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Distribution and ecological drivers of family celastraceae in Côte D'ivoire

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Most studies on drivers of plant diversity and distribution have focused on trees and combine several plant families. Climbers which are part of the particular characteristics of tropical rainforests due to their richness and abundance have been rarely related to ecological factors. This study evaluates the importance of vegetation type and total annual rainfall on the distribution of the Celastraceae plant family which are mostly climbers in Côte d'Ivoire using a herbarium database. A total of 1520 samples, encompassing16 genera, 60 species and 12 varieties of Celastraceae from over 363 localities in Côte d'Ivoire, were extracted from a database on Ivorian flora. Species' occurrences in localities were related to vegetation type and annual rainfall through a principal component analysis. A strong positive correlation (r = 0.81, P < 0.001) was found between the Celastraceae distribution and both the vegetation types and the rainfall. The Coastal evergreen and Western evergreen forests showed higher richness of Celastraceae climbers while the Sub-sudanian and Sudanian Savannas experienced lower richness than other vegetation types in Côte d'Ivoire.

Key words: Celastraceae, Tropical forest and savanna, climbing plants, species richness and spreading, rainfall.

INTRODUCTION

Among the West African vascular plant families, the Celastraceae *sensu* APG (1998, 2003, 2009), including Hippocrateaceae, is known at a regional scale only from Hallé (1958, 1962) and Hedin (1999). Taxa of African Tropical Celastraceae are mostly medium and tall climbers overlapping the high forest canopy. In addition, individuals available in the forest understory are mostly sterile and do not lead to full systematic identification. Moreover, it makes it difficult to link the diversity of such plants to its possible environmental drivers. This study aims to fill up for this gap by using large-scale digitized data of herbarium specimens and analysing the impacts of annual rainfall and vegetation types on Celastraceae species distribution in Côte d'Ivoire where this family has been intensively collected by several Botanists (Hallé, 1958, 1962; Hutchinson and Dalziel, 1958; Aké Assi,

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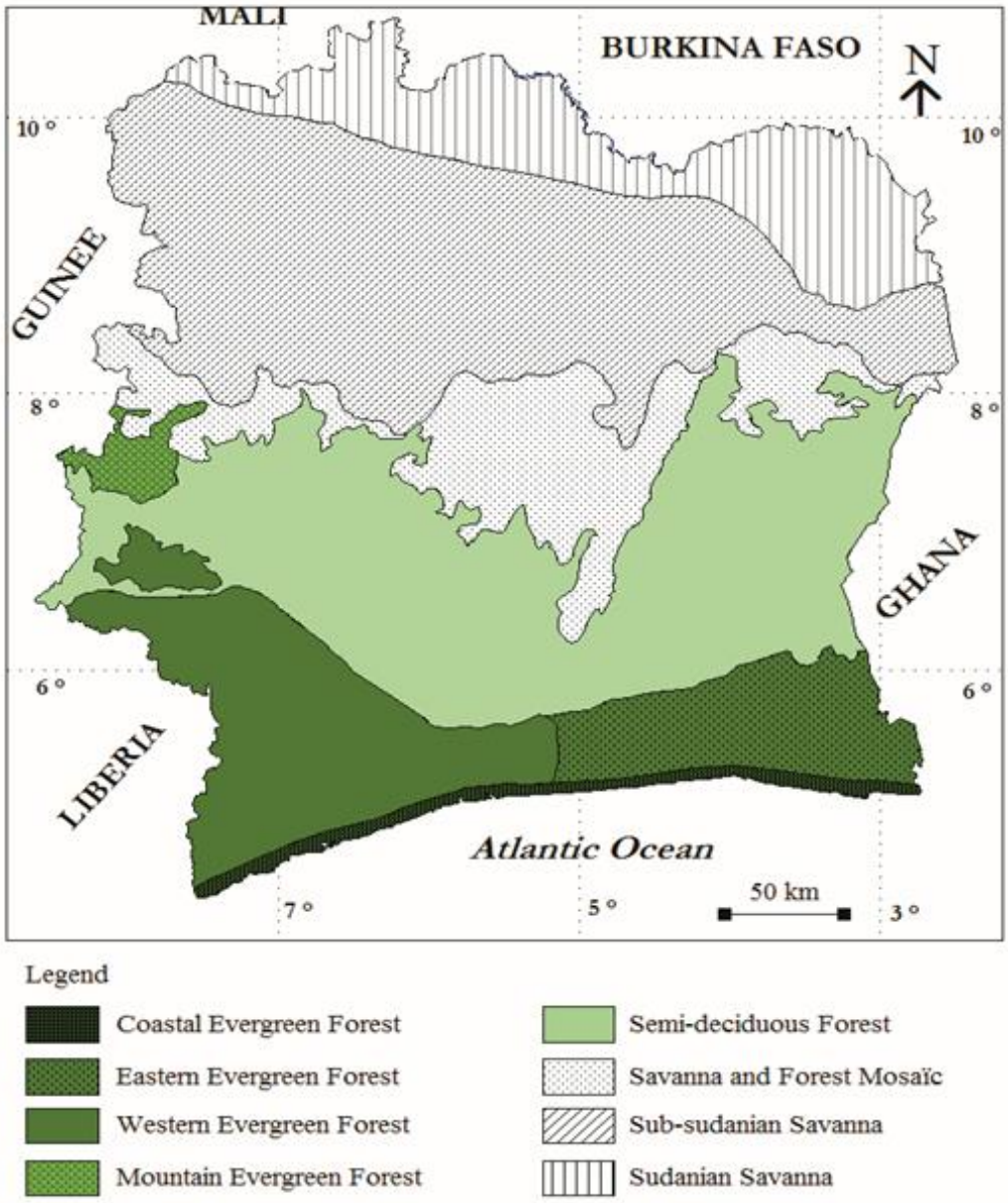

Figure 1. Map of main vegetation types of Côte d'Ivoire. This map is a result of combination of those of Monnier (1983) and Kouamé and Zoro Bi (2010)

2001; Jongkind, 2005).

