MORPHOLOGICAL VARIATIONS AMONG SELECTED *Euphorbia* SPECIES (EUPHORBIACEAE L.) IN NIGERIA

Supported by tetfund

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Abstract: A morphometric study of the six species of *Euphorbia* in some parts of Nigeria was performed. Quantitative features were measured, recorded and thereafter subjected to appropriate statistical analyses (principal components analysis and cluster analysis). Results from the data collected re used to explore variations among and within the selected species of *Euphorbia*, and cluster analyses were used to ascertain systematic groupings of the taxa. Results from the morphological examinations showed that the variation in leaf length, leaf width, internode length, petiole and internode lengths are diagnostic. The dendrogram revealed different levels of relationships among and within species of *Euphorbia*. Great affinity was observed between *E. prostrata* and *E. thymifolia* followed by *E. hirta* and *E. hyssopifolia* whereas *E.graminea* and *E. heterophylla* are distantly related to other species. The similarities observed among and within each collection of species of *E. hyssopifolia*, *E.hirta*, *E. prostrata* and *E. thymifolia* justifies why they are classified under the same subgenus *Chamaesyce.* Distribution wise, the species were found to be sympatric or allopatric.

Keywords: Morphometry, *Euphorbia*, PCA, cluster analyses

Introduction

The genus *Euphorbia* Linn. which belongs to the family Euphorbiaceae is a large and easily recognized cosmopolitan family with world-wide distribution. It belongs to the sub-class Euphorbidae in the order Euphorbiales, tribe Euphorbieae, and sub-tribe Euphorbiinae (Webster, 1975). It is known commonly as spurge family with 300 genera, 52 tribes in five sub-families and over 8,000 recognized species (Webster, 1975; Wurdack *et al*., 2004). The larger genera in the family include *Euphorbia* 2000 species; *Croton* about 700 species; *Phyllantus* consists of 500 species; *Acalypha* up to 430 species; *Jatropha* up to 175 species, *Manihot* 170 species *Glochidion* about 300 species, *Macaranga* (250 species); *Antidesma* consist of 150 species and *Tragia* 150 species (Judd *et al*., 1999; Aworinde *et al*., 2009).

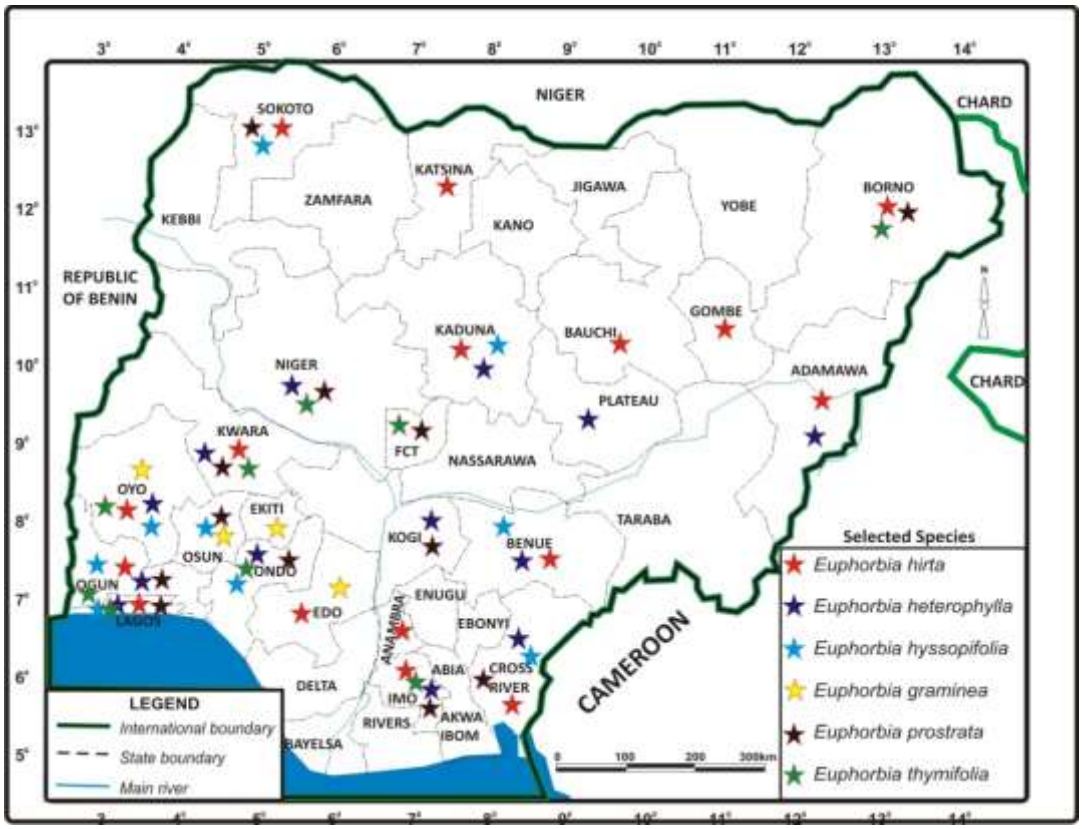
Euphorbia was named by King Juba (of Morocco) after his physician (Euphorbos). The scientific word "*Euphorbia"* is derived from Euphorbos which connotes "well fed" in reference to the physical features of King Juba's physician referred to above (Gledhill, 2008; Pritchard, 2008). Many herbaceous *Euphorbia* are commonly referred to as spurges (derived from the old French word spurges, which means to purge) because they contain sap which is active as purgative (Nancy, 1986). The sap is a milky latex, which is a typical characteristic of the group. The milky latex which is also toxic consists of diterpene esters and cause inflammation and a blistering rash if it comes in contact with human skin (Singia and Pathak, 1990).

The taxonomic value of morphology is well documented in botanical literatures (Steinmann and Porter 2001; Bryuns *et al.*, 2006; Zimmerman *et al.*, 2010; Dorsey *et al.*, 2013; Aubriot *et al.*, 2014). However, given the available information, the report on the morphometry of the *Euphorbia* is very scanty. The present study is therefore aimed at describing the morphometry of the vegetative part of six species of *Euphorbia* with the view of establishing characteristics of foliar structures with taxonomic value useful in the delimitation and identification of the species.

