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Some Aspects of the Forest Edges of Martinique and Evaluation of the Potential of Herbaceous Rubiaceae in These Environments

Jean-Philippe Claude

UMR ESPACE DEV-BIORECA Laboratory, University of Antilles, Schœlcher, France
Email: claudejeanphilippe1@gmail.com

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Abstract

The flora of the Lesser Antilles archipelago located in the Caribbean, presents a remarkable diversity of species belonging to the Rubiaceae family, with a representation of all possible forms of life. More than twenty are herbaceous plants present in the archipelago (three of which are endemic) and about fifteen in Martinique. Although several species are rather rare, others are described as ruderal, arval or ubiquitous, colonizing different types of environments. We therefore undertook to explore the ecology of herbaceous Rubiaceae of the forest edges of the island of Martinique, following a protocol distinct from that used for woody species. The results reveal that it is possible to find Rubiaceae, whatever the type of forest edge and the type of bioclimate. However, if some herbaceous Rubiaceae thrive there, probably attracting various pollinators, ensuring their ecological success, the majority of them remain rare. Yet the study shows that these forest edges support a diverse biodiversity, playing a role as transitional habitats by offering unique conditions that neither dense forests nor other open spaces provide.

Keywords

Rubiaceae, Forest Edges, Ecology, Martinique

1. Introduction

There are over 14,000 species and approximately 580 recognized genera of the Rubiaceae family worldwide, making it the fourth largest family of flowering plants with a primarily pantropical distribution [1]. In the Caribbean, the flora of the Lesser Antilles archipelago is composed of a remarkable diversity of Rubiaceae [2]-[5]. Rubiaceae form the fifth largest plant family in the archipelago with 129 species recorded, including 89 on the island of Martinique [2]-[5]. This mountainous island occupying a central position in the archipelago, hosts all forms of life in this family (trees, shrubs, bushes, lianas, herbaceous plants, epiphytes and aquatic plants) and these species occupy a very wide range of habitats [2]-[10].

Combining the censuses of the American botanist Richard Alden Howard and the French botanist Jacques Fournet, 20.2% of Rubiaceae in the Lesser Antilles are herbaceous (*i.e.* 26 species divided into 10 genera), and in Martinique, 15.7% are herbaceous (*i.e.* 14 species divided into 6 genera) (**Appendix 1**) [2] [3]. Their flowering can be annual, seasonal (rainy season) or regular but absent in the event of a long drought [2] [3]. Although several species are rather rare, others are described as ruderal, arval or ubiquitous, adapted to disturbed, open or cultivated environments [2] [3] [8]. They colonize forest edges, fields, ruins and even roadsides [2]-[4] [8]. Given their ability to colonize diverse and often disturbed habitats, we hypothesize that herbaceous Rubiaceae have a specific distribution and diversity influenced by variations in ecological conditions, for example, at forest edges, particularly in terms of light availability and humidity. This study aims to answer the following question: to what extent do ecological gradients present at forest edges modulate the floristic composition and spatial distribution of herbaceous Rubiaceae in Martinique? We therefore undertook to explore the ecology of herbaceous Rubiaceae in forest edges on the island of Martinique.

2. Materials and Methods

2.1. Study Area

Martinique, a mountainous and volcanic island in the Lesser Antilles archipelago (**Figure 1**), is the result of subduction between the North American and Caribbean plates, a phenomenon that gives rise to its unique topography marked by massifs in the north, hills in the south and a diversity of soil types [11]-[14].

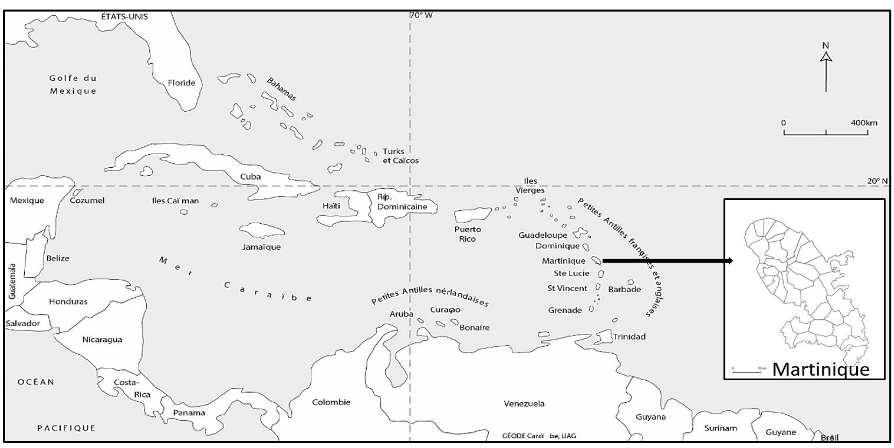

Figure 1. Location of Martinique in the Lesser Antilles archipelago, Caribbean.

This topographic and pedological diversity, influenced by orographic precipitation and altitudinal climatic variations, generates various bioclimates ranging from dry to hyper humid and various forests such as xerophilous forests at low altitude, mesophilous forests at medium altitude to submontane and montane rainforests [15]-[20].

Martinique, with its diversity of soils, reliefs, hydrography and vegetation, as well as a strong varied anthropization, offers a great heterogeneity of habitats favorable to herbaceous Rubiaceae, which disperse mainly by barochory and zoochory [4] [17] [21] [22]. Forest edges for example, transitional zones between forest and open environments, constitute habitats rich in biodiversity, in particular for pollinators, throughout the year [23]-[25]. These edges constitute ecological corridors that facilitate biological exchanges in a fragmented landscape, offering an ideal habitat for herbaceous Rubiaceae [23]-[25]. Despite its modest surface area (1128 km^2), Martinique is home to a diversity of species from the Rubiaceae family, contributing to the biodiversity of the archipelago, a component of the Caribbean hotspot recognized worldwide [4] [5] [26]-[28]. Around 89 species of the family are present on the island, including 14 herbaceous species divided into 6 genera, but the majority of them remain rare (**Appendix 1**, **Figure 2**), [2]-[5]. The identification of these plants is possible with the help of floras and reference works containing in particular illustrations facilitating their determination [2] [3] [8].

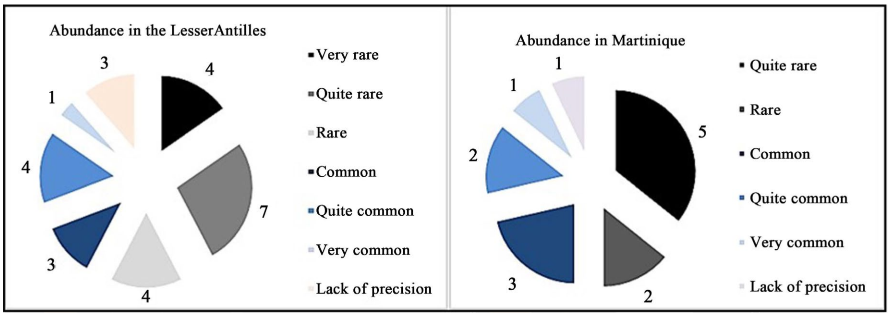

Figure 2. Abundance of herbaceous Rubiaceae [2] [3].

2.2. Methods

The data were collected exclusively by non-exhaustive floristic surveys, carried out in 2020 with the help of a few members of the Association of Martinican Botanists (**Figure 3**). This study uses an approach aimed at analyzing the main trends, as well as the interactions between plant species within largely herbaceous communities [23] [29]-[32]. Thus, walking on the hiking trails, in various bioclimates, 29 surveys were carried out targeting the Rubiaceae encountered in the forest edges of the island (**Appendix 2**). One of the main difficulties was then to identify as many species of the family as possible in these very dense edges, during our only passages on each of the hiking trails. Indeed, regardless of the bioclimate, these edges proved to be extremely dense, composed largely of herbaceous plants but including other physiognomic types (shrubs, lianas, liana shrubs, etc.) and therefore constituting multiple populations of very varied surfaces.

