Natural Resources, 2025, 16(13), 524-549
https://www.scirp.org/journal/nr
ISSN Online: 2158-7086
ISSN Print: 2158-706X

Ecology, Phenology and Conservation Issues of Six Threatened or Remarkable Rubiaceae in the Lesser Antilles

Jean-Philippe Claude, Yelji Abati, Philippe Joseph

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

How to cite this paper: Claude, J.-P., Abati, Y. and Joseph, P. (2025) Ecology, Phenology and Conservation Issues of Six Threatened or Remarkable Rubiaceae in the Lesser Antilles. *Natural Resources*, **16**, 524-549.
https://doi.org/10.4236/nr.2025.1613026

Received: September 17, 2025
Accepted: December 26, 2025
Published: December 29, 2025

Abstract

The study examines the ecology and phenology of six species of the Rubiaceae family, threatened or remarkable within the Lesser Antilles archipelago, with a focus on the island of Martinique. Monthly phenological observations carried out from 2016 to 2020, at the Ethnobotanical Park of the town of Marin in Martinique, were cross-referenced with bibliographic data and more than a hundred floristic inventories carried out between 2015 and 2020 on the island. The Ethnobotanical Park, home to approximately 812 individuals divided into approximately 146 species, 119 genera and 71 families, constitutes a privileged study site for monitoring the cycles of flowering, fruiting and stem growth. The phenological strategies and ecological profiles of *Erithalis fruticosa* (shrub), *Genipa americana* (tree), *Guettarda scabra* (tree), *Ixora ferrea* (shrub), *Randia* aculeata (shrub) and *Randia nitida* (tree) were characterized. The results obtained improve knowledge on the ecological dynamics of these species and can be used for future conservation and ecological restoration strategies in the Lesser Antilles.

Keywords

Lesser Antilles, Rubiaceae, Ecology, Phenology, Conservation

1. Introduction

The Lesser Antilles archipelago located in the Caribbean is composed of a chain of main islands and a myriad of islets, extending from the Virgin Islands in the north to Trinidad and Tobago in the south. These islands are the result of the subduction process between the North American and Caribbean plates, which led to the formation of an external arc composed of ancient limestone islands with low relief, an internal arc still active, of volcanic origin with more marked relief, separated by an intermediate arc resulting from underwater volcanic activities since the Miocene [1]-[3]. All of these islands, although of modest areas, benefit from a tropical climate and are home to exceptional biodiversity, contributing to the richness of the Caribbean global biodiversity hotspot [4]-[10].

The mountainous reliefs of the volcanic islands of the archipelago condition a staggered pattern of precipitation, and climate variations with altitude induce an altitudinal bioclimatic gradient, going from the dry coastline to the hyper-humid summits [7] [11]-[13]. This gradient, combined with a great diversity of soils, favors the formation of multiple habitats and the development of specialized flora, giving rise to a great variety of plant levels [7] [9] [11]-[15]. However, since colonization, the anthropization of these islands has continued to intensify, endangering the richness of their ecosystems [16]-[20]. Urbanization, agriculture, deforestation, pollution, invasive species and current climate change generate major ecological risks, threatening the stability, diversity and functioning of natural environments [7] [17] [19] [20]-[22].

The sustainable management of natural resources in the Lesser Antilles archipelago has long been hampered by a lack of institutional coordination and persistent socio-economic inequalities, limiting the effectiveness of regional and local conservation strategies [19] [23] [24]. Despite their ecological richness, these island ecosystems remain particularly vulnerable, due to their isolation, small size, and increasing anthropogenic pressure [7] [9] [16] [25]. Martinique, a volcanic island located in the heart of the archipelago, is home to rich but vulnerable ecosystems, subject to strong anthropogenic pressures and various ecological risks that can lead to the erosion of this biodiversity [7] [16] [17] [20] [23] [25]-[27]. In this context, the Ethnobotanical Park of the town of Marin located on the southern Caribbean coast of Martinique, at the place called "Rivière habitation", plays a strategic role in ex situ conservation, that is to say the preservation of threatened or remarkable species outside their natural environment.

There are six Rubiaceae preserved in this park: *Erithalis fruticosa*, *Genipa americana*, *Guettarda scabra*, *Ixora ferrea*, *Randia aculeata* and *Randia nitida*. As part of a doctoral project carried out on the Rubiaceae family, between 2015 and 2020 at the University of the Antilles, a study was specifically devoted to these six Rubiaceae. By combining phenological observations, floristic inventories and bibliographic analysis, the objective was to better understand their ecological requirements and their development rates. This approach aims to strengthen their in situ conservation, by promoting their maintenance in their natural habitat, but also to consider ecological restoration actions, including their reintroduction into their natural habitats for species threatened with extinction.

2. Materials and Methods

2.1. Bibliographic Data

The Rubiaceae constitute one of the largest families of flowering plants in the world and are among the five most represented families in the Lesser Antilles archipelago [4] [6] [26]-[28]. Their morphological and physiological diversity allows them to occupy a wide range of habitats, from dry, rocky or sandy coastlines to humid forests located at high altitudes, demonstrating a remarkable capacity for adaptation [4] [6] [8] [26]-[27] [29]. The volcanic islands of the archipelago such as Martinique present a heterogeneity of habitats and forest ecosystems ranging from the coast to the summits which can accommodate this diversity of species of the Rubiaceae family (**Figure 1** and **Figure 2**).

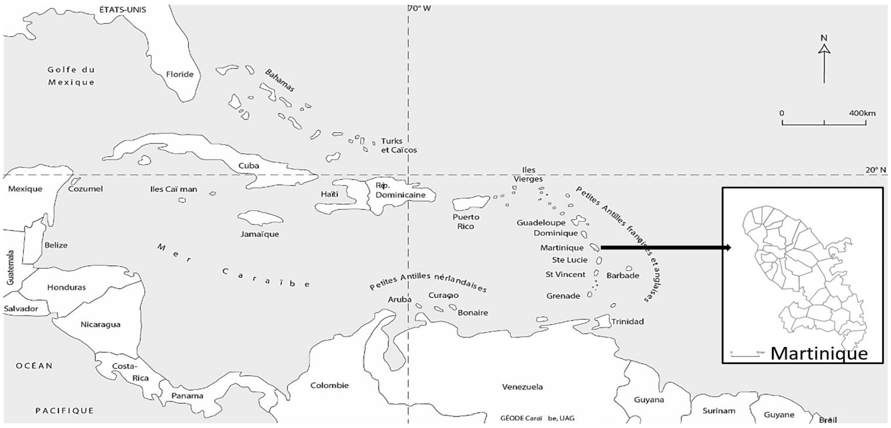

Figure 1. Location of the lesser Antilles archipelago and Martinique (Caribbean).

In the ecosystems of the Lesser Antilles, although the majority of these species are introduced or naturalized, they perform important ecological functions. Some actively participate in the dynamics of natural regeneration of degraded plant formations, thus contributing to the resilience of tropical island forests [7] [9] [26] [27]. This functionality makes them valuable allies to be taken into account in ecological restoration programs. According to the IUCN (International Union for Conservation of Nature), 11 categories are used to assess the extinction risk of a species and define its conservation status [30]. They apply at different scales (global, regional, etc.), meaning that a species can have a global status and another regional status. These categories are: Globally Extinct (EX), Extinct in the Wild (EW), Regionally Extinct (RE), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Applicable (NA) and Not Evaluated (NE) [30]. Among the species of the Rubiaceae family present in the French Antilles, some Rubiaceae thus have a conservation status of concern. This is the case of *Randia nitida* (or *Randia armata*), classified as critically endangered for decades and preserved in the ethnobotanical park of the town of Marin in the south of Martinique (**Figure 3**) [16] [20] [30].

