* were subjected to Gas and paper chromatography. Results of this study showed that these species contained aliphatic hydrocarbons (C₈, C₉, C₁₀, C₁₁, C₁₂, C₁₃, C₁₄, C₁₅, C₁₆, C₁₇, C₁₈, C₁₉, C₂₀, C₂₂, C₂₆, C₂₈, C₃₀, C₃₂, C₃₄ and C₃₆) and flavonoid classes (biflavonyl, flavone, flavonol, anthocyanin and glycosylflavone). C₈ to C₁₁ are widespread among the species of *Euphorbia* studied, while C₂₁ to C₃₀ are restricted to *E. heterophylla*, *E. splendens*, *E. hyssopifolia*, *E. milli*, *E. prostata*, *E. thymifolia* and *E. tirucalli* and C₃₁ to C₄₀ are not found in *E. hirta* and *E. desmondi* but are widely distributed among the other species studied. The hydrocarbons and flavonoids screening showed differences among the species and could be used to classify the genus. This result confirmed that *E. splendens* is distinct from *E. milli*.

Key words: Taxonomy, hydrocarbons, flavonoids, *Euphorbia*

INTRODUCTION

Euphorbia L. belongs to the tribe Euphorbieae in the family Euphorbiaceae. This family is highly heterogeneous and occurs mainly in the tropics, warm temperate and sub-tropic zones of the world. The members of this family are trees, shrubs or herbs producing milky latex. This family is spread over 290 genera and 7500 species and is well represented in Africa and Tropical America (Willis, 1973). In West Africa, about 65 genera and 266 species are represented in this family (Gill, 1988; Hutchison and Dalziel, 1954). However, among the 65 genera, *Euphorbia* L. is the most popular genus and is widespread all over the tropical, temperate and subtropical zones and includes about 22 species recorded in Nigeria. Attempts have been made by several authors to document the origin and distribution of most *Euphorbia* species (Hutchison and Dalziel, 1954; Keay, 1989).

In Nigeria, some members of this genus are used for different purposes. For instance *Euphorbia heterophylla* and *E. pulcherrima* are used for ornamental and landscaping. Also, *Euphorbia hirta* enhances mammary development and milk secretion in young guinea pig and as a galactagogue by women in Nigeria (Aworinde *et al.*, 2009).

Earlier works done on this genus were based on propagation, growth and physiology (David and Ruth, 1988; Kuhn *et al.*, 1996; Schurr, 1998; Buckeridge *et al.*, 2000; Qin *et al.*, 2004), developmental anatomy (Heckenberger *et al.*, 1998; Oparka and Turgeon, 1999), embryology and carpology (Raja Rajeswari Rao and Prakasa-Rao, 1975; Gori 1987; Bhanwra, 1987; Carmichael and Selbo, 1999), medicinal potentials of members of the family (Aworinde *et al.*, 2009; Anselm, 2004) and the application of morphology and anatomy in phylogeny, ecology and systematics (Tokuoka and Tobe, 1995, 2002; Chaturvedi and Dalal, 2000; Esser, 2003; Aworinde *et al.*, 2009).

The use of data generated from secondary metabolites and numerical methods in resolving the taxonomic problems in some taxa has gained much recognition for a long time. Some of the prominent works that have solved taxonomic problems among plant taxa with secondary metabolites include (Hsiao and Lin, 1995; Vicente *et al.*, 2007; Weiller *et al.*, 1994; Griesbach and Santamour, 2003; Slimestad, 2003; Andrey and Long, 1996; Gerard and Hendrik, 1980; Evans *et al.*, 2008; Davies, 1960; Zuloaga *et al.*, 1993). Mostly the sequence of proteins, flavonoid, amino acids and peptides are used (Stace, 1980; Harborne, 1973).

This present study described the importance of secondary metabolites (hydrocarbon and flavonoids) in some members of the genus *Euphorbia* with the aim of providing useful taxonomic data that would give further insight into proper classification, delineation and identification of the studied taxa.

MATERIALS AND METHODS

Sources of material: Plant materials used for this investigation were obtained from Field collections conducted between September, 2006 to December, 2008 in Niger Delta, Nigeria. These plant specimens were taken to Forestry Research Institute of Nigeria, Ibadan (FRI) and University of Port Harcourt Herbaria for proper identification.