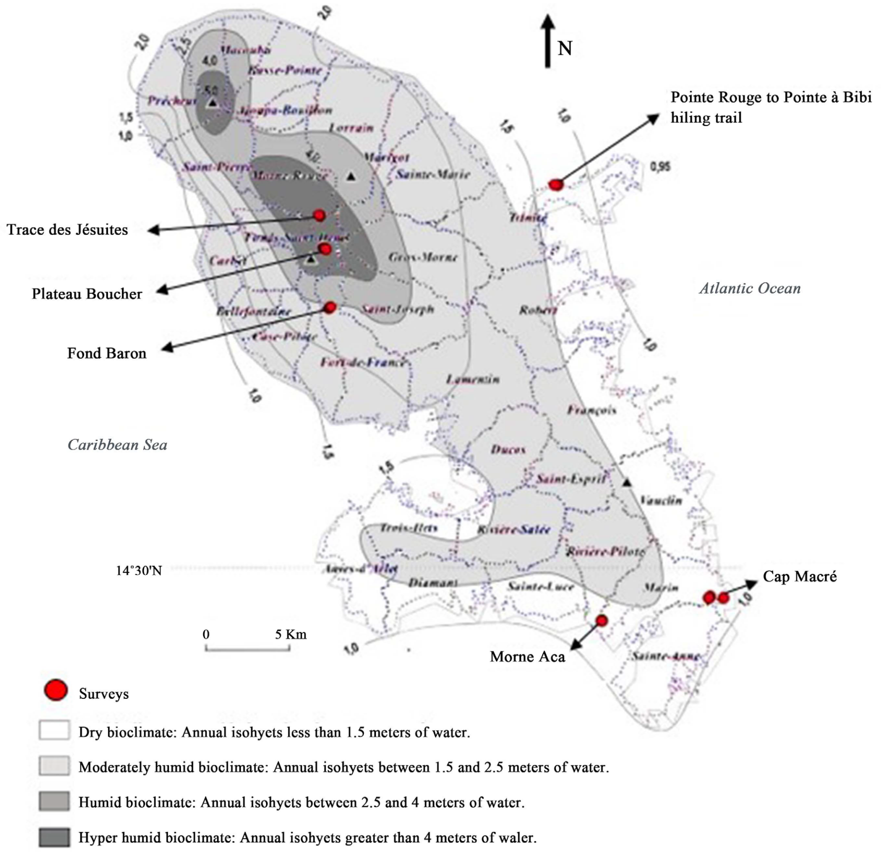

Figure 3. Location of surveys.

Wanting to inventory and obtain a representative sample of this diversity of populations was almost impossible. We therefore chose to arbitrarily select a reference surface corresponding to the square meter. This standard methodology consisted of placing wooden sample squares of 1 meter on each side, on non-contiguous surfaces where Rubiaceae were identified (Figure 4 and Figure 5).

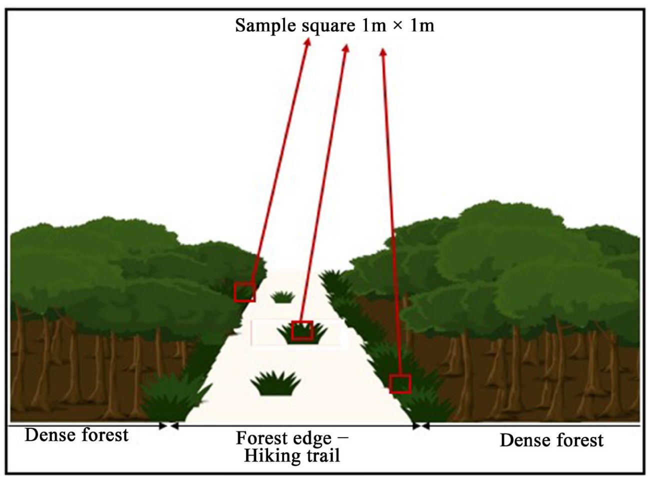

Figure 4. Cross-Sectional diagram illustrating the structure of the forest edges traversed.

Figure 5. Some photos to illustrate the different types of forest edges traveled and sample squares made of 1 m × 1 m. (1. Cap Macré, 2. Morne Aca, 3. Fond Baron, 4. Trace des Jésuites).

The objective of the sample squares was to provide an overview of the number of Rubiaceae, their abundances and densities per square meter, and the types of populations to which they can contribute. For each sample square, a set of ecological and floristic descriptors were systematically noted, such as the name of the species, their number of individuals, their height, their physiognomic type as well as their phenological state (flowering and fruiting periods). For lianas or seedlings (less than 10 cm), we simply noted their abundance when their identification was possible (+ very low (number 1 to 5); ++ low (number 5 to 15); +++ average (number 15 to 30); ++++ high (number 30 to 45); +++++ very high abundance (number 45 to 100 and more)). Furthermore, based on the GPS points of the surveys and the QGIS software version 3.36, the biotopes were characterized (**Appendix 2**). The average annual minimum and maximum temperatures, the average annual precipitation were noted using climatic data from Météo-France (French meteorological organization). The slope gradient and altitude were recovered using altimetric data from the IGN (National Geographic Institute, BDALTI 25 meters) and the soil types of the surrounding forests using pedological data from the IRD (Research Institute for Development, soil map of the Antilles at 1/20,000). The level of sunshine received on the ground was noted on site, according to two simple variables (medium (50% sunshine) or high (100% sunshine)). The data obtained were then entered into Excel software and ecological indices and indicators were used for the treatment of Rubiaceae or stations [2] [4] [15] [17] [29]-[31] [33].

We distinguish:

- Species richness (number of species identified);
- Abundance (number of individuals per species);
- Frequency (presence of a Rubiaceae in a specific number of sample squares);
- Density (ratio between the number of individuals of a species and the area of the surveys), calculated according to the following equation:

$$D = n/a . \quad (1)$$

where "D" is the density, "n" is the number of individuals of a species, "a" is the area of the sample square.

- The distribution index (distribution of Rubiaceae within the surveys, expressed by the product between the frequency and the density per species), calculated according to the following equation:

$$Id = F \times D . \quad (2)$$

where "Id" is the distribution index, "F" is the frequency and "D" the density.

- Simpson's diversity index (floristic diversity and numerical dominance of one or more species), calculated according to the following equation:

$$\lambda = \sum_{i=1}^{S} \left[n_i / N \right]^2 \quad (3)$$

where "λ" is the Simpson index, "S" is the total number of species, "n_i" is the number of individuals of a species and "N" is the total number of individuals. The index is close to 0 when the specific diversity is high, no species dominates numerically; and close to 1 when the diversity is low and one species dominates numerically. Finally, multivariate statistical processing was carried out using XLSTAT software in order to characterize of our surveys [29] [34] [35].

3. Results

3.1. Characteristics of the Surveys Carried Out

The surveys were carried out on various sites, covering bioclimates ranging from dry subhumid to hyperhumid (Figure 3, **Appendix 2** and **Appendix 3**). The sample squares are distributed in habitats corresponding to the edges of xerophilous, xero-mesophilous (transition zone), meso-hygrophilous (transition zone) and hygrophilous forests (**Table 1**). The altitudes range from 1 to 635 meters, and the slopes are gentle to moderate (**Appendix 2**). The hiking trails are more or less wide and of a diverse nature, ranging from secondary roads to stone and earth paths. However, the soils of the surrounding forests are mainly composed of vertisols (rarely marine alluvium) in dry subhumid bioclimates, and of red or brown montmorillonitic soils in more humid bioclimates (**Appendix 2**). Most of the surveys are located in semi-shaded areas, with sunlight on the ground limited by the canopy cover of the surrounding trees (**Appendix 2**). In total, the 29 surveys cover an area of 29 m^2. Approximately 2276 specimens were recorded, of very diverse physiognomic types, belonging to 96 species, divided into 79 genera and from 40 different families (**Appendix 3**).

Two species are invasive according to the DEAL (Directorate of the Environment, Planning and Housing in Martinique): *Clerodendron paniculatum* and *Dichrostachys cinerea* [36]. We find mostly herbaceous species but also lianas, ferns, or even seedlings or young individuals of future shrubs, trees and bushes. Among these specimens, 228 belong to 7 species, divided into 5 genera of the Rubiaceae family (**Appendix 3**).

Table 1. Summary table of floristic surveys carried out between August and October 2020 (**Appendix 2** and **Appendix 3**).

Bioclimate	Dry subhumid	Ecotone (transition between dry subhumid and humid subhumid)	Ecotone (transition between humid and humid subhumid)	Hyper humid
Forest edge	Xerophilous	Xero-mesophilous	Meso-hygrophilous	Hygrophilous
Number of sample squares	8	6	6	9
Total area (square meter)	8	6	6	9
Minimum area (square meter)	1	1	1	1
Number of families (all physiognomic types included)	21	14	16	18
Number of genera (all physiognomic types included)	40	18	20	27
Number of species (all physiognomic types included)	47	19	20	31
Number of individuals (all species included, excluding seedlings, lianas and ferns)	599	164	561	952
Physiognomic types encountered	tree, shrub, herbaceous, liana.	tree, shrub, bush, herbaceous, liana.	tree, shrub, herbaceous, fern.	shrub, herbaceous, fern.
Number of genera of the Rubiaceae family (all physiognomic types included)	3	3	2	2
Number of species of the Rubiaceae family (all physiognomic types included)	3	3	2	3

Continued

Number of individuals of the Rubiaceae family (all species included)	96	20	25	87
Location of place name	Morne Aca and Cap Macré	Pointe Rouge to Pointe à Bibi hiking trail	Fond Baron	Plateau Boucher and Trace des Jésuites
Municipality	Marin	Trinité	Fort-de-France	Fonds-Saint-Denis and Morne Rouge

3.1.1. Forest Edges of Xerophilous Forests: Cap Macré

The species recorded in the sample squares of Cap Macré, present diversified physiognomic types. The flowering of some species, which is conducive to attracting pollinators, indicates an active reproductive capacity (Table 2). The overall low density and abundance of species suggest a relatively stable environment, favourable to ruderal plants able to adapt to water stress and high light. In at least three surveys, the Simpson index approaches 1, reflecting a marked abundance of several species. Only one shrub and two herbaceous plants of the Rubiaceae family are recorded, of which only *Diodia ocymifolia* (herbaceous) stands out for its particularly high abundance and density.

