The *Lecaniodiscus Cupanioides* (*Sapindaceae)* Phytocoenose in the Forest Plantations of Toffo Forest Reserve (Atlantic Department, Southern Benin)

J. C. GANGLO[10] et B. DE FOUCAULT[11]

Abstract

Our investigation area is Toffo forest reserve (6°51'- 6°53' of north lat. to 2°05'-2°10' of east long .). A phytosociological study has been done in Toffo forest following the synusial approach. The *Lecaniodiscus cupanioides* phytocoenose is one of the most important plant-communities identified. It is composed of seven synusia where 228 species are recorded. The *Lecaniodiscus cupanioides* phytocoenose is a shrubby vegetation that indicates leached ferrallitic soils on weak to moderate slopes (3% to 9%). This plant-community is also indicative of the least productive teak plantations.

Key-words : Phytosociology, synusia, plant-communities, forest productivity, Benin.

La phytocénose à Lecaniodiscus cupanioides dans la forêt classée de Toffo (Département de l'Atlantique, Sud-Bénin)

Résumé

Notre zone d'étude est la forêt classée de Toffo (6°51'- 6°53' latitude nord et 2°05'-2°10' longitude est) où nous avaons fait une étude phytosociologique selon l'approche synusiale intétégrée. La phytocénose à *Lecaniodiscus cupanioides* est l'une des plus importantes communautés végétales identifiées dans la forêt. Elle est composée de sept synusies végétales où 228 plantes ont été inventoriées. Cette phytocénose est une végétation arbustive qui indique les sols ferralitiques lessivés sur pentes faibles à modérées. Elle indique aussi les plantations forestières les moins productives de Toffo.

Mots-clés : Phytosociologie, synusie, phytocénose, productivité des plantations, Bénin.

[10] University of Benin, Faculty of Agronomy, Department of Environment Management. 01 BP 526, Cotonou, République du Bénin; email: ganglocj@yahoo.fr

[11] Department of Botany, Faculty of Pharmacy, BP 83, F-59006 Lille Cedex; e-mail: bdefouca@pharma.univ-lille2.fr

Introduction

Phytosociology is the study of plant-communities. This science has been developed in Europe since the 1900s with Braun-Blanquet and his followers (Braun-Blanquet 1932; Guinochet 1955…). Apart from the classical approach of phytosociology so far developed, a new synusial approach of phytosociology has been recently developed (Gillet & al. 1991; Gillet 2000). As opposed to the classical approach, the synusial phytosociology studies the different levels of vegetation organisation, their relationships and ecological determinism. According to the relationships between the synusia, they are gathered to form coherent and gradually more complex plant-communities such as phytocoenoses, tesela and catena.

One of the interesting aspects of this new approach is the possible use of the synusia (elementary plant-communities) for micro-variation identification of ecological factors (soil, topography, geomorphology…). This new approach of phytosociology is applied to many forest vegetations and helps to successfully identify and characterize forest sites or interesting plant-communities (Decocq 2000; Yessoufou 2002; Aoudji 2003; Noumon 2003; Ganglo 2004; Awokou 2004; Dossa 2004, Tohngodo 2004). The purpose of this paper is to present one of the main phytocoenose identified in Toffo Forest Reserve.

Material and methods

Study area

Our investigation area is Toffo Forest Reserve (6°51'- 6°53' of north lat. to 2°05'- 2°10' of east long.) (fig. 1). This forest is submitted to the influence of a subequatorial climate with a long rainy season from March to July and a short rainy season from September to October. The long dry season extends from November to February and the short dry one covers August (fig. 2). From 1961 to 2003, the mean annual rainfall of the study area is 1030 mm; the mean daily temperature is 27.5 °C while the relative humidity varies from 52 to 95%.

Two major soils are found in the study area:

- the ferrallitic soils of the Continental Terminal geological period are found in the southern parts of the forest. In the upper horizons of these soils, sand is dominant (81-95%); the soils pH varies from 6.7 to 7.7 whereas the organic matter content is 0.5 to 8%; the C/N ratio is 10-13%; the cationic exchange capacity varies from 3 to 20 meq/100 g of soil and the saturation rate is 33 to 100%;
- the black cotton soils ("vertisols") develop in the northern part of the forest. Clay is dominant in their profiles (59-68%); the organic matter content is higher (3-28%) than in the ferrallitic soils; the C/N ratio is also high (12-18%); the pH is 6-7 whereas the cationic exchange capacity varies from 19-28 with a saturation rate of 80 to 100%.

