The Colonizing Flora of *Canarium schweinfurthii* in the Grassfields of Cameroon

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Agroforestry affords diversification and intensification of farming systems through the integration of indigenous trees such as canarium (*Canarium schweinfurthii* [Burseraceae]) which produce marketable products. Although biodiversity in agrosystems is one of the cornerstones of sustainability, little is known about the colonizing organisms of the species introduced. A study was carried out in six Divisions of the grassfields of Cameroon in order to identify the most common epiphytes and parasites of the canarium tree. Sixteen species of vascular epiphytes were recorded, of which 93.75% were holoepiphytes and 6.25% hemiepiphytes. Of the different families encountered, Orchidaceae represented 62.50%, Polypodiaceae 25%, and Davalliaceae and Cactaceae each only 6.25%. In the grassfields of Cameroon, the distribution patterns of vascular epiphytes vary in two ways. Horizontally, there is a significant difference between divisions ($P<0.001$). *Microsorium punctatum* and *Rhipsalis baccifera* were specific to Menoua Division and *Microcoelia macrorrhynchia* to Mezam Division. Vertically, there is also significant variation from the tree base to the canopy ($P<0.001$), the lower and middle canopy being the preferred positions. Four species of parasites were recorded: *Ficus thonningii*, *Ficus vallis-choudae* (Moraceae), *Hymenodyction floribundum* (Rubiaceae) and *Tapinanthus loranthus* (Loranthaceae). The Moraceae and Rubiaceae prefer the basal and lower trunk, whereas the Loranthaceae prefer the lower and upper canopy of the tree. The parasites, in contrast to the epiphytes, lead to the death of the canarium tree.

KEY WORDS: Agrosystems; biodiversity; epiphytes; parasites; ecology; plant protection.

INTRODUCTION

The cultivation of trees which provide non-timber forest products (NTFPs) is highly important in agroforestry. The canarium tree (*Canarium schweinfurthii*) is one of the candidate species that have traditionally provided local people with their daily needs for the full range of non-wood forest products (NWFPs), which could now be incorporated into agroforestry systems in West Africa (10). The main use of this member of the Burseraceae is based on its oleaginous fruit, which is both consumed by the farmers and marketed (15). The role of biodiversity in agrosystems is one of the building blocks of sustainability. Thus, complex agroforests combining profitability with biodiversity are presented as a model worthy of expansion. However, there is a difference in agroecosystems between planned biodiversity on the one hand, and unplanned, or associated, biodiversity on the other hand. The latter constitutes all those organisms, above and below ground, that have found niches to fill among the planted trees and crops (10). The extent to which unplanned biodiversity

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occurs in different agrosystems is not well known or understood. Animal pests and diseases of agroforestry trees are well documented in the pertinent literature, but there is a paucity of information on their colonizing flora. The present communication deals with the above-ground biodiversity. The objective of the study was to identify the most common epiphytes and parasites of the canarium tree, with the specific aim of assessing the effect of climate and tree crown stratum on the density of these organisms.

MATERIALS AND METHODS

Study site The western part of Cameroon, situated between 5° and 6° lat. N and 10°10' and 10°54' long. E, has a land surface, covering the West and Northwest provinces, of 31,290 km^2 with 2,577,139 inhabitants. The region has a subtropical climate with four seasons. However, the monsoon and the relief of the land have created a pseudo-tropical climate of altitude with only two seasons with low temperatures (2,5). The role of the monsoon is to delete the short season which is supposed to exist in July–August (Table 1). Geomorphologically, the grassfields area is individualized and characterized by the altitude and the volcanism. It is an entire high plateau more than 1500 m in altitude (Table 2) on average and oriented in the direction SSW-NNE, over the great fault line of Cameroon. Geologically, the plateau appears as bedrock with volcanic cover over the major part and another zone with detrital sediments. According to the temperature (Table 2), three periods of the year can be distinguished. During the dry season, from November to March, mean temperatures regularly increase, due to the increase in maximum temperature. Minimal temperatures decrease from November to December, and then rise in January–February. The daytime thermal amplitudes increase and are very large in January–February. At the beginning of the rainy season, from March to June–July, mean temperatures decrease regularly (2) and the maximal temperatures drop greatly. From July to October, the wetter period of the rainy season, the mean temperatures are very low, attaining their lowest values in July–August. The most important consequence of the altitude is the salubrity of the climate. As the vegetation is a reflection of the climate, the succession from forest to savanna has been entirely destroyed. The high population density has led to a general and considerable transformation of the natural vegetation. However, in some areas, one can find some relic forests. For example, in the southeastern part of Menoua Division, there is an evergreen atlantic forest of mean altitude. In certain parts of Nde and Haut Nkam Divisions, there is a semi-deciduous forest. A peri-forest savanna is found in Nde and Mbamboutos Divisions. An altitudinal sacred forest is found on the Mbamboutos mountain.