Hydrocarbon screening: Five (5.0) grams of fresh plant material (cut into 5 mm size) was dipped into a clean, dry beaker containing 10 mL of hexane and allowed to stand for 30 sec. The extract was filtered to remove dirt. The filtrate was then passed through Al_2O_3 (alumina column) and eluted with petroleum (hexane). The samples (extract) was saponified with methanolic KOH and Ketonic materials by reacting them with 2-4-dinitrophenylhydrazine in aqueous 2 M HCl. The extract was then subjected to Gas Chromatography (GC) (Englinton and Hamilton, 1963b).

Flavonoid screening: The procedure employed in the survey of the plant tissues for flavonoids (flavones and flavonols) is as stated by Bate-Smith (1962) and Harborne (1973) who have surveyed over 1000 angiosperm species for their flavonoids.

Cluster analysis: The results were scored 1 (presence) or 0 (absence) and the Euclidean distance (similarity distances) clustered using Past software to generate dendrogram which represented the diagrammatic illustration of the relationship among the species based on their degree of similarities.

RESULTS AND DISCUSSION

The results and findings of this study are presented in Table 1-3 and Fig. 1.

The occurrence of different hydrocarbon backbones is presented in Table 2. The result showed that C_8 - C_{11} occurred in all the *Euphorbia* species studied. However, C_{12} occurred in all the species except *E. pulcherima*, C_{13} , C_{14} and C_{17} were not identified in *E. splendens*, *E. hirta* and *E. pulcherima*.

Table 1: Occurrence and distribution of different aliphatic hydrocarbon backbones in the *Euphorbia* species

	Aliphatic hydrocarbon backbones																			
Species name	C ₈	C ₉	C ₁₀	C ₁₁	C ₁₂	C ₁₃	C ₁₄	C ₁₅	C ₁₆	C ₁₇	C ₁₈	C ₁₉	C ₂₀	C ₂₂	C ₂₆	C ₂₈	C ₃₀	C ₃₂	C ₃₄	C ₃₆
<i>E. heterophylla</i>	+	+	+	+	+	+	+	+	+	+	+	+	-	-	+	-	-	-	+	-
<i>E. splendens</i>	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-
<i>E. hirta</i>	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>E. pulcherima</i>	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>E. desmondi</i>	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-
<i>E. hypossifolia</i>	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+	-
<i>E. kamerunica</i>	+	+	+	+	+	+	+	+	-	+	+	-	-	-	-	-	-	+	+	-
<i>E. milli</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>E. prostrata</i>	+	+	+	+	+	+	+	-	-	+	-	-	-	-	-	-	+	-	+	-
<i>E. thymifolia</i>	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	+	+	+	+	-
<i>E. tirucalli</i>	+	+	+	+	+	+	+	+	-	+	+	+	-	-	-	+	-	+	+	-

+: Present, -: Absent

Table 2: Occurrence and distribution of different flavonoid groups in the *Euphorbia* species

Different flavonoids groups identified in the species									
Species name	Iso-Orientin	Azaleatin	Myricetin	Cyanidin	Quecertain	Isorhamnetin	Vitexin	Luteolin	Delphinidin
<i>E. heterophylla</i>	-	-	+	+	+	-	+	+	-
<i>E. splendens</i>	-	-	+	-	-	-	+	+	+
<i>E. hirta</i>	-	-	+	+	+	-	+	-	+
<i>E. pulcherima</i>	-	-	+	+	+	-	-	+	-
<i>E. desmondi</i>	-	-	+	+	-	-	-	-	-
<i>E. hypossifolia</i>	-	+	+	+	+	-	-	-	-
<i>E. kamerunica</i>	+	-	+	+	-	+	+	-	+
<i>E. milli</i>	+	-	+	-	+	+	+	-	+
<i>E. prostrata</i>	-	-	+	-	+	+	+	-	+
<i>E. thymifolia</i>	+	-	+	-	+	-	+	-	+
<i>E. tirucalli</i>	+	-	-	-	+	-	+	-	-

