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Research Article

Resilience of Vascular Epiphytes to the Effects of Anthropization in the Djapadji Enclave

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Abstract

The intensification of agricultural activities has led to a conversion of natural vegetation into fallow land and plantations in the Djapadji enclave. This study is therefore initiated to analyze the reactions of epiphytes to changes in land use, taking into account local microclimates. To achieve this objective, the diversity of epiphytes was characterized in the different biotopes of the Djapadji enclave. The floristic inventories made it possible to identify 16 species of vascular epiphytic plants in the study area. In the cocoa plantations, 12 epiphytic species were identified. Then, 11 epiphytic species were observed in the fallow land. Finally, 8 epiphytic species were collected in the rubber plantations. Of all the collections, the most diverse families are the Polypodiaceae represented by four epiphytic species: *Microsorum punctatum*, *Phymatodes scolopendria*, *Platycerium angolense* and *Microgramma owariensis*. The Orchidaceae are represented by *Ancistrorhynchus capitatus* and *Solenangis Scandens*. The Euphorbiaceae are also represented by two species: *Alchornea cordifolia* and *Croton hirtus*. Observations show that the crown area of the host trees influences the abundance of epiphytes. Trees whose branches cover a large horizontal surface have a greater tendency to shelter epiphytes. The Taï National Park, adjacent to the study site, also acts as a seed bank for the inventoried epiphytes. Given the ecological requirements of these epiphytes, it is appropriate to anticipate the degradation of their forest habitats in order to perpetuate them.

Keywords

Local Microclimates, Floristic Diversity, Epiphytes, Anthropogenic Pressure

1. Introduction

The expansion and development of anthropogenic activities continue to fragment and degrade tropical forests worldwide. This phenomenon is leading to a loss of biological diversity on a global scale. Brummitt, Bachman [1] estimate that 20% of global biological diversity is lost due to anthropogenic activities. All these pressures linked to anthropogenic activi-

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ties as well as changes in climate, reduce the quantity of habitats and alter their quality [2]. In all these biotopes threatened by anthropogenic activities, epiphytes are found. These are aerial plants that depend structurally on trees and constitute an important group in tropical forests [3-5]. These epiphytes constitute micro-habitats and then food sources for some animals and influence the water cycle [6]. However, many tropical agricultural systems have trees that function as facilities for epiphytes. This arrangement of host individuals allows epiphyte communities to persist in landscapes with reduced connectivity between forests [7].

In Côte d'Ivoire, the anthropization of natural habitats due to extensive agriculture is common to the entire forest area [8]. However, the case of the Djapadji enclave attracts attention. A forest enclave is an area of forest surrounded by other forest areas from which it differs by one or more essential characteristics. The Djapadji enclave, with an area of 7,100 hectares, is limited in its northern part by the Taï National Park and in the south by the Rapide-Grah classified forest. The Djapadji enclave is an area that has been excluded from the state forest domain in response to requests from indigenous populations who claim this space. This area, which is currently being declassified, is essentially made up of fallow land and agricultural plantations. The original vegetation of the area belongs to the mesophilic sector composed of dense humid semi-deciduous forests with *Celtis* spp. and *Triplochiton scleroxylon* with *Aubrevillea kerstingii* and *Khaya grandifolia* [9]. The intensification of agricultural activities has led to the transformation of the original vegetation into various secondary plant formations such as fallow land and forest plantations. The main perennial crops in the Djapadji enclave are cocoa and rubber plantations.

In tropical forests, the drop in humidity and strong sunlight due to the loss of plant cover strongly affects epiphytes, particularly taxa sensitive to drought [10]. Epiphyte distribution models also indicate that many epiphytic species may be threatened by a deterioration of the natural habitat [11, 12]. This study therefore aims to analyze the reactions of epiphytes to changes in land use, taking into account local microclimates. To achieve this objective, it is appropriate to characterize the diversity of epiphytes in the different biotopes of the Djapadji enclave. The ecology of epiphytes in the different biotopes of the Djapadji enclave will also be established.