These two types of soils are separated by a muddy and swampy soil of the Agbé River (fig. 1).

In Toffo Forest the spontaneous vegetation varies according to the soil-types. Thus, on ferrallitic soils, one can observe a shrubby *Lecaniodiscus cupanioides*-community that grows on plateaus and weak to moderate slopes, whereas *Mallotus oppositifolius* and *Reissentia indica*-community develops on the most sandy parts of the soils where slope ruptures favour sand accumulation. Within these two plant-communities, we observe some relic species of the semi-deciduous forest that has previously existed in the area: *Ceiba pentandra* and *Antiaris toxicaria* are the most common. On the black cotton soils, develops a liana-community of *Paullinia pinnata* and *Combretum hispidum* where the relic forest trees *Milicia excelsa* and *Diospyros mespiliformis* are commonly found. In the river zones, the vegetation varies according to the presence or absence of water. Therefore, we have frequently recorded *Nymphaea maculata* in stagnant water; *Leersia hexandra, Alternanthera sessilis, Mitragyna inermis, Berlinia grandiflora…* on muddy and swampy soils surrounding water points.

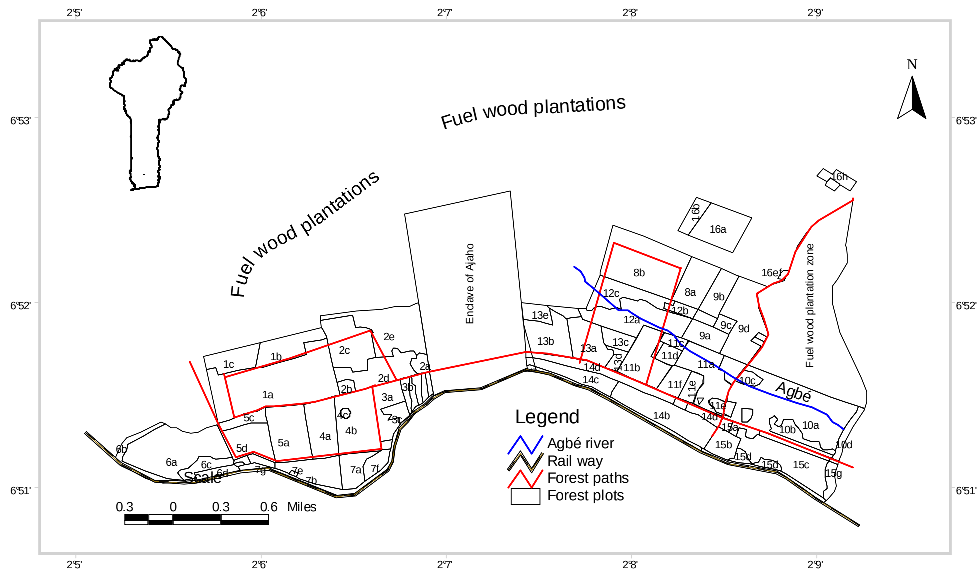

Figure 1. Toffo reserve forest

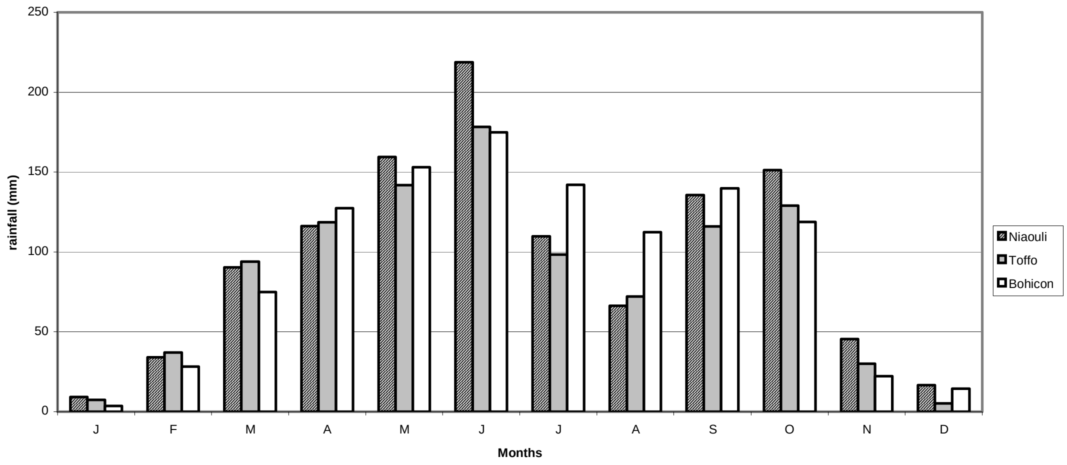

Figure 2. Mean annual rainfall of Niaouli, Toffo and Bohicon meteorological stations (1961-2003).