The six species studied here illustrate the ecological and functional diversity of this family within the natural ecosystems of the Lesser Antilles archipelago (**Table 1**) [6] [20] [26] [27] [30]. Indeed, *Erithalis fruticosa* and *Randia aculeata*, two relatively common species, thrive on dry coastlines and in xerophilous forests [6]

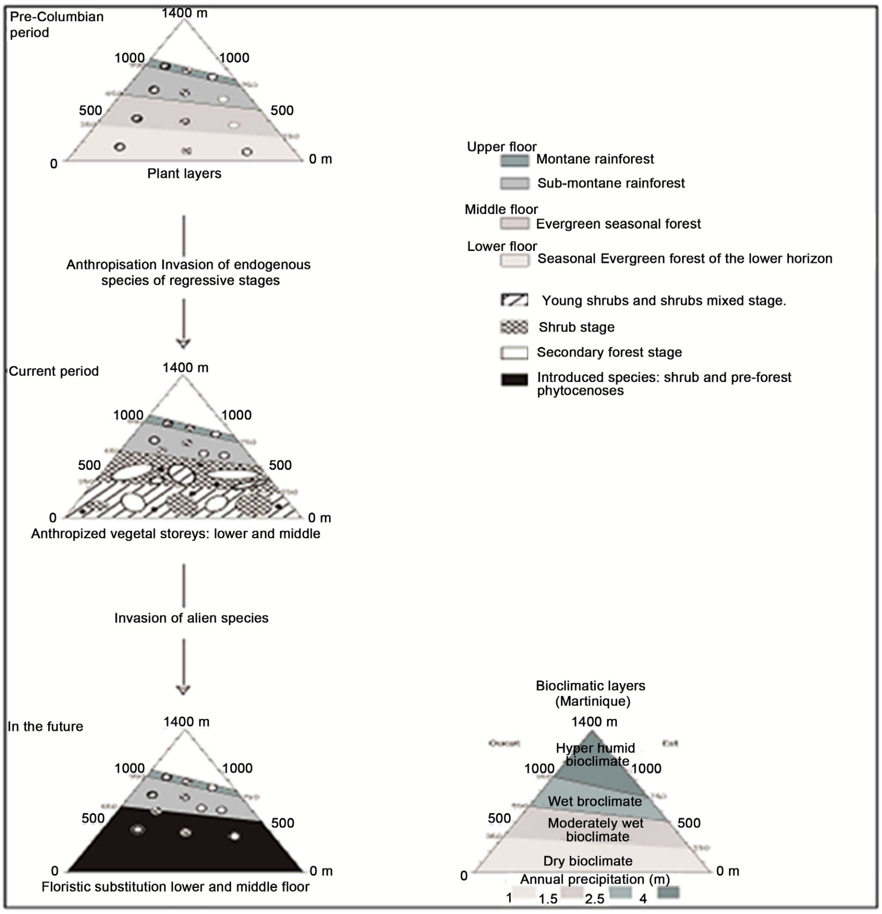

Figure 2. Schematic representation of the bioclimatic and plant stages in the Lesser Antilles (Amerindian period and present day) [13].

[26] [27]. Both are said to be valued for their traditional uses: *Randia aculeata* for its medicinal properties, particularly for treating snake bites, and *Erithalis fruticosa* for its Amerindian cultural uses, the resin was once used to make torches [7] [31] [32]. In contrast, *Genipa americana* and *Ixora ferrea* are rarer and occupy mesophilous to hygrophilous habitats [6] [26] [27]. The former is well known for its multiple uses: its fruit is edible, yielding a blackish dye used by Amerindians for their rituals, and has antibacterial properties [33] [34]. The latter may be primarily ornamental, like several other species of the same genus [35].

Guettarda scabra, although fairly common locally, is classified as critically endangered globally [30]. It grows in dry, often degraded areas, in xerophilous and xero-mesophilous forests [26] [27]. The genus provides a heavy wood prized for construction, while folk medicine uses it to treat various inflammatory or digestive disorders [8] [36].

Finally, *Randia nitida* appears to be the most threatened [6] [26] [27] [30]. This rare species, adapted to xero-mesophilous to mesophilous forests, is believed to have nutritional (edible fruit) and medicinal (healing, inflammation, digestive disorders) benefits, reinforcing the urgent need for conservation measures [8] [37]-[40].

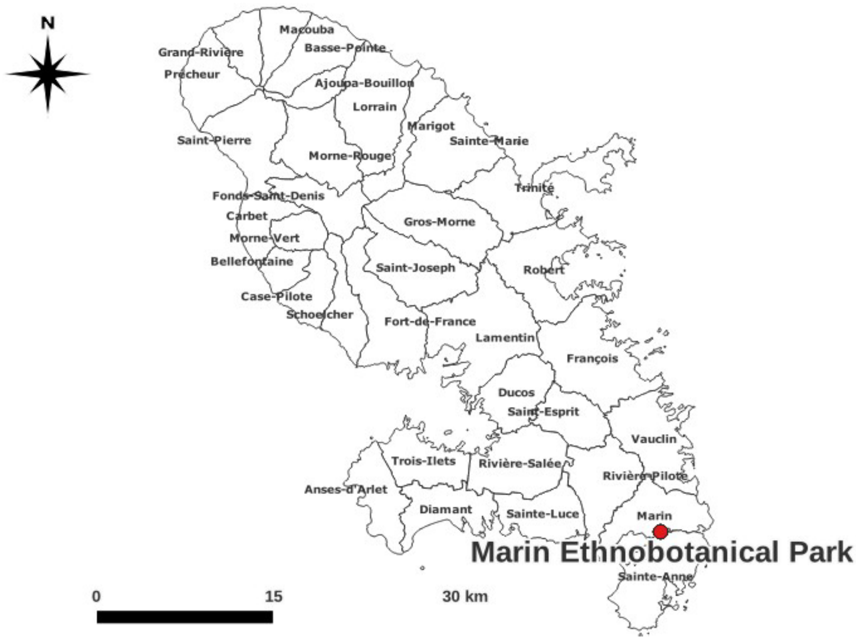

Figure 3. Location of the Ethnobotanical Park in the town of Marin, Martinique.

According to the most recent flora of the region, these six species also present varied phenological rhythms (flowering and fruiting staggered according to the species), which would allow for the consideration of differentiated management strategies (**Figure 4**) [6]. All of these elements together can contribute to the development of targeted conservation plans or to the development of restoration programs adapted to the ecological and cultural specificities of each taxon.

Table 1. Bibliographic data [6] [20] [26] [30].

Scientific name	Threat status worldwide (INPN)	Highest threat status in the french antilles (INPN)	*Abundance according to Fournet J.,* 2002	Remarkable uses	Ecological profile	Flowering period	Fruiting period
Erithalis fruticosa (*Shrub*)	LC—Least Concern	LC—Least Concern	Common	Cultural, religious, and utilitarian: Very hard and durable wood. The resin is flammable and was once used by Amerindians as torches. Medicinal: Measles and wounds, treating a newborn's bleeding navel, etc..	Dry coastline. Altitude: 0 to 80 meters.	All year round.	-
Genipa americana (*Tree*)	Not Assessed	Not Assessed	Fairly rare	Cultural and religious: Plant formerly used by Amerindians for ceremonies and blackish dye. Medicinal: Antibacterial. Food: Edible fruit.	Mesophilous vegetation layer, absent from primary mesophilous forest. Often planted. Altitude: 20 to 200 meters.	September-October. And often June-July.	

Continued

Guettarda scabra (*Tree*)	CR—Critically Endangered	LC—Least Concern	Fairly common	Utilitarian uses: Hard, heavy wood, poles for construction. Medicinal: Stomach problems, general inflammation.	Lower hills and dry, rocky coastline. Most common in xerophilous forest and xero-mesophilous forest, in degraded areas. Altitude: 0 to 100, even 500 meters.	Almost all year round, intermittently.	
Ixora ferrea (*Shrub*)	-	LC—Least Concern	Fairly rare	Ornamental plant. Utilitarian uses: hard and heavy wood, stakes, firewood, etc.	Mesophilous and hygrophilous forest. Altitude: 0 to 150, even 700 meters.	March-April	September
Randia aculeata (*Shrub*)	LC—Least Concern	LC—Least Concern	Common	Utilitarian uses: Brown wood, hard, heavy, strong, durable. Manufacture of fishing rods, Christmas trees, blue dye (fruit pulp)... Medicinal: Against snake bites, chronic pain, cancer, bone fever, wound care and infections...	Degraded or secondary xerophilous and xero-mesophilous forest. Lowland dry region, especially on the coast. Altitude: 0 to 150 meters.	Especially during long days.	-
Randia nitida or armata (*Tree*)	-	CR—Critically Endangered	Fairly rare	Food: edible fruit. Medicinal: helps with healing, to treat inflammatory diseases, diarrhea, etc.	Xero-mesophilous and mesophilous forest. Altitude: 0 to 200 meters.	-	-

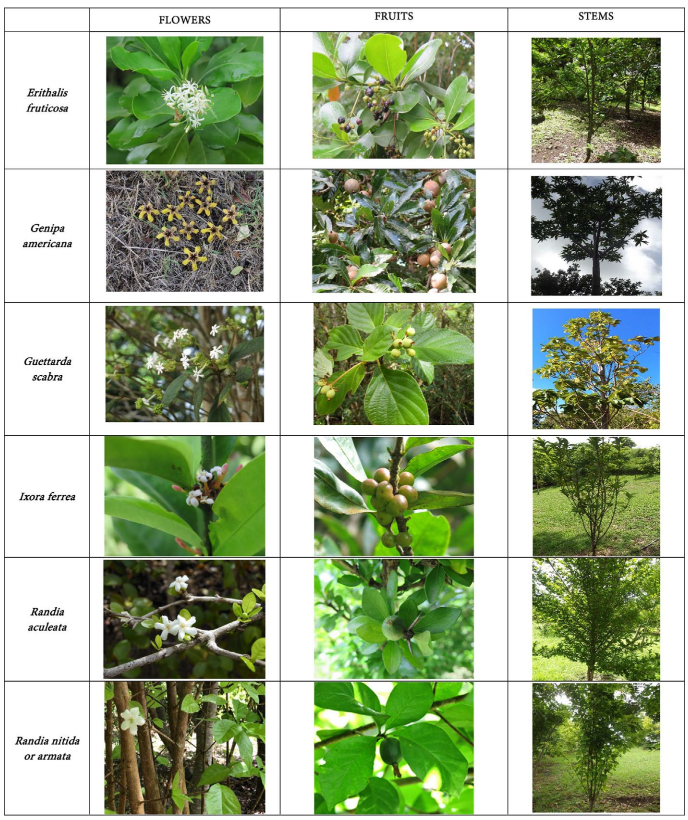

Figure 4. Illustrations of the flowers, fruits and stems of the six Rubiaceae studied.