2. Materials and Methods

2.1. Data Collection

The study area concerns all the lands of the village of Djapadji, which is an enclave within the classified forest of Rapide-Grah, limited in its northern part by the Taï National Park (Figure 1). All the main biotopes present were covered. These are fallow land, cocoa plantations and rubber plantations. In each biotope, 10 inventory plots were placed and a total of 30 plots over the entire study area. Each inventory plot is a square of 25 m on each side, or an area of 625 m².

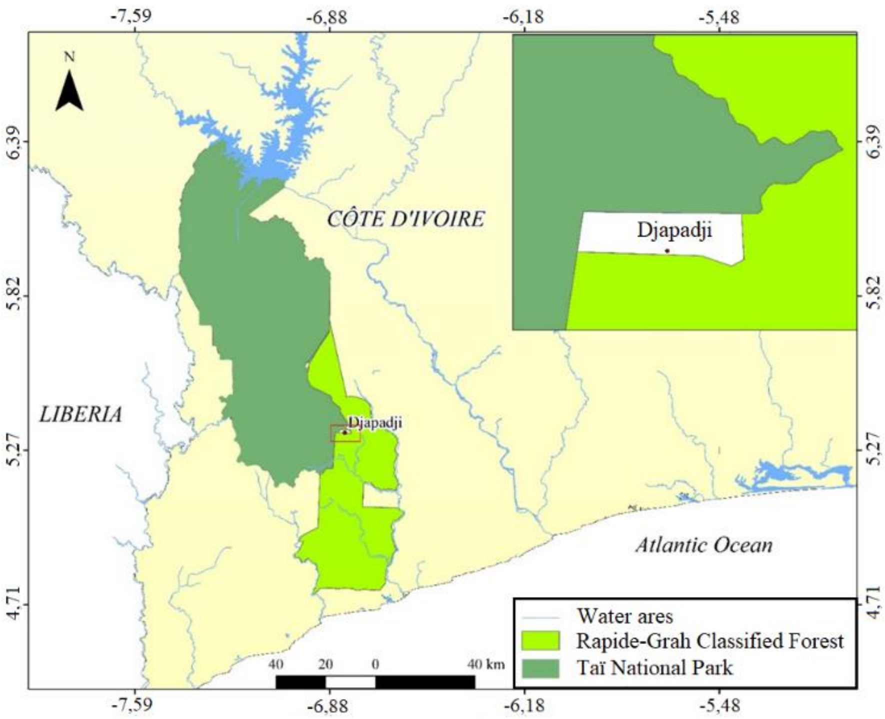

Figure 1. *Location of the Djapadji enclave in the Rapide-Grah classified forest.*

Each inventory plot is described according to environmental factors. The canopy coverage rate is estimated based on the percentage of the surface representing the canopy. When the canopy cover rate is average, the incident radiation reaching the lower strata is between 40% and 60% of the incident solar radiation. For lower cover values, the canopy is considered open. When canopy cover values are high, the canopy is considered closed. Water availability was assessed based on soil hydromorphy. Permanent or seasonal water availability in lowland areas, as well as land areas were characterized. On each inventory plot, woody plants with dbh greater than 5 cm are inventoried. Each host bearing epiphytes is listed, the epiphytes present are identified and then counted. The nature of the substrate was taken into account in the mode of attachment of epiphytes to their different hosts. Several studies [13, 14] have investigated substrate types and their importance for epiphytic plants. The main substrate types observed in this study were humus deposits at the internodes and rhytidomes of host plants.