MATERIALS AND METHODS

The materials source is the Ivoire-database compiled since 1997 by the Geneva Conservatory and Botanical Garden, which consists of botanical information-based on ca. 60'000 plant collections were deposited in various herbaria (Geneva, Abidjan, Wageningen and Paris) with geographic and ecological information (Gautier et al., 1999). From the Ivoire-database, the Celastraceae family consisting of about 1520 samples from 16 genera, 72 taxa made up of 60 species and 12 varieties collected over 363 localities were extracted. The occurrences and samples numbers of taxa were calculated and related to the eight main vegetation types (Figure 1) in Côte d'Ivoire. The similarity index of Sørensen (1948) was used to perform the comparison of the vegetation types according to their richness in Celastraceae taxa. The samples numbers and richness of Celastraceae were related to the total annual rainfall from the general meteorological data in localities through a linear regression. The distribution of taxa in the vegetation types and main ecosystems was performed using Principal Component Analysis with R Software and Venn diagram (Venn, 1880) respectively.

RESULTS

The Celastraceae plants recorded in Côte d'Ivoire are

essentially (86%) climbers and belong mostly to the genus *Salacia* L. which represents 51.4% of the flora (Table 1 and Figure 2). The climbing plants are medium size (2-8 long) for 64% and tall size (> 8 m long) for 22%; the non-climbing plants are medium size (2-8 m high) for 13% and small size (< 2m high) for 1% (Table 1 and Figure 2). Highest sample numbers and richness of Celastraceae were found in both coastal and western evergreen forests; whereas, their lowest values were obtained in sub-sudanian and Sudanian savannas areas (Table 1 and Figure 3). A strong positive correlation was found between the annual total rainfall and the Celastraceae richness (Figure 3).

No Celastraceae taxa were common to all the vegetation types (Table 1 and Figure 3). The commonest taxa were *Apodostigma pallens* (Planch.) R.Wilczek, *Helictonema velutinum* (Afz.) Pierre ex N.Hallé, *Salacia erecta* (G.Don) Walp. and *Salacia owabiensis* Hoyle sampled in 87.5% of the vegetation types (Table 1 and Figure 3). The taxa occurring in 37.5% of the vegetation types were the most abundant and expressed by 30.6 % of the flora (Figure 3). The ten rarest taxa as *Campylostemon laurentii* De Wild., *Maytenus buchananii* Loes., *Maytenus ovatus* Loes. var. *ovatus*, *Maytenus senegalensis* (Lam.) Exell, *Maytenus undata* (Thumb.) Blakel., *Reissantia parvifolia* (Oliv.) N.Hallé, *Salacia lehmbachii* Loes. var. *cucumerella* N.Hallé, *Salacia leptoclada* Tul., *Salacia longipes* (Oliv.) N.Hallé and *Simirestis atractaspis* N.Hallé were found in a single (12.5%) but variable vegetation type (Table 1 and Figure 3).

In terms of samples number, the five most collected Celastraceae taxa in Côte d'Ivoire (6.9%) were *Salacia nitida* (Benth.) N.E.Br., *Salacia owabiensis* Hoyle, *Apodostigma pallens* (Planch.) R.Wilczek, *Salacia erecta* (G.Don) Walp. and *Simicratea welwitschii* (Oliv.) N.Hallé with record number varying from 57 to 92 respectively (Table 1). The six (8.3%) less-collected Celastraceae taxa in Côte d'Ivoire are *Campylostemon laurentii* De Wild., *Maytenus undata* (Thumb.) Blakel., *Salacia lehmbachii* var. *cucumerella* N.Hallé, *Salacia leptoclada* Tul., *Salacia longipes* (Oliv.) N.Hallé and *Simirestis atractaspis* N.Hallé represented by only one sample each (Table 1).

In terms of occurrences of Celastraceae taxa, all the rainforests of Côte d'Ivoire, consisting of the evergreen forests except the montane evergreen forest and the semi-deciduous forest, are much more similar due to their high values of the similarity index (Table 2). The semi-deciduous forest and the savanna and forest mosaic are also much more similar. The Sub-sudanian savanna and the Sudanian savanna are more similar but different to all the other vegetation types (Table 2).

In terms of richness, there was a very strong influence ($r = 0.81$, $P < 0.001$) of both vegetation type and annual total rainfall on the Celastraceae plants distribution in Côte d'Ivoire (Figure 4). This influence of rainfall is positive. Among the vegetation types, coastal evergreen forests expressed the highest richness in Celastraceae while the Sudanian savanna was the lowest (Figure 4) in Côte d'Ivoire. The lowland rainforests showed higher richness in Celastraceae plants than the montane rainforests (Figure 4).

Based on the distribution of Celastraceae plants in Côte d'Ivoire, using PCA, three main groups of vegetation have been demonstrated (Figure 5). Eastern, coastal and montane evergreen forests are closer and constitute the Group 1. Western evergreen and semi-deciduous forest are closer to each other and designated as the Group 2. The third group is composed of the savanna vegetation types including the forest and savanna mosaic (Figure 5). Each vegetation group hosts some endemic taxa and some other taxa that are shared with one or two other groups (Figure 6 and Table 3). Group 1 showed the highest value of group endemic taxa with 11 taxa (15.3%). Group 2 with one taxa (1.4%) showed lowest value of group endemic taxa; while group 3 expressed intermediate value of group endemics with four taxa (5.6%). Nine-teen (19) taxa (26.4%) are common to the three groups of vegetation. Group 1 and 2 shared the highest value of common taxa between pairs of groups with 35 taxa (48.6%); while Group 1 and 3 had no taxa in common (Table 3).

