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Post Cultural Reconstitution in Semi-Deciduous Dense Forest of Bamo (Côte d'Ivoire)

ADINGRA Odette Marie M. ANOBLA
Doctorante au Laboratoire de Botanique.
UFR Biosciences. Université Félix Houphouët
Boigny 22 BP. 582 Abidjan 22. Côte d'Ivoire

Justin KASSI N'Dja
Maître de Conférences, Laboratoire de Botanique
UFR Biosciences. Université Félix Houphouët
Boigny 22 BP. 582 Abidjan 22. Côte d'Ivoire

***Abstract* – We analysed the floristic and phytoconological diversities along a chronosequence of post cultural steps in a system of semi deciduous dense forest of Côte d'Ivoire. A total of 414 species has been selected in the massive set. 97 of which (23.91%) were not involved in the chronosequence. Those species were grouped into 305 genera and 83 families. The most popular ones were the Fabaceae the Rubiaceae and the Poaceae. The hierarchical cluster of the phytosociological survey and the DCA helped identify 7 groups laid out along a gradient of forest maturity. The early steps. largely variable. were dominated by an invasive species: *Chromolaena odorata*. The succession leads gradually to a secondary forest similar to the semi deciduous forest with *Nesogordonia papaverifera* (A. Chev.) Cap. And *Khaya ivorensi* A. Chev. That forest demonstrates a high level of resilience when the source of propagules is close and abundant.**

***Keywords* – Secondary Succession, Biodiversity, Côte d'Ivoire.**

I. INTRODUCTION

Concerned about the perpetuation of their natural resources. Côte d'Ivoire authorities have initiated the listing of a major part of their forest heritage [1]. That concern entailed the development of a forest master plan in 1988 and re-edited in 2014 (Forest master plan 2014-2020) which highlights the management lines for a sustainable exploration of ivorian forests [1]. Thus. in 1996. 212 listed forests were numbered all over the territory [2]. The supervision. entrusted to SODEFOR. the ivorian forest development company. during the same period. is confronted with big problems [1]. The illegal settlements as well as deforestation. destructions. and conflicts increase the recurrence of these problems. Natives and foreigners entered illegally those forests. making use of the flaws in the patrolling system of SODEFOR. The reasons are many: rapid population increase. which implies the need for farmland. the intensive and excessive. even archaic use of forest resources to meet various needs. The consequences of those anthropogenic activities are obvious: drop in rainfall. erosion of the biological diveristy. climatic changes. soil degradations. decline in wooded lands. divisions of forests. etc.

According to Kassi & Decocq [3]. the permanence of fragmented and degraded rain forests will depend on their abilities of dispersion and/or persistence. Those abilities depend on the structure of the landscape. the availability of habitats. their specific life or functional types (« *Plant functional types* »). The description and the prediction of the dynamics of such a mixed and irregular forest stands come up rapidly against the representation of that diversity (Finegan [4]). The purpose of our survey is to study the dynamics of the post cultural fallow lands included in a mosaic of fallow forests of various durations. To be more specific. we will try to answer the following questions:

1) What is the local flora ?

2) Does the "primary" forest reconstitute. i.e does the floristic composition of the mature fallow lands aim at the former forests?

II. MATERIEL AND METHODS

2.1. Study area and Method

The listed forest of Bamo (5°54' et 5°55' N et 4°33' et 4°37 O) is at about three kilometers from d'Agboville. It is all about a semi-decidious dense forest in a sub-humid tropical climate belonging to the sector of mesophile. based on the subdivisions developped by Guillaumet & Adjanohoun [5]. The climacic vegetation is the humid semi-deciduous dense forest. according to Aubreville [6] and Schnell [7]. It covers an area of 255 hectares on a schist birrimian granitic basement on which ferralitic and hydromorphic soils developped. The climate (annual averages : 26.72°C and 1585.35 mm). determines a potential vegetation of a humid semi-deciduous dense forest. The sampling was carried out so as to include the remaining of the non exploited primary forests (n=19) and various fallow periods corresponding to more or less mature stages of the secondary post cultural successions (4-5 years : n=06. 6- 10 years : n=06. 11-22 years : n=10. 23- 27 years : n=09). We considered that those two types of forest represented a gradient of increasing human pressure on the vegetation.