2.2. Methods

This study is based on a methodological approach combining field observations, floristic inventories and bibliographic research, with the aim of enriching our knowledge on the phenological rhythms and ecological requirements of six remarkable or threatened species of the Rubiaceae family, present in Martinique and preserved in the Ethnobotanical Park of the town of Marin. Thus, between June 2016 and February 2020, monthly observations were carried out in this park to monitor the phenological cycles of these six species. Each month, a single visit made it possible to record, for all individuals, the main flowering and fruiting phases, as well as to qualify stem growth and the evolution of tree height using a descriptive gradient (slow, moderate, rapid, sustained, continuous or regular growth). However, the quantities of flowers and fruits produced were not estimated. Although this protocol of a single random monthly visit may underdetect very short-term blooms, repeating these observations over several years reduces this bias because they were cross-referenced with bibliographic data, thereby limiting potential underdetections and strengthening the reliability of the phenological trends described.

These data were enriched by the reuse of a database of 120 floristic inventories carried out randomly in different bioclimates and associated forests, across Martinique between 2015 and 2020, initially mobilized as part of doctoral work on the ecology of Rubiaceae, within the UMR ESPACE DEV-BIORECA laboratory of the University of the Antilles [26]. The areas of the transects (or minimum areas) varied according to the plant communities studied; on average from 240 square meters to more than 1000 square meters, generally from the dry to humid bioclimate, due to greater floristic richness in the forest formations of more humid bioclimates. These inventories were revisited in order to precisely identify the occurrences of the six targeted species, and to extract information such as their ecological profile and ecosystem affinity (belonging to types of plant formations and bioclimates), their ecological importance (population dynamics), as well as their ecological temperament (*i.e.* their behavior with respect to environmental gradients).

At the same time, a bibliographic review was conducted using scientific literature or online scientific databases (Google Scholar, ResearchGate, and the National Inventory of Natural Heritage—INPN) in order to gather existing knowledge on these species and thus describe the material part of our study. All of these elements made it possible to constitute a fairly comprehensive database for the analysis of the ecological dynamics specific to each species.

3. Results

3.1. Field Observations (June 2016-February 2020)

The town of "Marin", where the ethnobotanical park is located, is characterized by a tropical climate with an average annual temperature of 26.5˚C, oscillating between 24˚C and 29˚C, average annual rainfall of approximately 1800 mm, annual evapotranspiration of approximately 1675 mm, and annual insolation of approximately 2800 hours (**Table 2**) [41].

It is in this climatic context that the six species of the Rubiaceae family, a total of 33 individuals, were monitored from June 2016 to February 2020 at the Ethnobotanical Park. The 33 individuals correspond to all representatives of the six target species present in the park at the time of the study. This comprehensive park-wide sampling integrates different physiognomies and developmental stages, including both bushes, shrubs and young growing trees, making it representative of the ex situ populations maintained there. Although limited in size, the dataset provides original ecological and phenological trends, valuable for conservation purposes. However, any inferences at a broader regional scale must be made with caution. *Genipa americana*, initially in shrub form for the majority of individuals, has evolved into a tree with rather rapid and sustained growth (**Table 3**). Conversely, *Ixora ferrea* and *Erithalis fruticosa* showed fairly slow growth to reach the shrub stage, while *Guettarda scabra*, *Randia aculeata* and *Randia nitida*, showed moderate growth to become trees or shrubs (**Table 3**).

Table 2. Main climatic characteristics of the commune of Marin (Source: Météo-France and IGN).

Average annual minimum temperature	Average annual maximum temperature	Average annual temperature	Average annual rainfall	Annual evapotranspiration	Annual insolation
24˚C	29˚C	26.5˚C	≃1800 mm	≃1675 mm	≃2800 hours

Table 3. Growth characteristics of the 6 Rubiaceae preserved and observed at the Marin Ethnobotanical Park.

Scientific name	Number of individuals	Initial physiognomy (2016)	Terminal physiognomy (2020)	Annual growth type of stems	Annual growth type of individual heights
Erithalis fruticosa	3	1 shrub 2 bushes	Shrub	Slow and continuous	Slow and continuous
Genipa americana	9	8 shrubs 1 bush	Tree	Fast and sustained	Fast and sustained
Guettarda scabra	4	2 trees 2 bushes	Tree	Moderate	Moderate
Ixora ferrea	2	1 bush	Shrub	Slow and continuous	Slow and continuous
Randia aculeata	2	2 bushes	Shrub	Moderate	Moderate
Randia nitida or armata	13	13 bushes	Tree	Moderate	Moderate

Figure 5 shows the spatial distribution of observed individuals, mostly grouped by species within the park. While this distribution does not appear to directly im-

pact the growth rates or phenological cycles of the species, it nevertheless reflects a diversity of microenvironments, linked to the hilly topography of the site, located in a low-lying area and in close proximity to a watercourse. Thus, *Erithalis fruticosa* presents a flowering that appears almost continuous throughout the year, accompanied by intermittent fruiting equally distributed throughout the year (Table 4). *Genipa americana* flowers mainly during the rainy season, while its fruiting appears asynchronous and can extend over a large part of the year (Table 4).

Guettarda scabra flowers more during the shoulder season and the rainy period, resulting in fruiting that extends beyond the flowering peak, almost until the end of the year (Table 4). *Ixora ferrea* has a relatively brief flowering period early in the year during the dry season, with some late fruits observed thereafter, while *Randia aculeata* appears not to follow a strict cycle: flowers and fruits can be observed at different times of the year (Table 4). Finally, *Randia nitida* briefly loses its leaves before flowering, suggesting a floral peak at the end of the dry season, extending into the rainy season. Fruits, on the other hand, are visible throughout the year and mature at variable times (Table 4).

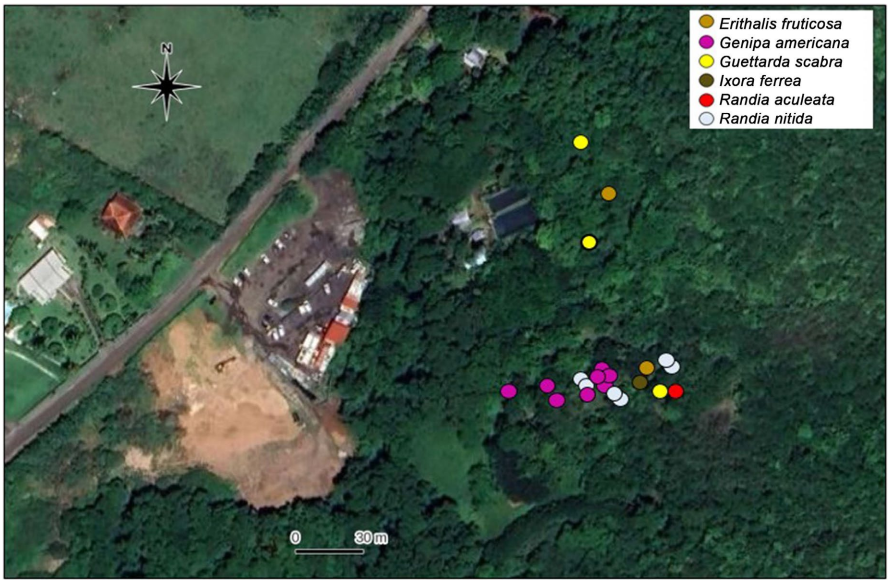

Figure 5. Location of the sites of the 6 Rubiaceae preserved at the Marin Ethnobotanical Park (several individuals of the same species are located close to each other).

3.2. Reuse of Floristic Inventory Data (2015-2020)

Between 2015 and 2020, 120 floristic inventories were carried out in Martinique and made it possible to note the presence of these six Rubiaceae in natural environments [26] [27].

The minimum areas of the transects carried out varied from 240 to more than 1000 m^2 and covered a diversity of plant formations presented in Table 5 (**Appendix 1** and **Appendix 2**).

Table 4. Phenological phases of flower and fruit production of the 6 Rubiaceae. Table produced according to the model of Lobo Segura, J. A., *et al.*, in 2007 [42].