Materials and Methods

Plant collection

Data were taken from six species of *Euphorbia* (*E. graminea, E. heterophylla, E. hirta, E. prostrata, E. hysssopifolia* and *E. thymifolia)* from the field and specimens from different herbaria were employed for the study. The fresh specimens were collected from different parts of Nigeria (Fig. 1). A complete list of the specimens examined and the raw data file are shown (Table 1). The fresh specimens were pressed with the aid of plant press. Identification and authentication was done appropriately at Forest Herbarium Ibadan (FHI) and the specimens were deposited both at FHI, Elikaf Herbarium of Olabisi Onabanjo University, Ago-Iwoye, Ogun State and Obafemi Awolowo University, Ile-Ife herbarium (IFE).



Source: Author survey (2019)

Fig. 1: Map of Nigeria showing locations where *Euphorbia* were collected

Table 1: Collection data of *Euphorbia* species studied

Taxa	Collector/Source/Date	Habitat	Habit	Root
E. graminea	**Sanusi, A.S., FHI, Obafemi Awolowo University, Ile – Ife, Osun State. 10/10/2018	Under tree	Perennial	Woody
	*Adeyemi, A.A., FHI 109674, Amina way, University of Ibadan, Campus, Ibadan, Oyo State. 10/2012	Under shade	Perennial	Woody
	*Ejike, FHI 110653, University of Ibadan premises, Ibadan, Oyo State. 28/10/2016	Under shade	Perennial	Woody
	*Adebokun, O., FHI 109579, University of Benin, Benin city, Edo State. 18/08/12	Under shade	Perennial	Woody
E. hyssopifolia	**Olorode, O., Olabisi OnabanjoUniversity, Ago – Iwoye, Ogun State. 01/2016	Open space	Perennial	Woody
	**Olorode, O. Ladi Kwali Conference centre, Abuja, Sheraton Hotel and Towers, Abuja FCT. 12/2015	Not specified	Annual	Non-woody
	**Sanusi, A.S., FHI, Forestry Research Institute of Nigeria premises, Ibadan, Oyo State. 10/10/2018	Along the road	Perennial	Woody
	*Keay, R.W.J, FHI 25971, Igbabi, Zaria. 13/07/1950	Not specified	Perennial	Woody
	*Daramola, Macaulay, Oguntayo, FHI 78475, Oban Forest Reserve, Calabar, Cross River State. 09/09/1975	Not specified	Annual	Non-woody
	*Okafor, J.C. and Macaulay, E.O., FHI 58580, Apapa, Lagos.28/04/1966	Not specified	Annual	Non-woody
	*Ibhanesebhor and Osanyinlusi, FHI 96989, Okitipupa, Ikale, Ondo State. 9/8/1982	Not specified	Perennial	Woody
	*George, E. P., FHI 98872, Oyo Polytechnic Campus, Ibadan, Oyo State. 1979	Not specified	Perennial	Woody
	*Ekwuno, P.O., FHI 63816, Bukaria, North West. 25/01/1971	Not specified	Annual	Non-woody
	*Latilo. M.G. FHI 99308, Ile-Ife, Oyo State. 27/03/1981	Not specified	Annual	Non-woody
	*Ibhanesebhor, FHI 100899, Argungu, river area, Sokoto State. 01/02/1984	Not specified	Annual	Non-woody
	*Ekwuno, Fagbemi and Osayinlusi, FHI 87848, Forest Reserve, Cross River State. 29/8/1978	Not specified	Perennial	Woody
E. heterophylla	*Gbile and Daramola, FHI 73623, N - Central, Zaria, Ahmadu Bello University, 22/11/1974	Under tree	Perennial	Woody
	*Obaseki, FHI 23814, Olokemeji, River bank, Ibadan, Oyo State. 20/02/1949	Under shade	Perennial	Woody
	*George E. Pilz, FHI 99168, Oyo, Polytechnic campus, Ibadan, Oyo State. 28/11/1976	CloseCommunity	Annual	Non-woody
	*Miss S. M. Dickson, FHI 41794, Queen Elizabeth School compound, Ilorin, Kwara State. 23/01/1958	Along the road	Annual	Non-woody
	*Awaodo, J.O., FHI 100722, Mangu, Plateau State. 22/07/1963	Not specified	Annual	Non-woody
	*Oyayomi, Fagbemi, Onijamowo, Ogunlayo and Arasi, FHI 92132, Naragatu game reserve, Jos, Plateau State. 26/11/1976	Close Community	Annual	Non-woody
	Sanusi, A.S., FHI, Obafemi Awolowo University, Ile – Ife, Osun State. 10/10/2018	Along the road	Perennial	Woody
	*Jackson, J.K., FHI 17773, Arikpa, Rest house, Kabba Province. 16/10/1967	Not specified	Annual	Non-woody
	*Ohaeri, A.O., FHI 9334, ABU, Samaru, Zaria. 21/05/1975	Not specified	Annual	Non-woody
	*Ekwuno and others, FHI 95638, Forest Reserve, Bende, Imo State. 11/01/1982	Not specified	Annual	Non-woody
	*Keay, R.W.J., FHI 6425, Kafancha, Railway Station. 1954	Not specified	Annual	Non-woody
	*Soladoye, M.O. and Ekwuno, FHI 84461, Opposite G.T.C, Lokoja, Kwara State. 19/10/1977	Not specified	Annual	Non-woody
	*Odewo, Ibhanesebhor and Odebode, FHI 91092, Eruwa Oyo State. 08/06/1978	Not specified	Annual	Non-woody
	*Uwana, O.A., FHI 26755, Ibadan, Oyo State. 04/12/1950	Not specified	Annual	Non-woody
	*Wit, P., FHI 27571, Ibadan, Oyo State. 17/08/1971	Along the road	Annual	Woody
	*Adesogan, A.K., FHI 100134, Forestry Hill, Ibadan, Oyo State. 22/07/1983	Along the road	Annual	Woody
E. heterophylla	*Daramola, B.O., FHI 103319, Otukpo, Ukpokolo-Ijiami Road, Benue State. 19/06/1978	Not specified	Annual	Non-woody
	*Adebayo, O., FHI 110265, Aruba, Sabo, Sagamu, Ogun State. 03/06/1997	CloseCommunity	Annual	Non-woody
	*Ariwaodo, J.O., FHI 100463, Bida Mokwa road, Niger State. 26/07/1983	Not specified	Annual	Non-woody
	*Odewo and Binuyo, FHI 102004, Ajobo village, Abeokuta, Ogun State. 30/08/1984	Not specified	Annual	Non-woody
	Oguntayo and Adejimi, FHI 83326, Owena Forest Reserve, Ondo State. 21/06/1977	Not specified	Annual	Non-woody
	*Ekwuno and others, FHI 97008, Obudu, Cross River State. 10/02/1982	Not specified	Annual	Non-woody
	*Olorunfemi and Oguntayo, FHI 84614, Owo Ondo State. 11/1977	Not specified	Annual	Non-woody
	*Odewo, Ibhanasebhor and Rasi, FHI 88115, Badagry along Ado-Ogo, Lagos State. 25/10/1978	Along the road	Annual	Non-woody
	*Odewo, T.K., FHI 87877, Gashaka, Gongola. 30/08/1977	Close community	Perennial	Woody
	*Keay, R.W.J., FHI 87877, Zaria. 26/08/1950	Close community	Annual	Non-woody