TABLE 1. Distribution of the rainfall (mm) in six Divisions of grassfields in Cameroon (data are multiannual averages for 1985-1998)

Division	Month												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
Mbamboutos	6.6	44.1	67.7	176.4	154.2	177.3	213.9	262.8	264.4	273.9	70.2	8.8	1720.3
Menoua	12.5	50.5	97.3	192.9	214.6	255.9	237.5	298.9	308.5	262.9	44.4	2.8	1978.5
Mezam	11.3	46.1	77.7	233.9	181.4	312.4	505.6	398.7	438.2	221.1	41.0	0.6	2468.0
Mifi	8.3	50.1	109.9	157.9	139.4	172.2	256.1	304.5	270.4	244.4	78.5	0.6	1792.3
Haut Nkam	11.0	48.0	79.5	129.7	115.1	137.9	192.6	236.9	249.1	240.7	109.4	18.5	1568.6
Nde	3.8	18.9	77.9	117.8	138.5	100.5	72.7	135.0	240.7	223.3	75.1	0.2	1204.4
Total	53.5	257.7	510.0	1008.6	943.1	1156.2	1478.3	1636.9	1771.2	1466.3	418.6	31.6	

TABLE 2. Altitude and mean temperature in six Divisions of grassfields in Cameroon

Division	Temperature (°C)	Altitude (m)
Mbamboutos	17.6	1800
Menoua	20.2	1919
Mezam	20.5	1520
Mifi	20.4	1460
Haut Nkam	20.3	1015
Nde	21.1	1300

Species selection The forests of Cameroon contain a wealth of underexploited tree resources, not least of which is the canarium tree, *C. schweinfurthii*. The uses of this tree are numerous and diverse. The tree, known in Cameroon as Mbieu (Bamilekies), hehe (Bassa), Abel (Ewondo, Boulou) and Sao eyidi (Douala), produces a highly nutritious seed (21). The fruits are important on both local and regional markets. The nut contains high quality oil (35.5% fat matter) (9) and the tree could become a major producer of cooking oil, comparable to that of the cotton plant. In some parts of Cameroon, the tree has an added bonus. Edible mushrooms that proliferate at the base of the canarium tree are harvested for consumption and for sale. In addition, the hard-coated seed and wood are used in handicrafts. The grassfields are the only part of Cameroon where the tree is found in the farming systems (0.3 trees/ha). The oil concentration of canarium serves as a better diesel oil than diesel fuel and could be utilized as a substitute for diesel (1). The bark and seeds are used to treat various illnesses in traditional medicine. These multiple uses (food, trade, handicrafts, traditional medicine) are known not only to the rural population in the humid savanna of Cameroon, but also to those of some other African countries (16). In the grassfields, farmers are already using this tree extensively in their farming systems. It is now up to researchers to identify the tree's potential in various combinations with crops and to improve its productivity.