2.2. Data Analysis

The floristic lists of the different biotopes were drawn up. The inventoried epiphytes were categorized according to the different ecological adaptations [15, 16]. The biological types of the species observed in epiphytic were determined according to the classification proposed by [17]. This involves classifying these plants according to the positioning of their survival organs. The chorological type which makes it possible to define the phytogeographic distribution area of a plant species was established on the basis of the work of [18]. Finally, the conservation status was addressed for each epiphyte by comparing the list established during the floristic inventories with that of [19]. To express the floristic diversity of the different inventoried biotopes, the diversity indices were calculated according to [20]. The floristic similarities between the different inventoried biotopes were evaluated from the similitude coefficient according to [21]. The equitability index according to [22], also called the regularity or equidistribution index. It reflects the way in which individuals are distributed across the different species present. This index made it possible to analyze the distribution of individuals across the species inventoried.

The data were analyzed and statistically processed using Excel 2021. The plots from the different biotopes were compared on the basis of the species occupying them as well as the environmental parameters. Canonical correspondence analysis makes it possible, under such conditions, to relate the two species and environmental variable matrices [23]. In this study, canonical correspondence analysis made it possible to evaluate the spatial distribution of epiphytes on plots from the different biotopes, depending on the opening of the canopy and the availability of water.

Tests for comparing the means of a variable are widely discussed [24-26]. The choice of a method depends on several parameters. In our case, where it was often a question of comparing means of variables tested on more than two groups, only the one-way analysis of variance (ANOVA 1) was used. The degree of freedom is $n - k$ where n and k are respectively the numbers of observations and groups. The significance level chosen for these analyses is 5 p. c. ($p = 0.05$). When the difference is significant, a post-hoc test (Tukey test) was carried out to classify and know which groups are different. In addition to the independence of observations, normality and homogeneity of variances (homoscedasticity) are constraints on the application of the analysis of variance. Normality is verified by the Shapiro-Wilk test. Homogeneity of variances was verified by the Bartlett test. XLSTAT software was used to carry out these tests. Tree barks have been classified into four categories based on the work of [27] which defines rough bark (with deep grooves and ridges), semi-rough bark (with small grooves and ridges), smooth bark (without peeling or cracks) and peeled bark (peeling in sheets).

3. Results

Of all the collections, the plots placed in the rubber plantations have the highest density in number of woody plants likely to shelter epiphytic flora. The number of woody plants with dbh greater than 5 cm varies between 18 and 32 depending on the plots. The average number of individuals present in the plots placed in the rubber plantations is 23.7 ± 4.03, i. e. a density of 379.2 individuals per hectare. Of all these individuals present, 31.94 ± 12.57 p. c. of plants carries at least one epiphyte. Concerning the plots placed in the cocoa plantations, the number of woody plants inventoried varies between 11 and 32 individuals depending on the plots. With an average of 19 ± 6.07 individuals per plot, the cocoa plantations have a density of 304 individuals per hectare. The rate of presence of epiphytes on the feet is $71.13 \pm 9.22\%$ of all the individuals inventoried. In the plots placed at the level of the fallows, the number of feet varies between 13 and 21, with an average of 15.9 ± 2.88 individuals per plot, or an average of 254.4 individuals per hectare. The rate of presence of epiphytes on woody individuals is $30.63 \pm 7.83\%$ on all the plots. The different values of densities of afforestation in the biotopes inventoried are significantly different (ANOVA: ddl = 2; $F = 7.530$; $\rho = 0.003$). The first group is represented by the rubber plantations are the most wooded biotopes. The second group is composed of cocoa plantations. The fallow lands, which represent the third group, are the least wooded of the different biotopes inventoried.

Out of all the collections carried out, 16 epiphytic plant species were observed. These are 12 epiphytic plants in cocoa plantations. Finally, 11 epiphytic plants were observed in the fallow lands. Finally, 8 epiphytic species are found in rubber plantations. The most observed species are *Platycerium angolense* with 71 occurrences in all the inventories, *Piper* *guineense* with 38 occurrences, *Cercestis afzelii* with 36 occurrences, *Phymatodes scolopendria* with 32 occurrences, *Heterotis rotundifalia* with 20 occurrences, *Nephrolepis biserrata* with 19 occurrences. The least observed are *Microsorum punctatum* with 8 occurrences, *Chromolaena odorata* with 7 occurrences, *Ancistrorhynchus capitatus* with 6 occurrences, *Nephrolepis biserrata* with 5 occurrences, *Solenangis Scandens* with 5 occurrences, *Cyperus sphacelatus* with 3 occurrences. Only 2 occurrences for each of the species *Alchornea cordifolia*, *Croton hirtus* and *Panicum maximum*, then only one occurrence for *Elaeis guineensis*, *Morinda lucida* and *Panicum maximun*.