	Different flavonoids groups identified in the species							
Species name	Penidin	Pelargonidin	Apigenin	Kayaflavone	Kaempferol	Chrysoriol	Tricin	Alkaloid
<i>E. heterophylla</i>	+	-	+	+	-	-	-	+
<i>E. splendens</i>	+	+	-	+	-	-	-	+
<i>E. hirta</i>	+	-	-	+	+	+	-	+
<i>E. pulcherima</i>	-	-	+	-	-	-	-	+
<i>E. desmondi</i>	-	-	-	-	+	-	-	+
<i>E. hypossifolia</i>	+	+	-	-	-	+	+	+
<i>E. kamerunica</i>	-	-	-	+	-	+	+	+
<i>E. milli</i>	-	-	+	-	-	-	+	+
<i>E. prostrata</i>	-	-	-	+	-	-	+	+
<i>E. thymifolia</i>	-	-	-	-	-	-	-	+
<i>E. tirucalli</i>	+	-	-	-	-	-	+	+

+: Present, -: Absent

while C₁₅ and C₁₈ did not occur in four (4) species namely *E. prostrata*, *E. pulcherima*, *E. hirta* and *E. splendens*. C₁₆ occurred in *E. heterophylla*, *E. desmondi*, *E. hypossifolia*, *E. milli* and

Table 3: Different flavonoid groups, spectral range, Rf values and colour in UV/UV+Ammonia in the *Euphorbia* species

Species name	RF value×100		Colour in UV/UV+NH ₃	Spectral Max in EtOH (nm)	Compound identified	Class of Flavonoid
	BAW	FORESTAL				
<i>E. heterophylla</i>	44	27	Yellow	256, 378	Myricetin	Flavonol
	-	50	Reddish-Brown	535	Cyanidin	Anthocyanin
	41	64	Yellow	255, 374	Quercetin	Flavonol
	41	-	Brownish	269, 336	Vitexin	Glycosylflavone
	78	67	Brownish	252, 268, 350	Luteolin	Flavone
	70	62	Brownish	352	Peonidin	Anthocyanin
	88	82	Brownish	269, 336	Apigenin	Flavone
	98	-	Brownish	269, 336	Kayaflavone	Biflavonyl
	-	30	Mauve	546	Delphinidin	Anthocyanin
<i>E. splendens</i>	-	29	Yellow	256, 378	Myricetin	Flavonol
	-	67	Yellow	520	Pelargonidin	Anthocyanin
	78	65	Brownish	252, 268, 350	Luteolin	Flavone
	98	-	Brownish	252, 269, 350	Kayaflavone	Biflavonyl
	40	-	Brownish	269, 336	Vitexin	Glycosylflavone
	70	62	Brownish	352	Peonidin	Anthocyanin
	-	48	Reddish-Brown	535	Cyanidin	Anthocyanin
<i>E. hirta</i>	-	31	Mauve	546	Delphinidin	Anthocyanin
	70	62	Brownish	352	Peonidin	Anthocyanin
	82	57	Yellow	268, 368	Kaempferol	Flavonol
	42	27	Yellow	256, 378	Myricetin	Flavonol
	65	42	Yellow	255, 374	Quercetin	Flavonol
	81	76	Yellow	252, 269, 350	Chrysoeriol	Flavone
	98	-	Brownish	269, 336	Kayaflavone	Biflavonyl
	40	-	Brownish	269, 336	Vitexin	Glycosylflavone
	26	43	Yellow	256, 378	Myricetin	Flavonol
	65	40	Yellow	255, 374	Quercetin	Flavonol
<i>E. pulcherima</i>	78	67	Yellow	252, 268, 350	Luteolin	Flavone
	90	82	Brownish	269, 336	Apigenin	Flavone
	-	50	Reddish-Brown	535	Cyanidin	Anthocyanin
	-	52	Reddish-Brown	535	Cyanidin	Anthocyanin
	82	55	Yellow	268, 368	Kaempferol	Flavonol
<i>E. desmondi</i>	45	28	Yellow	256, 378	Myricetin	Flavonol
	42	30	Mauve	546	Delphinidin	Anthocyanin
	-	48	Brownish	535	Cyanidin	Anthocyanin
<i>E. hyssopifolia</i>	50	48	Yellow	254, 369	Azaleatin	Flavonol
	-	62	Brownish	532	Peonidin	Anthocyanin
	44	28	Yellow	256, 378	Myricetin	Flavonol
	40	64	Yellow	255, 374	Quercetin	Flavonol
	72	72	Yellow	248, 269, 355	Tricin	Flavone
	80	-	Brownish	520	Pelargonidin	Anthocyanin
	85	76	Yellow	252, 268, 350	Chrysoeriol	Flavone
	-	49	Brownish	535	Cyanidin	Anthocyanin
	43	29	Yellow	256, 378	Myricetin	Flavonol
	83	76	Brownish	252, 268, 350	Chrysoeriol	Flavone
<i>E. kamerunica</i>	41	-	Yellow	252, 268, 350	Iso-Orientin	Glycosylflavone
	-	98	Brownish	269, 336	kayaflavone	Biflavonyl

