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Research Article

Ecological Characterization of Epiphytes Orchids in the Meridional Zone of Mount Togo

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ABSTRACT

Togo's semi-deciduous forest zone has a great diversity of plants and ecosystems that constitute a natural heritage that should be well studied for sustainable and efficient management. Thus, the main objective of this study is to determine the environmental factors responsible for the vertical stratification of Orchidaceae epiphytes. This study investigated the diversity of these epiphytes and their hosts in the semi-deciduous forest zone of Togo. A habitat characterization of these epiphytes has been done to define the adaptive strategies of these species to their natural environment. The floristic inventory identified 37 species of Orchidaceae and 50 species of phorophytes. These epiphytes are found particularly at 36.36% in position IV and 26, 46% in position V on phorophytes. Perceived luminosity, moisture content and anthropogenic pressure are the indicators responsible for the dispersion of Orchidaceae epiphytes according to different positions on phorophytes. The inventoried phorophytes are 40% mesophanerophytes and the megaphanerophytes represent only 27%. The chorology of phorophytes indicates a high proportion of introduced species represented at 20% and rank second behind those of Guinea- Congo which are represented at 49%.

Keywords: Orchidaceae; Biodiversity; Epiphyte; Vertical stratification; Togo

INTRODUCTION

Orchidaceae are among the most evolved and diversified plants of monocots [1,2]. This family is one of the largest flowering plant families in the world with about 880 genera and more than 25000 species [3-6].

Their shapes, beautiful flowers and aromas make them a resource of great economic, medicinal and food value [7-9]. Among the Bagam peoples of Cameroon, tubers of some orchids are highly valued in the diet [10]. World trade in Orchidaceae is estimated at US$ 1.3 billion [11]. Orchids are currently the second most popular pot crop in the United States with a total value exceeding US$ 144 million in 2005 [12]. Orchidaceae are also considered as bio-indicators for climate change [13]. To this purpose, many species of this family are used to assess the conservation status of forest ecosystems; they are important components and extremely sensitive to the slightest disturbance in ecosystems [14]. Ecologically, this family illustrates the best plant-animal relationship through flowers shape, pheromones and nectar production [15,16]. The tropical epiphytic orchids are very important in such relationships, especially with canopy-dependent fauna. They are also involved in ecosystem processes such as water sequestration and cycling, nutrient cycling, and are permanent sources of food and habitat for other organisms [17,18]. The positioning of these epiphytic orchids on the phorophyte is conditioned by several factors such as: temperature, luminous intensity, humidity, the thickness of the layer of the bryophytes, and slopes of the branches of the trees [19-22]. Epiphytism is one of the most important ways of life known to Orchidaceae [23] and remains very important for understanding ecological mechanisms in forest environments.

Because of these valuable assets, the Orchidaceae are overexploited worldwide. In West Africa, the habitat loss together with deforestation have caused considerable decline in orchid's survival [24]. Current knowledge of this family in Togo indicates that 91 species are distributed into 35 genera, 65% of which are subservient to semi-deciduous forests [25]. These forests in Togo's sub-humid mountainous area are among the hotspots for biodiversity conservation in sub- Saharan Africa [26]. However, this particular forest area has been decimated and currently it is reduced to several relics [27]. Increasing anthropogenic pressure on forest resources, together with habitat loss and climate change, appears to have irreversible consequences on the diversity of epiphytic

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Orchidaceae. Therefore, it is important to determine the extent to which these plants can be resilient, and to determine the role and intrinsic relationship between potential hosts and these epiphytic. Also determine environmental factors that discriminate against them for an essential understanding of this family's adaptation processes.

The aim of this study was to investigate the species diversity of epiphytic Orchidaceae and their phorophytes in the southern part of the Togo Mountains. The particular attention was given to the investigation of environmental factors responsible for vertical distribution of epiphytes. This study greatly contributes to the investigation of biodiversity conservation in the region of West Africa.