In the rubber plantations, 3 host species are identified. These are *Enthandrophragma cylindricum* which carries two epiphytic individuals which are *Cercestis afzelii* and *Piper guineense*. *Terminalia superba* is host to 3 epiphytic individuals of *Piper guineense*. The third host present remains *Hevea brasiliensis* which shelters 7 different epiphytes which are *Cercestis afzelii*, *Heterotis rotundifalia*, *Microsorum punctatum*, *Nephrolepis biserrata*, *Piper guineense*, *Platycerium angolense* and *Solenangis Scandens*. In cocoa plantations, 6 host species were identified. *Citrus sinensis* and *Mangifera indica* are host species of *Platycerium angolense* on all the harvests. As for *Coffea arabica*, this host species also shelters an individual of *Panicum maximum* in epiphyty. On *Cola nitida*, the epiphyte *Cercestis afzelii* is observed. As for *Elaeis guineensis*, this host shelters 3 individuals of *Nephrolepis biserrata*. *Theobroma cacao* is the host with the greatest diversity of epiphytic species with 10 epiphytes which are *Ancistrorhynchus capitatus*, *Cercestis afzelii*, *Croton hirtus*, *Cyperus sphacelatus*, *Heterotis rotundifalia*, *Microsorum punctatum*, *Nephrolepis biserrata*, *Phymatodes scolopendria*, *Platycerium angolense*, *Solenangis Scandens*. In fallows, epiphytes were observed on 13 different host species. The species bearing epiphytes in the fallows are *Alchornea cordifolia*, *Alstonia boonei*, *Ceiba pentandra*, *Coffea arabica*, *Elaeis guineensis*, *Funtumia africana*, *Macaranga barteri*, *Morinda lucida*, *Myrianthus arboreus*, *Pycnanthus angolensis*, *Rauvolfia vomitoria*, *Tabernaemontana crassa* and *Terminalia superba*. In all the inventories, 48 individuals were observed in epiphytic form. These are Nephrolepis biserrata with 14 occurrences, Cercestis afzelii with 12 occurrences, *Chromolaena odorata* with 7 occurrences and *Piper guineense* with 6 occurrences. The other epiphytes present have less than 5 occurrences each. These are *Alchornea cordifolia*, *Elaeis guineensis*, *Morinda lucida*, *Panicum maximun*, *Phymatodes scolopendria*, *Solenangis Scandens*.

The relative frequency and relative density values of the different epiphytes show varying levels of importance depending on the biotopes (Table 1). In cocoa plantations, the dominant epiphytes are *Platycerium angolense*, *Phymatodes scolopendria* and *Heterotis rotundifalia*. Concerning rubber plantations, the most dominant epiphytes are *Piper guineense*, *Cercestis afzelii* and *Platycerium angolense*. In fallow lands, the major epiphytes are *Nephrolepis biserrata*, *Cercestis afzelii* and *Chromolaena odorata*.