The extent of the study was 50 m x 30 m (1500 m^2). The study of the vegetation consisted of a complete list of every vascular species present in the sample surface according to the principle of synusial phytosociology [8]. Additional Itinerary inventories have been carried out everywhere in the forest including cultures. Those inventories helped complete the floristic list. The adopted nomenclature is that of APG III [9].

2.2. Data Analysis

We developped a floristic list including all the species in our 50 studies of vegetations. To which we added additional list of species developped during the itinerant prospections. For an exploratory multidimensional analysis. we used the following factors as explanatory variables: the durations of the fallow periods and the density of the primary forest. First. the studies were subject of an hierarchical cluster according to the dis-

similarity index by Bray- Curtis in order to analyse the assemblage of the species into plant communities. Then an analysis of the indicator species ([10]) to characterize them on the floristic level. In order to look for environmental gradients likely to justify the ordering of the plant groups. We later used an ordering technique. Based on the recommendation by Økland [11] : an analysis of the Detrended Correspondence Analysis (DCA). Hierarchical cluster and the obtained factor plans were interpreted on the basis of environment data. Thanks to Kruskal-Wallis tests and the correlation of Spearman respectively ($p < 0.05$). All the multivaried analysis have been carried out with the software R® and simple statistics on *Statview*®.

III. Result

3.1 Floristic analysis

The 50 plots selected as samples for the phytosociological study contained 316 species. The itinerant study helped this specific wealth of 415 plant species for the whole listed forests spread into 305 genres and 83 families. The best represented. i.e with ten species reported in table 1.

Table 1: Some botanic families represented in the listed forest of Bamo

N°	**Families**	**Genera**		**Species**	
		Number	(%)	Number	(%)
1	Fabaceae	33	10.75	42	10.14
2	Rubiaceae	26	8.47	29	7.00
3	Apocynaceae	21	6.84	25	6.04
4	Euphorbiaceae	19	6.19	25	6.04
5	Malvaceae	16	5.21	22	5.31
6	Moraceae	8	2.61	12	2.90
7	Annonaceae	8	2.61	14	3.38
8	Meliaceae	7	2.28	14	3.38
9	Sapindaceae	8	2.61	11	2.66
10	Poaceae	9	2.93	10	2.42

Ninety seven (97) species were not listed in the 50 surface study. For examples : *Dacryodes eudulis* (Burseraceae). *Elaeophorbia grandifolia* (Euphorbiaceae). *Gaertnera. Tieghemella heckelii Pierre ex A. Chev.* (Sapotaceae)... Other species were seen in ten forest studies and not listed in the fallow lands (examples. *Entandrophragma candollei. Tieghemella heckelii*...). There are other species that we can see both on ferralitic and hydromorphic soil (examples. *Cola nitida. Microdesmis keayana*).

3.2. Development of the specific wealth

Figure 1 shows an increase in the specific wealth with the duration of fallow period. The specific wealth moves from an average number of 47 species in the most recent fallow lands (A: 4 to 8 years) to an average number of 109 in the oldest fallow lands (E': 25 to 27 years). However. this value remains inferior to the one we noticed in the various types of primary forests. Forests with ferralitic soils are the richest (E : 169 species in average). then the primary forests with hydromorphe soil (165 species in average). gallery forests appear as the least luxuriant (an average number of 158).

3.3. The hierarchical cluster

The recolonisation process of fallow lands is carried out following various successive steps. On the threshold of the significance level of 75%. The hierarchic classification highlights 7 groups (Figure 2). that coincide with 4 duration groups of fallow periods (from A to D) and 3 forest types (E : primary forests with feralitic soil. G: primary forest with hydromorph soil. and F : Gallery forests. The duration of the fallow period is the main deciding factor of the groups ($H= 41.8$; $p<0.001$). with a slight separation between the most recent fallow lands (groups A : 4- 8 years. B : 9- 13 years. C : 14- 20 years and D : 15- 24 years; < 25 years) of other studies (records of primary forests + four records of longer fallow periods : 25-27 years). Groups A and B include the earliest steps of succession. They are located in the first branch of the cluster. Those early steps are not much structured. characterised by species of sub shrubby stratum (S_2) which height do not exceed five (5) metres in general.