The spatial distribution of Celastraceae plant taxa recorded in Côte d'Ivoire, using PCA, showed four groups of taxa.There was a large group around the center of the axes and three small groups of two-three taxa each above and below axis 1 (Figure 7). Above axis 1, there were two small groups of taxa on the right and the left of axis 2. The group at the right to axis 2 was constituted by *Salacia nitida* (Benth.) N.E.Br., *Salacia owabiensis* Hoyle and *Salacia whytei* Loes. (Figure 7). The latter taxa (*Salacia whytei* Loes.) is endemic to evergreen forests except montane forests; while *Salacia nitida* (Benth.) N.E.Br. is endemic to all evergreen and semi-deciduous forests. *Salacia owabiensis* showed larger distribution area including 87.5% of all the vegetation types. The group at the left of axis 2 encompases *Loeseneriella africana* R.Wilczek and *Salacia baumannii* Loes., which are common to both rainforests and savannas. The small group below axis 1 includes *Apodostigma pallens* (Planch.) R.Wilczek, *Salacia erecta* (G.Don) Walp. and *Salacia stuhlmaniana* Loes., which are also common to both rainforests and savannas. The largest group of taxa around the center of axes (Figure 7) is made of all the 64 remnant taxa. Therefore, the total annual rainfall and the 8 main vegetation types included in this manuscript cannot provide adequate separation for most of the Celastraceae plant taxa recorded in Côte d'Ivoire.

DISCUSSION

Family Celastraceae gathers 60 genera and nearly 850 worldwide mainly tropical but some representatives reach

Table 1. Samples numbers and richness of Celastraceae plants in the main vegetation types of Côte d'Ivoire.

Biology	Taxa	Coastal Everg. Forest	Eastern Everg. Forest	Western Everg. Forest	Montane Everg. Forest	Semi-decid. Forest	Savanna-Forest mosaïc	Sub-Sudanian Savanna	Sudanian Savanna	Total sample
MC	*Apodostigma pallens* (Planch.) R.Wilczek	4	10	22		10	10	8	4	**68**
MC	*Apodostigma pallens* var. *buchholzii* N.Hallé	1	2							**3**
TC	*Bequaertia mucronata* (Exell) R.Wilczek	2	5	3	16	2				**27**
TC	*Campylostemon angolense* Welw. ex Oliv.					2	6	6		**14**
MC	*Campylostemon laurentii* De Wild.			1						**1**
TC	*Campylostemon warneckeanum* Loes. ex Fritsch	3	3	8	1	8	7			**29**
TC	*Cuervea macrophylla* R.Wilczek ex N.Hallé	16	5	9		2				**31**
MC	*Helictonema velutinum* (Afz.) Pierre ex N.Hallé	5	5	1	1	2	7	2		**24**
TC	*Hippocratea myriantha* Oliv.	23	3	18						**44**
TC	*Hippocratea vignei* Hoyle	4		3		17				**24**
MC	*Loeseneriella africana* R.Wilczek var. *africana*	2	2		5	7				**15**
MC	*Loeseneriella africana* var. *schweinfurthiana* Loes.	1		3		3	3	3	1	**14**
TC	*Loeseneriella apocynoides* N.Hallé ex Raynal	7	3	3		1				**14**
TC	*Loeseneriella apocynoides* var. *guineensis* N.Hallé	4	4	5		2				**14**
TC	*Loeseneriella clematoides* (Loes.) R.Wilczek ex N.Hallé	8	3	2	6		2			**21**
TC	*Loeseneriella ectypetala* N.Hallé	6		6		12	2			**25**
TC	*Loeseneriella iotricha* (Loes.) N.Hallé	7	4	3	3	6	4			**27**
MC	*Loeseneriella rowlandii* (Loes.) N.Hallé	4	3	6	4	16	7			**40**
MT	*Maytenus buchananii* Loes.	5								**5**
MT	*Maytenus ovatus* Loes. var. *ovatus*	2								**2**
MT	*Maytenus senegalensis* (Lam.) Exell							14	3	**17**
MT	*Maytenus serrata* (Hochst. ex A.Rich.) Wilczek	8			1					**9**
MT	*Maytenus undata* (Thumb.) Blakel.				1					**1**
TC	*Prionostemma unguiculata* (Loes.) N.Hallé	16	4	2		14				**36**
MC	*Pristimera panicualata* (Vahl) N.Hallé	10		2		4	2			**17**
TC	*Pristimera plumbea* (Blak. & Wilczek) N.Hallé	1		1		3				**5**
TC	*Reissanthia indica* var. *astericantha* N.Hallé	4		1	1					**7**
MC	*Reissantia indica* N.Hallé var. *loeseneriana*	8	2		4	17	5	5		**41**
MC	*Reissantia parvifolia* (Oliv.) N.Hallé						2			**2**
MC	*Salacia adolfifriderici* Loes. ex Harms	2		2						**3**
MC	*Salacia baumannii* Loes.	5	3		5	5		2	2	**20**
MC	*Salacia cerasifera* Welw. ex Oliv.	3	3	3						**9**
MC	*Salacia chlorantha* Oliv.	1				1	2			**3**
MC	*Salacia columna* N.Hallé var. a*keassii* N.Hallé		2	5						**7**
MC	*Salacia columna* N.Hallé var. *columna*	9	4	4	6					**22**

Table 1. Contd.