Toffo Forest Reserve is actually covered by 802 ha of forest plantations where teak (*Tectona grandis*) is dominant (92% of the forest area); the second species in term of percentage of forest area covered is *Cassia siamea* (about 7%). As for the age structure, it is noteworthy that about 50% of the forest plantations are less than 15 years old, whereas 26% are more than 46 years old.

Phytosociological Study of the Spontaneous Vegetation

To achieve the phytosociological study, we use a forest map at 1/10000 scale for orientation on the field and phytocoenose mapping; a Global Positioning System (GPS) is used to record relevant points and phytocoenose contours; Suunto compass is used for field orientation whereas a machete helps for opening paths and secateurs are used to cut species sample for determination…

In the vegetation study, we use the synusial approach of phytosociology developed by Gillet & al. (1991) and Gillet (2000). This consists of two stages in vegetation assessment in the field.

First, vegetal synusia are identified and recorded. A vegetal synusia is a plant-community where an homogenous species composition is noted along with a dominant biological, morphological and adaptation strategy type (Gillet & al. 1991). To achieve their assessment, we pay attention to the variation of the vegetation structure (species component mainly) according to ecological factors (types of soil, slope, topographic positions…). In each synusia identified, relevés are done. We have distinguished the following categories of synusia: annual synusia, low perennial-herbaceous synusia, high perennial-herbaceous synusia, shrubby synusia, liana-synusia and tree-synusia. The surface of relevés varies from 500 m² in the annual and herbaceous synusia to 1,000 m² on the other ones. In each relevé, all the flowering species and easily identifiable ferns are recorded. An abundance-dominance coefficient is affected to each plant species recorded in the relevé, according to the following scale (Gillet & al. 1991; Gillet 2000) :

- r : species rarely represented, it covers less than 0,1% of the surface effectively covered (Sv) by the synusia;
- + : species with little abundance, it covers less than 1% of Sv;
- 1 : species quite abundant, covering less than 5% of Sv;
- 2 : very abundant species with less than 25% of Sv;
- 3 : species with any abundance but, with a recovery varying from 25 to 50% of Sv;
- 4 : species with any abundance but, with a recovery varying from 50 to 75% of Sv;
- 5 : species with any abundance but, with a recovery higher than 75% of Sv;

During the second stage of the field investigation, based on spatial and temporal relationships, the vegetal synusia are combined to describe phytocoenoses. We distinguish the same types of phytocoenoses as that of synusia apart from the spontaneous tree-phytocoenoses which are not represented in the plantations. In each relevé of phytocoenose, the synusia represented are recorded and assigned two coefficients; the first one is that of abundance-dominance with the same scale as above; the second one is the coefficient of aggregation which explains the spatial distribution and the degree of dispersion of the synusia within the phytocoenoses. The grid used is that of Gillet (2000):

1 : fragmented synusia, represented by individuals scattered in the phytocoenose;

2 : synusia composed of open fragments, more or less extended with vague contour and, where plant species are sparsely distributed;

3 : synusia with closed, well individualised but little extended fragments;

4 : synusia little scattered and composed of dense fragments, usually showing strips of connection;

5 : synusia very little scattered and composed of dense fragments with circular or egg-shaped contours.

The form of the synusia are also described:

- continuous spatial form on a considerable surface; the synusia is only limited by physical or ecological discontinuity such as roads, paths, variation in species composition, variation of the plantation age, etc.;
- fragmented spatial form; the synusia species are scattered and dispersed within the phytocoenose;
- linear form; for example the synusia growing linearly alongside roads;
- punctual form; the synusia only punctually develops where its biotope exists; this is usually the case of hygrophilous or hydrophilic synusia that punctually develop in micro water points within plantations;

Species Diversity Study

The species diversity has been assessed by means of species richness, Shannon-Wiever index (H') and Pielou evenness index (E). H' is calculated in each synusia as following:

$H' = -\sum Pi \ln Pi$,

where Pi = ri/r is the relative recovery of species i; ri is the recovery of species i and r is the total recovery of the species in the synusia.

The evenness index (E) is computed as following:

E = H' / H'max

where H'max = lnS. H'max is the value of H' when all species have the same recovery; S is the total number of species of the synusia.