MATERIAL AND METHODS

Geographic location

The study area is located in the southern part of the Togo Mountains, in the so-called Ecological Zone IV (6°15′ - 8°20′ N, 0°30′ - 1°00′ E) with the area of 4 620 km^2 (Figure 1). It is situated between the Ecological Zones II and III (Figure 1). The western part of the study area is situated in the border with the Republic of Ghana.

Collection of data

Floristic inventory: The method used in the floristic inventory is stratified sampling, which consists of classifying the study area into different types of plant formations and then choosing within each type a sample taken at random or in a systematic manner. The inventory covers both Orchidaceae and Phorophytes corresponding to the structural supports of the epiphyte species. Binoculars with integrated digital camera (Figure 2) were used to take pictures of species found in canopy of large forest trees.

The harvests are carried out following transect from South-West to North-East over all the sites surveyed. In this study, different landforms taken into account are: semi-deciduous forest islands (FDH), savannahs, fallows, agroforests and gallery forests (FR).

For ecological characterization, the adapted methodology of Johansson [28] was applied. It consists of splitting phorophytes into five parts, allowing the vertical stratification of Orchidaceae (Figure 3) to be studied [29,30]. Data collection took place from February 2014 to November 2016.

Identification of specimens

Species identification was done based on the basis of the determination keys through various flora notably that of Togo, Benin, and Senegal; then the herbarium parts existing at the University of Lomé herbarium. Nomenclature used in this study is that of Chase and all [4]. APG [31] classification was also used for phorophytes.

Data processing and analysis

Analysis of species richness data: Richness of Orchidaceae population was evaluated on the level of subfamily, tribe, genus and species. Phorophytes were determined on family and species level only.

Biological and phytogeographical spectrum: Biospectrum has been used to describe the species richness of each biological spectrum such as megaphanerophytes, mesophanerophytes and microphanerophytes. Biological types have been defined according to Raunkiaer [32] and phytogeographic affiliations (Chorology) of phorophytes in the Togo forest zone, following Aké Assi [33].

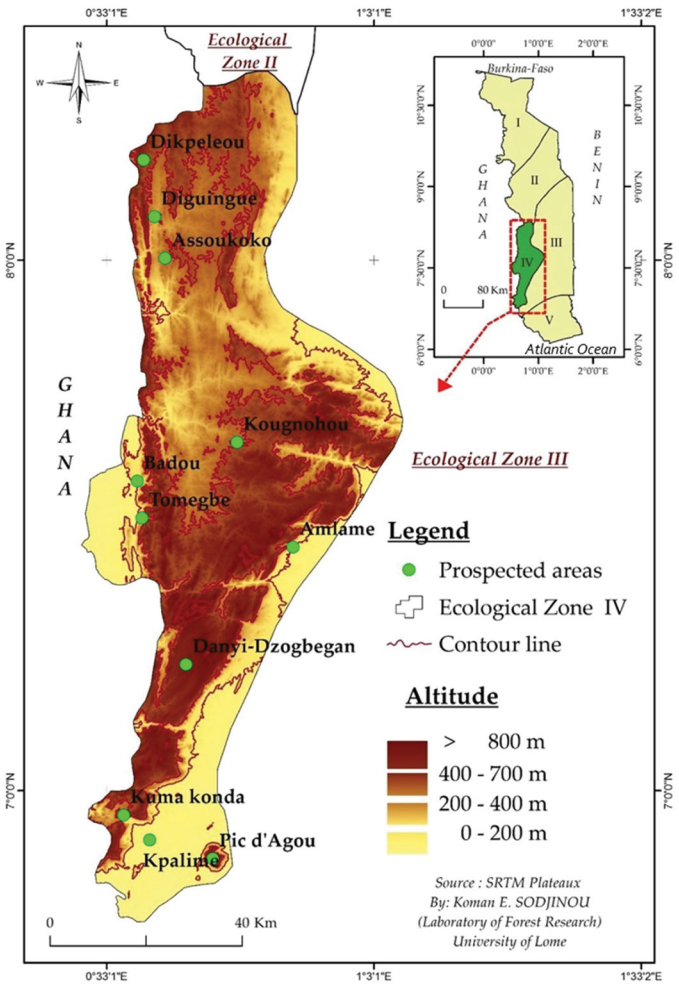

Figure 1: Location of the study area.
Source: Global Mapper (SRTM Plateaux).