E. hirta	**Olorode, O., University of Benin, Benin city, Edo State. 01/2015	Open space	Perennial	Woody
	**Olorode, O., Ogbomoso Methodist Church, Oyo State. 28/05/2016	Waste place	Perennial	Woody
	**Olorode, O., Usman Dan – Folio University, Sokoto State. 12/02/2016	Open space	Perennial	Woody
	**Olorode, O., Ahmadu Bello University, Zaria, Abuja, FCT. 12/2015	Open space	Perennial	Woody
	**Sanusi, A.S., FHI, Obafemi Awolowo University, Ile – Ife, Osun State. 10/10/2018	Between crevices	Perennial	Woody
	*Oguntayo and Adejimi, FHI 83439, Omo Forest Reserve, Ijebu – ode, Ogun state. 24/06/1977	Not specified	Annual	Non–woody
E. hirta	*Ibhanesebhor and Adejimi, FHI 89562, Kishi-Igbetti road, Oyo State. 05/05/1977	Along the road	Perennial	Woody
	*Ojelabi, A.W., FHI 106322, Nihort compound, Ibadan, Oyo State. 20/06/1992	Not specified	Perennial	Woody
	*Olorunfemi, Binuyo and Babagbemi, FHI 96418, Ago-Are, Irawo road, Oyo State. 20/10/1981	Along the road	Perennial	Woody
	*Ekwuno, P.O., FHI 95843, Obubra, Iyanmtte, Cross River State. 11/02/1982	Not specified	Perennial	Woody
	*Magbagbeda and others, FHI 94597, Abeokuta-Ilaro road, Abeokuta, Ogun State. 23/04/1981	Along the road	Perennial	Woody
	*Ibhanesebhor, G. FHI 77699, Gashaka Game reserve, Mambilla, North East. 13/11/1975	Not specified	Perennial	Woody
	*Ekwuno, P.O and others, FHI 95502, Oguta lake, Oguta, Imo State. 01/09/1981.	Not specified	Annual	Non-woody
	*Ekwuno, Fagbemi and Osanyinlusi, FHI 87624, Calabar, Cross River State. 20/08/1978.	Open space	Perennial	Woody
	*Hooker, R.H., FHI 51245, Maiduguri, Borno State. 10/12/1960	Open space	Perennial	Woody
	*Yusuff and Onabowo, FHI 107840, Refugee Camp, Oru, Ogun State. 08/10/1907	Along the road	Perennial	Woody
	*Daramola and others, FHI 103027, Iseyin, Oyo State. 10/08/1980	Not specified	Perennial	Woody
	*Olorunfemi, Binuyo and Babagbemi, FHI 94414, Wusasa, Zaria, Kaduna State. 23/01/1981	Open space	Perennial	Woody
	*Emwiogbon and Oguntayo, FHI 103401, Enugu-Otukpa, Otukpa, Benue State, 30/06/1973	Open space	Perennial	Woody
E. hirta	*Bell, G.S., FHI 48130, Fadama, Jangani, Thukur, Safaud, Katsina State. 10/01/1964	Close community	Annual	Non-woody
	*Latilo, M.G., FHI 35362, Owan Village, Benin, Edo State. 20/11/1955	Close community	Annual	Non-woody
	*Ekwuno, P., FHI 87510, Yankari, Bauchi State. 12/06/1976	Open space	Perennial	Woody
	*Olorunfemi, FHI 55841, Naraguta Forest Reserve, Jos, Plateau State. 19/06/1965	Open space	Perennial	Woody
	*Daramola, Emwiogbon, Oguntayo, FHI 103306, Makurdi, Benue State. 01/07/1978	Close community	Annual	Non-woody
	*Gbile, Wit and Daramola, FHI 64073, Elekoyangan, Ilorin Bacita road, Ilorin, Kwara State. 16/09/1971	Open space	Perennial	Woody
	*Olorunfemi, FHI 86706, Apomu, Akure, Ondo State. 19/01/1978	Close community	Annual	Non-woody
	*Odewo and Adedeji, FHI 98620, Gombi road, Yola, Gongola, Adamawa State. 14/10/1982	Open space	Perennial	Woody
E. prostrata	**Olorode, O.O., Owode, Ogbomoso, Oyo State. 30/05/2016	Open space	Perennial	Woody
	**Olorode, O.O., Oke Ado, Ogbomoso, Oyo State. 02/06/2016	Waste places	Annual	Non-Woody
	**Olorode, O.O., Oke Ado, Ogbomoso, Oyo State. 17/07/2016	Open space	Annual	Non-Woody
	**Olorode, O.O., Sawmill, Adelekan, Oja Jango, Ogbomoso, Oyo State. 26/05/2016	Open space	Annual	Non-Woody
	**Olorode, O.O., Ladi Kwali Conference Centre, Abuja Sheraton Hotel, Abuja FCT. 26/12/2015	Open space	Annual	Non-Woody
	**Olorode, O.O.,UNIBEN, Benin City,Edo State. 26/05/2015	Open space	Annual	Non-Woody
E. prostrata	*Olorunfemi and Oguntayo, FHI 86572, Owo, Ondo State. 31/01/1978	Between crevices	Perennial	Woody
	**Sanusi, A.S., FHI, Obafemi Awolowo University, Ile – Ife, Osun State. 10/10/2018	Between crevices	Perennial	Woody
	*Onochie, C.F.A., FHI 24746, Gwari, Niger State. 22/06/1958	Waste places	Annual	Non-Woody
	*Latilo, M.G., FHI 58426, Ibadan, Oyo State. 25/04/1966	Open space	Annual	Non-Woody
	*Latilo, M.G., FHI 62763, Gwadabawa, Sokoto State. 03/08/1969	Between crevices	Perennial	Woody
	*Ekwuno, P.O., FHI 94073, Forest Reserve, Kukawa, Borno State. 01/10/1980	Between crevices	Perennial	Woody
	*Latilo, M.G., FHI 62270, Yagba, Kabba. 14/11/1978	Close community	Annual	Non-woody
	*Daramola, B.O. and Binuyo, FHI 61949, Bida, Niger state. 01/03/1968	Close community	Annual	Non-woody
	*Brenan, J.P.M. FHI 8741, Idanre, Akure, Ondo state. 11/02/1982	Between crevices	Perennial	Woody
	*Onyeachusim , H.D. and Binuyo, A. FHI 58303, Kainji Dam site, Borgu, Ilorin, Kwara state. 05/03/1966	Between crevices	Perennial	Woody
	*Ekwuno, P.O. FHI 95903, Ikom Cross River State. 11/02/1982	Between crevices	Perennial	Woody
	*Ariwaodo and others, FHI 99529, Itunta-Ibere, Imo State. 02/1982	Close community	Annual	Non-woody
E. thymifolia	**Olorode, O. University of Uyo, main campus, Nwaniba Road, Akwa-Ibom State. 28/05/16	Between crevices	Perennial	Woody
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	**Olorode, O.O., Oke Ado, Ogbomoso, Oyo State. 02/06/2016	Waste places	Annual	Non-Woody
	**Olorode, O.O., Oke Ado, Ogbomoso, Oyo State. 17/07/2016	Open space	Annual	Non-Woody
	**Olorode, O.O., Sawmill, Adelekan, Oja Jango, Ogbomoso, Oyo State. 26/05/2016	Open space	Annual	Non-Woody
	**Olorode, O.O., Ladi Kwali Conference Centre, Abuja Sheraton Hotel, Abuja FCT. 26/12/2015	Open space	Annual	Non-Woody