Species	Phases	Dry season				Shoulder season		Rainy season				Shoulder season	
		January	February	March	April	May	June	Juily	August	September	October	November	December
Erithalis fruticosa	Flowering	■	■	■	■	■	■	■	■	■	■	■	■
	Fruiting	■	■	■	■		■	■	■			■	■
Genipa americana	Flowering						■	■	■	■	■	■	
	Fruiting	■	■				■	■	■	■	■	■	■
Guettarda scabra	Flowering				■	■	■	■	■	■	■		
	Fruiting					■	■	■	■	■	■	■	
Ixora ferrea	Flowering		■	■	■	■	■						
	Fruiting		■	■	■	■	■						
Randia aculeata	Flowering	■	■	■	■	■	■	■	■	■	■		
	Fruiting	■		■	■	■	■	■	■			■	■
Randia nitida or armata	Flowering				■	■	■	■	■	■	■		
	Fruiting	■	■	■	■	■			■	■	■	■	■

Table 5. Summary table of the characteristics of the 120 floristic inventories carried out in Martinique from 2015 to 2020 (**Appendix 1** and **Appendix 2**) [26] [27].

	Lower plant level							Medium plant level	
	Mangrove	Back-mangrove	Backshore	F.S.S.T.F.X	F.T.X.M	F.S.S.T.T	F.S.S.T.T	F.O.S.S.T	F.O.S.M.T
Number of inventories	5	9	11	55	10	17	1	5	7
Total area (m²)	3150	10790	6065	31110	6610	12560	500	3950	6250
Minimum inventory area (m²)	400 to 950	420 to 2200	240 to 800	350 to 1000	500 to 1000	450 to 1000	500	600 to 1000	700 to 1050
Number of inventories per commune in Martinique	(3) Trinité, (1) Robert, (1) Sainte-Anne	(9) Marin	(2) Trinité, (2) Vauclin, (3) Marin, (4) Sainte-Anne	(2) Case Pilote, (3) Schoelcher, (12) Vauclin, (10) Diamant, (14) Marin, (14) Sainte-Anne	(2) Schoelcher, (3) Diamant, (5) Marin	(9) Schoelcher, (3) Marin, (5) Vauclin	(1) Diamant	(1) Sainte-Marie, (1) Case Pilote, (2) Sainte-Luce, (1) Marin	(3) Sainte-Marie, (1) Case Pilote, (3) Fort-de-France
Inventory team	Members of the UMR SPACE DEV-BIORECA laboratory								

F.S.S.T.F.X: Tropical seasonal evergreen and xeric facies plant formations (xerophilous), **F.T.X.M:** Transitional xero-mesophilous plant formations (tropical seasonal evergreen), **F.S.S.T.T:** Typical tropical seasonal evergreen plant formations (mesophilous), **F.O.S.S.T:** Tropical seasonal ombro-evergreen plant formations (mesohygrophilous), **F.O.S.M.T:** Tropical sub-montane rainforest plant formations (hygrophilous).

Table 6 shows that *Guettarda scabra* was the most common species with 1271 individuals, followed by *Erithalis fruticosa* with 972 and *Randia aculeata* with 893. *Genipa americana*, *Ixora ferrea* and *Randia nitida* were rarer, with 2, 25 and 28 individuals respectively. The presence of seedlings for most of these species in several stations indicates a certain capacity for regeneration.

Table 7 describes their ecological temperament: *Erithalis fruticosa* and *Guettarda scabra* (and even *Genipa americana*) are strongly heliophilous, *Randia aculeata* shows a more mixed behavior, while *Ixora ferrea* and *Randia nitida* show a preference for more shaded conditions. The majority of these species belong to the lower or even middle strata of our forests with the exception of *Guettarda scabra* which can contribute to the canopy species (**Table 7**).

Table 6. Number of inventory stations and number of individuals of the 6 Rubiaceae (**Appendix 1** and **Appendix 2**) [26].

Species	Type	Number of adult individuals (excluding regenerations and dead trees)	Ecological significance	Stations where the species is present (excluding regenerations and seedlings)	Stations where the species is present at the regeneration/ seedling stage
Erithalis fruticosa	Shrub	972	very low	S27, S31, S33, S39, S47, S50, S52, S55, S56, S57, S59, S60, S61, S62, S64, S65, S66, S67, S83, S84, S85, S86, S95, S96, S97	S31, S33, S34, S35, S47, S50, S56, S61, S67, S83, S85, S86, S95, S96
Genipa americana	Tree	2	very low	S110	-
Guettarda scabra	Tree	1271	very low	S46, S47, S55, S56, S57, S60, S61, S62, S64, S65, S66, S67, S82, S83, S86, S108, S106, S116, S118	S46, S47, S56, S61, S63, S67, S83, S85, S103
Ixora ferrea	Shrub	25	very low	S88, S89, S90, S98, S103, S104, S107, S108	S89, S98, S103, S107
Randia aculeata	Shrub	893	very low	S6, S8, S9, S13, S20, S21, S22, S23, S32, S38, S44, S45, S46, S47, S49, S56, S57, S58, S59, S60, S61, S65, S66, S67, S83, S85, S86, S97, S100, S101, S103, S110, S111, S112, S114, S116, S118	S6, S25, S32, S44, S45, S47, S56, S58, S61, S63, S67, S83, S85, S86, S97, S100, S103, S115, S117
Randia nitida or armata	Tree	28	very low	S28, S29, S30	S71

Ecological importance: contribution of species in terms of abundance, biomass and space occupation to the forest communities studied (very low, low, medium, high and very high).

Guettarda scabra and *Erithalis fruticosa* occurred in shrub formation, mature shrub formation, presylvatic, and young sylvatic forests, in other words, primarily in extrasylvatic forests (**Table 7**). *Randia aculeata* appeared more prevalent in shrub formation and mature shrub formation (extrasylvatic forests), while the other species appeared more ecologically restricted, limited to the more advanced stages of our forests (intrasylvatic forests) (**Table 7**).

Table 8 shows their affinity for various ecosystem types. *Erithalis fruticosa* and *Randia aculeata* were more abundant in backshore forests and in xerophilous forests, while *Guettarda scabra* was particularly abundant in xerophilous forests. *Genipa americana*, although very poorly represented, was found only in mesophilous forests (**Table 8**). *Ixora ferrea*, poorly represented, seemed more associated with mesophilous or even hygrophilous formations, while *Randia nitida*, also poorly represented, clearly showed a weak affinity for coastal plant formations as well as for hygrophilous forests. *Erithalis fruticosa*, *Guettarda scabra*, and *Randia aculeata* could be found among the dominant species by their population abundance (number of individuals) or by their distribution (spatial distribution of species), while their basal area (phytomasses or biovolumes of plants) was very small. In contrast, for all other species, ecological dominance was clearly negligible.

Table 7. Temperament and ecological profile of the 6 Rubiaceae identified in the stations, according to the qualitative representation model by Professor Philippe JOSEPH [7] [26] [27].

Species	*Erithalis fruticosa*	*Genipa americana*	*Guettarda scabra*	*Ixora ferrea*	*Randia aculeata*	*Randia nitida* (*or armata*)
Physiognomy	Shrub	Tree	Tree	Shrub	Shrub	Tree
PH	++++		++++		+++	
SH	++	+	++		++	+
SGH			++			
HémSc				+	+	
SPME	Lower and Middle	Middle	Middle and Upper	Lower	Lower	Lower
O	NO	NO	T	NO	P	P
S.F	++++		+++		+++	
M.S.F	+++++		+++++		+++	
P.F	+++		++++		+	+
S.Y.S.F	+	+	++	+	+	+
S.S.F			S	+	+	

PH: Primary heliophile/**SH:** Secondary heliophile/**SGH:** Sylvatic gap heliophile/**HémSc:** Hemisciaphile/**SPME:** Stratigraphic position at maximum expansion/**O:** Obsolescence; (**T:** Total, **NO:** Not obsolete, **P:** Partial)/**(S.F):** Shrub formation**/(M.S.F):** Mature shrub formation/**(P.F):** Presylvatic formation/**(S.Y.S.F):** Structured young sylvatic formation/**(S.S.F):** Secondary sylvatic formation/**S:** Seedling**/Significance of descriptor:** (+) very low, (++) low, (+++) medium, (++++) high, and (+++++) very high.

Table 8. Ecosystem affinity of the 6 Rubiaceae identified in the stations, according to the qualitative representation model by Professor Philippe JOSEPH [7] [26] [27].

	A.M			A.P			F.S.S.T.F.X			F.T.X.M			F.S.S.T.T			F.O.S.S.T			F.O.S.M.T		
Species	Ab	D	ED	Ab	D	ED	Ab	D	ED	Ab	D	ED	Ab	D	ED	Ab	D	ED	Ab	D	ED
Erithalis fruticosa				+++++	M	Lo	+++	M	Lo	+	EL	EL									
Genipa americana													+	EF	EL						
Guettarda scabra	+	EL	EF	+	Lo	EL	++++	Lo	Lo	++	M	M	+	VL	VL						
Ixora ferrea													+	EL	EL	+	VL	EL	+	VL	EL
Randia aculeata				+++++	M	Lo	+++	Lo	VL	++	VL	EL	+	EL	EL						
Randia nitida							+	VL	EL				+	Lo	EL						

Ab: Abundance/**D:** distribution/**ED:** Ecological dominance/**M:** Medium, **Lo:** Low, **VL:** Very low, **EL:** Extremely low /**A.M:** Back-mangrove floristic units, **A.P:** Backshore floristic units, **F.S.S.T.F.X:** Tropical seasonal evergreen and xeric facies plant formations (xerophilous), **F.T.X.M:** Transitional xero-mesophilous plant formations (tropical seasonal evergreen), **F.S.S.T.T:** Typical tropical seasonal evergreen plant formations (mesophilous), **F.O.S.S.T:** Tropical seasonal ombro-evergreen plant formations (mesohygrophilous), **F.O.S.M.T:** Tropical sub-montane rainforest plant formations (hygrophilous). **Significance of descriptor:** (+) very low, (++) low, (+++) medium, (++++) high, and (+++++) very high.