Figure 2: Binoculars with integrated digital camera (Brand: BUSHNELL). (*Photo: Sodjinou K. Edjèdu*)

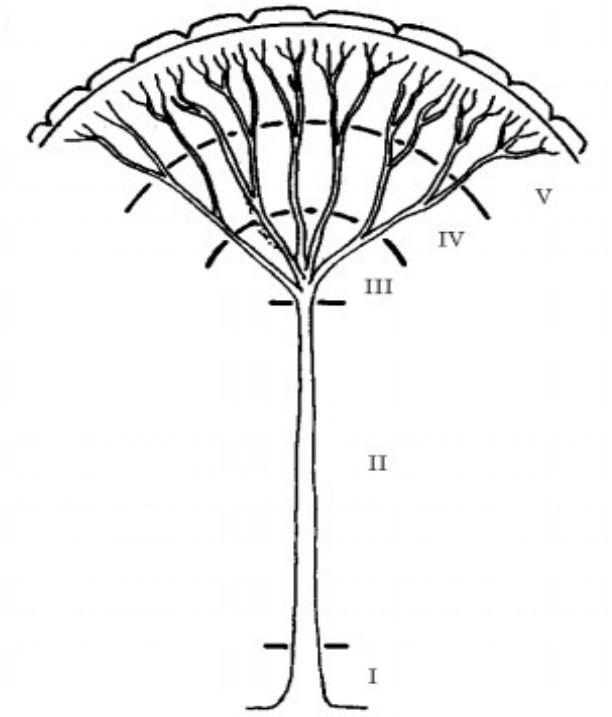

Figure 3: Subdivision of phorophyte of Orchidaceae (adapted from Johansson 1974).

Legend:

I. Basal part of the stem, mainly the buttresses for forest trees and 0-1m for savannah trees;
II. Stem above buttresses to the first branches for forest trees; > 1 m savannah trees case up to the first branches.
III. Basal part of the branches, representing the first third of their length;
IV. Middle part of the branches, second third of their length;
V. Distal third of the branches.

Statistical analyzes: Multivariate analyses are used to test correlations between species and different positions and those related to their habitats. The R software was used to make the AFC and the dendrogram.

RESULTS

Floristical assessment

Orchids species richness: This study revealed the presence of 37 epiphytic orchid species, belonging to 1 subfamily (Epidendroideae), 4 tribes (Cymbidieae, Dendrobieae, Epidendreae, Vandeae) and 19 genera (Annex 1). The most species rich tribe was Vandeae with 20 species, following by Dendrobieae and Cymbidieae with 2 genera each. The most represented genus is *Polystachia* with 10 species.

Phorophytes species richness: The inventory of Phorophytes of orchids carried out in the various formations of the area has enabled 50 species to be identified, divided into 44 genera and 22 families. These families are 90% Eudicots, 6% Magnoliids and 4% Monocots (Annex 2). Fabaceae and Malvaceae are the predominant families with respectively 9 species representing 18% and 8 species representing 16% of the listed species.

Biological types of phorophytes

Biospectrum of phorophytes of orchids (Figure 4) is reduced to 3 main biological types. Mesophanerophytes as the predominant phorophytes (40%) followed by microphanerophytes (33%) and megaphanerophytes (27%).

Chorology of phorophytes

Phytogeographical spectrum of phorophytes (Figure 5) reveals that the Guineo-Congolese (GC) zone species are the most represented with nearly 49% of the species inventoried. Introduced species (I) represent 20% followed by Afro-tropical (AT) species with 17.78% of the total.

Vertical distribution of epiphytes on phorophytes

Epiphytic orchids from Togo's forest zone are mainly more than 36% in the mid-branch part or second third of their length (position IV) followed respectively by 26.46% of those in the distal third of the branches (the position V) and 23.84% of those in the basal part of the branches, representing the first third of their length (position III). Species from the upper trunk to the first branches for forest trees and more than 1 m from savannah trees to the first branches represent only 13.13% (position II) (Figure 6). Species in the basal part of the trunk (position I) are almost non-existent. They are represented only by 0.2%.