Table 2. Contents of the sample squares made at Cap Macré in Marin.

			Square 1 (S1)					Square 2 (S2)					Square 3 (S3)					Square 4 (S4)				
	Simpson index		0.43867036					0.28125					0.33742198					0.44636678				
No.	**Species**	**Ph**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**
1	*Abrus precatorius*	L		5+					1+										1+			
2	*Capraria biflora*	He						40	1	0.0001												
3	*Cenchrus echinatus*	He						60	3	0.0003	Y											
4	*Citharexylum spinosum*	T						15	1	0.0001												
5	*Croton bixoides*	Sh											20	3	0.0003			50	2	0.0002		
6	*Cuscuta americana*	L		1+		Y																
7	*Desmodium incanum*	He											20	50	0.005	Y	Y					
8	*Desmodium sp*	He		10+																		
9	*Dichrostachys cinerea*	Sh						50	3	0.0003												
10	*Diodia ocymifolia*	He											30	80	0.0080	Y		20	10	0.0010	Yes	
11	*Eleocharis flavescens*	He											10	10	0.0010	Y		10	5	0.0005	Yes	
12	*Enicostema verticillatum*	He						20	2	0.0002	Y											
13	*Eugenia cordata*	Sh						20	1	0.0001												
14	*Guettarda odorata*	Sh	70	1	0.0001																	
15	*Haematoxylum campechianum*	T	80	2	0.0002																	

Continued

16	*Heliotropium ternatum*	He	90	5	0.0005	Y																
17	*Ipomoea setifera*	L		5+																		
18	*Leptochloa filiformis*	He						60	2	0.0002	Y											
19	*Leucaena leucocephala*	T	40	30	0.0030																	
20	*Pithecellobium unguis-cati*	T											160	8	0.0008							
21	*Sida rhombifolia*	He	10	55	0.0055			60	1	0.0001												
22	*Sida sp*	He	10	2	0.0002																	
23	*Spermacoce verticillata*	He						20	1	0.0001	Y											
24	*Spigelia anthelmia*	He						10	5	0.0005	Y	Y										
25	*Sporobolus jacquemontii*	He											80	15	0.0015	Y						
26	*Tabebuia heterophylla*	T						20	14	0.0014												
27	*Tragia volubilis*	L		2+																		
28	*Vernonia cinerea*	He						30	30	0.0030	Y	Y										

Legend. **S:** Survey/**Ph:** Physiognomic type in maximum morphogenetic development (**T**: Tree; **Sh**: Shrub; **He**: herbaceous; **L**: liana)/**H:** Height in cm/**A:** Abundance/**D:** Density (cm^2)/**Fl**: Flowers (Y: yes)/**F**: Fruits (Y: yes).

3.1.2. Forest Edges of Xerophilous Forests: Morne Aca

The surveys of Morne Aca, also in a xerophilous zone, also present a diversity of physiognomic types (Table 3).

Table 3. Contents of the sample squares made at Morne Aca in Marin.

			Square 1 (S5)					Square 2 (S6)					Square 3 (S7)					Square 4 (S8)				
	Simpson index		0.20199446					0.11005917					0.12755102					0.09157025				
No.	Species	Ph	H	A	D	Fl	F	H	A	D	Fl	F	H	A	D	Fl	F	H	A	D	Fl	F
1	*Bidens sp*	He											15	2	0.0002							
2	*Bursera simaruba*	T																10	1	0.0001		
3	*Cenchrus echinatus*	He						20	1	0.0001	Y		10	1	0.0001							
4	*Centrosema virginianum*	L												3+								
5	*Chamaecrista glandulosa var schwarzii*	B	80	16	0.0016	Y																
6	*Chamaecrista nictitans*	B						30	9	0.0009	Y		30	3	0.0003	Y		20	20	0.0020	Y	
7	*Chamaecrista obcordata*	B						30	8	0.0008			30	3	0.0003	Y		20	1	0.0001	Y	
8	*Chamaesyce hirta*	He						20	1	0.0001	Y	Y										
9	*Desmodium heterocarpum*	He	20	18	0.0018		Y						10	8	0.0008							
10	*Desmodium incanum*	He	30	5	0.0005	Y		30	1	0.0001	Y		30	8	0.0008	Y		20	1	0.0001	Y	
11	*Eriochloa polystachya*	He						15	8	0.0008												
12	*Leucaena leucocephala*	T	110	30	0.0030																	
13	*Lonchocarpus punctatus*	T																10	1	0.0001		
14	*Ocimum gratissimum*	He						10	5	0.0005	Y											

Continued

15	*Oxalis barrelieri*	He						20	6	0.0006	Y		10	2	0.0002	Y		15	2	0.0002	Y	
16	*Paspalum conjugatum*	He											50	3	0.0003	Y						
17	*Sida acuta*	He	30	14	0.0014	Y	Y	10	10	0.0010		Y	50	7	0.0007		Y	20	10	0.0010	Y	Y
18	*Spermacoce verticillata*	He	40	1	0.0001	Y		20	1	0.0001	Y		20	1	0.0001	Y		10	1	0.0001	Y	
19	*Spigelia anthelmia*	He						10	1	0.0001	Y											
20	*Sporobolus jacquemontii*	He						70	5	0.0005	Y											
21	*Stachytarpheta jamaicensis*	He	40	11	0.0011	Y		20	8	0.0008	Y							20	12	0.0012	Y	
22	*Stachytarpheta sp*	He											20	4	0.0004							
23	*Synedrella nodiflora*	He						15	1	0.0001								20	5	0.0005		
24	*Urena lobata*	B																20	1	0.0001		
25	*Urvillea ulmacea*	L																	1+			

Legend. **S:** Survey/**Ph:** Physiognomic type in maximum morphogenetic development (**T**: Tree; **B**: Bush; **He**: herbaceous; **L**: liana)/**H:** Height in cm/**A:** Abundance/**D:** Density (cm^2)/**Fl**: Flowers (Y: yes)/**F**: Fruits (Y: yes).

The abundance of flowering plants indicates an environment favorable to ecological interactions, such as pollination, despite the water stress conditions. The abundance of these species is low but the low values of the Simpson index confirm the presence of a diversity of species in the sample squares.

None of them dominate numerically and the densities are therefore very low, which also characterizes these environments as relatively stable for ruderal plants. We also note the presence of a single Rubiaceae, *Spermacoce verticillata*, with a single individual and therefore a low density in all the sample squares.

3.1.3. Xero-Mesophilic Forest Edges (Ecotone): Pointe Rouge to Pointe À Bibi Hiking Trail

In these surveys of xero-mesophilic edges, we observe a transition towards a slightly more humid environment, with a very marked presence of trees such as *Cassipourea guianensis*, *Garcinia humilis* and *Pisonia fragans* (Table 4 and Table 5).

Table 4. Contents of the first three sample squares made on the trail from Pointe Rouge to Pointe à Bibi, in Trinité.

			Square 1 (S9)					Square 2 (S10)					Square 3 (S11)				
	Simpson index		0.727810651					0.401920439					0.533163265				
No.	**Species**	**Ph**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**
1	*Cassipourea guianensis*	T											10	1	0.0001		
2	*Cordia collococca*	T						40	1	0.0001							
3	*Erythroxylum havanense*	Sh	20	1	0.0001			15	1	0.0001			20	2	0.0002		
4	*Eugenia monticola*	B						10	1	0.0001							
5	*Garcinia humilis*	T	20	11	0.0011			50	8	0.0008			20	3	0.0003		
6	*Geophila repens*	He		3+		Y	Y		3+			Y		3+			

Continued

7	*Macfadyena unguis-cati*	L		1+													
8	*Paullinia cururu*	L							1+					3+			
9	*Pisonia fragans*	T	15	1	0.0001			30	15	0.0015			20	20	0.0020		
10	*Securidaca diversifolia*	L							1+								
11	*Spondias mombin*	T						10	1	0.0001			10	2	0.0002		

Legend. **S:** Survey/**Ph:** Physiognomic type in maximum morphogenetic development (**T**: Tree; **Sh**: Shrub; **B**: Bush; **He**: herbaceous; **L**: liana)/**H:** Height in cm/**A:** Abundance/**D:** Density (cm^2)/**Fl:** Flowers (Y: yes)/**F:** Fruits (Y: yes).

We note the presence of numerous lianas, shrubs and small trees. The few herbaceous plants present are mainly Rubiaceae, often in flower, indicating a good adaptation to the conditions of the ecotone. The diversity of physiognomic types shows an ecological complexity favorable to pollination and seed dispersal. These plant compositions are however characterized by a low diversity of species as shown by the high values of the Simpson index in the majority of sample squares. Floristic diversity is often low and species also have low abundances and densities, probably linked to a response to the very moderate humidity and light conditions of these sites.

Table 5. Contents of the last three sample squares made on the trail from Pointe Rouge to Pointe à Bibi, in Trinité.