METHODOLOGY

The study was carried out in six Divisions of the grassfields, namely, Mezam, Haut Nkam, Menoua, Mifi, Mbamboutos and Nde. In each Division, three localities were chosen at random and explored. From the architectural viewpoint, trees can be divided roughly into the trunk, the branches and the twigs (6,18,20). The trunk can further be divided into its basal part and the trunk itself, and the crown into equal thirds (7). This zonation is widely accepted (19,22,23). Fieldwork was carried out between January 1997 and December 1998. For each organism (epiphytes, parasites), the experimental design incorporated six Divisions, three localities, six tree crown levels (tree base=1, lower trunk=2, upper trunk=3, lower canopy=4, middle canopy=5 and upper canopy=6) representing $6 \times 6 \times 3$ treatments. Each experimental unit was made up of ten trees. Identification of epiphytes and parasites was done mostly *in situ*. Samples of epiphytes and parasites that could not be identified *in situ* were collected and identified at the National Herbarium at Yaoundé (Cameroon). The species were the main component, with the Divisions and tree crown levels representing the sub- and sub-sub-components, respectively. The localities represented the replications (3). The spelling of scientific names followed various manuals of botany (11-13) and the Flora of West Tropical Africa (8). Data were collected on the percentage of trees colonized and on the density of epiphytes and parasites on the host tree.

RESULTS AND DISCUSSION

The colonizing flora of the canarium tree from the plant kingdom in the grassfields of Cameroon is varied and diverse, constituting mainly epiphytes and plant parasites.

COMMON LIFE FORMS OF THE CANARIUM TREE

Diversity of epiphytes The vegetation of *C. schweinfurthii* in the grassfields of Cameroon is composed of 16 species of vascular epiphytes belonging to four families: Orchidaceae, Davalliaceae, Polypodiaceae and Cactaceae. Among these, 6.25% are hemiepiphytes whereas 93.75% are holoepiphytes (epiphytes passing their whole life on a phorophyte, in contrast to the first group).The hemiepiphytes are represented only by *Nephrolepis undulata*. The mean density of these species varied significantly from 5.6 individuals in *Microcoelia macrorrhynchia* to 33.8 individuals in *Calyptrochilum emarginatum*. The main component species of the flora were *Bulbophyllum colubrinum*, *Drynaria laurentii*, *Platycerium angolense*, *Platycerium stemaria*, *Polystachya odorata*, *Rangaeris rhipsalisocia*, *Rhipsalis baccifera*, *C. emarginatum*, *Tridactyle tridactylites*, *Tridactyle tridentata*, *M. macrorrhynchia*, *N. undulata*, *Graphorchis lurida*, *Chamaengis vesicata*, *Microgramma owariensis* and *Microsorium punctatum*. The floristic composition of the canarium tree in the grassfields is very poor compared with that obtained in the semi-deciduous forest of Cameroon, where 34 epiphytic species were identified on the species by other authors (23). *D. laurentii*, *P. angolense* and *P. stemaria* were among the most common Pteridophytes found on the tree. These findings are in agreement with those of earlier workers (23) and suggest that these three epiphytes have an affinity for *C. schweinfurthii*. The fundamental difference in the floristic composition between the semi-deciduous forest and the savanna highlands is based on the agro-ecological niches. Most of the trees encountered in the grassfields are found in domesticated areas, in contrast to the situation in the forest zone. We noticed that smooth-barked trees carried fewer epiphytes than rough-barked trees.

Diversity of plant parasites The parasites identified belong to three families: the mistletoe family, Loranthaceae (one species); the mulberry family, Moraceae (two species); and the rose family, Rubiaceae (one species). Although the Moraceae are the most abundant (with two species), in terms of density (number of individuals) the Loranthaceae are the most important and the damage they cause is also considerable. In view of this trend, the future of the canarium tree in the grassfields will become bleak if nothing is done to protect the species. The density of the parasites was consistent in Mifi and Menoua Divisions. The main species involved are *T. loranthus*, *F. thonningii*, *F. vallis-choudae* and *H. floribundum*.

SPATIAL DISTRIBUTION OF THE LIFE FORMS

The distribution patterns of the *C. schweinfurthii* vascular epiphytes and plant parasites vary in two ways: horizontally and vertically.