4. Discussion

The island context of Martinique is characterized by strong anthropogenic pressure and a rich and extremely vulnerable biodiversity [4] [6] [7] [9] [16] [20]-[22] [25] [26].

Urbanization, agriculture, the introduction of invasive species, and current climate change are increasingly creating major ecological risks, threatening the stability, diversity, and functioning of natural ecosystems [7] [17] [19] [21] [22].

Several in situ conservation measures have been in place in Martinique since the beginning of the 20th century to oversee the preservation of plant biodiversity. Currently, there are several dozen terrestrial and marine areas with various legal statuses, such as strict biological reserves, national or regional nature reserves, regional or marine natural parks, prefectural biotope protection decrees, and nature reserves [30]. The Martinique Regional Natural Park, for example, extends over 2/3 of the island, including forest, agricultural, coastal and marine areas, and its main mission is the protection and enhancement of natural and cultural heritage, the sustainable development of territories, as well as supporting communities in the concerted management of the island's remarkable and sensitive areas [43].

In addition to protected areas, certain territories without regulatory status play an essential role in the knowledge and inventory of natural heritage, in particular the 24 Natural Zones of Ecological, Faunistic and Floristic Interest (ZNIEFF) spread across the entire island [30].

At the same time, targeted actions are implemented to preserve heritage and threatened species, through tools such as National Action Plans or Conservation Master Plans led in particular by the National Botanical Conservatory of Martinique [44]. These plans aim to coordinate targeted preservation actions for heritage and threatened plant species, by defining priorities, management objectives and concrete conservation measures, generally over periods of 5 to 10 years [44].

It is also worth noting the existence of projects such as those led by public organizations such as INRAE (National Research Institute for Agriculture, Food and the Environment) and CIRAD (Centre for International Cooperation in Agricultural Research for Development), aimed at the conservation and characterization of tropical plant biological resources with the aim of promoting their agronomic, scientific, and heritage value [45].

Municipalities are beginning to integrate these issues into their urban planning documents, although this approach remains poorly coordinated with local scientific actors. The lack of unified governance and synergies between regional actors have long limited the overall effectiveness of all these tools, despite their individual relevance [7] [17] [19] [24].

A stronger integration of scientific approaches is also necessary to strengthen their impact. This is the existential objective of the Ethnobotanical Park of the city of Marin, created in 2017. Its purpose is to strengthen the effectiveness and coherence of conservation and ecological restoration actions carried out on the island, through its scientific role focused on the study of the phenological cycles of species and the conservation of seed banks of threatened native plant species.

It constitutes a strategic asset that is currently little used and can provide essential data for the adaptive management of ecosystems. Our study, conducted between 2016 and 2020 on six threatened or remarkable Rubiaceae conserved at the Marin Ethnobotanical Park, is part of this dynamic. The combined approach based on phenological observations and floristic inventories provides original data on the seasonal cycles, growth rates, and ecological preferences of the species studied, namely *Erithalis fruticosa*, *Genipa americana*, *Guettarda scabra*, *Ixora ferrea*, *Randia aculeata*, and *Randia nitida* [26] [27].

The results demonstrate variability in phenological strategies and different ecological profiles and temperaments, ranging from fast-growing and heliophilous species such as *Genipa americana* or *Guettarda scabra*, to others that are slower and shade-tolerant such as *Ixora ferrea* or *Randia nitida*. Some exhibit almost continuous flowering (*Erithalis fruticosa*), while others follow marked seasonal cycles. Finally, their ecological distribution varies according to the formations: some are found in the extra-sylvatic and xerophilous stages (*Erithalis fruticosa*, *Guettarda scabra*, *Randia aculeata*), while others are more restricted to mesophilous or hygrophilous intra-sylvatic forests (*Genipa americana*, *Ixora ferrea*, *Randia nitida*). In terms of in situ conservation, the data collected can be used to refine management strategies for natural populations. For example, species such as *Guettarda scabra* or *Randia aculeata*, relatively common in xerophilous or degraded habitats, could be integrated into rehabilitation programs for open or disturbed environments, as indicator species of ecosystem resilience [7]. Others, such as *Randia nitida* or *Genipa americana*, which are more ecologically demanding, require specific interventions in mesophilous or transitional habitats, including site protection, regulation of uses and possibly the reconstitution of microhabitats.

Based on these results, several management measures can be proposed to strengthen the conservation of the six Rubiaceae studied. Seed collection could, for example, be carried out opportunistically, during peak fruiting periods, and stored in local seed banks to secure genetic resources for potential reintroduction programs. Restoration efforts should prioritize degraded xero-mesophilic and mesophilic habitats, which represent the natural ecological niches of the rarest species. At the same time, annual monitoring would be relevant and advisable to assess the effectiveness of existing conservation actions. This monitoring would include the assessment of natural regeneration, growth, and survival of young recruits planted in different habitats, and the early detection of restoration failures. This information would allow management strategies to be adapted if necessary, for example, by reinforcing plantations or adjusting restoration sites.

Pending the implementation of these measures, the Marin Ethnobotanical Park represents a major asset for ex situ conservation in Martinique. The phenological and growth data collected in its living collections provide valuable information for refining propagation protocols, consolidating ex situ populations, and supporting future reintroduction or translocation programs.

Strengthening the integration of scientific data generated by the park with the actions of national and regional partners would significantly enhance the coherence of conservation strategies and contribute to the sustainability of threatened or remarkable Rubiaceae in the Lesser Antilles.

5. Conclusions

This study provided a deeper understanding of the phenological rhythms and ecological requirements of six threatened or remarkable Rubiaceae species in the Lesser Antilles, particularly in Martinique, through an interdisciplinary approach combining field observations, floristic inventories, and documentary analysis. Monthly observations conducted between 2016 and 2020 at the Ethnobotanical Park of the town of Marin, a reference site for ex situ conservation, provided valuable data on the seasonal behavior of these species in a controlled environmental context.

These results were enriched by the use of a database of 120 floristic inventories, conducted across Martinique between 2015 and 2020 as part of a doctoral project, allowing for a detailed characterization of the ecological profiles of the species studied. All the information collected contributes to our knowledge of the local dynamics of these Rubiaceae, and provides a useful scientific basis for the implementation of targeted conservation strategies, by identifying the ecological conditions conducive to their maintenance in the natural environment. Furthermore, the results obtained at the park strengthen ex situ conservation capacities, particularly for the safeguarding of genetic material and future reintroduction projects, thus laying the foundations for more coherent and sustainable management of threatened flora in the Lesser Antilles.

Acknowledgements

Monthly observations from 2016 to 2020, at the Ethnobotanical Park of the town of Marin in Martinique, were carried out by Jean-Philippe CLAUDE and Yelji ABATI. The floristic inventories were carried out from 2015 to 2020 with members of the UMR ESPACE DEV-BIORECA laboratory of the University of the Antilles. Several ecoclimatic data were collected from public organisations: Météo-France (French meteorological organisation), the IRD (Institute of Research for Development), the IGN (National Geographic Institute), the CTM (Territorial Collectivity of Martinique), and the DEAL (Department of Environment, Planning and Housing of Martinique).

Data Availability

The raw data from the observations carried out at the Ethnobotanical Park, in the town of Marin in Martinique, are not accessible online to the public. However, the floristic inventories and their analyses can be consulted from the thesis available online: https://theses.fr/2020ANTI0548.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Bouysse, P. (1984) The Lesser Antilles Island Arc: Structure and Geodynamic Evolution. *Initial Reports of the Deep Sea Drilling Project*, **78**, 83-103. https://doi.org/10.2973/dsdp.proc.78a.107.1984

[2] Germa, A. (2008) Evolution volcano-tectonique de l'île de la Martinique (arc insulaire des petites antilles): Nouvelles contraintes géochronologiques et géomorphologiques. Master's Thesis, Université Paris Sud-Paris XI. https://theses.fr/2008PA112308

[3] Boudon, G. and Balcone-Boissard, H. (2021) Volcanological Evolution of Montagne Pelée (Martinique): A Textbook Case of Alternating Plinian and Dome-Forming Eruptions. *Earth-Science Reviews*, **221**, Article ID: 103754. https://doi.org/10.1016/j.earscirev.2021.103754

[4] Howard, R.A., Garay, L.A., Sweet, H.R. and Proctor, G.R. (1974) Flora of the Lesser Antilles: Leeward and Windward Islands. Arnold Arboretum, Harvard University. https://doi.org/10.5962/t.187734

[5] Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. and Kent, J. (2000) Biodiversity Hotspots for Conservation Priorities. *Nature*, **403**, 853-858. https://doi.org/10.1038/35002501

[6] Fournet, J. (2002) Flore illustrée des phanérogames de Guadeloupe et de Martinique. Montpellier. CIRAD-Editions.