			Square 4 (S12)					**Square 5 (S13)**					**Square 6 (S14)**				
	Simpson index		0.50059453					0.26					0.223761157				
No.	**Species**	**Ph**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**
1	*Cassipourea guianensis*	T	10	20	0.0020								10	10	0.0010		
2	*Erythroxylum havanense*	Sh											20	1	0.0001		
3	*Eugenia ligustrina*	Sh						10	2	0.0002			20	20	0.0020		
4	*Garcinia humilis*	T	10	2	0.0002												
5	*Geophila repens*	He		4+					3+								
6	*Guettarda odorata*	Sh											10	10	0.0010		
7	*Inga laurina*	T	10	2	0.0002												
8	*Myrcia citrifolia*	Sh						50	3	0.0003			10	5	0.0005		
9	*Ocotea coriacea*	T											20	1	0.0001		
10	*Oxalis frutescens*	He						20	3	0.0003	Y						
11	*Pisonia fragans*	T	15	3	0.0003			10	2	0.0002							
12	*Spermacoce assurgens*	He											30	10	0.0010	Y	
13	*Tabebuia heterophylla*	T	5	2	0.0002												
14	*Cassipourea guianensis*	T	10	20	0.0020								10	10	0.0010		
15	*Erythroxylum havanense*	Sh											20	1	0.0001		
16	*Eugenia ligustrina*	Sh						10	2	0.0002			20	20	0.0020		

Continued

17	*Garcinia humilis*	T	10	2	0.0002												
18	*Geophila repens*	He		4+					3+								
19	*Guettarda odorata*	Sh											10	10	0.0010		

Legend. **S:** Survey/**Ph:** Physiognomic type in maximum morphogenetic development (**T**: Tree; **Sh**: Shrub; **He**: herbaceous)/**H:** Height in cm/**A:** Abundance/**D:** Density (cm²)/**Fl**: Flowers (Y: yes)/**F**: Fruits (Y: yes).

Furthermore, we note the presence of three Rubiaceae including *Geophila repens,* an herbaceous plant very widespread in the sample squares, forming fairly dense carpets whose individuals were difficult to differentiate and count. The species nevertheless seems very adapted to this ecotone, with an average to high abundance of individuals depending on the squares. *Spermacoce assurgens* is another herbaceous Rubiaceae present in a single square but with a relatively notable abundance and density. Its individuals were in flower when we visited. Finally, the shrub *Guettarda odorata* is also present in a single square with a relatively notable abundance and density.

3.1.4. Meso-Hygrophilous Forest Edges (Ecotone): Fond Baron

In the first surveys of this meso-hygrophilous ecotone, herbaceous plants predominate, with species such as *Diodia ocymifolia* and *Hyptis atrorubens*, often in flower. Plant diversity, both in terms of species and heights, is notable, even if the Simpson index values reveal high population abundances of the species *Hyptis atrorubens* or *Wedelia trilobata*. Many species were in flower during our visit, ensuring a strong attraction for pollinators and good seed dispersal. These transition zones with a moderate water supply allow species to adapt to humidity variations. The low density of plants seems to promote a balance between competition and survival in this partially shaded habitat (**Table 6**).

Table 6. Contents of the first three sample squares made at Fond Baron, in Fort-de-France.

			Square 1 (S15)					Square 2 (S16)					Square 3 (S17)				
	Simpson index		0.58490566					0.514609765					0.516711111				
No.	**Species**	**Ph**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**
1	*Centella asiatica*	He							2+								
2	*Commelina diffusa*	He											30	40	0.0040		
3	*Desmodium incanum*	He		3+										2+		Y	
4	*Diodia ocymifolia*	He	70	1	0.0001	Y		70	6	0.0006	Y		30	2	0.0002	Y	
5	*Hyptis atrorubens*	He	40	2	0.0002	Y		30	70	0.0070	Y		70	100	0.0100	Y	
6	*Leptochloa filiformis*	He						20	1	0.0001	Y		20	3	0.0003	Y	
7	*Nautilocalyx melittifolius*	He	30	3	0.0003												
8	*Nephrolepis multiflora*	F							4+								
9	*Piper dilatatum*	Sh	60	2	0.0002								15	3	0.0003		

Continued

10	*Pseudelephantopus spicatus*	He						80	1	0.0001							
11	*Scleria pterota*	He	70	5	0.0005	Y		50	4	0.0004							
12	*Vigna luteola*	He							2+								
13	*Wedelia trilobata*	He	50	40	0.0040	Y		30	20	0.0020	Y		80	2	0.0002	Y	

Legend. **S:** Survey/**Ph:** Physiognomic type in maximum morphogenetic development (**Sh**: Shrub; **He**: herbaceous; **F**: Fern)/**H:** Height in cm/**A:** Abundance/**D:** Density (cm^2)/**Fl**: Flowers (Y: yes)/**F**: Fruits (Y: yes).

The last sample squares at Fond Baron also show a diversified vegetation of mainly herbaceous species and mostly in flower (Table 7). The low values of the Simpson index confirm this floristic diversity and that no species dominates numerically with the exception of the high population abundance of *Desmodium incanum* in square 6 (Survey 20). The density of species is low, but the majority of these plants thrive in this humid environment, with a high production of flowers and fruits favoring reproduction. We note the presence of two Rubiaceae: *Diodia ocymifolia* (herbaceous) and *Gonzalagunia hirsuta* (shrub) whose abundances and densities are low. *Diodia ocymifolia* is nevertheless better distributed in the squares than *Gonzalagunia hirsuta.*

Table 7. Contents of the last three sample squares made at Fond Baron, in Fort-de-France.

			Square 4 (S18)					**Square 5 (S19)**					**Square 6 (S20)**				
	Simpson index		0.2288					0.120661157					0.389010847				
No.	**Species**	**Ph**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**
1	*Boehmeria nivea*	He	50	7	0.0007	Y											
2	*Centella asiatica*	He		1+													
3	*Clerodendron paniculatum*	He											40	2	0.0002		
4	*Commelina diffusa*	He	20	2	0.0002	Y		20	5	0.0005			10	20	0.0020		
5	*Cyperus luzulae*	He											50	3	0.0003	Y	
6	*Desmodium incanum*	He						30	10	0.0010	Y		50	100	0.0100	Y	
7	*Diodia ocymifolia*	He	50	7	0.0007	Y		40	3	0.0003	Y		50	2	0.0002	Y	
8	*Gonzalagunia hirsuta*	Sh						50	4	0.0004							
9	*Hyptis atrorubens*	He						30	10	0.0010	Y						
10	*Impatiens hawkeri*	He											50	2	0.0002	Y	
11	*Leptochloa filiformis*	He						30	5	0.0005			30	2	0.0002	Y	
12	*Nautilocalyx melittifolius*	He	50	6	0.0006	Y		10	2	0.0002							
13	*Ocotea coriacea*	T	20	1	0.0001												
14	*Piper dilatatum*	Sh											30	5	0.0005		
15	*Scleria pterota*	He						30	6	0.0006	Y						
16	*Sida rhombifolia*	He						50	5	0.0005	Y						

Continued

17	*Vigna luteola*	He										2+		
18	*Wedelia trilobata*	He	30	2	0.0002	Y	30	5	0.0005	Y	40	40	0.0040	Y
19	*Boehmeria nivea*	He	50	7	0.0007	Y								
20	*Centella asiatica*	He		1+										

Legend. **S:** Survey/**Ph:** Physiognomic type in maximum morphogenetic development (**T**: Tree; **Sh**: Shrub; **He**: herbaceous)/**H:** Height in cm/**A:** Abundance/**D:** Density (cm^2)/**Fl**: Flowers (Y: yes)/**F**: Fruits (Y: yes).

3.1.5. Hygrophilous Forest Edges: Boucher Plateau

Surveys conducted on the Plateau Boucher, in a hyper-humid bioclimate, reveal a hygrophilous environment that is particularly favorable to the development of herbaceous plants, characterized by abundant flowering (Table 8). Some species sometimes display high population density and abundance, while overall floristic diversity remains significant, as shown by the Simpson index. This illustrates the strong resilience and adaptability of species to wetlands. The production of flowers and fruits observed in many plants highlights the essential role of these edges as reproduction and dispersal habitats. In addition, the presence of two herbaceous Rubiaceae is noted. The first, *Diodia ocymifolia* is well distributed in all the squares but its abundances and densities are low. The second, *Spermacoce sp.* was difficult to determine and only has one individual, present in a single square.

Table 8. Contents of the sample squares made at Plateau Boucher, in Fonds-Saint-Denis.