Ecological Factors Study

The study of ecological factors has been done by using soil drilling device for tactile soil texture appreciation; the Munsell code is used to determine soil colour; a machete serves to refresh soil profile horizons and take soil samples; polyethylene containers are used to carry soil samples to the laboratory for analysis; the slope meter device Suunto serves to measure slopes…

The soil types are studied within each phytocoenose; we then appreciate up to 50 cm depth, tactile soil texture through four punctual drillings at least; apart from this, at representative points of each phytocoenose, two soil profiles of 2 m depth, 2 m long and 1 m large are dug for detailed soil description; topographic parameters such as slopes, topographic positions, exhibition are also noted; per profile, one soil sample is taken in each of the first two horizons for laboratory analysis at Agonkanmey (Cotonou, southern Benin). In the laboratory, phosphorus has been extracted by the method of Bray I: the solution used is hydrochloric acid in ammonium fluoride and the concentration is determined by means of standard curves. Soil pH has been determined by means of a pH-meter which electrodes are immerged in a soil solution made of 20 g of soil and 50 ml of distilled water. Soil texture has been determined by using the soil-hydrometer method. The exchangeable cations were extracted with ammonium acetate and titrated. Carbon and organic matter have been determined by the method of Walkley and Black. The nitrogen content has been determined by the method of Kjeldalh.

Forest Plantation Parameters Study

The measurements of dendrometric parameters (diameter and height) have been done by means of tape measure and Blum-Leiss. The dendrometric parameters are studied in representative parts of the phytocoenose. Therefore, four rectangular sample plots of 300 m² (15 m * 20 m) are assessed so that the following parameters are recorded: diameter at breast height (1.30 m) are measured with tape measure; by means of Blum-Leiss, the height of the two largest trees are measured in each plot in order to calculate top height; also the height of two trees within the mean diameter class is measured so that we calculate the mean height.

Results

The factorial analysis of correspondence helps to objectively confirm the types of synusia identified during the field surveys of the whole forest. We only present here the synusia effectively recorded in the Lecaniodiscus cupanioides phytocoenose.

Structural Characteristics of the Phytocoenose

Species Diversity in the Synusia

The *Lecaniodiscus cupanioides*-community is composed of seven synusia (tab. 1). A total of 228 species are recorded in the phytocoenose. From tab. 1, we notice that the mean number of species per relevé in the synusia varies from two to forty-two. The *Chromolaena odorata* synusia and the *Ceiba pentandra* and *Triplochiton scleroxylon* synusia are the least diversified whereas the *Scadoxus multiflorus* synusia, the *Lecaniodiscus cupanioides* synusia and the *Crinum jagus* synusia are the richest ones. As opposed to the least diversified synusia, the most diversified ones are characterised by the presence of many juvenile individuals of shrub, liana and, tree species.

Table 1. Species diversity of the synusia recorded in the *Lecaniodiscus cupanioides* phytocoenose

Synusia	Developmental stages	Mean values of		
		species richness per relevé	Shannon-Wiener diversity index per relevé	Pielou evenness Coefficient per relevé
Asystasia gangetica and *Phaulopsis falcisepala* synusia	1	10 b	1.60 a	0.82 a
Crinum jagus and *Sansevieria liberica* synusia	2	17 c	2.10 a	0.76 a
Scadoxus multiflorus synusia	2	42 a	2.23 a	0.60 a
Imperata cylindrica synusia	2	12 cd	2.07 a	0.85 a
Chromolaena odorata synusia	3	02 c	0.38 b	0.48 a
Lecaniodiscus cupanioides synusia	4	27 a	1.70 a	0.78 a
Ceiba pentandra and *Triplochiton scleroxylon* synusia	5	02 c	0.62 b	0.75 a

Within each column, the numbers followed by the same letters are not significantly different at 5% of probability level.

Synusial Composition

The synusial composition of the phytocoenose is presented in tab. 2. The shrubby *Lecaniodiscus cupanioides* synusia is the unifying synusia of the phytocoenose. It covers more than the half surface (58%) of the phytocoenose with a mean frequency of 100%. The companion synusia are various: annual synusia, low-perennial-herbaceous synusia, high-perennial-herbaceous synusia and tree-synusia (tab. 2). Their frequencies vary from 33% to 100% with mean recoveries of 0.1 to 2%.