MC	*Salacia columna* N.Hallé	11			11					**22**
MC	*Salacia cornifolia* Hook.f.	7		11		4				**22**
MC	*Salacia debilis* (G.Don) Walp.	3	3	7	7	18				**38**
MC	*Salacia elegans* Welw. ex Oliv.	4		6	7	4	2			**22**
MC	*Salacia erecta* (G.Don) Walp.	12	3	19	7	12	9	3		**64**
MC	*Salacia howesii* Hutch. & Moss	3		1		1				**5**
MC	*Salacia ituriensis* LoeSalacia	5				2				**6**
MC	*Salacia lateritia* N.Hallé	8	10	23	2					**42**
MT	*Salacia lehmbachii* Loes.	18	2	6	2	7				**35**
MT	*Salacia lehmbachii* Loes. var. *aurantiaca* N.Hallé	10	2	6		6				**24**
MT	*Salacia lehmbachii* Loes. var. *leonensis* N.Hallé	1	1	17	8	6				**33**
MT	*Salacia lehmbachii* var. *cucumerella* N.Hallé				1					**1**
MC	*Salacia leptoclada* Tul.							1		**1**
MC	*Salacia letestui* Pellegr.	1		1		1				**3**
MC	*Salacia longipes* (Oliv.) N.Hallé	1								**1**
MC	*Salacia longipes* var. *camerunenis* N.Hallé	5			2					**6**
MC	*Salacia miegei* N.Hallé	6	2	12						**20**
MC	*Salacia nitida* (Benth.) N.E.Br.	12	48	24	4	4				**92**
MC	*Salacia nitida* N.E.Br.var. *bipindensis* Loes.	2		1			1			**4**
MC	*Salacia oliveriana* Loes.	6	6	3						**14**
MC	*Salacia oliveriana* Loes. var. *adiopodoumella* N.Hallé	11	7			2				**20**
MC	*Salacia owabiensis* Hoyle	18	16	8	14	15	2		3	**75**
ST	*Salacia pallens* Oliv.	7		2	2	9		2		**23**
MC	*Salacia pyriformis* (Sabine) Steud.		2	2	3					**7**
MC	*Salacia staudtiana* Loes.	13	3		7	7				**30**
MC	*Salacia staudtiana* Loes. var. *leonensis* Loes.	8	7		4					**19**
MC	*Salacia staudtiana* var. *tshopoensis* De Wild.	1	1	1						**2**
MC	*Salacia stuhlmaniana* Loes.			10		5	5	6	3	**29**
MC	*Salacia togoica* Loes.	3		4	3	9	5	3		**26**
MC	*Salacia whytei* Loes.	18	9	14						**41**
MC	*Salacia zenkeri* Loes.	6	6	15						**27**
TC	*Salacighia letestuana* (Pellegr.) Blak.	17	5	14	3	3				**41**
MC	*Simicratea welwitschii* (Oliv.) N.Hallé	29	5	5	2	13	5			**57**
MC	*Simirestis atractaspis* N.Hallé							1		**1**
MC	*Simirestis dewildemaniana* N.Hallé	3		3	3					**9**
MC	*Simirestis tisserantii* N.Hallé	2	1		1					**4**
TC	*Tristemonathus nigrisilvae* N.Hallé	7	4	1						**12**

Table 1. Contd.

Samples	**424**	**207**	**325**	**147**	**258**	**86**	**56**	**16**	**1520**
Richness	**61**	**40**	**49**	**33**	**39**	**21**	**13**	**6**	

MC, Medium climber (2-8 m long); TCT, all climber (> 8 m long); MT, Medium tree (2-8 m high); ST, Small tree (< 2 m high). Everg., evergreen; decid., deciduous.

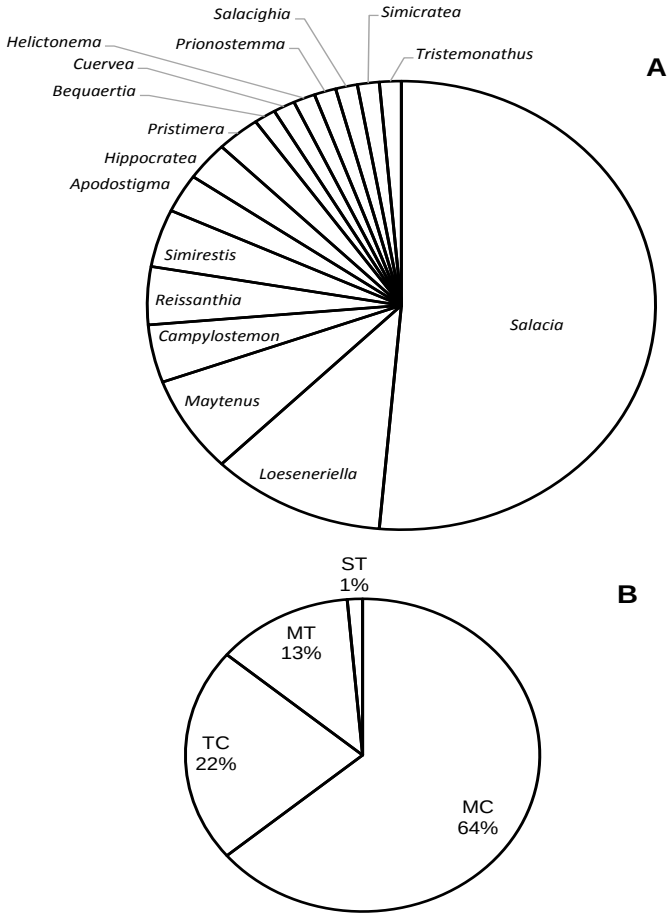

Figure 2. Diagrams of Celastraceae genera (A) and plant categories (B) assessed in Côte d'Ivoire. MC = Medium climber (2-8 m long), TC = Tall climber (> 8 m long), MT = Medium tree (2-8 m high) and ST = Small tree (< 2 m high).