			Square 1 (S21)				Square 2 (S22)				Square 3 (S23)				Square 4 (S24)				Square 5 (S25)				
	Simpson index		0.374818338				0.444079474				0.289550781				0.235				0.273483948				
No.	Species	Ph	H	A	D	Fl	H	A	D	Fl	H	A	D	Fl	H	A	D	Fl	H	A	D	Fl	F
1	*Ageratum houstonianum*	He					80	7	0.0007	Y													
2	*Boehmeria nivea*	He																	70	1	0.0001	Y	
3	*Chloris inflata*	He	90	50	0.0050	Y																	
4	*Commelina diffusa*	He													60	15	0.0015	Y					
5	*Cyperus surinamensis*	He													30	2	0.0002	Y	60	1	0.0001	Y	
6	*Diodia ocymifolia*	He	70	2	0.0002	Y	80	4	0.0004	Y	60	10	0.0010	Y	100	9	0.0009	Y	60	10	0.0010	Y	
7	*Hyptis atrorubens*	He	50	5	0.0005		60	100	0.0100	Y					60	50	0.0050		60	20	0.0020		
8	*Kyllinga erecta var polyphylla*	He													50	20	0.0020	Y	60	1	0.0001	Y	
9	*Leptochloa filiformis*	He	50	3	0.0003	Y	60	4	0.0004	Y					20	6	0.0006	Y					
10	*Ludwigia octovalvis*	He					80	1	0.0001						30	1	0.0001		100	1	0.0001	Y	Y
11	*Nephrolepis multiflora*	F		3+								3+				2+				3+			
12	*Oxalis barrelieri*	He	70	8	0.0008	Y					30	7	0.0007	Y	40	1	0.0001						
13	*Phyllanthus urinaria*	He																	60	4	0.0004		Y
14	*Pseudelephantopus spicatus*	He													40	6	0.0006						
15	*Rhynchospora polyphylla*	He					60	10	0.0010														

Continued

16	*Rubus rosifolius*	B											20	1	0.0001												
17	*Scleria pterota*	He						90	2	0.0002			60	10	0.0010	Y											
18	*Sida rhombifolia*	He											70	6	0.0006	Y											
19	*Spermacoce sp*	He	40	1	0.0001																						
20	*Vigna luteola*	He	70	3	0.0003	Y			3+					2+					2+								
21	*Wedelia trilobata*	He	60	15	0.0015			50	30	0.0030	Y		30	30	0.0030	Y		60	10	0.0010	Y		60	20	0.0020	Y	

Legend. **S:** Survey/**Ph:** Physiognomic type in maximum morphogenetic development (**B**: Bush; **He**: herbaceous; **F**: Fern)/**H:** Height in cm/**A:** Abundance/**D:** Density (cm^2)/**Fl**: Flowers (Y: yes)/**F**: Fruits (Y: yes).

3.1.6. Hygrophilous Forest Edges: Trace Des Jésuites

In the hygrophilous edges of the Trace des Jésuites, herbaceous species, particularly *Hyptis atrorubens*, largely dominate (Table 9). The Simpson index highlights a numerical dominance of certain species, moderately reducing floristic diversity. Despite an overall low density, the abundant flowering promotes the attraction of pollinators and the dispersal of seeds, demonstrating a balance between competition and survival in this shaded and very humid habitat. This plant diversity contributes to the ecological richness of these edges, which play a key role in maintaining biodiversity in a humid tropical environment. Among the species present, we regularly note *Diodia ocymifolia* and *Spermacoce assurgens*, whose densities and abundances generally remain low, although they can be locally high.

Table 9. Contents of the sample squares made at the Trace des Jésuites, in Morne Rouge.

			Square 1 (S26)					Square 2 (S27)					Square 3 (S28)					Square 4 (S29)				
	Simpson index		0.43174876					0.91342448					0.414141414					0.50786808				
No.	**Species**	**Ph**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**	**H**	**A**	**D**	**Fl**	**F**
1	*Ageratum conyzoides*	He	30	1	0.0001	Y												30	1	0.0001		
2	*Bidens pilosa*	He	30	1	0.0001	Y																
3	*Cuphea carthagenensis*	He	30	1	0.0001	Y												50	20	0.0020		
4	*Desmodium incanum*	He	30	100	0.0100	Y		30	1	0.0001	Y		40	20	0.0020	Y						
5	*Diodia ocymifolia*	He	30	10	0.0010	Y												50	30	0.0030	Y	
6	*Hyptis atrorubens*	He	50	150	0.0150	Y		60	150	0.0150	Y							70	150	0.0150	Y	
7	*Kyllinga sp*	He											30	2	0.0002							
8	*Oxalis barrelieri*	He											30	3	0.0003	Y		30	3	0.0003	Y	
9	*Polygala paniculata*	He											30	1	0.0001	Y						
10	*Pseudelephantopus spicatus*	He	50	1	0.0001			25	3	0.0003												
11	*Pterolepis glomerata*	He	15	1	0.0001													40	1	0.0001		
12	*Rhynchospora nervosa*	He	30	6	0.0006																	
13	*Sauvagesia erecta*	He						30	1	0.0001	Y		30	1	0.0001	Y						
14	*Scleria pterota*	He	50	3	0.0003													50	10	0.0010		
15	*Spermacoce assurgens*	He	30	1	0.0001	Y		30	2	0.0002	Y		40	6	0.0006	Y		30	2	0.0002	Y	

Legend. **S:** Survey/**Ph:** Physiognomic type in maximum morphogenetic development (**He**: herbaceous)/**H:** Height in cm/**A:** Abundance/**D:** Density (cm^2)/**Fl**: Flowers (Y: yes)/**F**: Fruits (Y: yes).

3.2. Global Data Analysis Using CAH, AFC and ACP

3.2.1. Ascending Hierarchical Classification (HAC)

A hierarchical ascending classification (HAC) was carried out using a presence/absence table of all species. It is composed of 96 columns (species of all families, all physiognomic types included) and 29 rows (surveys or sample squares), (**Appendix 3**). The general dissimilarity and the "complete link" aggregation method offered the possibility of showing the differences in floristic compositions between our surveys, in the form of distinct groups or classes. The dendrograms obtained thus show five main groups or classes (**Figure 6** and **Table 10**). These groups demonstrate a great heterogeneity of floristic compositions. While the majority of our edge surveys reflect the typical vegetation of adjacent forests, some have particularities that distinguish them from this general model (**Table 10**). The surveys of groups or classes 3 and 5, initially different in their location, nevertheless show a convergence of their floristic composition. Among the species that compose them, a significant number could be described as "erratic", reflecting an ecological flexibility that could be linked to the dynamic conditions of these edges.

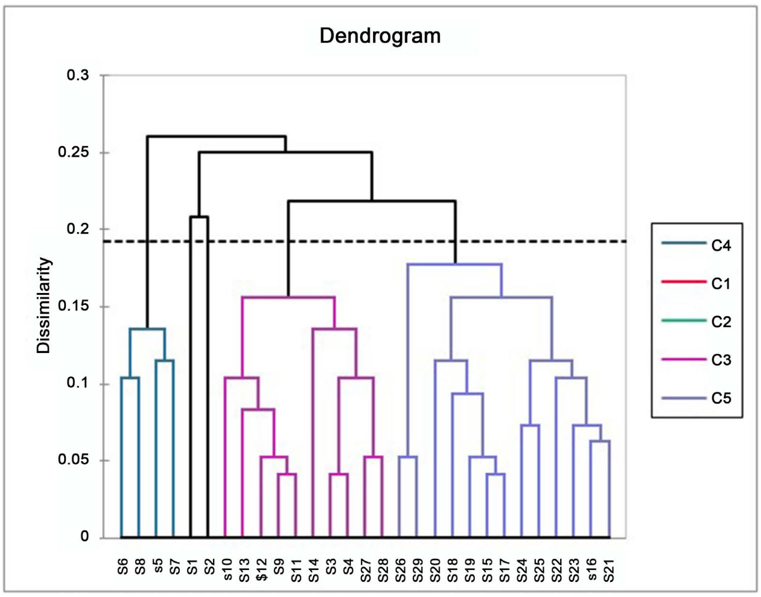

Figure 6. Dendrogram of dissimilarity of the 29 surveys according to their floristic composition.

Table 10. Typology of stations according to their floristic compositions.

No.	Intra-class variance	Surveys	Corresponding bioclimate type	Corresponding forest type	Floristic composition
CLASS 1	0000	S1	Dry Subhumid	Xerophilous	Diversity of physiognomic types of species (tree, shrub, herbaceous, liana). Relatively low floristic diversity. Presence of two Rubiaceae *Diodia ocymifolia* and *Spermacoce verticillata*.

Continued

CLASS 2	0000	S2	Dry Subhumid	Xerophilous	Diversity of physiognomic types of species (tree, shrub, herbaceous, liana). Relatively high floristic diversity. Presence of only one Rubiaceae: *Spermacoce verticillata*.
CLASS 3	4911	S3; S4; S9; S10; S11; S12; S13; S14; S27; S28.	Dry Subhumid/ Ecotone (dry subhumid to humid subhumid)/ Hyper humid	Xerophilous/ Xero-mesophilous/ Hygrophilous	Mixed composition of several types of edges. Diversity of physiognomic types of species (tree, shrub, herbaceous, liana). Low to high floristic diversity. Regular presence of several Rubiaceae: *Diodia ocymifolia*, *Geophila repens*, *Guettarda odorata*, *Spermacoce assurgens*.
CLASS 4	5750	S5; S6; S7; S8.	Dry Subhumid	Xerophilous	Diversity of physiognomic types of species (tree, shrub, bush, herbaceous, liana). Relatively high floristic diversity. Presence of only one Rubiaceae: *Spermacoce verticillata*.
CLASS 5	5308	S15; S16; S17; S18; S19; S20; S21; S22; S23; S24; S25; S26; S29.	Ecotone (humid to humid subhumid)/Hyper humid	Meso-hygrophilous/Hygrophilous	Mixed composition of several types of edges exclusively from humid bioclimates. Diversity of physiognomic types of species (tree, shrub, herbaceous, ferns). Moderate to high floristic diversity. Regular presence of several Rubiaceae: *Diodia ocymifolia*, *Gonzalagunia hirsuta*, *Spermacoce assurgens*. *Spermacoce sp*.