	**Olorode, O.O.,UNIBEN, Benin City,Edo State. 26/05/2015	Open space	Annual	Non-Woody
E. prostrata	*Olorunfemi and Oguntayo, FHI 86572, Owo, Ondo State. 31/01/1978	Between crevices	Perennial	Woody
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	*Ekwuno, P.O. FHI 95903, Ikom Cross River State. 11/02/1982	Between crevices	Perennial	Woody
	*Ariwaodo and others, FHI 99529, Itunta-Ibere, Imo State. 02/1982	Close community	Annual	Non-woody
E. thymifolia	**Olorode, O. University of Uyo, main campus, Nwaniba Road, Akwa-Ibom State. 28/05/16	Between crevices	Perennial	Woody
	**Sanusi, A.S., FHI, Obafemi Awolowo University, Ile – Ife, Osun State. 10/10/2018	Between crevices	Perennial	Woody

Quantitative analyses

Morphological characters measured quantitatively are leaf length, leaf width, leaf blade perimeter, internode length, number of lateral nerves, petiole and internode lengths. The morphometric analyses of the quantitative data were done according to Soladoye *et al.* (2013). The length of the leaf was obtained by spreading the middle leaf on a flat surface on the laboratory bench, while the width of the same median leaf was chosen and measured with the aid of a line ruler and thread. The measurement was taken to the nearest millimeters. Counts were taken for the number of lateral nerves.

Statistical analyses

The observations were expressed as mean ± standard error The values generated were then input into Microsoft Excel spreadsheet and raw data were coded to allow analysis using Statistical Package for Social Sciences (SPSS) for windows version 14. The program generated dendrograms which grouped the *Euphorbia* species investigated according to their morphological characters using cluster analysis (Sneath and Sokal, 1973).

Results and Discussion

The map (Fig. 1) shows the states in the country where the species are available. The distribution area of *Euphorbia* covers almost all the 36 states in Nigeria. According to the geographical distribution of the species, most of the taxa studied are very common in Nigeria. Among the species studied, *E. graminea* is shown to be apparently uncommon in Nigeria.

The mean and standard error of the intraspecific variation within each of the selected species of *Euphorbia* are shown in Table 2 while correlation matrix of characters in the taxa studied is presented in Table 3. It shows that closeness or similarity could be observed among species when certain characters are employed. For instance, when leaf length was correlated with leaf width, the degree of affinity was 0.944 and 0.790 when correlated with petiole length. Also, leaf width is highly correlated with leaf blade perimeter in having the value of 0.945 but when internode length was correlated with number of lateral nerves it was 0.892. In other words, it is indicated that there is a significant correlation between leaf length and leaf width, leaf width and leaf blade, internode length and number of lateral nerves.

Table 2: Variation of Morphological Characters within each species of *Euphorbia* studied