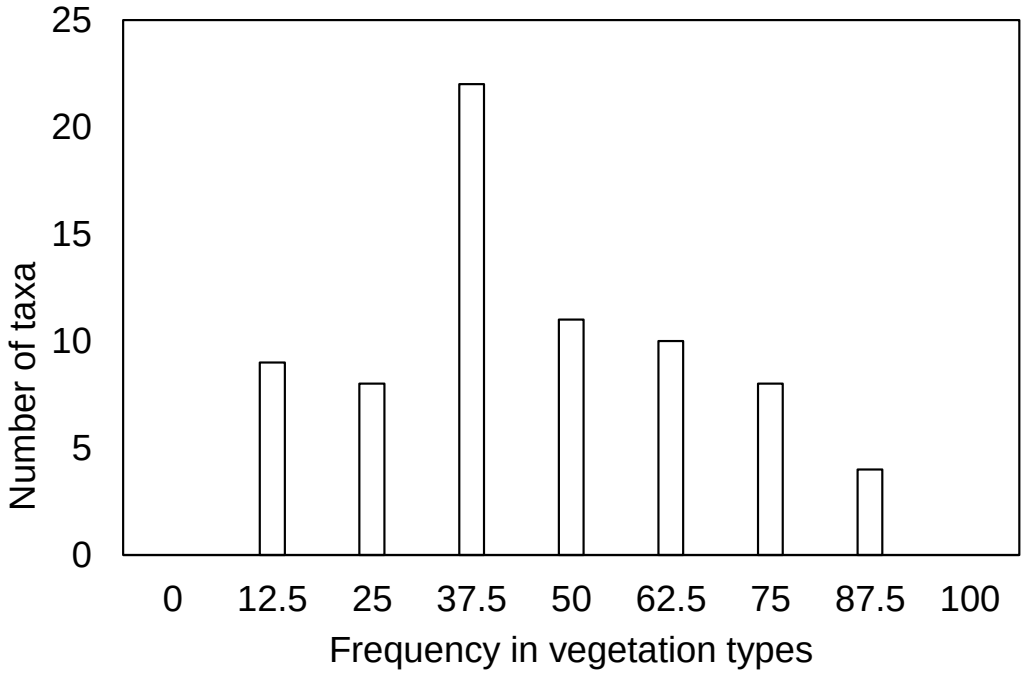

Figure 3. Diagram of the Celastraceae plant distribution frequency in the main vegetation types of Côte d'Ivoire.

Table 2. Sørensen's similarity coefficient between couples of vegetation types.

	Coastal Everg. Forest	Eastern Everg. Forest	Western Everg. Forest	Montane Everg. Forest	Semi-decid. Forest	Savanna and Forest mosaïc	Sub-Sudanian	Sudanian Savanna
Coastal Everg. Forest		71	77	58	71	43	24	13
Eastern Everg. Forest			72	58	62	35	20	14
Western Everg. Forest				54	77	55	22	14
Montane Everg. Forest					57	50	27	11
Semi-decid. Forest						68	36	20
Savanna and Forest mosaïc							47	26
Sub-Sudanian								53
Sudanian Savanna								

Coefficient values are in percentage and expressed above the diagonal. Higher coefficient between couple of vegetation types means strong similarity between these vegetation types. Below the diagonal, these valeus have been replaced by colors to illustrate the blocs of vegetation types according to Celastraceae richness and diversity. Everg. means evergreen; decid. means deciduous.

the temperate regions (Spichiger et representatives reach the temperate regions (Spichiger et al., 2000; Botineau, 2010). The most important genera are Maytenus Molina with 200 species form the hot tropical regions, Salacia L. Celastraceae flora in Côte d'Ivoire follows the characteristics of several large families of vascular plants occurring in the tropics. Indeed, large tropical plant families such as Orchidaceae, Poaceae and Rubiaceae have usually some large genera such as *Bulbophyllum* Thouars, *Panicum* L. and *Psychotria* L. respectively coexisting with several small genera (Hutchinson and Dalziel, 1954, 1958; 1963, 1968, 1972; Lebrun and Stork, with 200 species form the tropics, Euonymus L. with 180 species from the temperate regions and Hippocratea L. with 100 species from the tropics (Botineau, 2010).The predominance of the genus *Salacia* L. in the 1991, 1992, 1995, 1997; Hawthorne and Jongkind, 2006). But the substantial occurrence (51.4%) of taxa represented by *Salacia* L. among Celastraceae plants in Côte d'Ivoire (Table 1 and Figure 2) was exceptional. *Salacia* L. is about 200 species of lianas, shrubs, and small trees found throughout the tropics (Simmons, 2004; Botineau, 2010). Around 100 species are found in tropical Africa (Jongkind, 2006) and around 80 of these in the

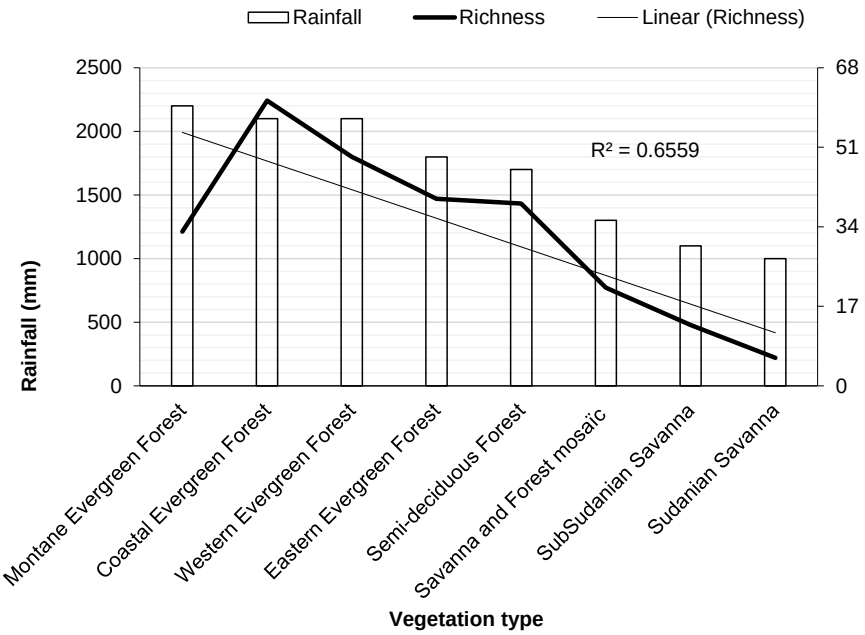

Figure 4. Ordination of Celastraceae plants' richness according to both the vegetation types and annual total rainfall **.**