The Dendrogram applied to the data (Figure 7) highlights the correlation between the different niches colonized by epiphytic orchids. Three main groups are clearly discriminated against. The first (G1) is the species of the base of the trunk or the species growing on the buttress. The second group (G2) is that of the trunk species and the third groups (G3) consist of the species of the crown (species of the position III, IV and V). It should be noted that a number species is likely can live in the three positions (III, IV and V).

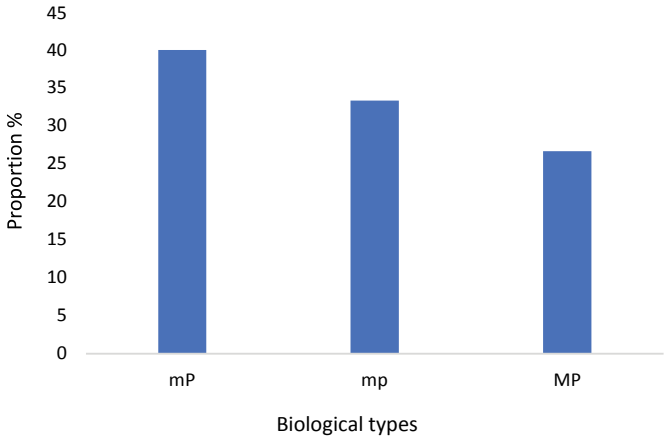

Figure 4: Biological types of phorophytes.

Legend: MP: megaphanerophytes; mP: mesophanerophytes; mp: microphanerophytes.

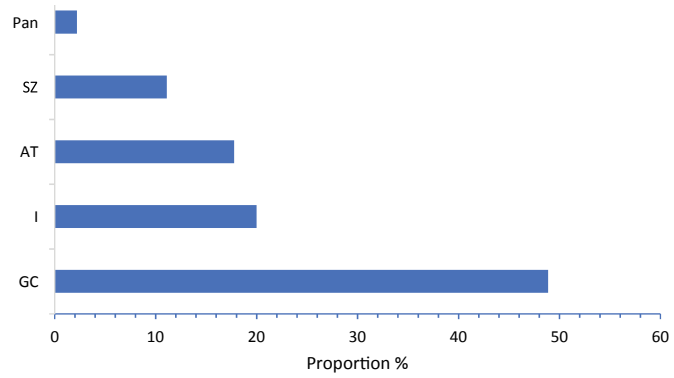

Figure 5: Chorology of phorophytes in the forest zone.

Legend**: AT**: Afrotropical or transitional species; **GC**: Guineo-Congolese; I: Introduced species; **Pan:** Pantropicales; **SZ:** Sudano-Zambesian

Relationship between the diversity of epiphytic orchids and different plant formations

The pattern of distribution of epiphytes according to the different of plant formations (Figure 8) indicates that the species belonging to the most humid and closed plant formations are different from those which are much drier. Gallery forests and fallows are correlated with axis 1, while Axis 2 pits agroforests against islands of dense semi-deciduous forests. Agroforestry species form a group that is clearly discriminated against to others on axis 2. There is also a similarity between species restricted to riparian forests (FR) and agroforests, as most agroforests are located in forest galleries.

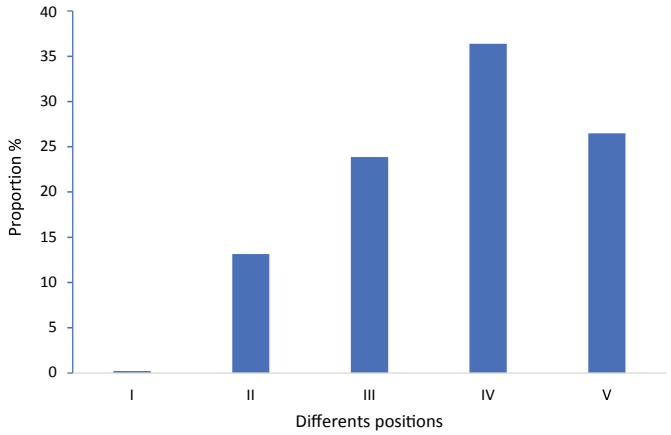

Figure 6: Distribution of epiphytic Orchidaceae on phorophyte.