Characters / Species	Leaf length	Leaf width	Leaf blade perimeter	Internode Length	No of Lateral Nerves	Petiole Length
E. graminea(Ife)	50.48±1.71	32.62±0.78	114.67±4.04	44.81±4.76	13-23	30.83±2.10
E. graminea (Ibadan)	43.48±1.60	20.71±0.96	114.00±2.74	40.33±1.62	13 -20	24.38±0.76
E. graminea (Ago-Iwoye)	50.76±1.51	32.19±0.68	113.52±2.90	42.71±2.90	13 – 24	30.40±1.82
E. heterophylla (Ife)	88.35±40.04	43.75±2.73	213.90±8.77	39.35±5.15	11 – 30	21.95±1.98
E. heterophylla (Ibadan)	57.10±1.45	24.10±1.70	114.20±2.62	41.20±0.67	17 – 24	17.70±0.95
E. heterophylla (Ago-Iwoye)	89.75±0.62	31.10±0.37	145.80±2.55	41.20±0.67	15 – 30	19.45±0.28
E. hyssopifolia (Ago-Iwoye)	34.05±0.71	10.74±0.52	83.32±0.89	31.79±0.11	2 – 3	1.32±0.10
E. hyssopifolia (Ife)	31.70±0.85	8.75±0.60	78.50±1.67	29.40±1.21	2 – 3	1.35±0.10
E. hyssopifolia (Ibadan)	31.30±0.81	8.75±0.63	78.50±1.67	29.40±1.21	2 – 3	1.35±0.10
E. hyssopifolia (Abuja)	14.05±0.61	5.43±0.22	31.43±0.91	20.81±1.47	2 – 3	1.64±0.10
E. hirta(Sokoto)	11.65±0.36	4.70±0.24	31.25±0.98	25.10±1.53	3 – 6	2.55±0.14
E. hirta (Ago-Iwoye)	10.85±0.34	3.56±0.15	14.75±0.27	23.40±1.06	3 – 6	3.25±0.19
E. hirta (Ibadan)	28.25±1.13	18.70±6.99	62.70±1.62	27.15±1.21	2 – 5	2.95±0.09
E. hirta (Ife)	27.90±0.99	12.85±0.44	67.80±2.66	30.20±1.76	5 – 8	3.35±0.18
E. prostrata(Oke-Ado, Ogbomoso)	4.74±0.16	3.19±0.08	13.40±0.31	7.85±0.45	2 – 3	1.55±0.10
E. prostrata (Owode, Ogbomoso)	3.88±0.14	2.30±0.11	13.33±0.78	10.85±0.56	2 – 3	1.55±0.10
E. prostrata(Abuja)	4.98±0.19	2.93±0.13	20.93±1.46	11.34±0.52	2 – 3	1.60±0.09
E. prostrata (Benin)	4.35±0.15	2.35±0.12	13.90±0.82	11.10±0.59	2 – 3	1.55±0.10
E. prostrata (Ibadan)	7.60±0.22	3.75±0.12	13.51±1.82	18.50±0.70	2 - 3	1.80±0.07
E. prostrata (Ife)	7.25±0.18	3.85±0.10	15.04±1.79	15.6±0.98	2 – 3	1.60±0.09
E. thymifolia(Ife)	7.22±0.25	4.38±0.14	16.55±1.21	9.33±0.23	1 – 3	1.15±0.08
E. thymifolia (Ibadan)	7.55±0.19	4.14±0.16	12.33±0.80	9.67±0.22	2 – 3	1.24±0.10
E. thymifolia (Uyo)	5.14±0.28	2.95±0.15	8.14±0.42	16.29±0.80	2 – 3	1.14±0.08
E. thymifolia (Ago-Iwoye)	8.63±0.24	4.58±0.13	10.90±0.29	10.23±0.27	2 – 3	1.30±0.11

Units are in millimeters (mm) except for number of lateral nerves which are count data; Measurements represent mean±standard error

Table 3: Correlation matrix based on intraspecific variation within the speciesof *Euphorbia* studied

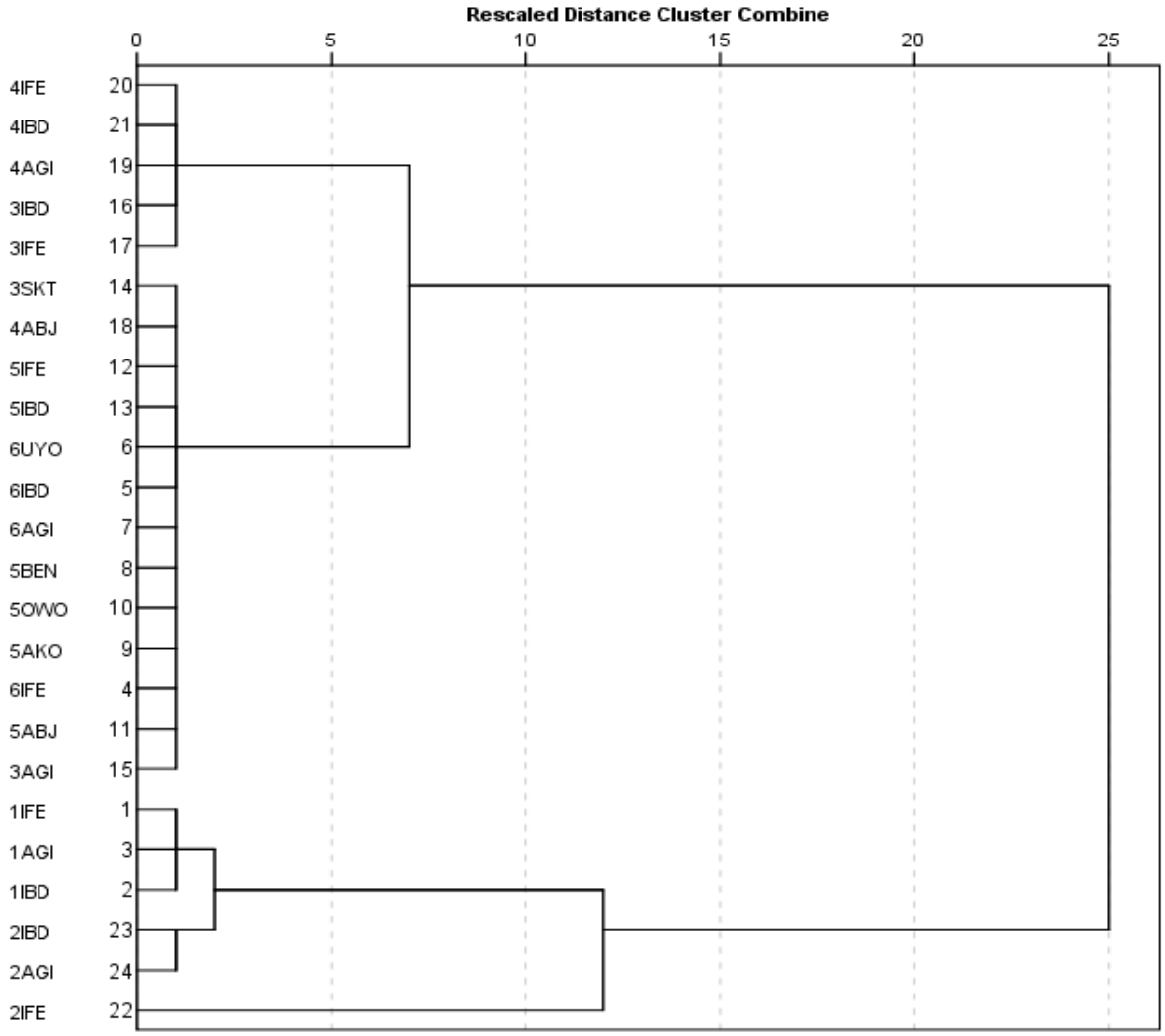
Characters	Leaf length	Leaf width	Leaf blade Perimeter	Internode Length	No of lateral nerves	Petiole length
Leaf length	1.000	0.944	0.979	0.861	0.916	0.790
Leaf width		1.000	0.945	0.842	0.938	0.896
Leaf blade perimeter			1.000	0.872	0.892	0.795
Internode length				1.000	0.799	0.797
No. of lateral nerves					1.000	0.933
Petiole length						1.000