Table 3: Continue

Species name	RF value×100		Colour in UV/UV+NH ₃	Spectral Max in EtOH (nm)	Compound identified	Class of Flavonoid
	BAW	FORESTAL				
<i>E. milli</i>	74	52	Yellow	254, 369	Isorhamnetin	Flavonol
	73	71	Yellow	248, 269, 355	Tricin	Flavone
	43	-	Reddish-Brown	546	Delphinidin	Anthocyanin
	-	27	Yellow	256, 378	Myricetin	Flavonol
	41	41	Yellow	252, 268, 350	Iso-Orientin	Glycosylflavone
	43	-	Reddish-Brown	546	Delphinidin	Anthocyanin
	40	42	Brownish	269, 336	Vitexin	Glycosylflavone
	64	40	Yellow	255, 374	Quercetin	Flavonol
	89	82	Brownish	269, 336	Apigenin	Flavone
	74	52	Yellow	254, 369	Isorhamnetin	Flavonol
<i>E. prostrata</i>	73	71	Yellow	248, 269,355	Tricin	Flavone
	-	31	Mauve	546	Delphinidin	Anthocyanin
	63	42	Yellow	255, 374	Quercetin	Flavonol
	98	-	Brownish	269, 336	kayaflavone	Biflavonyl
	42	27	Yellow	256, 378	Myricetin	Flavonol
	41	42	Brownish	269, 336	Vitexin	Glycosylflavone
	74	52	Yellow	254, 369	Isorhamnetin	Flavonol
<i>E. thymifolia</i>	73	70	Yellow	248, 269,355	Tricin	Flavone
	-	33	Mauve	546	Delphinidin	Anthocyanin
	43	26	Yellow	256, 378	Myricetin	Flavonol
	66	40	Yellow	255, 374	Quercetin	Flavonol
	40	41	Yellow	252, 268, 350	Iso-Orientin	Glycosylflavone
	41	42	Brownish	269, 336	Vitexin	Glycosylflavone
<i>E. tirucalli</i>	40	41	Brownish	269, 336	Vitexin	Glycosylflavone
	69	-	Brownish	532	Peonidin	Anthocyanin
	40	42	Yellow	252, 268, 350	Iso-Orientin	Glycosylflavone
	64	43	Yellow	255, 374	Quercetin	Flavonol
	72	71	Yellow	248, 269,355	Tricin	Flavone

EtOH: Ethanol, BAW: Butanol, acetic acid and water (4:1:5), UV: Ultra violet, Forestal: Concentrated hydrochloric acid, Acetic acid and water (3:30:10), NH₃: Ammonia

E. thymifolia while C₁₉ occurred in five species namely *E. heterophylla*, *E. desmondi*, *E. hypossifolia*, *E. milli* and *E. tirucalli*. C₂₀, C₂₂ C₂₆ and C₃₆ are restricted to *E. milli*. The hydrocarbon C₂₈ is restricted to *E. hypossifolia*, *E. milli*, *E. thymifolia* and *E. tirucalli* while C₃₄ occurred in all the species except *E. hirta* and *E. desmondi*. In the same vein, C₃₀ did not occur in *E. heterophylla*, *E. desmondi*, *E. hirta*, *E. pulcherima*, *E. kamerunica* and *E. tirucalli* while C₃₂ did not occur in *E. heterophylla*, *E. desmondi*, *E. hirta*, *E. pulcherima* and *E. prostrata*.