Legend: I: species of the basal part of the trunk, mainly buttresses or 0-1 meter for savannah trees (0.2%); II: trunk species above foothills to first branches for forest trees; Above 1 meter savanna trees up to the first branches (13.13%); III: the basal part of the branches, representing the first third of their length (23.84%); IV: the middle part of the branches or second third of their length (36.36%); V: the distal third of the branches (26.46%).

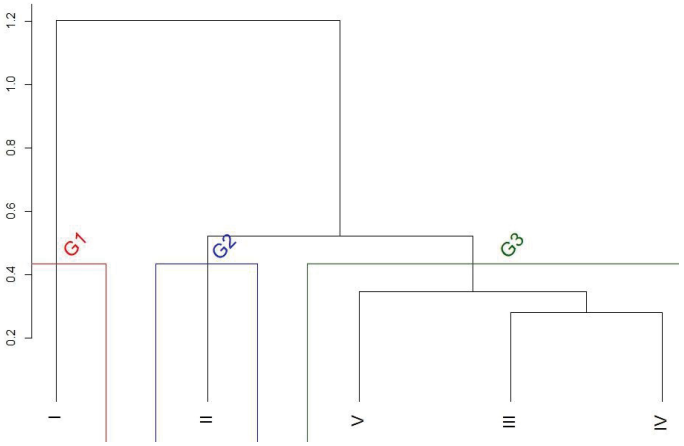

Figure 7: Dendrogram showing the relationship between epiphytes and different positions on phorophyte.

Legend:

G1: Species of the basal part of the trunk, mainly buttresses or 0-1 meter for savannah trees

G2: Trunk species above foothills to first branches for forest trees; Above 1 meter case savanna trees up to the first branches;

G3: Species of the crown (III= the basal part of the branches, representing the first third of their length; IV= the middle part of the branches or second third of their length; V= the distal third of the branches).

Dendrogram (Figure 9) proves this similarity between the different plant formations and the diversity of epiphytic orchids. Three main groups are thus discriminated against. GI is epiphytic orchid's species harvested from savannah and fallow land. G2 is the group of semi-deciduous forest species. G3 includes epiphytic orchids species harvested from gallery forest and Agroforests.

This study showed diversity in terms of the origins of epiphytic orchids hosts from Togo. Indeed, some host plants are derived from Togo spontaneous flora: case of *Aubrevillea kerstingii*, *Dacryodes klaineana*, *Entandrophragma cylindricum*, *Milicia excelsa* while others are derived from the introduced flora: case of *Citrus sinensis*, *Mangifera indica*, *Persea americana*, *Theobroma cacao*.

Agroforests contain a wide variety of epiphytes Orchidaceae in Togo. Thirty-seven species were identified of which 29 species present in agroforests. In these agroforests underbrush crops which are mainly cash crops and fruit trees are also potential hosts for epiphytes in the same way as trees spared on plantations.

Depending on the types of landform studied, the Host-orchidaceae grouping seems to be preferential. Indeed, in agroforests *Aerangis biloba* is preferentially found on *Coffea* sp and *Irvingia gabonensis*, whereas *Microcoelia konduensis*, *Rhipidoglossum rutilum* and *Polystachya elegans* grow exclusively on *Theobroma cacao*, *Citrus sinensis* and *Morinda lucida*.