Table 1. *Importance of epiphytes inventoried in the different biotopes of the Djapadji enclave.*

Species	Cocoa plantation		Hevea plantation		Fallow	
	Frequency	**Density**	**Frequency**	**Density**	**Frequency**	**Density**
Alchornea cordifolia	0	0	0	0	0.1	0.04
Ancistrorhynchus capitatus	0.4	0.05	0	0	0	0
Cercestis afzelii	0.4	0.04	0.8	0.24	0.6	0.25
Chromolaena odorata	0	0	0	0	0.7	0.15
Croton hirtus	0.2	0.02	0	0	0	0
Cyperus sphacelatus	0.3	0.02	0	0	0	0
Elaeis guineensis	0	0	0	0	0.1	0.02
Heterotis rotundifalia	0.5	0.14	0.1	0.03	0	0
Microsorum punctatum	0.4	0.05	0.1	0.01	0	0
Morinda lucida	0	0	0	0	0.1	0.02
Nephrolepis biserrata	0.5	0.04	0.5	0.06	0.8	0.29
Panicum maximum	0.2	0.02	0	0	0.1	0.02
Phymatodes scolopendria	0.9	0.23	0	0	0.1	0.02

Species	Cocoa plantation		Hevea plantation		Fallow	
	Frequency	Density	Frequency	Density	Frequency	Density
Piper guineense	0	0	0.9	0.41	0.2	0.13
Platycerium angolense	1	0.4	0.6	0.23	0	0
Solenangis Scandens	0.1	0.01	0.1	0.01	0.3	0.06

Based on the IUCN Red List (2023), 4 epiphytic species are considered to be of least concern. These are *Alchornea cordifolia*, *Elaeis guineensis*, *Nephrolepis biserrata* and *Piper guineense*. *Microsorum punctatum*, on the other hand, is considered to be threatened with extinction.

The most diverse families are the Polypodiaceae represented by four epiphytic species which are *Microsorum punctatum*, *Phymatodes scolopendria*, *Platycerium angolense* and *Microgramma owariensis*. The Orchidaceae are represented by Ancistrorhynchus capitatus and *Solenangis Scandens*. The Euphorbiaceae are also represented by two species which are *Alchornea cordifolia* and *Croton hirtus*. The other families which are the Araceae, Arecaceae, Asteraceae, Cyperaceae, Nephrolepidaceae, Piperaceae, Poaceae and Rubiaceae are each represented by a single species.

The spectrum of biological types of all the epiphytic species inventoried in the Djapadji enclave indicates that the hemicryptophytes with 52% are the most abundant, followed by the microphanerophytic vines which represent 21% of the epiphytes inventoried. They are followed by microphanerophytes with 12%, therophytes with 5%, nanophanerophytes and chamaephytes with each 4% of epiphytes. Megaphanerophytes, mesophanerophytes, nanophanerophytes with 1%, are the least abundant.

There are no significant differences between the estimated means of the diversity indices observed in the different biotopes (Table 2). The values of the diversity index according to Simpson are higher in fallow land. However, these observed differences are not significant (ANOVA: ddl = 2; F = 1.375; ρ = 0.270). Shannon diversity indices show high values in cocoa plantations. These differences are not statistically different (ANOVA: ddl = 2; F = 3.102; ρ = 0.061). In the distribution of individuals between species, the equitability of the distributions shows significant differences (ANOVA: ddl = 2; F = 11.028; ρ = 0.0003). Epiphytes are more equitably distributed in cocoa and rubber plantations than those observed in fallow land.

Table 2. *Diversity indices in the biotopes of the Djapadji enclave.*

Biotopes	Simpson index	Shannon index	Pielou equitability
Fallow	$0{,}77 \pm 0{,}17^{a}$	$1{,}24 \pm 0{,}35^{a}$	$1{,}16 \pm 0{,}14^{a}$
Cocoa plantation	$0{,}74 \pm 0{,}08^{a}$	$1{,}47 \pm 0{,}35^{a}$	$0{,}94 \pm 0{,}08^{b}$
Hevea plantation	$0{,}69 \pm 0{,}07^{a}$	$1{,}13 \pm 0{,}22^{a}$	$1{,}02 \pm 0{,}07^{b}$

Values in the same column followed by the same letter are not significantly different at the 5% threshold following the Newman-Keuls test.