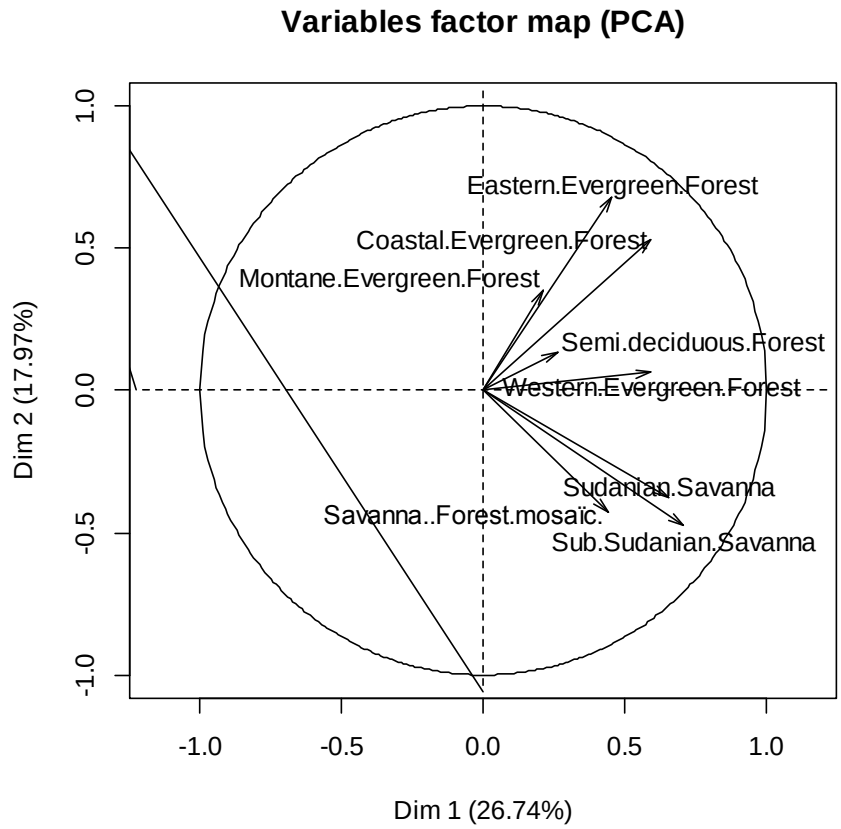

Figure 5. Groups of vegetation according to Celastraceae plants distribution in Côte d'Ivoire. Group 1 rich of 65 taxa consists of evergreen forests except Western evergreen forest; Group 2 with 57 taxa gathers Western evergreen and semi-deciduous forest; Group 3 about 25 taxa unifies all vegetation types in savanna area including the savanna and forest mosaic.