Highly significant at P≤0.01

Table 4: Principal component analysis of intraspecific variation within the species of *Euphorbia* studied

Component	Initial Eigenvalues			Extraction sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.404	90.065	90.065	5.404	90.065	90.065
2	.302	5.034	95.100			
3	.207	3.452	98.552			
4	.055	.917	99.468			
5	.024	.401	99.870			
6	.008	.130	100.000			

The components are represented by the following numbers: 1 – Leaf length, 2 – Leaf width, 3 – Leaf blade perimeter, 4 – Internode length, 5 – No of lateral nerves, 6– Petiole length



E. graminea*; 2 – *E . heterophylla*; 3 – *E. hirta*; 4 – *E. hyssopifolia*; 5 – *E. prostrata*; 6 – *E. thymifolia

ABJ – Abuja ; AKO - Oke-Ado,Ogbomoso; OWO - Owode, Ogbomoso; BEN-UNIBEN ; IBD- Ibadan ; IFE – Ife; UYO – Uyo; AGI – Ago-Iwoye ; SKT – Sokoto

Fig. 3: Dendrogram using average linkage (within group) based on intraspecific variation within the *Euphorbia* species studied

The cumulative Principal Component Analysis (PCA) of the intraspecific variation (Table 4) showed that one out of six characters examined accounted for about 90.065% importance in the delimitation of the species. This one character is leaf length while the remaining five indicate the similarities that exist between the species of *Euphorbia* studied.

Table 5 shows the factor loading of the six quantitative morphological characters show that some characters are more valuable in delimiting the species. Differences based on morphometry of intraspecific variation within each of *Euphorbia* species are revealed in Table 6, showing the average linkage between groups on agglomeration schedule. The cluster that occurs between species 20 (*E. hyssopifolia* from Ife) and species 21 (*E. hyssopifolia* from Ibadan), had a coefficient of 0.670 whereas between species 8 (*E. prostrata* from Benin) and species 10 (*E. prostrata* from Owode, Ogbomoso), it was 0.670, indicating a great degree of variation between the morphometry.

Table 5: Factor loading of intraspecific variation within the species of *Euphorbia* studied

Characters	Component 1
Leaf length	0.966
Leaf width	0.978
Leaf blade perimeter	0.964
Internode length	0.907
No of lateral nerves	0.963
Petiole length	0.914
Leaf length	0.966

Table 6: Cluster analysis of intraspecific variation basedlinkage between groups

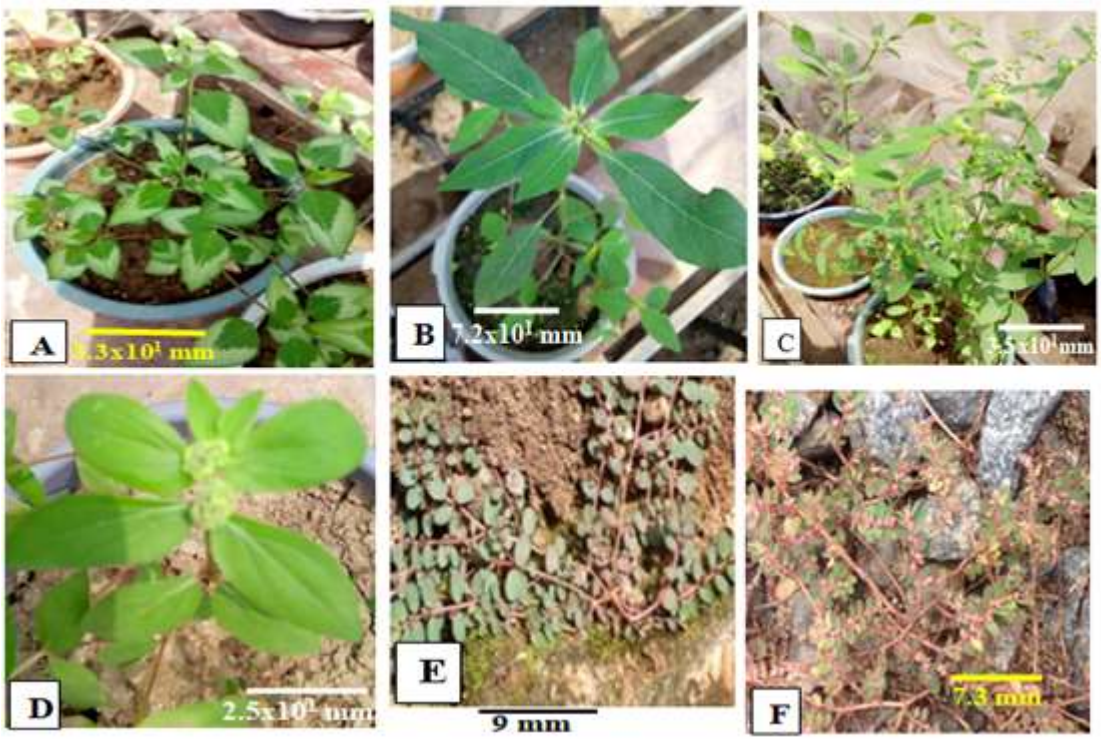
Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	20	21	0.160	0	0	10
2	8	10	0.670	0	0	6
3	5	7	2.740	0	0	8
4	1	3	7.740	0	0	16
5	12	13	10.760	0	0	11
6	8	9	10.845	2	0	7
7	4	8	24.677	0	6	8
8	4	5	26.463	7	3	12
9	14	18	28.170	0	0	19
10	19	20	39.210	0	1	17
11	6	12	47.600	0	5	14
12	4	11	69.882	8	0	14
13	16	17	76.650	0	0	17
14	4	6	78.672	12	11	15
15	4	15	180.721	14	0	19
16	1	2	240.660	4	0	20
17	16	19	318.245	13	10	21
18	23	24	376.970	0	0	20
19	4	14	487.949	15	9	21
20	1	23	1348.572	16	18	22
21	4	16	4318.166	19	17	23
22	1	22	7857.224	20	0	23
23	1	4	17275.814	22	21	0