[7] Joseph, P., (2009) La végétation forestière des petites antilles: Synthèse bi-ogéographique et écologique, bilan et perspectives. KARTHALA Editions.

[8] Rollet, B., Fiard, J.P. and Huc, R. (2010) Arbres des Petites Antilles. Agris.fao.org.

[9] Joseph, P., Claude, J., Baillard, K., Abati, Y., Jean-Francois, Y., Major, P., *et al.* (2020) Contribution to the Knowledge of the Phytocenotic Diversity of the Lesser Antilles Revisiting Some Old and More Recent Floristic Data. *OALib*, **07**, 1-44. https://doi.org/10.4236/oalib.1106191

[10] Madani, A.B. and Cantet, P. (2021) Scénarios climatiques sur les Antilles françaises. Météo-France (DIRAG/EC-MPF). https://www.drias-climat.fr/Note_QQ_C3AF_CNRM-CM5_ARPEGE62

[11] Joseph, P. (2012) Quelques traits généraux de la diversité sylvatique des Petites Antilles. *VertigO*, **14**. https://doi.org/10.4000/vertigo.12492

[12] Joseph, P. (2015). Climax phase forest species of the lesser Antilles Forests. *International Journal of Recent Research and Review*, **VIII**, 57-69. https://www.ijrrr.com/issues8-4.htm

[13] Joseph, P. (2017) Contribution to the Knowledge of the Specific Aspects of the Lesser Antilles Flora: The Vegetation Inversions (the Case of Martinique's Lower Plant Level). *International Journal of Current Research*, **9**, 46960-46976. http://www.journalcra.com

[14] Venkatapen, C. (2012) Étude des déterminants géographiques et spatialisation des stocks de carbone des sols de la Martinique. Master's Thesis, University of the French Antilles and French Guiana. https://theses.fr/2012AGUY0513/

[15] Fujisaki, K., Demenois, J., Albrecht, A., Blanfort, V., Blazy, J.M., Teste, A., *et al.* (2023) Synthèse biophysique sur le stockage de carbone dans les sols en Martinique. Cirad-

Agritrop. https://agritrop.cirad.fr/604898/

[16] Fiard, J.P. (1992) Arbres rares et menacés de la Martinique. La Société.

[17] Joseph, P. (2004) La problématique du développement durable dans les Petites Antilles (quelques enseignements généraux). https://shs.hal.science/halshs-00003054v1

[18] Joseph, P. (2006) Hypothèses sur l'évolution de la végétation littorale des Petites Antilles depuis l'époque précolombienne: Le cas de la Martinique. *Cybergeo*. https://doi.org/10.4000/cybergeo.1784

[19] Burac, M. (2010) Gouvernance et biodiversité insulaire: Le cas des Antilles françaises. Biodiversité Insulaire, 260.

[20] Bernard, J.F., Étifier-Chalono, É., Feldmann, P., Fiard, J.P., Fournet, J., Jérémie, J., *et al.* (2014) Livre rouge des plantes menacées aux Antilles françaises. MNHN.

[21] Joseph, P. and Abati, Y. (2016) The Flower Plants Introduced in the Lesser Antilles: Martinique's Example (General Summary of the Key Data and Ecosystem Impacts. *IOSR Journal of Environmental Science*, *Toxicology and Food Technology*, **10**, 88-108. https://doi.org/10.9790/2402-10080288108

[22] Abati, Y. (2021) Écologie des principales espèces végétales potentiellement invasives des Petites Antilles: Le cas de la Martinique. Master's Thesis, Université des Antilles.

[23] Gargominy, O. (2003) Biodiversité et conservation dans les collectivités françaises d'outremer, IUCN: International Union for Conservation of Nature. Comité national des Membres de l'UICN de France.

[24] Marc, J. and Saffache, P. (2011) Disparités et limites du développement durable dans les Petites Antilles: Le cas de la Martinique et de la Dominique. In: Taglioni, F., Ed., *Insularité et développement durable*, IRD Éditions, 433-451. https://doi.org/10.4000/books.irdeditions.5778

[25] Fiard, J.P. (1994) Les forêts du nord de la montagne pelée et des édifices volcaniques du piton du mont Conil et du morne Sibérie: Martinique. Master's Thesis, University of the Antilles.

[26] Claude, J.P. (2020) Écologie des Rubiacées des Petites Antilles: Le cas de la Martinique. Master's Thesis, Université de Guyane. https://theses.fr/2020ANTI0548

[27] Claude, J.P., Joseph, P., Abati, Y., Major, P., Jean-Francois, Y., Ely-Marius, S., *et al.* (2023) Considerations on the Ecology of *Rubiaceae* in Martinique (Lesser Antilles). *Ecology*, *Environment and Conservation*, **29**, 1001-1023. https://doi.org/10.53550/eec.2023.v29i03.001

[28] Razafimandimbison, S.G. and Rydin, C. (2024) Phylogeny and Classification of the Coffee Family (*Rubiaceae*, *Gentianales*): Overview and Outlook. *Taxon*, **73**, 673-717. https://doi.org/10.1002/tax.13167

[29] Fournet, J. and Hammerton J.L. (1991) Weeds of the Lesser Antilles/Mauvaises Herbes des Petites Antilles. Inrae-Quae. Editions CARDI, Collection: Techniques et pratiques, 214.

[30] INPN (National Inventory of Natural Heritage) (2025) Botanical and Ecological Data.

[31] Sastre, C. and Breuil, A. (2007) Plantes, milieux et paysages des Antilles françaises: Écologie, biologie, identification, protection et usages. Biotope, 672.

[32] Murillo, P.G. and Martín, I.A. (2021) Plantas y serpientes: Una revisión de las plantas utilizadas popularmente como tratamiento antiofídico. *Folia Botanica Extremadurensis*, **15**, 5-31.

[33] Grenand, P. and Prévost, M. (1994) Les plantes colorantes utilisées en Guyane française. *Journal d'agriculture traditionnelle et de botanique appliquée*, **36**, 139-172. https://doi.org/10.3406/jatba.1994.3538

[34] Longuefosse, J.L. (2011) Plantes médicinales caribéennes. Volume 2. Edition Orphie.

[35] Claude, J., Ranguin, N., Abati, Y. and Joseph, P. (2024) Ornamentals of *Rubiaceae* Family: Current Status and Potency Evaluation of Its Phytocoenosis for Dooryard Gardening in Martinique. *Ornamental Horticulture*, **30**, 1-14. https://doi.org/10.1590/2447-536x.v30.e242778

[36] de Albuquerque, U.P., de Medeiros, P.M., de Almeida, A.L.S., Monteiro, J.M., de Freitas Lins Neto, E.M., de Melo, J.G., *et al.* (2007) Medicinal Plants of the Caatinga (Semi-Arid) Vegetation of NE Brazil: A Quantitative Approach. *Journal of Ethnopharmacology*, **114**, 325-354. https://doi.org/10.1016/j.jep.2007.08.017

[37] Duke, J.A. (1970) Ethnobotanical Observations on the Chocó Indians. *Economic Botany*, **24**, 344-366. https://doi.org/10.1007/bf02860669

[38] Erbano, M. and Duarte, M.R. (2011) Macro and Microscopic Analysis of the Leaf and Stem of *Randia armata* (Sw.) DC., *Rubiaceae*. *Latin American Journal of Pharmacy*, *Buenos Aires*, **30**, 1239-1243.

[39] Odonne, G., Valadeau, C., Alban-Castillo, J., Stien, D., Sauvain, M. and Bourdy, G. (2013) Medical Ethnobotany of the Chayahuita of the Paranapura Basin (Peruvian Amazon). *Journal of Ethnopharmacology*, **146**, 127-153. https://doi.org/10.1016/j.jep.2012.12.014

[40] Cruz-Silva, S.C.B.D., Matias, R., Bono, J.A.M., Santos, K.S. and Ludwig, J. (2016) Antifungal Potential of Extracts and Fractions of *Randia* Nitida Leaves on Soybean Pathogens and Their Phytochemistry. *Revista Caatinga*, **29**, 594-602. https://doi.org/10.1590/1983-21252016v29n309rc

[41] Météo-France (French Meteorological Organisation) (2025) Weather and Climate Data.

[42] Lobo Segura, J.A., Aguilar, R., Chacón Madrigal, E. and Fuchs Castillo, E.J. (2007) Fenología de especies de árboles de la Península de Osa y la región de Golfo Dulce, Costa Rica.

[43] PNRM (Parc Naturel Régional de la Martinique) (2025) Ecological Information on Natural Spaces. https://pnr-martinique.com

[44] CBNMQ (Conservatoire Botanique National de la Martinique) (2025) Botanical and Ecological Data, Ecological Information. https://cbn-martinique.org

[45] Pavis, C., Umber, M. and Boisseau, M. (2015) Projet CRB Plantes Tropicales 2016-2017: Conservation et caractérisation des ressources biologiques végétales pour leur valorisation. INRAE-CIRAD.