Biotope Characteristics and Ecological Indicatory Value

Lecaniodiscus cupanioides phytocoenose is the shrubby vegetation that grows on ferrallitic soils in the undergrowth of teak plantations (fig. 3). It especially grows on leached ferrallitic soils. The soil profiles described in the phytocoenose and the results of soil analysis are presented in tab. 3-5 and, in appendices 1 and 2. From these tables, we deduce that the phytocoenose is commonly found on brown-reddish soils in the upper horizons; the soils turn to red with depth. Tab. 3-5 show that the soils' upper horizons are mostly sandy (81 to 92%); silt and clay respectively account for 2-6% and 6-13% of the soil.

The soil organic matter is 0.5 to 3% in the upper horizons while the C/N ratio varies from 10 to 13%. One can also note that the soils are slightly acidic to alkaline (pH 6.8-7.7) and their saturation rate is about 65%.

The phytocoenose is usually found on weak to moderate slopes with 3% to 9% of inclination (82% of the relevés).

From the biotope characteristics, we can conclude that the *Lecaniodiscus cupanioides* phytocoenose is an undergrowth shrubby vegetation indicative of leached ferrallitic soils usually found on weak to moderate slopes.

Table 2. Synusial composition of the *Lecaniodiscus cupanioides* phytocoenose.

Order numbers	**1**	**2**	**3**	**4**	**5**	**6**	**FR**	**RM**
Relevé numbers	L26	L38	L39	L40	L43	L59		
Synusial composition								
Unifying synusia								
Lecaniodiscus cupanioides shrubby synusia	○ 4/3	○ 4/3	○ 4/3	○ 3/3	○ 4/3	○ 5/4	100	58,3
Companion synusia								
Asystasia gangetica and *Phaulopsis falcisepala* annual synusia	◌ +/1	◌ +/1	-	-	-	◌ +/1	50	0,2
Imperata cylindrica low-perennial-herbaceous synusia	◌ 1/1	-	-	-	◌ 1/1	-	33	1,0
Scadoxus multiflorus low-perennial-herbaceous synusia	-	◌ +/1	◌ 1/1	-	-	-	33	0,6
Crinum jagus and Sansevieria liberica low-perennial-herbaceous synusia	-	-	-	◌ 1/1	-	◌ +/1	33	0,6
Chromolaena odorata high-perennial-herbaceous synusia	◌ 1/1	◌ 1/1	◌ +/1	◌ +/1	◌ 1/1	◌ +/1	100	1,7
Ceiba pentandra and *Triplochiton scleroxylon* tree-synusia	◌ +/1	-	-	-	◌ +/1	-	33	0,1

Two coefficients x/y are noted in each cell of tab. 2; they respectively stand for abundance-dominance coefficient and dispersion index of the synusia within the phytocoenose.

Table 3. Tactile soil texture in the upper horizons in the *Lecaniodiscus cupanioides* phytocoenose.

Depth (cm)	**Relevés numbers**				
-	R26Pleca	R39Pleca	R40Pleca	R43Pleca	R53Pleca
0-10	Sandy-silty	sandy	Sandy-silty	Silty-sandy	Silty-sandy
10-20	Sandy-silty	sandy	Sandy-silty	Sandy-silty	Silty-sandy
20-30	Clayey-sandy	sandy	Clayey-sandy	Silty-clayey-sandy	Clayey-silty-sandy
30-40	Clayey-sandy	Clayey-sandy	Clayey-sandy	Clayey-sandy	Clayey-sandy
40-50	-	Clayey-sandy	Clayey-sandy	Clayey-sandy	Clayey-sandy

Table 4. Results of soil analysis in the soil profile n° 1 of the *Lecaniodiscus cupanioides* phytocoenose.

Horizons	Depth (cm)	clay (%)	Fine silt (%)	Coarse silt (%)	Fine sand (%)	Coarse sand (%)	C(%)	N (%)	C/N	M.O (%)	pH eau	Ca Cmolec/kg	Mg Cmolec/kg	K Cmolec/kg	Na Cmolec/kg	CEC Cmolec/kg	saturation rate (%)
A11	0-5	13	4,1	2	31	50	1,9	0,2	13	3,3	7,7	13	3,3	0,7	0,5	19	95
A12	5-41	9,8	2,8	1,7	30	56	0,6	0,1	10	1,1	6,8	1,2	0,6	0,2	0,4	3	76

Table 5. Results of soil analysis in the soil profile n° 2 of the *Lecaniodiscus cupanioides* phytocoenose.