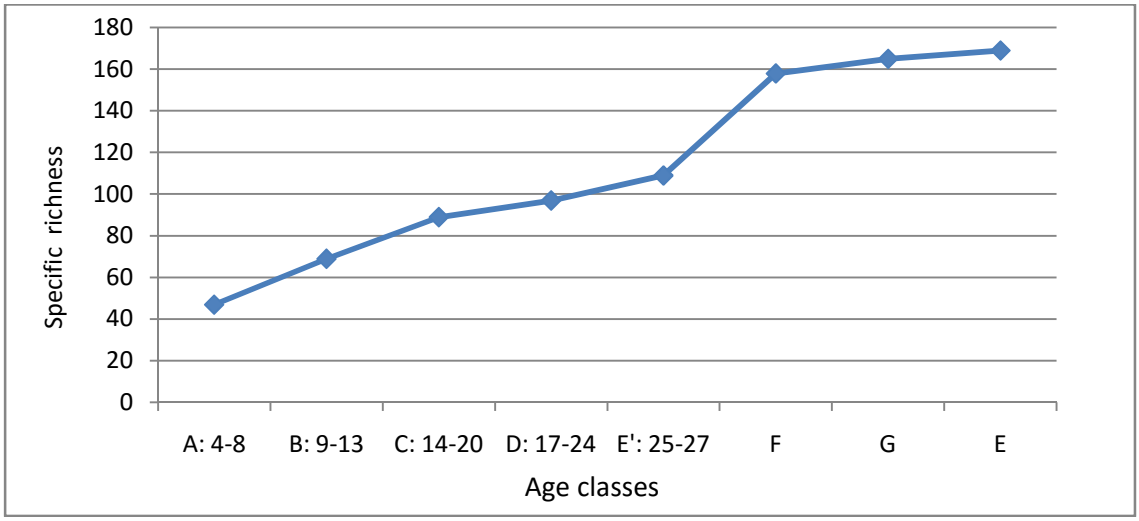

Fig.1. Evolution of the specific wealth according the duration of the fallow period
Caption : A : 4-8 years ; B : 9-13 years ; C : 14-20 years ; D : 17-24 years ; E' : 25-27 years ; F : Gallery forest ; G : hydromorphe soil forest ; E : ferralitic soil forest

Groups with higher number of species and with a strong indicator value (i.e about 100) are those of primary forests and of longer fallow periods (beyond 25 years). Species especially present in the most recent fallow lands (below 9 years) have an indicator value. because they are lower level of fidelity. The species largely available in those recent fallow lands are an invasive species known as *Chromolaena odorata.* They make up. alone. more than 85% of the global vegetation of group A. But. the recovery of that species decrease as the fallow land lasts longer. In the oldest fallow lands from group B (between 9 and 13 years). the *Chromolaena odorata* recovers at just 15%. Picture 19 shows the evolution of the recovery of *Chromolaena odorata* during the succession. Let's note that *Chromolaena odorata* is a perenial plant. very ramified. bushy. sometimes creeping when it has the opportunity to rest on something in its environment. The spread of that species is done by cuttings. either by regeneration from stocks or by disseminations of seeds (in the wind). that helped colonise the degraded areas. The two groups (A and B) are rich in early heliophile species.

3.4. The ordering

The analysis of the sorted out Correspondances (DCA) confirm the major floristic differences that appear between the sites. entailing the heterogeneous of the habitats (Figure 3). We considered just two ordering lines for this study. Line 1 represents the major gradient of the ordering of the study. It sets a clear difference between the fallow periods (recent and longer). in the positive part of line 1. and those of primary forests in the negative part. Line 2. particularly. separates the three studies of the gallery forests from the other study of primary forests from all the other records from primary forests (ferralitique soil and hydromorphic soil) The plots of the gallery forests. however. share similar aspects with the plots of other forests: higher floristic wealth than in fallow lands. (158-169). the existense of all plant stratum (close structural organisation) and above all species in common. The species typical to gallery forests is *Treculia africana* ssp. *africana*.