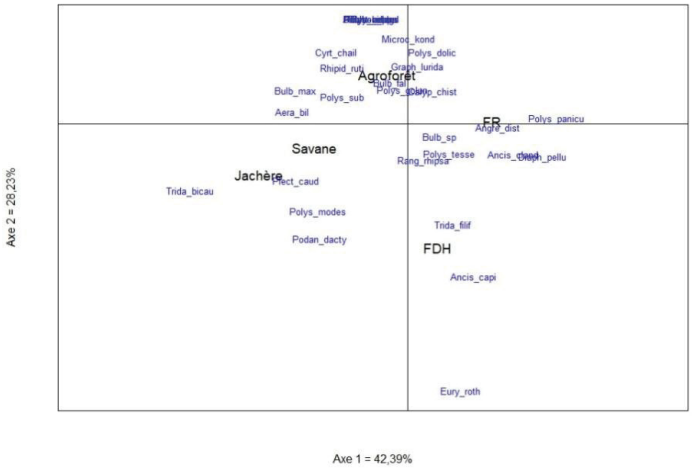

Figure 8: Ordination of the distribution of the orchids species in the different plant formations.

Legend: **FDH:** deciduous forest islands, **Savanes**: savannas; **Jachères**: fallows; **Agroforêts:** agroforests; **FR:** gallery forests.

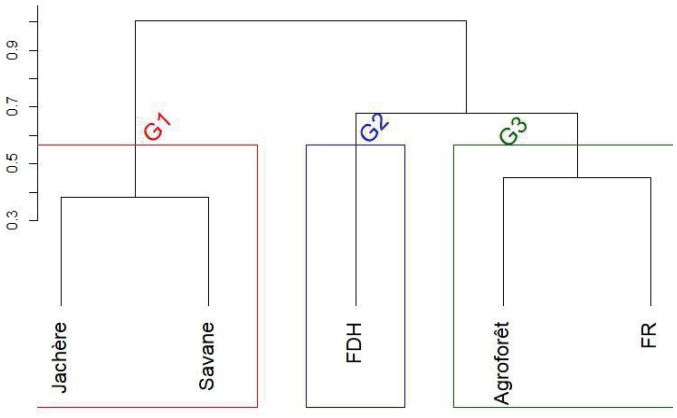

Figure 9: Dendrogram of the relationship between Epiphytic orchids and the different plant formations.

Legend: **FDH:** deciduous forest islands, **Savanes**: savannas; **Jachères**: fallows; **Agroforêts:** agroforests; **FR:** gallery forests.

In dense humid forests and galleries, *Diaphananthe pellucida*, *Ancistrorhynchus capitata*, *Ancistrorhynchus clandestinus*, and *Ancistrorhynchus cephalotes* occur on hosts such as *Aubrevillea kerstingii*, *Pseudospondias microcarpa*, *Lonchocarpus sericeus*, and *Lecaniodiscus cupanioides*. In the savannah and at the edge of forests, it is easy to find the same epiphyte species on several phorophytes. This is the case of *Plectrelminthus caudatus*, *Polystachya subulata*, and *Podangis dactyloceras*, which grow on *Vitex doniana*, *Pterocarpus erinaceus*, *Crossopteryx febrifuga*, *Sterculia oblonga*.

DISCUSSION

Inventory of epiphytic Orchids in the southern part of the Togo Mountains revealed that the genus *Polystachya* is the most predominant. The genus *Polystachya* is mainly present in Africa and has about 200 species. It is a very prolific genus in areas of dense moist forest. This is the case of Gabon (30 species), Cameroon (more than 55 species) and Equatorial Guinea (23 species) [34-36].