Horizontal distribution of the epiphytes There is a significant difference ($P<0.001$) in horizontal distribution among the Divisions, which indicates that the climatic conditions are different. The mean density of the epiphytes ranged from 10.1 individuals (Mbamboutos) to 19.0 individuals (Menoua). In each Division the most important species are represented by those for which the mean density is above the grand mean (12.9). The highest mean density was found in *R. baccifera* (42.7 in Menoua), *P. stemaria* (33.8 in Mifi), *R. rhipsalisocia* (42.3 in Mezam), *T. tridactylites* (33.5 in Mbamboutos), *P. stemaria* (36.7 in Haut Nkam) and *C. emarginatum* (45.9 in Nde Division). Six species were frequent in all of the Divisions: *R. rhipsalisocia*, *G. lurida*, *C. emarginatum*, *P. odorata*, *D. laurentii* and *T. tridactylites*. Among them *C. emarginatum* was the most abundant (33.8 individuals). Certain species were specific to some Divisions: *M. punctatum* and *R. baccifera* in Menoua Division and *M. macrorrhynchia* in Mezam Division (Table 3). These differences may be related to the particular climate or microclimate of the Division. The total annual rainfall in the grassfields varies from 1204.4 mm (Nde) to 2468.0 mm (Mezam). Menoua (1978.5 mm) and Mezam are the wettest Divisions in the area, and Menoua is also the highest site (1919 m).

TABLE 3. Horizontal distribution of the common epiphytes of *Canarium schweinfurthii* in six Divisions of grassfields in Cameroon

Species	Division						Mean (n=6)	SEM
	Menoua	Mifi	Mezam	Mbamboutos	Haut Nkam	Nde		
Microsorium punctatum	31.0	0	0	0	0	0	5.2	5.2
Rhipsalis baccifera	42.7	0	0	0	0	0	7.1	7.1
Microcoelia macrorrhynchia	0	0	33.4	0	0	0	5.6	5.6
Tridactyle tridentata	0	115.7	28.5	3.3	0	0	24.6	19.6
Tridactyle tridactylites	36.8	31.1	35.0	33.5	6.4	21.8	27.4	4.7
Drynaria laurentii	14.0	24.0	1.5	13.0	12.9	17.7	13.9	3.0
Polystachya odorata	32.1	18.6	22.2	27.0	37.0	11.7	24.8	3.8
Platycerium stemaria	0	33.8	0	17.2	36.7	0	14.5	7.0
Platycerium angolense	0	27.2	0	1.1	31.5	1.0	10.1	18.3
Calyptrochilum emarginatum	18.6	20.5	36.0	21.5	56.0	45.9	33.8	5.5
Nephrolepis undulata	12.0	17.0	28.5	12.2	0	35.3	17.5	5.2
Graphorchis lurida	21.1	20.8	23.0	6.0	2.5	25.0	16.4	3.9
Microgramma owariensis	7.8	6.8	0	0	30.9	0	7.6	4.9
Rangaeris rhipsalisocia	3.6	3.3	42.3	17.0	1.3	0.8	11.4	6.6
Chamaengis vesicata	36.8	0	0	0	0	26.8	10.6	2.5
Mean (n=15)	19.0	14.8	16.7	10.1	14.3	12.4	12.9	
SEM	3.2	8.5	4.3	2.9	8.1	4.0		

The figures represent the mean number of epiphytes; SEM = standard error of the mean.