The variation and occurrence of these hydrocarbons is of taxonomic value since some of them are restricted to some species of this genus while others are widely distributed. This aspect of the phytochemical result is in line Harborne (1973), who reported alkanes with carbon backbone of C₂₅ to C₃₅ in angiosperms. It also confirms the report of Englinton and Hamilton (1963a and 1963b) who reported the occurrence of C₃₃, C₃₁, C₃₀, C₂₉, C₂₈, C₂₇, C₂₆ and C₂₅ in *Euphorbia aphylla* and Sorensen (1968) who reported the occurrence of acetylenes with carbon chain mostly C₁₄ to C₁₈ in higher plants. The hydrocarbon screening indicated that most of these *Euphorbia* species under investigation are distinct but some are more closely related and supports Laurence (1934) who used

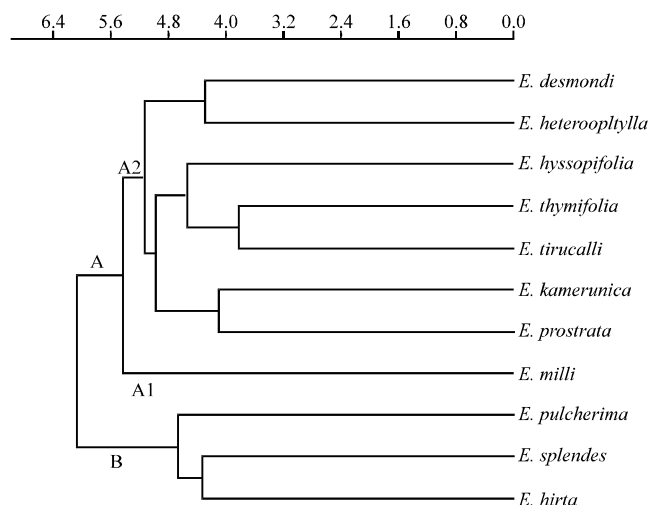


Fig. 1: Dendrogram showing the relationship among the *Euphorbia* species studied

the isoelectric of the proteins in *Euphorbia* to distinguish *E. splendens* from *E. milli*. This hydrocarbon results are also in line with the reports of Sonibare *et al.* (2005) and Evans *et al.* (2008) who reported the occurrence and taxonomic values of hydrocarbon in higher plants and their occurrence in the resin dots of different species of plants. The classes and types of different flavonoids identified in the *Euphorbia* species under different chromatograms and the occurrences are as shown in Table 2 and 3. Biflavonyl occurred in all the species except *E. pulcherima*, *E. desmondi*, *E. hyssopifolia*, *E. thymifolia* and *E. tirucalli*. Also, flavone did not occur in *E. pulcherima*, *E. desmondi* and *E. thymifolia* while glycosylflavone was not identified in *E. pulcherima*, *E. desmondi* and *E. thymifolia*. *E. heterophylla*, *E. splendens*, *E. hirta*, *E. kamerunica* and *E. prostrata* contain all the classes of flavonoid identified in the species studied. The implication of this is that the species that has similar flavonoid classes are more closely related compared to those that do not have such class of flavonoid. The occurrence of these flavonoids in the plants is in line with the previous reports by Harborne (1973), Vicente *et al.* (2007), Griesbach and Santamour (2003) and Slimestad (2003) who reported that these compounds are widely distributed in plants and are of taxonomic value.

The dendrogram as shown in Fig. 1 shows the clustering of the *Euphorbia* species based on the different chemicals (hydrocarbons and flavonoids) identified in them. These species studied formed two main clusters A and B. Cluster A contains eight species among the eleven species studied. *E. milli* is distinct from all other species and formed a separate sub-cluster A1 while the other seven species are contained in A2. *E. desmondi* and *E. heterophylla* are more closely related, *E. hyssopifolia*, *E. thymifolia* and *E. tirucalli* are closely related while *E. kamerunica* and *E. prostrata* are more closely related. However, cluster B contained *E. pulcherima*, *E. splendens* and *E. hirta*. The findings of this work is in consistent with the previous studies conducted by Keay (1989), Priti and Shital (1979), Davis and Heywood (1973), Hutchison and Dalziel (1954) and Laurence (1934).