This analysis suggests that forest edges play a role as transitional habitats, serving as intermediate zones between forest ecosystems and other types of environments. They thus shelter a diverse set of species with varied ecological profiles. These areas could therefore contribute to regional diversity by supporting populations of species with varied ecological needs, some of which do not find favorable conditions in dense forests or adjacent open spaces.

3.2.2. Factorial Correspondence Analysis (FCA)

A factorial correspondence analysis (FCA) was performed using the same species presence/absence table, composed of 96 columns (species from all families, all physiognomic types included) and 29 rows (surveys or sample squares). Only the Hellinger distance allows to obtain a link between rows and columns, with the p-value (1.000) almost similar to the alpha significance level (0.9999), but the F1 and F2 axes support more than 30% of the information and give the best possible quality of data representation (**Figure 7**).

These axes demonstrate that the floristic compositions of our surveys are very heterogeneous (**Figure 7**, **Table 10**). While the floristic composition of the majority of our surveys reflects the adjacent forest type, some surveys are exceptions.

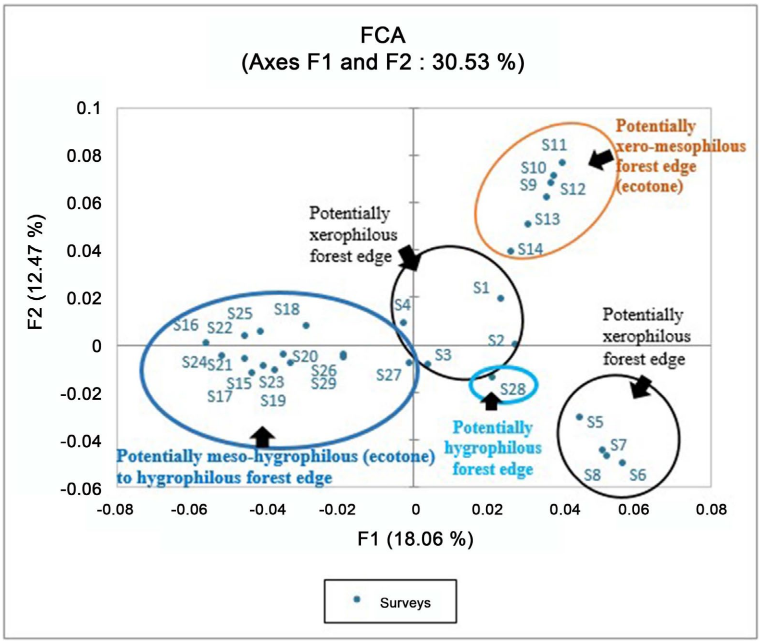

Figure 7. Factorial correspondence analysis (**Appendix 2** and **Appendix 3**).

Survey 28 carried out in a hyper-humid bioclimate at the Trace des Jésuites, for example, stands out from other surveys of the same bioclimate, and the surveys of the dry subhumid bioclimate, xerophilous forests, are split into two distinct groups (Figure 7). Forest edges therefore appear to constitute transitional habitats, sheltering large pools of species with different ecological profiles, including a significant number of so-called "erratic" species.

3.2.3. Principal Component Analysis (PCA)

A principal component analysis (PCA) was also carried out, this time using a cross-tabulation of data, composed of 29 rows (surveys or sample squares) and 7 columns (eco-climatic factors), (**Appendix 2**).

The eco-climatic factors that we took into account were as follows: altitude (meter), slope (%), annual rainfall (mm), average minimum annual temperature (˚C), average maximum annual temperature (˚C), soil type and level of sunshine. For these last two parameters, we had to assign numerical values to each variable in order to be able to take them into account. Thus, the numerical variables are as follows for the types of soils: Marine alluvium (1), Vertisols (2), Fersiallitic soils (3), Red or brown montmorillonitic soils (4). The numerical variables are as follows for the level of sunshine: medium (1), high (2). The links between the variables are very well taken into account, because the F1 and F2 axes of the PCA obtained using the Person Coefficient, support more than 90% of the information and give an excellent quality of their representation (Figure 8).

Figure 8 shows four groups of coherent surveys according to the ecological differences between the areas studied. Axis F1 organizes the surveys mainly according to humidity, altitude and shade gradients. It contrasts areas adapted to dry and open environments (edges of xerophilous and xero-mesophilous forests)

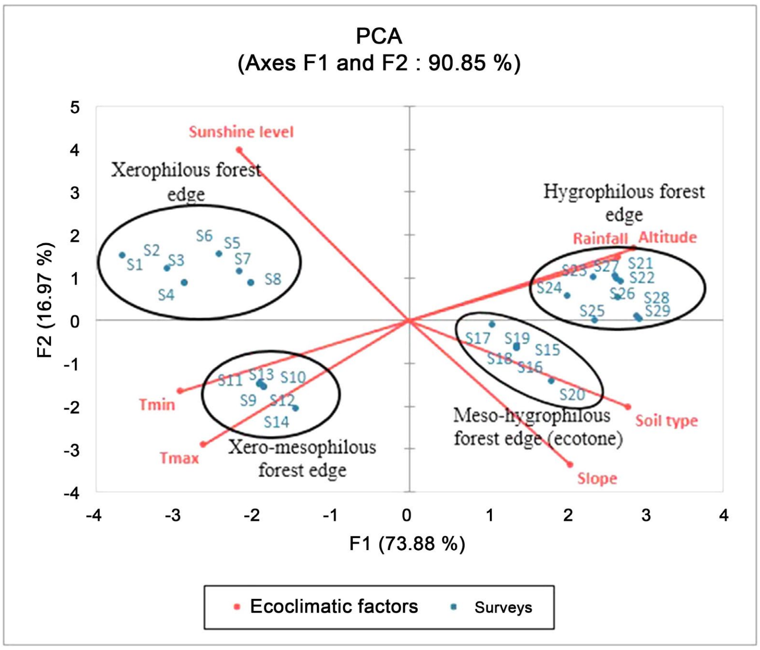

Figure 8. Principal component analysis of the eco-climatic factor matrix (**Appendix 2**). Legend. T_{min} = Average annual minimum temperatures, T_{max} = Average annual maximum temperatures.

with areas adapted to humid and shaded environments (edges of meso-hygrophilous and hygrophilous forests). Axis F2, on the other hand, allows us to single out the surveys of ecotones (transition zones). This PCA attests to the plurality of forest edges inventoried in various bioclimates.

4. Discussion

Finally, five species of herbaceous Rubiaceae divided into three genera were recorded at forest edges: *Diodia ocymifolia, Geophila repens, Spermacoce assurgens, Spermacoce verticillata* and an undetermined species, *Spermacoce sp.* Two shrubby Rubiaceae, *Gonzalagunia hirsuta* and *Guettarda odorata,* were also observed. This low number of species confirms the rarity of herbaceous Rubiaceae, although additional inventories are necessary (**Table 11**) [2] [3] [8].

Table 11. Contents of the sample squares made at Plateau Boucher, in Fonds-Saint-Denis.

	Bioclimate		Dry subhumid				Ecotone (transition between dry subhumid and humid subhumid)				Ecotone (subhumid humid to ***hyperhumid***)				***Hyper humid***			
	Forest edge		Xerophilous				Xero-mesophilous				Meso-hygrophilous				Hygrophilous			
No.	**Species**	**Ph**	**A**	**D**	**F**	**Id**	**A**	**D**	**F**	**Id**	**A**	**D**	**F**	**Id**	**A**	**D**	**F**	**Id**
1	*Diodia ocymifolia*	**He**	**90**	**11.25**	**2**	**2.81**					**21**	**4**	**6**	**3.5**	**75**	**8**	**7**	**6.48**
2	*Geophila repens*	**He**					**3+**		**5**									
3	*Gonzalagunia hirsuta*	**Sh**									**4**	**1**	**1**	**0.11**				

Continued

4	*Guettarda odorata*	**Sh**	**1**	**0.125**	**1**	**0.01**	**10**	**2**	**1**	**0.27**				
5	*Spermacoce assurgens*	**He**									**11**	**1**	**4**	**0.54**
6	*Spermacoce sp*	**He**									**1**	**0**	**1**	**0.01**
7	*Spermacoce verticillata*	**He**	**5**	**0.625**	**5**	**0.39**	**10**	**2**	**1**	**0.27**				

Legend. **Ph:** Physiognomic type in maximum morphogenetic development (**Sh**: Shrub; **He**: herbaceous)/**A:** Abundance/**D:** Density (cm^2)/**F**: Frequency/**Id**: Distribution index.