TABLE 4. Vertical distribution of the epiphytes of *Canarium schweinfurthii* in six Divisions of grassfields in Cameroon

Tree stratum	Division						Mean (n=6)	SEM
	Mifi	Mezam	Nde	Haut Nkam	Menoua	Mbamboutos		
Tree base	0	0	0	0	0	0	0	0
Lower trunk	11.0	0	1	0	0.3	8.0	3.4	1.1
Upper trunk	16.0	0	12.4	3.0	13.8	0	7.5	3.9
Lower canopy	35.0	52.0	22.1	41.5	67.0	24.0	40.3	4.0
Middle canopy	23.8	37.3	26.2	32.0	21.0	22.7	27.2	3.4
Upper canopy	3.0	10.8	12.6	9.6	11.7	5.9	8.9	1.4
Mean (n=6)	14.8	16.7	12.4	14.3	19.0	10.1	14.5	
SEM	3.9	9.2	4.3	7.3	10.1	4.4		

The figures represent the mean number of epiphytes; SEM = standard error of the mean.

Vertical distribution of the epiphytes There is also significant variation ($P<0.001$) in vertical distribution. The conditions at the lower levels of the forest tree are remarkably constant and differ widely from those at the upper levels, which are similar to those in the

TABLE 5. Spatial distribution of the parasites of *Canarium schweinfurthii*

Species	Division						Mean (n=6)	SEM
	Menoua	Nde	Mezam	Mbamboutos	Mifi	Haut Nkam		
Ficus thonningii	2.5	1.1	1.5	0	2.8	1.3	1.5	0.5
Ficus vallis-choudae	1.9	0	0	0.6	0.8	0	0.5	0.3
Tapinanthus loranthus	5.3	13.9	11.1	3.7	18.2	2.3	9.1	2.6
Hymenodyction floribundum	1.4	0	0	0.5	0	1.7	0.6	0.3
Mean (n=4)	2.8	3.7	3.1	1.2	5.4	1.3	2.9	
SEM	0.8	3.4	2.7	0.8	4.3	0.5		

open (19). These species of epiphytes differ widely in their microclimatic requirements. The density of the epiphytes ranged between 0 at the base of the tree and 40.3 individuals in the lower canopy (Table 4). This finding suggests that the ecological conditions along the tree gradient are not homogeneous.

Some species are restricted to very well illuminated or to very shady habitats (hygrophytes, sciaphytes), whereas some are tolerant of a wide range of conditions (17), and still others avoid both strong light and deep shade (mesophytes). The heliophilous species, with their high light demands, are represented by *T. tridactylites*, *P. angolense* and *R. rhipsalisocia*. Their optimal distribution is in the lower canopy. These specific differences in requirements or tolerance are the main reason for the very marked variation in the composition of the epiphytic vegetation, both with height above ground and from tree to tree. The microclimatic gradients are by no means regular but change from place to place owing to the density of their crowns. Microclimatic differences other than those due to the vertical gradients sometimes have an important effect on the epiphytic vegetation. Studies carried out on the vertical and geographical range of the epiphytes concluded that light is the chief controlling factor of the vertical distribution of the epiphytes (7). The species × stratum interaction was also significant ($P<0.01$). This was exemplified by *T. tridactylites*, which preferred the upper canopy in all Divisions. The heliophily of *T. tridactylites* is in agreement with the results obtained in the Adamawa region (Mapongmetsem, Motalindja Mompea, Laissou Moussou and Nyomo, submitted).

Horizontal distribution of the plant parasites *Ficus vallis-choudae* and *H. floribundum* are absent in Nde and Mezam Divisions. The density of *T. loranthus* ranges from 5.3 (Menoua) to 18.2 (Mifi). Menoua Division is the only one where all four parasites are found (Table 5). This may be one of the reasons behind the mortality of numerous canarium trees in the area. The future of the canarium tree, like that of the shea tree (3), is bleak in this part of the country.

Vertical distribution of the plant parasites The middle and upper canopies are the preferred positions for *T. loranthus*. Of the Moraceae and Rubiaceae, the base and lower trunk parts are the main niches for *F. thonningii*, *F. vallis-choudae* and *H. floribundum*.