Horizons	Depth (cm)	Clay (%)	Fine silt (%)	Coarse silt (%)	Fine sand (%)	Coarse sand (%)	C (%)	N (%)	C/N	M.O (%)	pH eau	Ca Cmolec/kg	Mg Cmolec/kg	K Cmolec/kg	Na Cmolec/kg	CEC Cmolec/kg	Saturation rate (%)
A11	0-8	6,85	3,81	1,95	50,21	37,18	1,58	0,13	12,10	2,72	7,0	11,80	6,15	0,60	0,36	18,10	100
A12	8-38	6,06	0,76	1,45	31,46	60,33	3,3	0,30	11,0	0,57	6,9	1,0	0,53	0,16	0,31	3,0	66

Figure 3. **The *Lecaniodiscus cupanioides* phytocoenose in Toffo forest reserve.**

Silvicultural Indicative Value of the Phytocoenose

In tab. 6, we present repeated measurements of productivity indices within undergrowth phytocoenoses identified in the Toffo Forest Reserve. From table 6, we realise that productivity indices are very homogeneous within each phytocoenose with limited amplitude (5 m at most), little standard of deviation (2 m at most) and moderate variation coefficient (9% at most). Tab. 6 helps to understand that the *Lecaniodiscus cupanioides* phytocoenose indicates the least productive teak plantations.

Table 6. Variation of plantation productivity within phytocoenoses.

Replication number	*Lecaniodiscus cupanioides* phytocoenose (m)	*Mallotus oppositifolius* and *Reissentia indica* phytocoenose (m)	*Paullinia pinnata* and *Combretum hispidum* phytocoenose (m)	*Cola millenii* and *Icacina tricantha* phytocoenose (m)
1	20.0	26.1	23.4	19.0
2	18.8	25.8	24.7	19.4
3	18.8	26.1	24.7	16.7
4	20.0	25.2	25.5	20.0
5	18.1	23.2	24.1	-
6	18.1	26.7	20.4	-
7	23.2	27.1	21.4	-
8	21.5	-	-	-
Mean index (m)	**19.81 c**	**25.74 a**	**23.41 b**	**18.78 c**
Amplitude of productivity indices (m)	5.1	3.9	4.7	3.3
Standard deviation (m)	1.79	1.28	1.94	1.44
Variation coefficient (%)	9.03	4.97	8.29	7.67

Within each column, the numbers followed by the same letters are not significantly different at 5% of probability level.

Vegetation dynamics in the phytocoenose

From the analysis of the synusial composition of the phytocoenose, we can deduce the following vegetation succession order (tab. 1):

- the pioneer annual stage of succession is represented by the *Asystasia gangetica* and *Phaulopsis falcisepala* annual synusia;
- the second vegetation succession stage is made of the low-perennial-herbaceous synusia of *Imperata cylindrica* which is found on oligotrophic leached and depleted soils. On mesotrophic sites, the second stage of vegetation succession is represented by the low-perennial-herbaceous synusia of *Scadoxus multiflorus* or that of *Crinum jagus* and *Sansevieria liberica*;
- the third stage of vegetation succession is represented by the high-perennial herbaceous synusia of *Chromolaena odorata*;
- the fourth succession stage is made up of the shrubby *Lecaniodiscus cupanioides* synusia;
- the last dynamics stage of the spontaneous vegetation succession is represented by isolated individuals of the *Ceiba pentandra* and *Triplochiton scleroxylon* tree-synusia.

Distribution Area

From our observation on the spontaneous vegetation in southern and central Benin, we realise that the *Lecaniodiscus cupanioides* phytocoenose extends to the ferrallitic soils of south and center Benin (6°25' - 7°1' of north lat. and 1°30'-2°45' of east long). Indeed, this phytocoenose is the main plant-community identified in Djigbé Forest Reserve with an important extension to other forest plantations of southern and central Benin: Ouèdo Forest, Agrimey Forest, Bonou Forest…

Discussion

Species Diversity in the Lecaniodiscus cupanioides-Community

First it is important to point out that the synusial approach of phytosociology is considered as a refinement of the classical approach (Gillet 2000). The synusia which is the elementary plant-community of the synusial approach, is characterised by an homogenous species composition along with a dominant biological, morphological and adaptation strategy type (Gillet & al. 1991). What is of great interest in this approach is that the synusia can be correlated with micro variations of forest sites. For instance, in the forest studied the *imperata cylindrica* synusia is quite indicatory of leached and depleted soils; the *Phaulopsis falcisepala* synusia always indicates wet micro forest sites; the *Icacina trichantha* synusia is always found at the foot of slopes surrounding water points. From the synusial approach it is therefore possible in forest management to take into account such micro site variations and then fully address forest potentialities and constraints.