Regarding the positioning of the epiphytes on the phorophyte, position IV seems the most represented with nearly 36% of the epiphytes inventoried. Accumulation of species from position V and those from position IV represents more than half of the epiphytes inventoried in this study. These are the shade species protected by the leaves of the vault that would benefit for their development from dew and water mist accumulated in the atmosphere. These results are comparable to those obtained by other researchers, with the greatest biological diversity in canopies being in position IV [22,37,38]. It is widely accepted that position IV is an area that offers a wide variety of micro-habitats because the branches are more or less flat, and favour a humus deposit of that would promote the development of epiphytes [19,37,39]. Position IV is more prolific in species than position V which is considered an insecure area with difficult access to epiphytes *in situ* [30]. Species in position I considered as high humidity species [29,30,40,41] are virtually absent. These results would probably reflect the dryness of the climate in recent years, or merely the externalization of the consequences of climate change. Adjossou [27] revealed a deplorable decline of epiphytes in ecological zones and blamed climate change, deforestation and human activities for this situation. It should be emphasized that in forest islet margins and in savannahs, which are plant formations exposed to regular wildfires, it would be difficult to find the epiphytes proliferating at position (I). This study disagrees with those of Hietz [42]; Holz and Gradstein [43] who have shown that the more open the medium, the canopy species descend to the lowest positions. The vertical distribution of epiphytes is very strategic and detrimental to Orchidaceae. Thus, the slightest biotic or abiotic variation, however minor, can make these epiphytes vulnerable [44,45]. However, several species are able to survive in different distinct niches. In this study *Plectrelminthus caudatus* is often identified in positions III, IV and V; and *Polystachya subulata* in positions II, III, IV and V. It is commonly accepted by other researchers that distinct epiphytic niches often cover several Johansson areas although there are differences in terms of micro-habitat characteristics [19,46-48]. Thus, it is possible to reduce the 5 zones of Johansson in 3 main zones. We can therefore group the species of the base of the trunk in a separate group. Trunk species in another group and crown species in the third group. Elements such as sunstroke, the nature and acidity of the host's bark, the humidity of the air, the porosity of the leaves of the vault should necessarily be included in addition to different types of plant formation to be able to attest that the vertical stratification of Orchidaceae is specifically a function of micro-habitats.

Diversity related to the types of landform reveals a characterization of the plant formations according to environmental and ecological conditions although there are species with a wide distribution. The conditions that discriminate this diversity of epiphytes are among others: air humidity, brightness, topography and anthropogenic actions. These results are in agreement with those of García-González et al. [49] who acknowledge that many species may be affected by a combination of microclimatic and ecological factors, such as humidity in microenvironments, proximity to water sources, sunstroke, competition or wind speed and direction. According to the results of epiphytic orchid's diversity as a function of plant formations, it should be noted that agroforests conserve diversity better than other plant formations that are more exposed to different forms of anthropic pressure. For example, in dense moist forests, large trees are regularly sampled as lumber or other. Gallery forests are often converted to agroforest coffee or cocoa. So, it can be assumed that axis 1 in Figure 7 reflects an increasing moisture gradient from fallows to riparian forests. Axis 2, on the other hand, indicates the different forms of anthropic pressure (deforestation, honey harvesting, bushfires...) which weighs more on these islets of semi-deciduous dense forests than on agroforests.

In ecological zone 4, there is diversity within hosts of Epiphytic Orchids. It has been proven that in this area, 20% of inventoried phorophytes are introduced plants. Most of these introduced plants are found in agroforests. This reflects the extent of agricultural activities in the industry and also the level of anthropogenic pressure on forest resources. It should be recalled that megaphanerophytes only represent 27%, thus proving the high rate of harvesting of large trees from the environment for various reasons (timber, wood energy, etc.). It is undoubtedly for these reasons Orchidaceae epiphytes have adapted to fruit trees, which are mostly introduced plants. These results are in agreement with those of Nadège et al. [50] who found in the western region of Cameroon that epiphytes, mainly epiphytic Orchids, have taken refuge on fruit trees in plantations. He identified *Persea americana* as one of the most diversified phorophytes.

CONCLUSION

This study has identified 37 species of epiphytic orchids in Togo's forest zone. These epiphytic species belong to 19 genera, 4 tribes and one subfamily. The most represented genus is *Polystachya*. In addition, the study clearly shows that the preferred positions of the epiphytic Orchids in Togo's ecological zone IV are positions IV and V. Deforestation, wildfires, humidity rate and sun exposure coupled with the Climate change effects could be considered as contributors to the diversity and vertical distribution of the identified species. Indeed, agroforests are likely to host a great diversity of species because *coffee* and *cocoa* trees have, like trees spared in the fields, constitue potential phorophyte. In addition, the study noted the existence of relationships between Orchidaceae epiphytes and their phorophytes; further studies are needed to formally attest to this relationship, which is essential for the sustainable development and management of this natural resource.

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