Appendix 1. List of 120 Stations of Floristic Inventory [26]

Station	Municipality	Latitude	Longitude
1	Marin	1602031	729548
2	Marin	1602790	730343
3	Marin	1602804.212	730448.953
4	Marin	1602635.67	729086.75
5	Marin	1602702.58	729166.36
6	Marin	1602832.66	729254.34
7	Marin	1603153.387	729538.061
8	Marin	1603128.362	729578.997
9	Marin	1603232.518	729542.695
10	Marin	1603228	729674
11	Marin	1603299	729802
12	Marin	1602758.07	730266.76
13	Marin	1602779.81	730231.56
14	Trinité	1,629,234	720,802
15	Robert	1,621,000	723,455
16	Trinité	1,633,603	727,300
17	Trinité	1,633,665	727,750
18	Sainte-Anne	1,594,081	728,106
19	Sainte-Marie	1,632,981	709,011
20	Vauclin	1,605,426	731,836
21	Vauclin	1,605,425	731,812
22	Vauclin	1,605,458	731,742
23	Vauclin	1,605,573	731,777
24	Vauclin	1,605,392	731,742
25	Vauclin	1,605,476	731,898
26	Vauclin	1,605,603	731,905
27	Vauclin	1,605,546	731,951
28	Vauclin	1,605,678	731,892
29	Vauclin	1,605,489	731,943
30	Vauclin	1,605,446	732,031
31	Sainte-Anne	1,596,214	728,435
32	Sainte-Anne	1,596,267	728,688
33	Sainte-Anne	1595999.6	728,691
34	Sainte-Anne	1596055.71	728419.08
35	Sainte-Anne	1595861.2	728400.4
36	Sainte-Anne	1595721.1	728207.6

Continued

37	Sainte-Anne	1595767.6	728957.4
38	Sainte-Anne	1596079.8	728883.2
39	Sainte-Anne	1596794	728901
40	Sainte-Anne	1596814.8	728864.2
41	Sainte-Anne	1597047.7	728,891
42	Sainte-Anne	1596943.4	728911.1
43	Sainte-Marie	1,635,425	709,662
44	Sainte-Anne	1594747.8	727796.9
45	Sainte-Anne	1594877.7	727664.3
46	Trinité	1633012.664	723263.003
47	Trinité	1632970.626	723193.05
48	Sainte-Anne	1596236.7	728530.3
49	Sainte-Anne	1,598,801	731,246
50	Sainte-Anne	1596230.4	727970
51	Marin	1,601,365	730,633
52	Marin	1,601,395	730,640
53	Marin	1,601,582	729,986
54	Marin	1,601,515	729,983
55	Diamant	1602644.1	710598.1
56	Diamant	1602490.7	710584.2
57	Diamant	1,602,544	710568.5
58	Diamant	1602803.6	710674.1
59	Diamant	1602798	710624.1
60	Diamant	1602519.9	710484.1
61	Diamant	1602552.8	710448.9
62	Diamant	1602620	710550.8
63	Diamant	1602782.7	710589.8
64	Diamant	1602573.5	710500.9
65	Diamant	1602653.7	710634.6
66	Diamant	1602632.3	710644.4
67	Diamant	1602597.62	710624.569
68	Vauclin	1606351.026	732132.936
69	Vauclin	1606278.180	732237.385
70	Vauclin	1606245.193	732278.094
71	Vauclin	1606232.594	732309.914
72	Vauclin	1606316.108	732195.638
73	Vauclin	1606165.132	732544.927

Continued

74	Marin	1600827.3	728519
75	Marin	1600805.9	728492.3
76	Marin	1600789	728462.8
77	Marin	1600763.6	728438.3
78	Marin	1600738.6	728405.8
79	Marin	1600807.7	728538.6
80	Marin	1600786.3	728560.5
81	Marin	1600737.7	728472.6
82	Marin	1600766.7	728476.2
83	Marin	1598933.353	726089.815
84	Marin	1598910.04	726131.789
85	Marin	1598964.295	726048.418
86	Marin	1599059.894	726027.099
87	Fort de France	1623701.061	705193.128
88	Fort de France	1623631.194	705126.389
89	Fort de France	1623653.201	705102.174
90	Case-Pilote	1623964.111	703308.368
91	Marin	1601000.510	730073.266
92	Marin	1600958.733	730097.480
93	Marin	1600935.651	730078.230
94	Marin	1601008.769	730099.153
95	Vauclin	1604298.099	734510.52
96	Vauclin	1604458.993	734534.568
97	Sainte-Anne	1593740.426	728079.439
98	Sainte-Luce	1603732.913	722993.613
99	Sainte-Luce	1603655.382	722823.402
100	Case-Pilote	1620776.101	699786.154
101	Case-Pilote	1620872.739	699733.764
102	Schoelcher	1620854.731	704085.829
103	Schoelcher	1620652.683	704241.155
104	Case-Pilote	1623076.7	701880.338
105	Sainte-Marie	1633707.432	710027.972
106	Fort de France	1,623,610	704,779
107	Marin	1,599,548	726,211
108	Diamant	1,604,706	712,505
109	Schoelcher	1,617,852	705,223
110	Schoelcher	1,617,795	705,287

Continued

111	Schoelcher	1,617,949	705,237
112	Schoelcher	1,617,974	705,287
113	Schoelcher	1,618,098	705,376
114	Schoelcher	1,618,423	705,380
115	Schoelcher	1,618,466	705,455
116	Schoelcher	1,618,569	705,636
117	Schoelcher	1,618,747	705,711
118	Schoelcher	1,619,300	705,344
119	Schoelcher	1,618,566	705,426
120	Schoelcher	1,618,687	705,451

Appendix 2. Characteristics of the 120 Inventory Stations of the Thesis [26]

S	SE	*Bioclimate or mesoclimate*	Tmin	Tmax	Taverage	Rain	Eva	Ins	H
1	SYSF	ecotone (xero-mesophile)	23.2	28.9	26.1	1854	1675	2800	51
2	SYSF	ecotone (xero-mesophile)	23.1	28.4	25.8	1853	1675	2800	64
3	SYSF	ecotone (xero-mesophile)	23.1	28.4	25.8	1853	1675	2800	66
4	PF	subhumid dry	23.2	28.9	26.1	1854	1675	2800	45
5	PF	subhumid dry	23.2	28.9	26.1	1854	1675	2800	49
6	PF	subhumid dry	23.2	28.9	26.1	1854	1675	2800	82
7	PF	subhumid dry	22.4	27.9	25.2	1900	1675	2800	84
8	PF	subhumid dry	22.4	27.9	25.2	1900	1675	2800	69
9	PF	subhumid dry	22.4	27.9	25.2	1900	1675	2800	108
10	SYSF	subhumid dry	22.4	27.9	25.2	1900	1675	2800	56
11	SYSF	subhumid dry	22.4	27.9	25.2	1900	1675	2800	72
12	PF	subhumid dry	23.1	28.4	25.8	1853	1675	2800	69
13	MSF	subhumid dry	23.1	28.4	25.8	1853	1675	2800	71
14	Mangrove	subhumid dry	23.8	30.4	27.1	2093	1625	2700	3
15	Mangrove	subhumid dry	24.6	30	27.3	1572	1625	2700	1
16	Mangrove	subhumid dry	23.4	30.8	27.1	1783	1650	2700	5
17	Mangrove	subhumid dry	23.4	30.8	27.1	1783	1650	2700	1
18	Mangrove	subhumid dry	24	29.5	26.8	1393	1625	2900	3
19	SSF	humid	21	28.1	24.6	3870	1575	2400	252
20	SYSF	subhumid humid	23.3	28.4	25.9	1575	1675	2700	152
21	SYSF	subhumid dry	23.3	28.4	25.9	1575	1675	2700	143
22	SYSF	subhumid humid	23.3	28.4	25.9	1575	1675	2700	131
23	SYSF	subhumid humid	23.3	28.4	25.9	1575	1675	2700	140
24	SYSF	subhumid dry	23.3	28.4	25.9	1575	1675	2700	130
25	SYSF	subhumid dry	23.3	28.4	25.9	1575	1675	2700	194
26	PF	subhumid dry	23.3	28.4	25.9	1575	1675	2700	182
27	SYSF	subhumid dry	23.3	28.4	25.9	1575	1675	2700	196
28	SYSF	Subhumide humid	23.3	28.4	25.9	1575	1675	2700	145
29	PF	subhumid humide	23.3	28.4	25.9	1575	1675	2700	201
30	SYSF	subhumid dry	23.5	28.9	26.2	1489	1675	2700	166
31	PF	subhumid dry	24.2	29.7	27.0	1441	1625	2900	71
32	SYSF	subhumid dry	24.2	29.7	27.0	1441	1625	2900	65
33	SYSF	subhumid dry	23.9	29.3	26.6	1421	1625	2900	89
34	SYSF	subhumid dry	24.2	29.7	27.0	1441	1625	2900	80