The mean numbers of species per relevé vary from two to forty-two (tab. 1) according to the types of synusia. The herbaceous perennial synusia are the most diverse because of the presence of many juvenile shrubs, liana and trees. In Massi Forest (northern Lama, central Benin), Yessoufou (2002) obtained according to the types of synusia, two to nine species per relevé; also in Koto Forest (northern Lama, central Benin), Noumon (2003) obtained according to the types of synusia two to twenty-eight species per relevé. The numbers of species we obtain in the *Lecaniodiscus cupanioides* community (which grows on ferralitic soils in southern Lama) are therefore higher than those of northern Lama. This may be due to the particular type of soil (back cotton soil) of northern Lama which is periodically flooded with water that can preclude the development of some species.

In Pahou Forest (southern Benin) the mean numbers of species are higher (five to sixty five according to the types of synusia) than what we obtain in Toffo Forest. This may be attributed to the plantation species of Pahou

Forest (*Acacia auriculiformis*) which favours more abundant undergrowth than teak (Toffo Forest) and maybe species richness.

In southeast Benin the mean numbers of species per relevé vary from two to fifty five according to the synusia (Awokou 2003; Dossa 2003; Tohngodo 2003). The southeast Benin forests studied by these authors are a mosaic of natural forests and plantations; in these forests, the presence of rivers favours high soil humidity that may contribute to higher species richness.

When we consider the Shannon index, its mean values vary from 0.38 to 2.23 with a significant difference at 5% of probability level between the least diverse synusia and the most diverse ones (tab. 1). The Pielou coefficient mean values vary from 0.48 to 0.82 without any significant difference at 5% level of probability. These values are similar to those obtained in many Benin forests (0.29 to 2.5 for Shannon index and 0.3-0.84 for Pielou coefficient) (Aoudji 2003; Noumon 2003; Awokou 2004; Dossa 2004; Tohngodo 2004).

In Central African Republic, vegetation is also studied by the synusial approach of phytosociology (Yangakola 2004). In a mosaic of forests and savannas, the mean values of species obtained by this author per relevé is too few (one to eleven) in comparison with those obtained in the *Lecaniodiscus cupaniodes* community. However the Shannon index values (2.6 to 5.2) are higher than what we obtain in the plant-community described here. The mean values of the Pielou coefficient are also in general higher (0.8 to 0.9) in the vegetation studied in Central African Republic.

Species Diversity According to Developmental Stages

In the Toffo Forest Reserve, we globally identify five developmental stages (tab. 1). The first developmental stage is represented by the *Asystasia gangetica* and *Phaulopsis falcisepala* annual synusia; the second developmental stage is represented by the low-herbaceous-perennial synusia (*Crinum jagus* and *Sansevieria liberica* synusia, *Scadoxus multiflorus* synusia and *Imperata cylindrica* synusia); the third developmental stage is represented by the *Chromolaena odorata* high-herbaceous-perennial synusia; the fourth stage is represented by the *Lecaniodiscus cupanioides* shrubby synusia; the last developmental stage is represented by the *Ceiba pentandra* and *Triplochiton scleroxylon* tree synusia.

When we consider the Pielou Evenness Index (tab. 1), we realise that there is no significant difference, at 5% of probability level, between the developmental stages identified.

When we consider the Shannon-Wiever Index, the same conclusion can be drawn apart from the *Chromolaena odorata* synusia and the *Ceiba pentandra* and *Triplochiton scleroxylon* synusia. The diversity of these two synusia is less balanced because of the dominance respectively of *Chromolaena odorata* and *Triplochiton scleroxylon.*

As to the species richness, there is significant differences, at 5% of probability level, between developmental stages. Apart from three synusia: the *Chromolaena odorata* synusia, the *Scadoxus multiflorus* synusia and that of *Ceiba pentandra* and *Triplochiton scleroxylon*, we note a gradual improvement of species richness with developmental stages. The poverty of species richness of the *Chromolaena odorata* synusia is due to the tabular cover of *Chromolaena odorata* that prevent other species from growing. As to the *Ceiba pentandra* and *Triplochiton scleroxylon* tree-synusia, this plant-community is represented only by some relict species scattered in the plantations. The *Scadoxus multiflorus* synusia species richness is due to the presence of many juvenile shrubs, lianas and trees inside that plant-community.

The improvement of species richness with developmental stages can be attributed to gradual site quality improvement through litter fall and better soil organic matter content. From this point of view, our results are similar to those of Quian & al. (1997) who obtained a significant difference of α-diversity between immature and old-growth stands in Vancouver Island. Our results also agree with that of Pausas (1994). Indeed, in his study of the Pyrenean *Pinus Sylvestris* Forest, this author found out that site quality variables are more important in effecting species diversity than structural parameters.