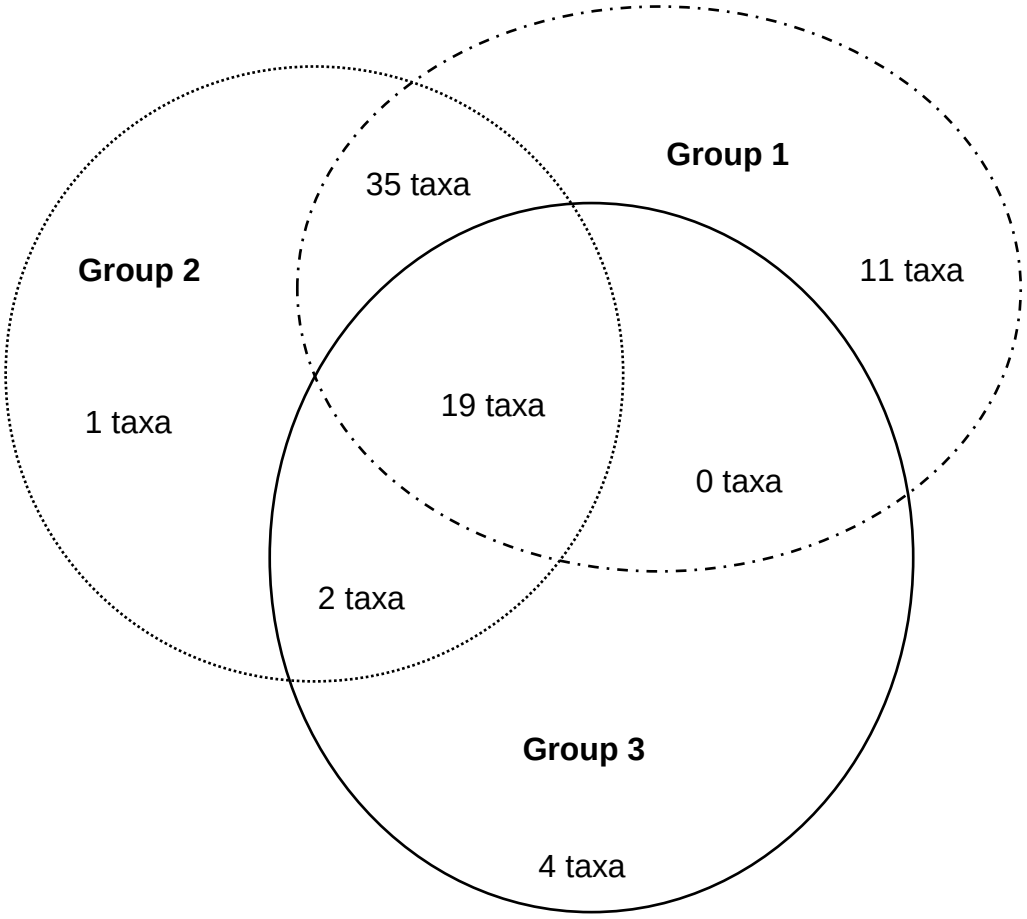

Figure 6. Venn diagram of the vegetation groups of Côte d'Ivoire according to Celastraceae distribution. Taxa endemic to these forest groups are as follow: **Group 1**. *Apodostigma pallens* var. *buchholzii* N.Hallé, *Maytenus buchananii* Loes., *Maytenus ovatus* Loes. var. *ovatus*, *Maytenus serrata* (Hochst. ex A.Rich.) Wilczek, *Maytenus undata* (Thumb.) Blakel.,*Salacia columna* N.Hallé, Salacia lehmbachii var. *cucumerella* N.Hallé, *Salacia longipes* (Oliv.) N.Hallé, *Salacia longipes* var. *camerunenis* N.Hallé, *Salacia staudtiana* Loes. var*. leonensis* Loes., *Simirestis tisserantii* N.Hallé. **Group 2.** *Campylostemon laurentii* De Wild. **Group 3.** *Maytenus senegalensis* (Lam.) Exell, *Reissantia parvifolia* (Oliv.) N.Hallé, *Salacia leptoclada* Tul., *Simirestis atractaspis* N.Hallé; Taxa common to all the three groups are *Apodostigma pallens* (Planch.) R.Wilczek, *Campylostemon warneckeanum* Loes. ex Fritsch, *Helictonema velutinum* (Afz.) Pierre ex N.Hallé, *Loeseneriella africana* var. *schweinfurthiana* Loes., *Loeseneriella clematoides* (Loes.) R.Wilczek ex N.Hallé, *Loeseneriella ectypetala* N.Hallé, *Loeseneriella iotricha* (Loes.) N.Hallé, *Loeseneriella rowlandii* (Loes.) N.Hallé, *Pristimera panicualata* (Vahl) N.Hallé, *Reissantia indica* N.Hallé var. *loeseneriana, Salacia baumannii* Loes., *Salacia chlorantha* Oliv., *Salacia elegans* Welw. ex Oliv., *Salacia erecta* (G.Don) Walp., *Salacia nitida* N.E.Br.var. *bipindensis* Loes., *Salacia owabiensis* Hoyle, *Salacia pallens* Oliv., *Salacia togoica* Loes., *Simicratea welwitschii* (Oliv.) N.Hallé. Refer to Table 3 for taxa common to couples of vegetation types.

Cameroon-Gabon centre of biodiversity (Gosline and Cheek, 2014). The most recent review of the entire genus is an unpublished thesis by Hedin (1999). Recent species description has been confined to South America (Lombardi, 2007, 2009, 2010) and India (Udayan et al., 2012, 2013).

A proportion of about 86% of the Celastraceae flora in Côte d'Ivoire, represented by climbing plants confirmed the character of tropical plant family attributed to Celastraceae (Hallé, 1958, 1962; Hutchinson and Dalziel, 1954; Lebrun and Stork, 1991, 1992; Hawthorne and Jongkind, 2006) which is among the vascular plants medium occurring families usually common to African tropical forests understory and canopy.

The decreasing of both Celastraceae samples number and richness (Table 1 and Figure 4) from the rainforest to the savanna types follows the natural distribution rules of climber plants in tropical vegetation types (ORSTOM and

Table 3. Celastraceae plant taxa common to couples of vegetation groups.

	Group 1	Group 3
Group 2	*Bequaertia mucronata* (Exell) R.Wilczek *Cuervea macrophylla* R.Wilczek ex N.Hallé *Hippocratea myriantha* Oliv. *Hippocratea vignei* Hoyle *Loeseneriella africana* R.Wilczek var. africana *Loeseneriella apocynoides* N.Hallé ex Raynal *Loeseneriella apocynoides* var. *guineensis* N.Hallé *Prionostemma unguiculata* (Loes.) N.Hallé *Pristimera plumbea* (Blak. & Wilczek) N.Hallé *Reissanthia indica* var. *astericantha* N.Hallé *Salacia adolfifriderici* Loes. ex Harms *Salacia cerasifera* Welw. ex Oliv. *Salacia columna* N. Hallé var. *akeassii* N. Hallé *Salacia columna* N. Hallé var. *columna* *Salacia cornifolia* Hook.f. *Salacia debilis* (G.Don) Walp. *Salacia howesii* Hutch. & Moss *Salacia ituriensis* Loes. *Salacia lateritia* N. Hallé *Salacia lehmbachii* Loes. *Salacia lehmbachii* Loes. var. *aurantiaca* N.Hallé *Salacia lehmbachii* Loes. var. *leonensis* N.Hallé *Salacia letestui* Pellegr. *Salacia miegei* N. Hallé *Salacia nitida* (Benth.) N.E.Br. *Salacia oliveriana* Loes. *Salacia oliveriana* Loes. var. *adiopodoumella* N.Hallé *Salacia pyriformis* (Sabine) Steud. *Salacia staudtiana* Loes. *Salacia staudtiana* var. *tshopoensis* De Wild. *Salacia whytei* Loes. *Salacia zenkeri* Loes. *Salacighia letestuana* (Pellegr.) Blak. *Simirestis dewildemaniana* N.Hallé *Tristemonathus nigrisilvae* N.Hallé	*Salacia stuhlmaniana* Loes. *Campylostemon angolense* Welw. ex Oliv.
Group 3	No common taxa	

UNESCO, 1983; Blanc, 2002). Indeed, tropical rainforests have this characteristic to harbour many medium and tall climbers (Schimper, 1903; Richards, 1996) among which Celastraceae is one of the most abundant families in Côte d'Ivoire (Aké Assi, 2001, 2002; Kouamé et al., 2007). Moreover, Celastraceae is almost exclusively a forest plants family (Hallé, 1958, 1962; Hutchinson and Dalziel, 1958; Hawthorne and Jongkind, 2006); even in savanna and montane areas where these taxa occur in forest patches on plateaus and along rivers. The genus *Maytenus* Molina possesses exclusively medium size trees (Table 1) and is better spread in coastal evergreen forests, montane evergreen forests and savanna area in Côte d'Ivoire. The different groups of taxa according to their distribution in the vegetation types (Tables 1 to 3 and Figures 5 to 7) express the capacity of these taxa to live or adapt as a response to local ecological conditions. Hence, ubiquitous taxa such as *Apodostigma pallens* (Planch.) R.Wilczek, *Helictonema velutinum* (Afz.) Pierre ex N.Hallé, *Salacia erecta* (G.Don) Walp., *Salacia owabiensis* Hoyle have been assessed in 87.5% of the vegetation types (Table 1) due to their large tolerance to local ecological conditions. Higher samples numbers of these taxa (Table 1) confirmed the overall local abundance of such Celastraceae in Côte d'Ivoire. Consequently, Celastraceae