With a Sorensen similarity coefficient estimated at 63%, the epiphytic floras of cocoa and rubber plantations have a high floristic similarity. The floristic similarities between the other biotopes are less significant. The similarities between the epiphytic floras of rubber plantations and fallows are estimated at 44% according to the Sorensen similarity coefficient. Fallows and cocoa plantations, with a floristic similarity of 31% in the epiphytic flora, represent the least similar biotopes.

Concerning the distribution of epiphytes according to the trunk diameters of the host species, it appears that epiphytes are present on all classes of host diameters (Figure 2). Of all the collections, 20 host species were identified. In rubber plantations, *Hevea braziliensis* plants bearing epiphytes have dbh between 5 cm and 40 cm. In cocoa plantations, *Theobroma cacao* plants bearing epiphytes have dbh between 10 cm and 30 cm. Of the 18 other species bearing epiphytes, the trunk diameters are between 5 cm and 55 cm. The dominant class among epiphyte hosts, on all collections, is that between 20 cm and 25 cm. It is followed by that between 15 cm and 20 cm for the trunk diameter.

The proportion of individuals observed on epiphytes with semi-rough trunks is the most important (Figure 3). This is 73%

of the listed epiphytic individuals represented by 9 species. The most collected individuals are *Platycerium angolense* with 67 occurrences, *Piper guineense* with 32 occurrences, *Phymatodes scolopendria* with 30 occurrences and *Cercestis afzelii* with 22 occurrences. The epiphytes observed on humus deposits constitute 16% of all occurrences. Out of a total of 9 species, *Nephrolepis biserrata* is the most observed on humus deposits with 24 occurrences. The other aspects of the trunks of epiphyte tutors are less represented. These are the host species whose trunks are peeled, rough and smooth.

The Principal Component Analysis conducted on all the floristic and environmental variables presents 3 newly formed axes (Figure 4). The drop after axis F2 prompts us to limit our interpretations to the first two axes which represent 86.40% of the total variance. The epiphytes most contributing to the formation of axis 1 are, in the negative part, *Heterotis rotundifalia* and *Piper guineense* which are characteristic of rubber plantations and cocoa plantations. In the positive part of axis 1, we find fallow lands in which the most important contributions in the formation of this axis are *Ancistrorhynchus capitatus*, *Cercestis afzelii*, *Croton hirtus*, *Cyperus sphacelatus*, *Elaeis guineensis*, *Morinda lucida*, *Nephrolepis biserrata* and *Panicum maximum*. At the level of axis 2, the epiphytes that contribute the most to the formation of this axis in its negative part are *Alchornea cordifolia*, *Phymatodes scolopendria* and *Solenangis Scandens*. The negative part of axis 2 is represented by cocoa plantations. As for the positive part, represented by rubber plantations and fallow land, the epiphytes that contribute the most to the formation of the axis are *Chromolaena odorata* and *Platycerium angolense*.

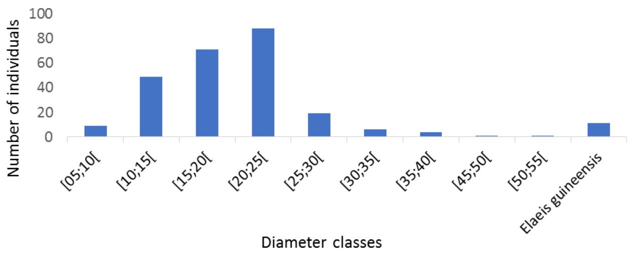

Figure 2. *Proportions of epiphytes according to the diameter at breast height of the host species.*