CONCLUSION

This study has established the occurrence of different aliphatic hydrocarbon backbones and different classes of flavonoids in the genus *Euphorbia* in Nigeria and conclude that these secondary metabolites identified in this study are restricted to some of the species and are of great taxonomic value.

REFERENCES

- Andrey, B.I. and Q.P. Long, 1996. Fatty acids and triacylglycerols in the seeds of *Pinaceae* species. *Phytochem*, 42: 1051-1053.
- Anselm, A., 2004. Nature Power, Christian Approach to Herbal Medicine. 3rd Edn. Publ. Generation Press Ltd., Lagos, Nigeria, pp: 290.
- Aworinde, D.O., D.U. Nwoye, A.A. Jayeola, A.O. Olagoke and A.A. Ogundele, 2009. Taxonomic significance of foliar epidermis in some members of euphorbiaceae family in Nigeria. *Res. J. Bot.*, 4: 17-28.
- Bate-Smith, E.C., 1962. Methods for the identification of Flavonoids in Angiosperms. *J. Linn. Soc. Bot.*, 58: 39-39.
- Bhanwra, P.K., 1987. Embriology of *Euphorbia maddenii* and *Euphorbia nivulia*. *Curr. Sci.*, 56: 1062-1064.
- Buckeridge, S.M., N.K. Suda and F.J. Giorgini, 2000. Cell wall hydraolases in the seed of *Euphorbia heterophylla* during germination and early seedling development. *Brazilian J. Plant Physiol.*, 15: 3-3.
- Carmichael, J.S. and S.M. Selbo, 1999. Ovule, embryo sac and endosperm developement in leafy spurge (*Euphorbia esula*). *Can. J. Bot./ Rev. Can. Bot.*, 77: 599-610.
- Chaturvedi, A. and L.P. Dalal, 2000. Embryology of *Euphorbia milii* des moul with probable phylogeny of the embryo sacs in *Euphorbiaceae*. *J. Indian Bot. Soc.*, 79: 143-147.
- David, W. and S. Ruth, 1988. Axillary bud inhibition induced by young leaves or bract in *Euphorbia pulcherrima*. *Ann. Bot.*, 62: 435-440.
- Davies, R.G., 1960. Some problems of numerical taxonomy. *Sci. Prog.*, 69: 315-339.
- Davis, P.H. and V.H. Heywood, 1973. Principles of Angiosperm Taxonomy. Robert E. Krieger Publ. Comp., Huntington, Huntington, New York, USA.
- Englinton, G. and R.J. Hamilton, 1963a. The Distribution of Alkanes. In: *Chemical Plant Taxonomy*, Swain, T. (Ed.). Academic Press, London, pp: 187-218.
- Englinton, G. and R.J. Hamilton, 1963b. The Distribution of Alkanes. In: *Comparative Phytochemistry*, Swain, T. (Ed.). Academic Press, London.
- Esser, H.J., 2003. Fruit characters in Malaesian. *Euphorbiaceae*, 10: 169-177.
- Evans, J.O., R.V. Torell, J.M. Valcarce and G.G. Smith, 2008. Analytical pyrolysis-pattern recognition for the characterisation of leafy spurge (*Euphorbia esula* L.) biotypes. *Ann. Applied Biol.*, 119: 47-58.
- Gerard, J.N. and H.V. Hendrik, 1980. Chemical relationship between Pinaccae. *Biochem. Syst. Ecol.*, 8: 237-240.
- Gill, L.N., 1988. Taxonomy of Flowering Plants. Africana-FEP Publishers, Nigeria, Pages: 28.
- Gori, P., 1987. The fine structure of the developing *Euphorbia dulcis* endosperm. *Ann. Bot.*, 60: 563-569.
- Griesbach, R.J. and F.S. Santamour, 2003. Anthocyanins in cones of *Abies*, *Picea*, *Pinus*, *Pseudotsuga* and *Tsuga* (Pinaccae). *Biochem. Syst. Ecol.*, 31: 261-268.