1 – *E. graminea* (Ife)*;* 2 – *E. graminea* (Ibadan); 3 – *E. graminea* (Ago-Iwoye); *E. hirta;* 4 – *E. thymifolia* (Ife); *E. hyssopifolia;* 5 – *E. thymifolia* (Ibadan);6 – *E. thymifolia* (Uyo); 7 – *E. thymifolia* (Ago-Iwoye); 8 – *E. prostrata* (Benin)*;* 9 – *E. prostrata* (Oke-Ado, Ogbomoso); 10 – *E. prostrata* (Owode, Ogbomoso);11 – *E. prostrata* (Abuja); 12 – *E. prostrata* (Ife); 13 – *E. prostrata* (Ibadan); 14 – *E. hirta* (Sokoto); 15 – *E. hirta* (Ago-Iwoye); 16 – *E. hirta* (Ibadan); 17 – *E. hirta* (Ife); 18 – *E. hyssopifolia* (Abuja) ; 19 – *E. hyssopifolia* (Ago-Iwoye) ; 20 – *E. hyssopifolia* (Ife) ; 21 – *E. hyssopifolia* (Ibadan); 22 – *E .heterophylla* (Ife)*;* 23 – *E .heterophylla* (Ibadan)*;* ; 24 – *E .heterophylla* (Ago-Iwoye)

The dendrogram (Fig. 3) obtained from intraspecies variation within the species of *Euphorbia* studied shows grouping of the taxa into two major clusters. The first major cluster consists of two subclusters. The first subcluster include: *E. hyssopifolia* (from Ile-Ife, Ibadan and Ago-Iwoye) and *E. hirta* (from Ibadan and Ile-Ife). The second subcluster include: *E. hirta* (from Sokoto and Ago-Iwoye), *E. hyssopifolia* (from Abuja), *E. prostrata* (from Ile-Ife, Ibadan, Benin, Owode, and Oke-Ado in Ogbomoso), *E. thymifolia* (from Uyo, Ibadan, Ago-Iwoye, Abuja). It is important to note that all these species share some common features which include: plant habit, oblique obovate-oblong leaf blade, obliquely rounded leaf base, short petiole length, small-sized leaf, few lateral nerves etc. These similarities observed in the above-mentioned species support their classification into the subgenus *Chamaesyce*.

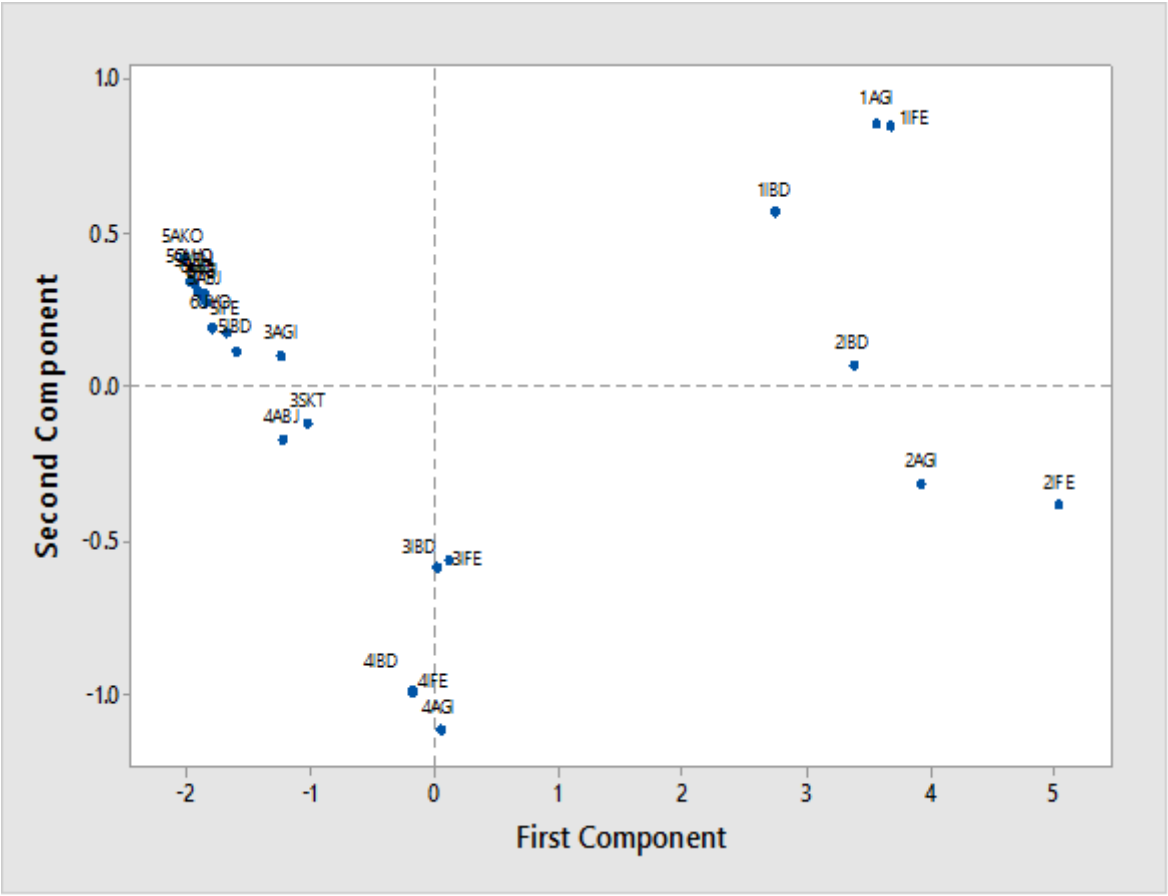
Based on the dendrogram, the second major cluster also consist *E. graminea* (from Ile-Ife, Ago-Iwoye and Ibadan) and *E. heterophylla* (from Ibadan, Ago-Iwoye and Ile-Ife). The significant closeness observed among these species is mainly due to presence of large-sized leaves, long petiole length, erect stem nature, many lateral nerves, etc.