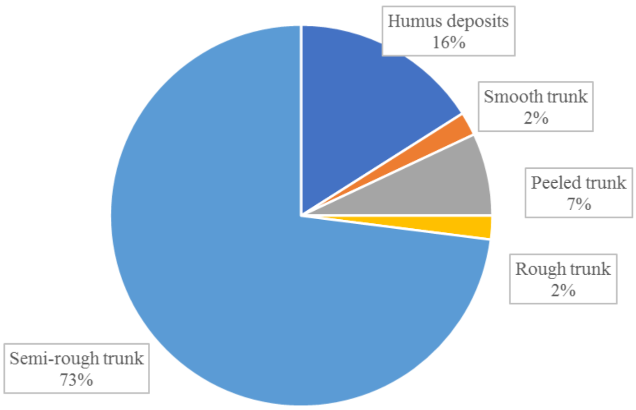

Figure 3. *Modes of attachment of epiphytes to woody hosts.*

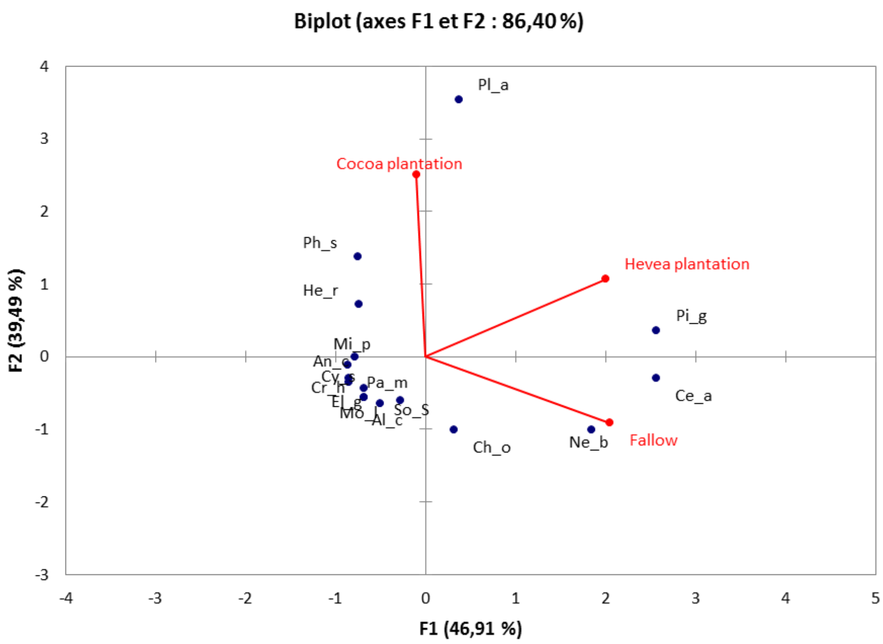

Figure 4. *Distribution of epiphytes in biotopes following principal component analysis.*

4. Discussion

A low afforestation rate is observed in all the biotopes inventoried. This may be linked to the special status of the study site which is a classified forest in the process of being declassified. This legal status making these peasant plantations illegal has certainly not allowed for peaceful peasant activity. The cocoa and rubber plantations inventoried as part of this study are poorly maintained plantations with significant grass cover in the undergrowth. The population densities in the Djapadji enclave are lower than the national averages for cocoa and rubber crops varying between 600 and 1000 individuals per hectare [28, 29]. However, the afforestation densities are higher in the rubber plantations than in the cocoa plantations of the Djapadji enclave. The epiphyte colonization rate of Theobroma cacao is higher than that of *Hevea braziliensis*. The work of Aka, Neuba [30] shows that there are approximately 11 epiphytic species recorded on individuals of Theobroma cacao in Ivory Coast. In the context of this study, 12 plant species were observed in epiphytic form in cocoa plantations. This difference is linked to the fact that accidental and ephemeral epiphytes were taken into account.

All the biotopes covered during this study have a closed undergrowth dominated by herbaceous plants of the Cyperaceae family. The canopy is open, dominated by species of the middle stratum whose height does not exceed 10 meters. This configuration justifies the significant presence of heliophilous epiphytes and accidental or ephemeral epiphytes. Out of 16 epiphytes recorded, 7 are accidental epiphytes. This shows that nearly half of the epiphytes are terrestrial plants that have found themselves in a situation of ephemeral epiphytes due to the dispersion of their reproductive organs. The work of Gnagbo, Kouame [12] terrestrial plants are also observed in ephemeral epiphytic situations in formerly anthropized areas of the Azagny National Park. This arrangement shows that in rainy areas, the dispersal organs of plants easily regenerate on humus deposits in the internodes of host plants.