Ecological and Silvicultural Indicative Values

From the results of many authors (Schnell 1952; Mullenders 1954; Guinochet 1955; Pignatti & al. 1995…) plant-communities are the response of vegetation to the synthetic actions of ecological factors. Our results support that assertion. Indeed, within *Lecaniodiscus cupanioides* phytocoenose, we note homogenous ecological factors, represented by leached ferrallitic soils on weak to moderate slopes with specific physical and chemical properties (described so far), that are responsible of the plant-community discrimination. The homogeneity of ecological factors within this plant-community has induced homogenous productivity indices (tab. 6). The implication of this is very interesting in forest management and supports the successful identification and characterisation of forest sites. Indeed, Steen and Coupé (1997) in the Cariboo Forest region in British Columbia obtained interesting results on site classification based on plant-communities mainly. Klinka & al. (2003) also develop in the Alex Fraser Research Forest of British Columbia a site mapping method based on plant-communities mainly. In Massi and Koto Forest Reserves (north Lama in Central Benin) and also in Pahou Forest (southern Benin) many forest sites are also identified on the base of the undergrowth phytocoenoses (Yessoufou 2002; Ganglo 2002; 2004; Aoudji 2003; Noumon 2003).

Management Specification

Lecaniodiscus cupanioides forest site is among the least productive of Toffo Forest. Because of its topographic positions usually on slopes, the site is subjected to erosion. The plant-community is also seasonally subjected to fire damages. It is therefore important to protect the plantation against seasonal fires to enable undergrowth development that will favour litter fall and soil fertility improvement. Fire damages will also be precluded by abundant undergrowth.

In the phytocoenose, some indigenous forest species are commonly found: *Antiaris toxicaria, Ceiba pentandra, Triplochiton scleroxylon, Afzelia africana, Milicia excelsa*. Silvicutural operations must aim at their regeneration and tending so that forest biodiversity be improved. *Khaya grandifoliola* is not native to Toffo Forest but we note its abundant natural regeneration. Silvicultural treatments must also favour such regeneration.

Conclusion

The *Lecaniodiscus cupanioides* phytocoenose is composed of seven synusia in which 228 species are recorded. This phytocoenose is indicatory of leached ferrallitic soils on weak to moderate slopes. The forest plantation of the phytocoenose is among the least productive of the forest.

In order to produce high wood quality on the biotope of *Lecaniodiscus cupanioides* phytocoenose, we suggest an improvement of soil quality through undergrowth protection against fire damages; this will enable abundant litter fall. We also suggest that silvicultural treatments be guided so that to enable natural regeneration and growth of the native forest species found in the phytocoenose: *Antiaris toxicaria, Ceiba pentandra, Triplochiton scleroxylon, Afzelia africana, Milicia excelsa…*

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Appendix 1. Description of the soil profile n° 1 in the *Lecaniodiscus cupanioides* phytocoenose.

Horizons	Depth (cm)	Colour	texture	structure	Root-profile	Biological activities	transition
A11	0-5	10R4/3 brown-reddish	Sandy-silty	Crumby weakly developed	Some too fine, fine and medium roots	-	distinct
A12	5-41	10R5/4 brown-reddish	Sandy-silty	Crumby weakly developed	Quite many medium and big roots	Some worm-galleries	gradual
B11	41-99	10R4/6 red	Clayey-silty	Sub-angular polyedric well developed	Some fine, medium and big roots	Some ant-galleries	gradual
B12	99-200	10R4/6 red	Clayey-silty-sandy	Sub-angular polyedric well developed	Scarce fine and medium roots	Some ant-galleries	-

Appendix 2. Description of the soil profile n°2 in the *Lecaniodiscus cupanioides* phytocoenose.

Horizons	Depth (cm)	Colour	texture	structure	Root-profile	Biological activities	transition
A11	0-8	10YR3/3 dark-brown	Sandy-silty	Crumby weakly developed	Many too fine, and fine roots	Some ant-galleries	distinct
A12	8-38	10R5/4 brown-reddish	Sandy	Sand particles	Some big and medium roots	Some ant-galleries	gradual
B11	38-93	10R4/4 brown-reddish	Clayey-sandy	Sub-angular polyedric weakly developed	Some fine, medium and big roots	Some ant-galleries	gradual
B12	93-200	10R4/8 red	Clayey-sandy	Sub-angular polyedric moderately developed	Scarce fine and medium roots	-	-