Also, the component plots (Fig. 4) shows variation among the taxa. The Figure shows that the accession of *E. graminea* and *E. heterophylla* is a well-distinguished group, although *E. graminea* is morphologically different from *E. heterophylla*. The most important morphological difference is the leaf margin, type of branching and the presence of stipule in *E. heterophylla* which is absent in *E. graminea*. Leaf base and leaf apex can also serve as distinguishing features between *E. graminea* and *E. heterophylla*. From the component plots, it was shown that the highest similarity or closeness exist between *E. prostrata* and *E. thymifolia*. It is important to note that that *E. hirta* and *E. hyssopifolia* also shares some common features with *E. prostrata* and *E. thymifolia* which indicate subgeneric relationship among these accessions.



A. *Euphorbia graminea;* B. *Euphorbia heterophylla;* C. *Euphorbia hyssopifolia;* D. *Euphorbia hirta;* E. *Euphorbia prostrata;* F. *Euphorbia thymifolia*

Plate 1: Morphology of the species of *Euphorbia* (Source: Author's survey)



E. graminea*; 2 – *E . heterophylla*; 3 – *E. hirta*; 4 – *E. hyssopifolia*; 5 – *E. prostrata*; 6 – *E. thymifolia

ABJ – Abuja ; AKO - Oke-Ado,Ogbomoso; OWO - Owode, Ogbomoso; BEN-UNIBEN ; IBD- Ibadan ; IFE – Ife; UYO – Uyo; AGI – Ago-Iwoye ; SKT - Sokoto

Fig. 4: Component plot in rotated space for the intraspecific variation within the *Euphorbia* species studied

The approach of morphometry in which numerical methods are used in evaluating affinity or similarity between taxonomic units and the employment of these affinities in the preparation of classification systems are useful in establishing relationships among taxa (Sneath and Sokal, 1973; Henderson, 2006; El Gazzar, 2008; Soladoye *et al.,* 2010). A detailed account of the morphometric studies and their impact on taxonomy has been given by Soladoye *et al*. (2010), Kolawole *et al.* (2016) and Rahman *et al*. (2013). From the results obtained morphometry has yielded very useful taxonomic information. In this study, there are variations in lengths, shapes and sizes of the leaf within collection of each species from the different localities. These variations within species may be due to the age of plant, location and place of collection, sunlight intensity and genetic factors which occur as a result of mutation (Jongebloed *et al*., 2004; Soladoye *et al*., 2010).

Based on the result of this work, it is evident that the leaf characters play major roles in plant systematic and these characters include growth habit, leaf length, leaf width, leaf blade perimeter, internode length, petiole length and number of lateral nerves. The leaf morphological characters have proven to have a taxonomic importance in delimiting *Euphorbia* species. The leaf size reveals considerable difference amongst the studied species. The highest value of leaf length, leaf width and lateral nerves was recorded in *E. heterophylla* and smallest value in *E. thymifolia*. *E. graminea* shows the largest value for internode length and petiole length but *E. thymifolia* has the least value. Soladoye *et al.* (2010, 2013), Rahman *et al*. (2013), Kolawole *et al.* (2016) and Jeruto *et al.* (2017) recognized the usefulness of the above-mentioned characters in taxonomic analyses.

Based on the leaf arrangement and the leaf size *E. heterophylla* and *E. graminea* are distinguished from the other four species. Leaf base in *E. hirta*, *E. hyssopifolia*, *E. thymifolia* and *E. prostrata* bear oblique bases which clearly bring these four species together and clearly separate them from the other two species. They also have few lateral nerves (between 2 – 6) unlike *E. heterophylla* and *E. graminea* which have many lateral nerves up to 34 .The foliage leaves of *E. graminea* and *E. heterophylla* however differ from those of most other four species in the well defined long petiole while the petiole of the other four species are similar in having short petiole.

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The length, manner of branching and orientation of the shoot system determine the general plant habit. *E. graminea*, *E. heterophylla* and *E. hyssopifolia* are similar in general habit in having erect stems which are long and thick with large internodes. *E. prostrata*, *E. thymifolia* and *E. hirta* share some features with each other including prostrate stem with short, slender and weak stems and short-spaced internodes (Fig. 2). However, *E. hirta* may be erect or prostrate depending on the community.

The greater affinity observed between *E. prostrata* and *E. thymifolia* is in congruence with their current subgeneric and sectional delimitation based on their morphological features (Radcliff-Smith, 1980; Mosango, 2008). Both species belong to the subgenus *Chamaesyce* section *Chamaesyce* which is typified by a number of synapomorphic attributes such as leaves opposite, stipules unequal leaf base, cyathia axillary or clustered, glands often with membranous appendages and seeds without caruncle.

Distribution pattern and adaptation to specific habitats have long been recognised as important characteristics of plant species. Distributions of the taxa were given on the map according to White (1983). Most of the Nigerian species of *Euphorbia* have wide distributions. The distribution of *E. heterophylla*, *E. hirta*, *E. hyssopifolia*, *E. prostrata* and *E. thymifolia* are wider but *E. graminea* has fairly restricted distributions. Distribution wise, the species were found to be sympatric (*E. graminea* and *E. heterophylla*) or allopatric *(E. hirta, E. hyssopifolia, E. prostrata* and *E. thymifolia).*

Conclusion

The study revealed a number of important morphological characters and these characters exhibit interesting interspecific and intraspecific variations that are of diagnostic significance for identification and delimitation. The difference observed in the data and figures of the characters such as leaflet length and width, lamina length, fruit length and width, number of leaflet pairs per leaf and number of lateral nerves of leaflets of the species studied are therefore of taxonomic importance. The similarities observed among and within each collection of species of *E. hyssopifolia, E.hirta, E. prostrata* and *E. thymifolia* justifies why they are classified under the same subgenus *Chamaesyce.*

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Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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