The first two lines of DCA represent 6.08% of the total floristic variability while the percentage of all the first four lines is 8.5%. The specific values correspond to the variance of the species on a given line. The length of the gradient shows the beta diversity [12]. The low level of variance in the entire information collected from the data is said to have to do with a floristic connection between the various groups of fallow lands and secondly between the mature fallow lands and the study of forests. Therefore. there are not two very distinct groups of floristic composition (groups of fallow lands *vs* groups of forests). That could have a negative impact on the regeneration and thus on the distribution of species.

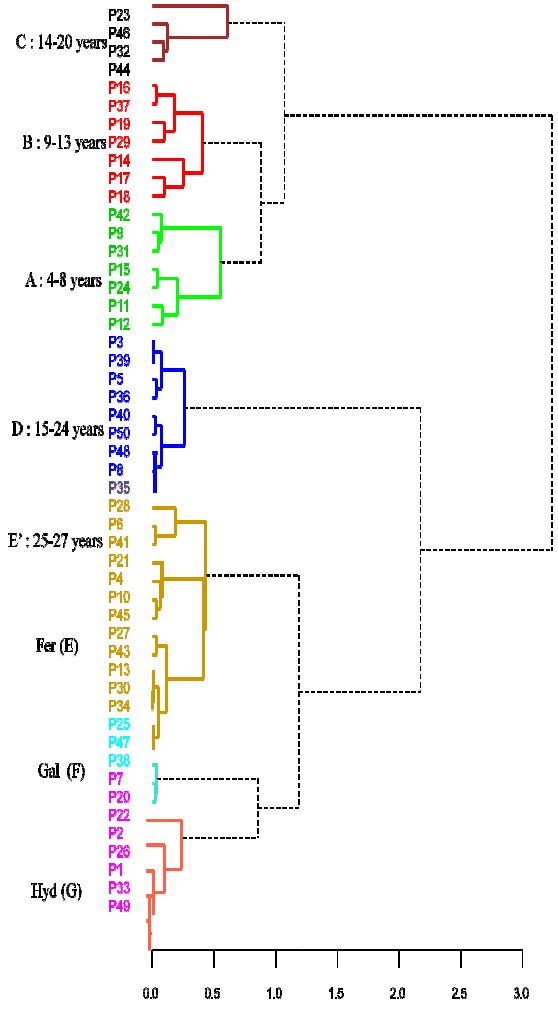

Fig. 2. Hierarchical classification of 50 records
Caption : Fer (E) : Ferralitic forest ; Gal (F): Gallery forest; Hyd (G): Hydromorphic forest

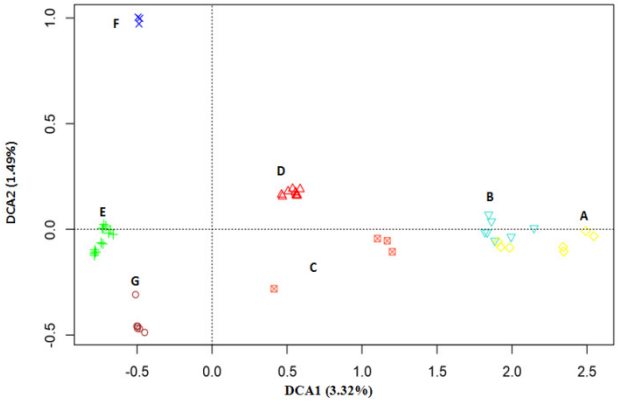

Fig.3. Representation of the plant communities studied in the listed forest of Bamo according to their specific composition on the first lines of DCA (DCA: Detrended Correspondence Analysis). The first two lines of DCA represent 6.80 percent of the whole floristic variability.

IV. Discussion

The classified forest of Bamo had no reference flora. Our botanic lists helps number 414 species on an area of 225 hectares. Our results help set up an attempt of floristic list. The cultivated species (*Theobroma cacao*. *Musa sapientum*…) are not included in the 414 species listed in the old fallow lands. The fallow lands in their early steps are dominated by an invasive species : *Chromolaena odorata* (Asteraceae). many other pionner species join this group : *Rauvolfia vomitoria* (Apocyanaceae). *Ficus* spp.. *Albizia* spp... The forest stands looks mosaic at various stages of maturity.