Among these species, *Diodia ocymifolia* stands out for its high frequency, high density and wide distribution in various types of edges, demonstrating tolerance to humidity variations and notable competitiveness. *Geophila repens* forms dense mats in xero-mesophilic ecotones, while *Spermacoce assurgens* prefers wetter edges, where its distribution is notable but its abundance low. *Spermacoce verticillata,* on the other hand, is confined to xerophilous and xero-mesophilous edges, with a more marked presence in dry environments, while *Spermacoce sp.* is limited to a single individual recorded. The observed herbaceous Rubiaceae, except *Diodia ocymifolia*, show specific ecological preferences, limiting their distribution. These observations highlight the importance of forest edges as intermediate habitats hosting a variety of species, ranging from plants tolerant to fluctuating conditions to specialized species [23]-[25]. Some edges, particularly in humid bioclimates, display relatively high diversity, while those dominated by pioneer species such as *Diodia ocymifolia* display more restricted diversity. These variations reflect the influence of environmental conditions on the structure of plant communities [15]-[20]. These observations made on the island of Martinique find parallels in other tropical regions where certain species of Rubiaceae show great tolerance to environmental variations.

Studies conducted in Forest Guinea reveal, for example, that Rubiaceae are among the most represented families, illustrating their adaptation to varied ecological conditions [37]. Forest edges, located at the interface between open environments and forests, undoubtedly play a key role in the conservation of regional biodiversity in Martinique, by providing refuges and ecological corridors between different habitats [23]-[25].

5. Conclusion

At the end of a campaign of 29 floristic surveys carried out in the forest edges of the island of Martinique, our results confirm the influence of ecological variations, particularly in terms of light availability and humidity, on the distribution and floristic composition of herbaceous Rubiaceae. Although they represent a small proportion of the Rubiaceae present on the island, these plants show a great capacity to adapt to environmental gradients, allowing certain species, such as *Diodia ocymifolia*, to occupy both xerophilous and humid areas. Other species have a more restricted distribution, suggesting specific ecological preferences. These observations highlight the importance of forest edges as dynamic ecological corridors, offering a diversity of niches conducive to the cohabitation of species with varied ecological needs. By promoting pollination and seed dispersal, these transitional habitats play a crucial role in the resilience of plant communities. This study therefore highlights the need to preserve these areas in order to maintain the floristic and functional biodiversity of the island forest ecosystems of Martinique.

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Data Availability

There is no data available, made available to readers. On the other hand, data for woody Rubiaceae are available from the thesis conducted on Rubiaceae in Martinique, accessible online (https://theses.fr/2020ANTI0548).

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix 1. List of Herbaceous Rubiaceae in the Lesser Antilles [2] [3] [10]

No.	Scientific name	Synonymy	Presence in Martinique	Flowering period	Estimation of abundance	Endemism	Threat status in Martinique (INPN)
1	*Diodia ocymifolia*	*Spermacoce ocymifolia*	Yes	Almost all year round.	Common		Not rated
2	*Diodia rigida*	*Hexasepalum apiculatum*	Yes		Rare		
3	*Géophila repens*		Yes		Quite rare		Not rated
4	*Hedyotis callitrichoides*	*Oldenlandiopsis callitrichoides*		During the rainy season.	Rare		
5	*Hedyotis corymbosa*	*Oldenlandia corymbosa*	Yes	Almost all year round.	Quite rare		Not rated
6	*Hedyotis lancifolia*	*Oldenlandia lancifolia*	Yes		Quite rare		Not rated
7	*Hoffmannia pedunculata*				Very rare	Possibly endemic to Jamaica.	
8	*Mitracarpus hirtus*		Yes	Almost all year round, intermittently.	Quite common		Not rated
9	*Mitracarpus polycladus*						
10	*Pentodon pentandrus*			All year round, except for exceptional drought.	Quite rare		
11	*Psychotria discolor*	*Notopleura discolor*	Yes	All year round.	Quite rare		Not rated
12	*Psychotria gardenioides*		Yes		Very rare		
13	*Serissa foetida*				Very rare		
14	*Sipanea pratensis*				Very rare		
15	*Spermacoce assurgens*	*Spermacoce remota*	Yes	All year round.	Very common		Not rated
16	*Spermacoce berteroana*				Rare	Lesser Antilles	
17	*Spermacoce confusa*		Yes	Almost all year round.	Quite rare		Not rated
18	*Spermacoce densiflora*		Yes		Rare		Not rated
19	*Spermacoce dussii*			Almost all year round, except during long droughts.	Quite rare	Guadeloupe	
20	*Spermacoce eryngioides*		Yes	Almost all year round.	Common		Not rated
21	*Spermacoce ernstii*						
22	*Spermacoce latifolia*			All year round.	Quite common		
23	*Spermacoce prostrata*		Yes	Almost all year round.	Common		Not rated
24	*Spermacoce riparia*	*Spermacoce laevis*			Quite common		
25	*Spermacoce tetraquetra*						
26	*Spermacoce verticillata*		Yes		Quite rare		Not rated

Appendix 2. List of the 29 Floristic Surveys

No.	Location	Latitude	Longitude	T_{min}	T_{max}	Annual Rainfall	Level of sunshine	Altitude	Slope	Soil
S1	*Cap Macré*	1601537.462	735661.077	23.6	29	1641	high	1	0%	Marine alluvium
S2	*Cap Macré*	1601600.46	734691.971	23.4	28.8	1685	high	3	1%	Vertisols
S3	*Cap Macré*	1601524.257	734636.176	23.4	28.8	1685	high	5	8.9%	Vertisols
S4	*Cap Macré*	1601518.844	734630.42	23.4	28.8	1685	high	5	8.9%	Vertisols
S5	Morne Aca	1599875.254	726377.855	22.6	28.4	1697	high	224	12%	Vertisols
S6	Morne Aca	1599786.339	726327.511	22.6	28.4	1697	high	214	3%	Vertisols
S7	Morne Aca	1599757.151	726323.398	22.6	28.4	1697	high	213	17.7	Vertisols
S8	Morne Aca	1599751.683	726320.491	22.6	28.4	1697	high	213	17.7%	Vertisols
S9	Pointe Rouge to Pointe à Bibi	1632851.888	723003.514	23.8	30.6	1945	medium	18	18%	Fersiallitic soils
S10	Pointe Rouge to Pointe à Bibi	1632881.348	723004.832	23.8	30.6	1945	medium	13	16.7%	Fersiallitic soils
S11	Pointe Rouge to Pointe à Bibi	1632882.75	723002.278	23.8	30.6	1945	medium	13	16.7%	Fersiallitic soils
S12	Pointe Rouge to Pointe à Bibi	1632860.584	722994.881	23.8	30.6	1994	medium	18	18%	Fersiallitic soils
S13	Pointe Rouge to Pointe à Bibi	1632866.9	722995.6	23.8	30.6	1994	medium	13	16.7%	Fersiallitic soils
S14	Pointe Rouge to Pointe à Bibi	1632889.671	722745.591	23.8	30.6	1994	medium	58	30.5%	Fersiallitic soils
S15	Fond Baron	1623498.353	705354.726	20.2	26.8	2613	medium	433	31%	Red or brown montmorillonitic soils
S16	Fond Baron	1623495.12	705339.001	20.2	26.8	2613	medium	433	31%	Red or brown montmo-rillonitic soils
S17	Fond Baron	1623560.645	705379.985	20.2	26.8	2613	medium	427	19.8%	Red or brown montmo-rillonitic soils
S18	Fond Baron	1623545.479	705429.188	20.2	26.8	2613	medium	420	31.7%	Red or brown montmo-rillonitic soils
S19	Fond Baron	1623539.652	705417.459	20.2	26.8	2613	medium	420	31.7%	Red or brown montmo-rillonitic soils

Continued

S20	Fond Baron	1623568.246	705489.718	20.2	26.8	2613	medium	407	49%	Red or brown montmo-rillonitic soils
S21	Plateau Boucher	1628052.279	704912.979	18.6	25.6	5088	medium	635	20.5%	Red or brown montmo-rillonitic soils
S22	Plateau Boucher	1628047.851	704955.099	18.6	25.6	5088	medium	635	18.8%	Red or brown montmo-rillonitic soils
S23	Plateau Boucher	1628046.581	704977.844	18.6	25.6	5088	medium	635	17.6%	Red or brown montmo-rillonitic soils
S24	Plateau Boucher	1627971.113	705070.648	19.6	26.6	4532	medium	615	17.5%	Red or brown montmo-rillonitic soils
S25	Plateau Boucher	1627899.66	705114.617	19.6	26.6	4532	medium	619	30.4%	Red or brown montmo-rillonitic soils
S26	Trace des Jésuites	1630489.461	704634.000	18.9	25.8	5343	medium	550	25.7%	Red or brown montmo-rillonitic soils
S27	Trace des Jésuites	1630538.9	704623.0	18.9	25.8	5343	medium	546	14.9%	Red or brown montmo-rillonitic soils
S28	Trace des Jésuites	1630570.1	704619.1	18.9	25.8	5343	medium	540	35.4%	Red or brown montmo-rillonitic soils
S29	Trace des Jésuites	1630613.0	704602.7	18.9	25.8	5343	medium	542	37%	Red or brown montmo-rillonitic soils