Continued

35	SYSF	subhumid dry	23.9	29.3	26.6	1421	1625	2900	123
36	PF	subhumid dry	23.9	29.3	26.6	1421	1625	2900	30
37	SYSF	subhumid dry	23.9	29.3	26.6	1421	1625	2900	107
38	PF	subhumid dry	24.2	29.7	27.0	1441	1625	2900	38
39	PF	subhumid dry	24.2	29.7	27.0	1441	1625	2900	63
40	SYSF	subhumid dry	24.2	29.7	27.0	1441	1625	2900	51
41	SYSF	subhumid dry	24.6	29.9	27.3	1476	1625	2900	71
42	SYSF	subhumid dry	24.2	29.7	27.0	1441	1625	2900	82
43	SSF	humid	21.7	28.7	25.2	3123	1575	2400	177
44	SF	subhumid dry	24.3	29.6	27.0	1397	1625	2900	3
45	MSF	subhumid dry	24.3	29.6	27.0	1397	1625	2900	7
46	PF	subhumid humid	23.9	30.8	27.4	1951	1625	2700	14
47	PF	subhumid humid	23.9	30.8	27.4	1951	1625	2700	19
48	PF	subhumid dry	24.2	29.7	27.0	1441	1625	2900	54
49	SYSF	subhumid dry	23.6	28.9	26.3	1625	1675	2900	85
50	SYSF	subhumid dry	24.4	29.6	27.0	1438	1625	2900	13
51	SSF	subhumid humid	23.2	28.6	25.9	1814	1625	2800	30
52	SYSF	subhumid dry	23.2	28.6	25.9	1814	1625	2800	30
53	SYSF	ecotone (xero-mesophile)	23.5	28.7	26.1	1810	1625	2800	80
54	SSF	ecotone (xero-mesophile)	23.5	28.7	26.1	1810	1625	2800	80
55	SF	subhumid dry	22.8	30.9	26.9	1609	1575	2700	108
56	MSF	subhumid dry	22.8	30.9	26.9	1609	1575	2700	136
57	SF	subhumid dry	22.8	30.9	26.9	1609	1575	2700	127
58	SYSF	ecotone (xero-mesophile)	22.8	30.9	26.9	1609	1575	2700	97
59	SYSF	ecotone (xero-mesophile)	22.8	30.9	26.9	1609	1575	2700	103
60	SF	subhumid dry	22.8	30.9	26.9	1609	1575	2700	130
61	PF	subhumid dry	22.8	30.9	26.9	1609	1575	2700	124
62	SF	subhumid dry	22.8	30.9	26.9	1609	1575	2700	108
63	SYSF	ecotone (xero-mesophile)	22.8	30.9	26.9	1609	1575	2700	103
64	SF	subhumid dry	22.8	30.9	26.9	1609	1575	2700	116
65	PF	subhumid dry	22.8	30.9	26.9	1609	1575	2700	108
66	SF	subhumid dry	22.8	30.9	26.9	1609	1575	2700	115
67	MSF	subhumid dry	22.8	30.9	26.9	1609	1575	2700	115
68	SF	subhumid dry	24	29	26.5	1393	1675	2700	33
69	SF	subhumid dry	24	29	26.5	1393	1675	2700	67

Continued

70	SF	subhumid dry	24	29	26.5	1393	1675	2700	79
71	PF	subhumid dry	24	29	26.5	1393	1675	2700	80
72	PF	subhumid dry	24	29	26.5	1393	1675	2700	61
73	PF	subhumid dry	24	29	26.5	1393	1675	2700	80
74	E.C.D	subhumid humid	23.2	29.1	26.2	1751	1625	2800	4
75	E.C.D	subhumid humid	23.2	29.1	26.2	1751	1625	2800	4
76	E.C.D	subhumid humid	23.2	29.1	26.2	1751	1625	2800	4
77	E.C.D	subhumid humid	23.2	29.1	26.2	1751	1625	2800	4
78	E.C.D	subhumid humid	23.2	29.1	26.2	1751	1625	2800	4
79	E.C.D	subhumid humid	23.2	29.1	26.2	1751	1625	2800	4
80	E.C.D	subhumid humid	23.2	29.1	26.2	1751	1625	2800	4
81	E.C.D	subhumid humid	23.2	29.1	26.2	1751	1625	2800	4
82	E.C.D	subhumid humid	23.2	29.1	26.2	1751	1625	2800	4
83	PF	subhumid dry	23.4	29	26.2	1592	1625	2800	2
84	SF	subhumid dry	23.4	29	26.2	1592	1625	2800	2
85	PF	subhumid dry	23.4	29	26.2	1592	1625	2800	8
86	SF	subhumid dry	22.7	28.4	25.6	1698	1625	2800	26
87	SSF	Humid	20.2	26.7	23.5	2613	1650	2500	443
88	SSF	Humid	20.2	26.7	23.5	2613	1650	2500	387
89	SSF	Humid	20.2	26.7	23.5	2613	1650	2500	400
90	SSF	Humid	19.7	26.7	23.2	2479	1675	2500	592
91	SYSF	subhumid dry	23.8	28.7	26.3	1814	1650	2800	33
92	SYSF	subhumid dry	23.8	29.2	26.5	1741	1650	2800	37
93	PF	subhumid dry	23.8	29.2	26.5	1741	1650	2800	41
94	SYSF	subhumid dry	23.2	28.7	26.0	1814	1650	2800	27
95	SYSF	subhumid dry	24.2	29.2	26.7	1513	1700	2800	8
96	MSF	subhumid dry	24.2	29.2	26.7	1513	1700	2800	14
97	PF	subhumid dry	24.3	29.5	26.9	1387	1625	2900	2
98	SSF	ecotone (meso-hygrophilic)	22.3	28.3	25.3	1965	1600	2700	294
99	SSF	ecotone (meso-hygrophilic)	22.3	28.3	25.3	1965	1600	2700	257
100	SYSF	subhumid dry	23.4	31.5	27.5	1748	1775	2700	101
101	PF	subhumid dry	23.4	31.5	27.5	1748	1775	2700	62
102	SSF	subhumid humid	21.3	29.1	25.2	1749	1725	2700	180
103	SSF	subhumid humid	21.3	29.1	25.2	1749	1725	2700	130
104	SSF	ecotone (meso-hygrophilic)	20.7	28.3	24.5	2319	1675	2600	611

Continued

105	SSF	ecotone (meso-hygrophilic)	**21**	**28.4**	**24.7**	**3443**	**1575**	**2400**	**447**
106	SSF	Humid	**19.6**	**26.6**	**23.1**	**2507**	**1650**	**2500**	**500**
107	SYSF	ecotone (meso-hygrophilic)	**22.7**	**28.4**	**25.6**	**1698**	**1625**	**2800**	**259**
108	SSF	subhumid humid	**21.3**	**29**	**25.2**	**1757**	**1575**	**2700**	**363**
109	SSF	subhumid humid	**23.4**	**30.7**	**27.1**	**1708**	**1750**	**2700**	**20**
110	SSF	subhumid humid	**23.4**	**30.7**	**27.1**	**1708**	**1750**	**2700**	**21**
111	SYSF	subhumid dry	**23.4**	**30.7**	**27.1**	**1708**	**1750**	**2700**	**34**
112	PF	subhumid dry	**23.4**	**30.7**	**27.1**	**1708**	**1750**	**2700**	**42**
113	PF	subhumid dry	**23**	**30.2**	**26.6**	**1705**	**1750**	**2700**	**58**
114	FVTD	subhumidhumid	**23**	**30.2**	**26.6**	**1705**	**1750**	**2700**	**35**
115	FVTD	subhumid humid	**23**	**30.2**	**26.6**	**1705**	**1750**	**2700**	**33**
116	FVTD	ecotone (xero-mesophil)	**23**	**30.2**	**26.6**	**1705**	**1750**	**2700**	**109**
117	FVTD	subhumid humid	**23**	**30.2**	**26.6**	**1705**	**1750**	**2700**	**80**
118	SYSF	ecotone (xero-mesophil)	**22.4**	**29.7**	**26.1**	**1738**	**1750**	**2700**	**195**
119	FVTD	subhumid humid	**23**	**30.2**	**26.6**	**1705**	**1750**	**2700**	**39**
120	SSF	subhumid humid	**23**	**30.2**	**26.6**	**1705**	**1750**	**2700**	**45**

S = station; SE = Stage of evolution; Tmin = Minimum temperatures (˚C); Tmax = Maximum temperatures (˚C); Taverage = Average temperatures (˚C); Rain = Rainfall; Eva = Evapotranspiration; Ins = Insolation; H = Height; SE = Stage of evolution: (S.F): Shrub formation/(M.S.F): Mature shrub formation/(P.F): Presylvatic formation/(S.Y.S.F): Structured young sylvatic formation/(S.S.F): Secondary sylvatic formation/(E.C.D): Degraded back-mangrove plant eco-unit/(FVTD): Very degraded plant formation.