On *Ancistrorhynchus capitatus* and *Solenangis Scandens*, two epiphytic Orchidaceae observed during collections, adaptations to decication are observed. According to the work of Siaz-Torres, Mora-Olivo [31], some Orchidaceae have prominent pseudobulbs. These pseudobulbs are organs made of water-storing tissues that Orchidaceae use to adapt to water deficit [32, 33]. The hemi-epiphytes *Cercestis afzelii* and *Piper guineense* are climbing vines that use soil nutrients during decication [34].

The structure and shape of host trees exert an influence on the fixation of epiphytes. Trees with larger crowns are essential for the maintenance of epiphytes in the different forest agrosystems of the Djapadji enclave. The crown area of host trees has an important influence on the abundance of epiphytes. DaRocha, Antoniazzi [35] in a study on the actors that shape bromeliad and ant communities in the canopies of cocoa agroforestry and Atlantic Forest in Brazil present similar observations. It appears that trees with branches covering a large horizontal surface have a greater disposition to shelter epiphytes. Zotz and Bader [14] also found a positive correlation between epiphyte abundance and the physiognomy of host trees.

5. Conclusions

This study allows us to understand some aspects of the ecological characterization of epiphytes in highly anthropized stands. Of all the collections carried out, 16 epiphytic plant species were observed. Cocoa plantations constitute the most diverse biotope in epiphytes. This is linked to the trunk of Theobroma cacao which has a structure allowing it to be easily colonized by epiphytes. Cocoa and rubber tree fields have the best provisions to shelter more epiphytes compared to fallow land. The most inventoried epiphytes are *Platycerium angolense*, *Piper guineense*, *Cercestis afzelii*, *Phymatodes scolopendria*, *Heterotis rotundifalia*. These are species resilient to desiccation. Due to recurring and increasingly intense anthropic activities, the specific diversity of vascular epiphytes is low in the Djapadji enclave. However, this site has a good disposition for the reconstitution of epiphytic flora. The significant presence of strict epiphytes indicates that the Taï National Park, adjacent to the study site, plays a seed bank function. It would be the area from which strict epiphytes seem to recolonize the Djapadji enclave. Given the ecological requirements of these epiphytes, it is appropriate to anticipate the degradation of their forest habitats in order to perpetuate them.

Abbreviations

ANOVA	Analysis of Variance
IUCN	International Union for Conservation of Nature

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Author Contributions

Gnagbo Anthelme: Conceptualization, Data curation, Funding acquisition, Methodology, Project administration, Software, Writing – original draft, Writing – review & editing

Egnankou Wadja Mathieu: Investigation, Writing – original draft, Writing – review & editing

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Tiébré Marie-Solange: Writing – review & editing

Adou Yao Constant Yves: Validation, Writing – review & editing

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

Anthelme Gnagbo is a lecturer and researcher at the Jean Lorougnon Guédé University in Côte d'Ivoire. Holder of a PhD in biological sciences, he specializes in forest ecology, biodiversity and reforestation. His research focuses mainly on the restoration of forest ecosystems and the conservation of plant species, with particular attention to the impact of human activities on deforestation. Within his university, he teaches various disciplines related to biology, and he is heavily involved in research projects aimed at improving sustainable forest management in West Africa. In collaboration with international partners, he conducts studies on the survival of planted species and the dynamics of tropical forests. His work contributes to environmental protection and the development of sustainable agricultural practices.

Research Fields

Anthelme Gnagbo: Agroforestry, Botany, Ecology, Remote sensing

Wadja Mathieu Egnankou: Wetland, Botany, Mangrove, Ecology

Franck Placide Junior Pagny: Weed science, Ecology, Agroforestry

Marie Solange Tiebré: Weed science, Ecology, Agroforestry

Constant Yves Adou Yao: Botany, Ecology, Biostatistics