Appendix 3. List of the 96 Species Recorded

No.	Family	Name Species	Synonymy	Physiognomy in maximum morphogenetic development	Invasive in Martinique according to DEAL	Abbreviations
1	*Fabaceae*	*Abrus precatorius*		Liana		ABPRE
2	*Asteraceae*	*Ageratum conyzoides*		Herbaceous		AGCON
3	*Asteraceae*	*Ageratum houstonianum*		Herbaceous		AGHOU
4	*Asteraceae*	*Bidens pilosa*		Herbaceous		BIDPIL
5	*Asteraceae*	*Bidens sp*		Herbaceous		BIDSP
6	*Urticaceae*	*Boehmeria nivea*		Herbaceous		BOEHIV
7	*Burseraceae*	*Bursera simaruba*		Tree		BURSIM
8	*Scrophulariaceae*	*Capraria biflora*		Herbaceous		CAPBIF
9	*Rhizophoraceae*	*Cassipourea guianensis*		Tree		CASGUI
10	*Poaceae*	*Cenchrus echinatus*		Herbaceous		CENECH
11	*Apiaceae*	*Centella asiatica*		Herbaceous		CENASI
12	*Fabaceae*	*Centrosema virginianum*		Liana		CEVIR
13	*Caesalpiniaceae*	*Chamaecrista glandulosa var schwarzii*		Shrub		CHAGLAN
14	*Caesalpiniaceae*	*Chamaecrista nictitans*		Shrub		CHANIC
15	*Caesalpiniaceae*	*Chamaecrista obcordata*		Shrub		CHAOB
16	*Euphorbiaceae*	*Chamaesyce hirta*	*Euphorbia hirta*	Herbaceous		CHAHIR
17	*Poaceae*	*Chloris inflata*	*Chloris barbata*	Herbaceous		CHINF
18	*Verbenaceae*	*Citharexylum spinosum*		Tree		CITSPI
19	*Verbenaceae*	*Clerodendron paniculatum*		Herbaceous	Yes	CLERPAN
20	*Commelinaceae*	*Commelina diffusa*		Herbaceous		COMDIF
21	*Boraginaceae*	*Cordia collococca*		Tree		CORDCOL
22	*Euphorbiaceae*	*Croton bixoides*		Shrub		CROBIX
23	*Lythraceae*	*Cuphea carthagenensis*		Herbaceous		CUPCAR
24	*Convolvulaceae*	*Cuscuta americana*		Liana		CUSAME
25	*Cyperaceae*	*Cyperus luzulae*		Herbaceous		CYPLUZ
26	*Cyperaceae*	*Cyperus surinamensis*		Herbaceous		CYPSUR
27	*Fabaceae*	*Desmodium heterocarpum*		Herbaceous		DESHET
28	*Fabaceae*	*Desmodium incanum*		Herbaceous		DESINC
29	*Fabaceae*	*Desmodium sp*		Herbaceous		DESSP

Continued

30	*Mimosaceae*	*Dichrostachys cinerea*		Shrub	Yes	DICCIN
31	*Rubiaceae*	*Diodia ocymifolia*	*Spermacoce ocymifolia*	Herbaceous		DIOCY
32	*Cyperaceae*	*Eleocharis flavescens*		Herbaceous		ELEOFLA
33	*Gentianaceae*	*Enicostema verticillatum*		Herbaceous		ENVER
34	*Poaceae*	*Eriochloa polystachya*		Herbaceous		ERPOL
35	*Erythroxylaceae*	*Erythroxylum havanense*		Shrub		ERYTHAV
36	*Myrtaceae*	*Eugenia cordata*		Shrub		EUCOR
37	*Myrtaceae*	*Eugenia ligustrina*		Shrub		EULIG
38	*Myrtaceae*	*Eugenia monticola*		Bush		EUMON
39	*Clusiaceae*	*Garcinia humilis*		Tree		GARCHUM
40	*Rubiaceae*	*Geophila repens*		Herbaceous		GEOREP
41	*Rubiaceae*	*Gonzalagunia hirsuta*		Shrub		GONHIR
42	*Rubiaceae*	*Guettarda odorata*		Shrub		GUETODO
43	*Caesalpiniaceae*	*Haematoxylum campechianum*		Tree		HAECAM
44	*Boraginaceae*	*Heliotropium ternatum*	*Euploca ternata*	Herbaceous		HELTER
45	*Lamiaceae*	*Hyptis atrorubens*		Herbaceous		HYPATR
46	*Balsaminaceae*	*Impatiens hawkeri*		Herbaceous		IMPHAW
47	*Mimosaceae*	*Inga laurina*		Tree		INGLAU
48	*Convolvulaceae*	*Ipomoea setifera*		Liana		IPOSET
49	*Cyperaceae*	*Kyllinga erecta var polyphylla*		Herbaceous		KYLPOL
50	*Cyperaceae*	*Kyllinga sp*		Herbaceous		KYLSP
51	*Poaceae*	*Leptochloa filiformis*		Herbaceous		LEPFIL
52	*Mimosaceae*	*Leucaena leucocephala*		Tree		LEULEU
53	*Fabaceae*	*Lonchocarpus punctatus*		Tree		LONPUN
54	*Onagraceae*	*Ludwigia octovalvis*		Herbaceous		LUDOCT
55	*Bignoniaceae*	*Macfadyena unguis-cati*	*Dolichandra unguis-cati*	Liana		MACUNG
56	*Myrtaceae*	*Myrcia citrifolia*		Shrub		MYRCIT
57	*Gesneriaceae*	*Nautilocalyx melittifolius*	*Chrysothemis melittifolia*	Herbaceous		NAUMEL
58	*Nephrolepidaceae*	*Nephrolepis multiflora*		Fern		NEPMUT
59	*Lamiaceae*	*Ocimum gratissimum*		Herbaceous		OCIGRA
60	*Lauraceae*	*Ocotea coriacea*	*Damburneya coriacea*	Tree		OCOCOR
61	*Oxalidaceae*	*Oxalis barrelieri*		Herbaceous		OXABAR
62	*Oxalidaceae*	*Oxalis frutescens*		Herbaceous		OXAFRUT

Continued

63	*Poaceae*	*Paspalum conjugatum*		Herbaceous	PASPCON
64	*Sapindaceae*	*Paullinia cururu*		Liana	PAULCUR
65	*Euphorbiaceae*	*Phyllanthus urinaria*	*Emblica urinaria*	Herbaceous	PHYLURI
66	*Piperaceae*	*Piper dilatatum*		Shrub	PIPDIL
67	*Nyctaginaceae*	*Pisonia fragans*		Tree	PISFRA
68	*Mimosaceae*	*Pithecellobium unguis-cati*		Tree	PITUNG
69	*Polygalaceae*	*Polygala paniculata*		Herbaceous	POLPAN
70	*Asteraceae*	*Pseudelephantopus spicatus*		Herbaceous	PSEUSPI
71	*Melastomataceae*	*Pterolepis glomerata*		Herbaceous	PTERGLO
72	*Cyperaceae*	*Rhynchospora nervosa*		Herbaceous	RHYNER
73	*Cyperaceae*	*Rhynchospora polyphylla*		Herbaceous	RHYNPOL
74	*Rosaceae*	*Rubus rosifolius*		Bush	RUBROS
75	*Ochnaceae*	*Sauvagesia erecta*		Herbaceous	SAUEREC
76	*Cyperaceae*	*Scleria pterota*	*Scleria melaleuca*	Herbaceous	SCLERPTER
77	*Polygalaceae*	*Securidaca diversifolia*		Liana	SECUDIV
78	*Malvaceae*	*Sida acuta*		Herbaceous	SIDACU
79	*Malvaceae*	*Sida rhombifolia*		Herbaceous	SIDARHO
80	*Malvaceae*	*Sida sp*		Herbaceous	SIDASP
81	*Rubiaceae*	*Spermacoce assurgens*	*Spermacoce remota*	Herbaceous	SPERASU
82	*Rubiaceae*	*Spermacoce sp*		Herbaceous	SPERSP
83	*Rubiaceae*	*Spermacoce verticillata*		Herbaceous	SPERVER
84	*Loganiaceae*	*Spigelia anthelmia*		Herbaceous	SPIGANT
85	*Anacardiaceae*	*Spondias mombin*		Tree	SPONMON
86	*Poaceae*	*Sporobolus jacquemontii*		Herbaceous	SPORJAC
87	*Verbenaceae*	*Stachytarpheta jamaicensis*		Herbaceous	STACJAM
88	*Verbenaceae*	*Stachytarpheta sp*		Herbaceous	STACSP
89	*Asteraceae*	*Synedrella nodiflora*		Herbaceous	SYNNOD
90	*Bignoniaceae*	*Tabebuia heterophylla*		Tree	TABHET
91	*Euphorbiaceae*	*Tragia volubilis*		Liana	TRAGVOL
92	*Malvaceae*	*Urena lobata*		Bush	URELOB
93	*Sapindaceae*	*Urvillea ulmacea*		Liana	URVULM
94	*Asteraceae*	*Vernonia cinerea*	*Cyanthillium cinereum*	Herbaceous	VERCIN
95	*Fabaceae*	*Vigna luteola*		Herbaceous	VIGLUT
96	*Asteraceae*	*Wedelia trilobata*	*Sphagneticola trilobata*	Herbaceous	WEDTRI