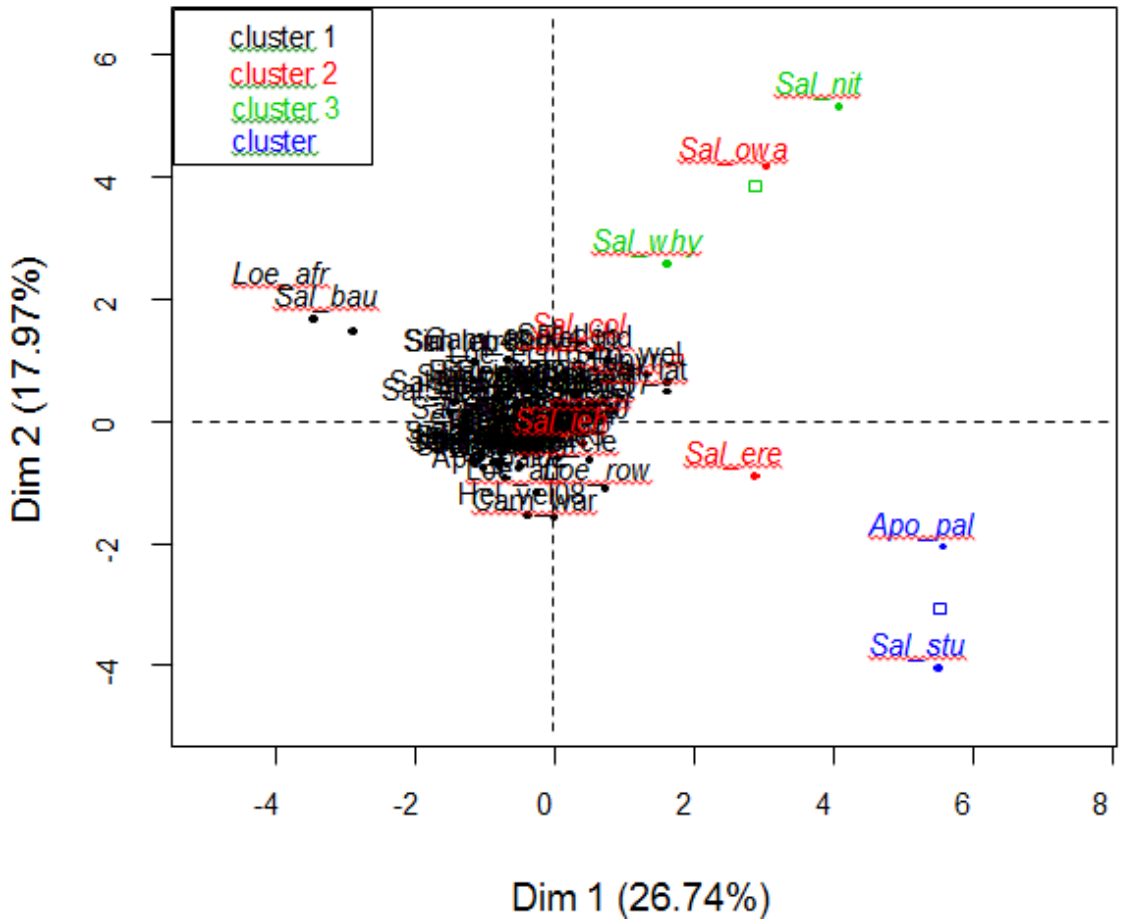

Figure 7. Spatial distribution of Celastraceae plants assessed in Côte d'Ivoire through a PCA. The taxa names are abbreviated using the three first letters of the genera and those of the specific epithets.

species has been able to live and develop in all the 8 vegetation types in Côte d'Ivoire (Table 1 and Figure 3) revealing that ecological conditions are quite different in these main vegetation types.

Among the rainforest types, the highest samples number and richness of Celastraceae found in both coastal and western evergreen forests (Table 1 and Figure 3) could be explained by the higher intensity of plants assessments in both areas in Côte d'Ivoire. Banco forest and Taï forest which do two national parks exist respectively in these forest zones are also the most studied forests in Côte d'Ivoire (de Koning, 1983; Riezebos et al., 1994). But this difference of sampling effort cannot explain the lowest values of both sample number and richness of Celastraceae, in comparison to the rainforest types (Figure 3).

The strong and positive correlation between the annual rainfall and the Celastraceae richness (Figure 4) reveals that local annual total rainfall is among the factors that lead to establishment and development of Celastraceae in an area as reported by Parmentier et al. (2007, 2011) and Fayolle et al. (2014) for tropical trees. Therefore, Celastraceae taxa endemic to one or other vegetation type (Table 1) such as *Maytenus buchananii* Loes., *Salacia lehmbachii* Loes var. *cucumerella* N.Hallé, *Reissantia parvifolia* (Oliv.) N.Hallé can establish and develop only in the ecological conditions prevailing in these vegetation types.

Conclusion

The Celastraceae plant family consists of almost exclusively of climbing life habits that live in all vegetation types of Côte d'Ivoire, even though there are different levels of abundance and richness across these vegetation types. The total annual rainfall was to positively influence the richness of Celastraceae as well. Based on spatial distribution of these plants, the natural main vegetation types of Côte d'Ivoire could be classified into three groups of two to three vegetation types each. Despite the difficulties to assess fertile materials of most climbing plants such as those in the family Celastraceae, a database such as the one used here holds promise to

improve our understanding of some major biogeographic and ecological patterns of these climbers across broad geographic localities.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Appendix

Celastraceae distribution frequency in the main vegetation types.

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