- Harborne, J.B., 1973. *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. Chapman and Hall, London, pp: 83-106.
- Heckenberger, U., I.K. Herde and R. Feil, 1998. Ratio between plant tissues during development. *Prop. Bot.*, 235: 512-559.
- Hsiao, J.Y. and M.L. Lin, 1995. A chemotaxonomic study of essential oils from the leaves of genus *Clerodendrum* (Verbenaceae) native to Taiwan. *Bot. Bull. Acad. Sin.*, 36: 247-251.
- Hutchison, J. and J.M. Dalziel, 1954. *Flora of West Tropical Africa*. Vol. 1, Crown Agents for Oversea Governments and Administrations, London, UK.
- Keay, R.W.J., 1989. *Trees of Nigerian*. Clarendon Press, Oxford, UK.
- Kuhn, J., U. Marshall and G. Tardieu, 1996. Leaf development in *Ricinus communis* during drought stress. *J. Exp. Bot.*, 45: 950-1110.
- Laurence, S.M., 1934. Species relationships in *Euphorbia* as shown by the electrophoresis of latex. *Am. J. Bot.*, 21: 293-313.
- Oparka, C. and P. Turgeon, 1999. Export functions of plant tissues. *Anat. Plants*, 38: 59-83.
- Priti, S. and P.M. Shital, 1979. *An Introduction to Taxonomy of Angiosperms*. Vikas Publishers Ltd., New Delhi, ISBN: 9780706907643, Pages: 546.
- Qin, W., L. Wei-Da, L. Yi, P. Shu-Lin, X. Ying, T. Lin and C. Fang, 2004. Plant regeneration from epicotyl explant of *Jatropha curcas*. *J. Plant Physiol. Mol. Biol.*, 30: 475-478.
- Raja Rajeswari Rao, K. and P.S. Prakasa-Rao, 1975. Embryo development in *Euphorbia peplus* L. *Curr. Sci.*, 44: 57-59.
- Schurr, U., 1998. Leaf development in *Ricinus communis*. *J. Plant Sci.*, 15: 293-298.
- Slimestad, R., 2003. Flavonoids in buds and young needles of *Picea*, *Pinus* and *Abies*. *Biochem. Syst. Ecol.*, 31: 1247-1255.
- Sonibare, M.A., A.A. Jayeola and A. Egunyomi, 2005. Chemotaxonomic significance of leaf alkanes in species of *Ficus* (Moraceae). *Biochem. Syst. Ecol.*, 33: 79-86.
- Sorensen, N.A., 1968. The taxonomic significance of acetylenic compound. *Recent Adv. Phytochem.*, 1: 187-228.
- Stace, C.A., 1980. *Plant Taxonomy and Biosystematics*. Edward Arnold Publishers Ltd., USA.
- Tokuoka, T. and H. Tobe, 1995. Embryology and systematics of Euphorbiaceae sens. lat.: A review and perspective. *J. Plant Res.*, 108: 97-106.
- Tokuoka, T. and H. Tobe, 2002. Ovules and seeds in Euphorbioideae (Euphorbiaceae) structure and systematic implications. *J. Plant Res.*, 115: 361-374.
- Vicente, P.E., O.B. Karina, T.S. Marcus and J.P.F. Marcilo, 2007. Self-organizing maps in chemotaxonomic studies of Asteraceae: A classification of tribes using flavonoid data. *J. Braz. Chem. Soc.*, 18: 891-899.
- Weiller, C.M., R.K. Crowden and J.M. Powell, 1994. Morphology and taxonomic significance of the leaf epicuticular waxes in the Epacridaceae. *Aust. Syst. Bot.*, 7: 125-152.
- Willis, J.C., 1973. *A Dictionary of Flowering Plants and Ferns*. 8th Edn., Cambridge University Press, Cambridge.
- Zuloaga, F., J. Dubcovsky and O. Morrone, 1993. Infrageneric phenetic relations in new world panicum (Poaceae: Panicoideae: Paniceae): A numerical analysis. *Canadian J. Bot.*, 71: 1312-1327.