Our results can be compared with those we collected in other listed forests of Côte d'Ivoire. In the south of National Park of Taï. 1.233 species were listed in the evergreen dense forest [2]. In the Banco forest. well known on the botanic level. 624 species have discovered by Kassi [2]. These results reveal that the Bamo forest is as diversified as the other forests of Côte d'Ivoire.

The hierarchical cluster shows the floristic composition of the records is closely dependant on the duration of the fallow periods where they have been carried out. Our conclusions confirm those of Kassi [2] and of Kassi and Decocq [3] that explains that the floristic evolution goes along with the structural evolution. Likewise. Rivera *et al*. [13]. notice that the compositional parametres (richness. density) and structure (diversity) of the forest stands increase along the ecological successions at least until the preclimacic state. According to Legendre & Legendre [14] the number of species therein is said to be dependent on the stability of the area. It entails. actually. a higher level of organisation in such a way that a more stable environment contains more ecological niches. more species. In our area study. the early steps are dominated by a very invasive species. *Chromolaena odorata* (Astéracées) an alien species [3]. and no more by *Trema guineensis*. *Musanga cecropioides*. *Macaranga hurifolia*... as many various authors pointed out ([14]) in the south west of Côte d'Ivoire. That species vanish rapidly during the succession as the vegetation turn progressively into a forest. and the superior stratum deprives her from sunlight. So they seem not to alter the functionning of the ecosystem. The ordering shows that the main gradient responsible for the strucuring of the plant groups is a maturity gradient. that acts in a complex way on the environment factors. The vegetation of the longer fallow periods (from 25 to 27 years) are the same groups as the records of primary forests. It suggests that the Bamo forests would demonstrate some stamina faced with dirsruption. although the secondary forests remain less diversified than the primary forets. The interpretation of Line 2 suggests that gallery forests. seem more vulnerable than the other primary forest types.

The analysis of the mesologic factors show that the regeneration seem to be influenced by some factors such as the durations of the fallow periods. the remanants and the forest density or the forest proximity. i.e. the distance in relation with the main source of the propagules. This influence has already been reported by many [3]. The surface of the farmed lands seem not to be a determining factor in the reconstitution of the initial vegetation. However. this result should be considered with reservations because all the fallow lands under study have relatively reduced surfaces (an average of 1 hectare). According to Kassi & Decocq [3]. bats and birds tend to use the remanants as perch. That therefore makes room for the dispersion of zoochores species and have a negative influence of the structures of the plant communities.

Unfortunately the forest is disapearing gradually due to the the fact that it is near the city of Agboville. Medical plants sellers collect some medical plants thereby causing the premature extinction of trees. shrubs herbs and lianas.

V. Conclusion

Globally speaking. our studies suggest a rather reduced influence of farming practices on the plant diversity of post cultural stages. The secondary succession. which has been highlighted. looks highly directional and deterministic. All these results also suggest that the traditional farming on small plots. one hectare in average. included in a forest master plan. i.e. the main source of propagule is not far. would preserve the potentials of the area and favour the regeneration of the forests once the farms are abandonned. Finally. in order to preserve the biodiversity. it seems better to favour a natural regeneration of the forest. instead of resorting to artificial refforestations. However. because the natural regeneration process is very low. concerning 97 species among which many valuable trees and some rare species. thus compromising the reconstitution of these forests entities. A sustainable laying out of this forest will require the introduction of new. valuable and rare species. This study has also provided some primary insight about the flora of the Bamo forest. It will serve as a valuable tool for further study. The solution for a sustainable management of those forests is the joint management. It is a notion that imposes itself today.

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AUTHOR'S PROFILE

ADINGRA Odette Marie M. ANOBLA

Ph.D. student, at the Laboratory of Botany, UFR - Biosciences, University Félix Houphouët - Boigny, Côte d'Ivoire.

Justin KASSI N'Dja

Ph.D., Senior Lecturer and Researcher at the Laboratory of University Félix Houphouët - Boigny, Côte d'Ivoire. Research focus: Botany, vegetation, plant biodiversity, conservation.
e-mail : kassindja@yahoo.fr