BIOLOGY AND PHYSIOLOGY OF THE LIFE FORMS

Epiphytes The epiphytes grow at sites where the supply of nutrients is meager and fluctuating. Moreover, they exist in positions where firm support is essential. For fixation and absorption of nutrients, a strongly developed surface of the root-system is indispensable. Only diffused light reaches these epiphytes. Owing to the poverty of their water supply, measures must be taken to avoid excessive transpiration. A desert plant accomplishes this by diminishing its transpiration surface, but an epiphyte cannot afford to act similarly, because it requires a large assimilatory surface in order to make up for the weakness of the illumination (4,7,20). Furthermore, the leaves are constructed so as to retain their supply of water. The sources of mineral nutrients in the aerial habitat are diverse: as bark, dust from the air, or materials in solution in rain water, accumulation of organic detritus between epiphyte and host, or in special catchment organs of the epiphyte. The accumulation of dead organic matter or humus is closely linked to the architecture of the tree. In this category are included *P. odorata*, *G. lurida*, *C. vesicata*, *C. emarginatum* and *B. colubrinum*. For others, a powerful root system is utilized to capture nutrients and water on the trunk of their host or directly from the atmosphere. This is exemplified by *T. tridactylites* and *R. rhipsalisocia,* which illustrate the importance of substratum humidity to distribution of these species.

Plant parasites There is a nutritional relationship between parasites and their hosts. The parasites of the Loranthaceae family are xerophilous, whereas those of the Rubiaceae and Moraceae are hygrophilous or mesophilous. The growth and parasitic action of the latter families differ from those of the Loranthaceae. Parasitic plants are distributed mostly by birds, which swallow the seeds and disperse them in their droppings as they fly from branch to branch (4,14). We established that Loranthaceae seeds exude a white latex that enables them to stick firmly to the branches, where they subsequently germinate. The Moraceae and Rubiaceae do not possess this quality but their seeds exploit any opportunity to attach to the tree by logging themselves onto compost, a pitchfork mark or into a wound on the trunk. The *Ficus* (Moraceae) leads to the death of its host but the parasite survives to become a full-grown tree. To do this, it develops an intricate root system that tunnels its way into the soil and enables the parasite to feed itself when the host dies. This may explain why parasites of this family choose to infect the base of the trunk of the host species. Most parasites appeared to prefer riverine patches rather than the open savannah. Our study is still at a stage where we cannot draw up firm recommendations, but we can make some suggestions. To avoid infection with Moraceae and Rubiaceae, it might be useful to examine trees and eliminate the factors that can facilitate the germination of these parasites, such as compost and bark wounds. However, it is more complicated to prevent infestation with Loranthaceae, because they attack the tree higher up in the crown – where it might be difficult to locate the seeds because of their size. The best option is to examine the tree and destroy any Loranthaceae before they bear fruits. Many plants died after infestation with parasites.

Based on the above, I suggest that parasitism should be reconsidered as a form of predation in which the parasite leads to the death of the host and the parasite can either die or survive.

CONCLUSIONS

This study illustrated the variability in epiphyte and parasite patterns (vertical, horizontal). The inventory of the epiphytes and parasites of *C. schweinfurthii*, from its base to upper canopy, shows clear floristic differences. The tree base is poor in epiphytes, whereas the middle part (lower and upper canopy) is the richest. In our study, trunks did not harbor exclusive or clearly preferential species. However, various species with a wider range attain their greatest presence in the lower canopy. The Orchidaceae was the most diversified family. Epiphytes and parasites use different strategies to exploit the environmental conditions. Among the epiphytes identified, some offer interesting prospects for horticulture, as their attractive flowers exude a pleasant perfume. These include *P. odorata*, *C. emarginatum* and *T. tridactylites*. The parasites represented a real danger for the tree in the grassfields. *Tapinanthus* preferred the canopy, whereas *Ficus* and *Hymenodiction* needed the tree base. In terms of density, *Tapinanthus* is the most important plant parasite species. A word of caution: *T. loranthus* is used in traditional medicine and its importance is related to the nature of the host tree species. Furthermore, its flowers are visited by bees. Unlike in Asia, the use of epiphytes as ornamental plants is not yet a reality, because they are still not domesticated.

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