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Effect of legumineous trees on the floral diversity and ligneous regeneration in zone of evergreen wet dense forest of Ivory Coast

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Abstract

In order to rehabilite degraded grounds and abandoned in fallows after cultural practices, an Australian acacias have been introduced in Côte d'Ivoire. Thirty years after these experimentations, this study is executed to appreciate their effect on the ligneous biodiversity and ligneous regeneration under the populatings of three acacias species. The quadrat method (35x50m and 6x6m) realized in each of these populatings permitted to list 104 ligneous species with a dominance of Fabaceae. High rates of ligneous regeneration (between 89.76±0.61 and 100.00±0.61) were recorded under these populatings of leguminous trees. The prediction of the diversity parameters and the regeneration rates according to the age of biotopes showed positive correlations between the ligneous floral diversity and the age. Negative correlation between the regeneration and the age is observed. Besides, the individual influences of every species of acacia on the diversity and the ligneous regeneration are not significant.

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Introduction

The forests which return numerous ecosystematic services are unfortunately threatened by multiple attacks. The fundamental modifications of composition and quality undergone by the majority of the forests on the planet caused the loss of their original condition (Matthews *et al.,* 2000). Most of the deforestations were observed in the tropical countries, particularly in South America and Africa. The wet tropical space of sub-Saharan Africa is particularly affected by this phenomenon, even if certain countries knew a net earnings of forest surface between 1990 and 2010 (FAO, 2011).

In Ivory Coast, the development of the industrial farming and the galloping urbanization requiring a greater need for lands caused a decrease of forests (Kouadio, 2010 ; Voui Bi, 2014). The national forest cover passed from 16 million hectares to approximately 1,385 million hectares in century (Koné *et al.*, 2014).

The solutions tried to slow down the losses of the forest ecosystems guided the politics of reforestation of the Ivory Coast forest heritage. Among of these, we can quote the introduction of the Australian acacias in Ivory Coast. It aimed at an express reconquest of the forest place setting, because these species have a fast growth (N' Guessan, 2006). This study is interested in the tests made in the forest of Anguédédou. It aims to understand the contribution of these leguminous trees on the regeneration of the ligneous species and the floristic diversity.

Materials and methods

Site of study

This study took place in the Classified Forest of Anguédédou (CFA), situated near the city of Abidjan (5°22'-5°26' N and 4°04'-4°13' W). This forest is located in the South of Côte d'Ivoire, in the zone. The climate is tropical wet, of subequatorial type. Mean monthly temperatures in CFA are relatively low. Mean annual rainfall are abundant. They are distibuated on four seasons, whose two rainy seasons and two dryer seasons (Eldin, 1971). The vegetation is of wet evergreen forest type belonging to the ombrophilous sector of the Guinean domain (Guillaumet and Adjanohoun, 1971). It is characterized by *Turraeantho africanae-Heisteriotum parvifoliae*. The grounds of the site of study which base on tertiary sands in several facies, are of ferralitic type, impoverished in clay. They are very deep, light, sablo-clayey and ferruginous grounds (N'Guessan, 2006).

Materials

The experimental parcels were a populatings of acacias. They were constituted by a three years old populating of *Acacia mangium* (PMan3), an eight years old populatings of *Acacia mangium* (PMan8) and *Acacia auriculiformis* (PAur8), an eleven years old populating of *Acacia mangium* (PMan11) and a twenty seven years old populatings of *Acacia auriculiformis* (PAur27) and *Acacia crassicarpa* (PCra27). We used graduated ribbons to measure the circumferences of the individuals and statement cards.

Methods

We used quadrat method (Picard, 2006) The inventory were realized on rectangular plots 50 x 35 m and square plots 6x6m. In differents populating of acacia, one rectangular plot was installated and five square plots were defined in each rectangular plot. All the species were registred and the circumferences of the individuals were measured. For each species, adult trees and regenerations (diameter < 5 cm) were listed separately. Data were analyzed using XLStat software and PAST software. Diversity and equitability were respectively detetminated by Shannon index (H) and Pielou index (J').

$H = -\sum (ni/N) Log_2 (ni/N)$ (1)

Where *ni* is the number of individuals for species *i* and *N* is the number of individual for all species.

$J' = H/ln\ S$ (2)

Where *H* is Shannon index and *S* is the number of the number of species inventoried

The ligneous regeneration was estimated by the rate of regeneration (RR). When $RR \geq 70$ %, the regeneration is considered good. It is medium if $50\ \% \leq RR < 70\ \%$, and bad when $RR < 50$ % (Koulibaly, 2008).

$RR = (n/N)\ x\ 100$ (3)

Where *n* is the number of young individuals (diameter < 5cm) and *N* the number of all individuals.

One way ANOVA with Tukey's post-hoc test was made to compare the averages of floristic parameters (floristic richness, Shannon index, Pielou index and regeneration rates). A simple linear regression was used to test if there is a relationship between these floristic parameters and the age of acacia's populating.

Results

We identified 104 ligneous species belonging to 83 genres classified in 40 families. The most important families are Fabaceae, Annonaceae and Sapindaceae (Fig. 1). In terms of specific richness, PCra27 was the richest populating is and PMan3 was the least rich populating (Table 1). Shannon index varied between 2,81 (PMan3) and 3,80 (PCra27), whereas Piélou index was equal for all the populatings, except for PCra27 (Table 1). Regeneration rate was higher in the youngest populatings and varied between 89,76 % and 100 %. Otherwise, the averages of these rates were significantly different ($p<0,0001$). There was two categories of populating.

In the first category we finded PAur27, PMan11, PMan8, PAur8 and PMan3 where the regeneration rates were highest. The second category contained PCra27 only (Table 2).

Table 1. Floristic diversity in the populatings of acacias.

	Specific richness	Shannon index	Piélou index
PAur8	30	3,22	0,95
PAur27	28	3,15	0,95
PCra27	52	3,8	0,96
PMan3	19	2,81	0,95
PMan8	26	3,11	0,95
PMan11	26	3,08	0,95

Table 2. Average values of regeneration rate in the populatings of acacias.

Parcels	Regeneration rate
PAur8	100,00±0,61a
PAur27	97,80±0,61a
PCra27	89,76±0,61b
PMan3	100,00±0,61a
PMan8	100,00±0,61a
PMan11	100,00±0,61a
Statistical parameters	*F=44,704*
	P< 0,0001

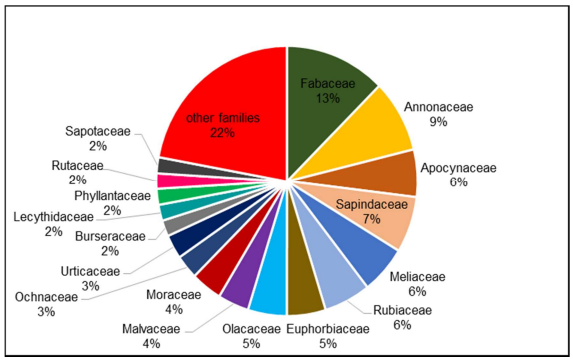
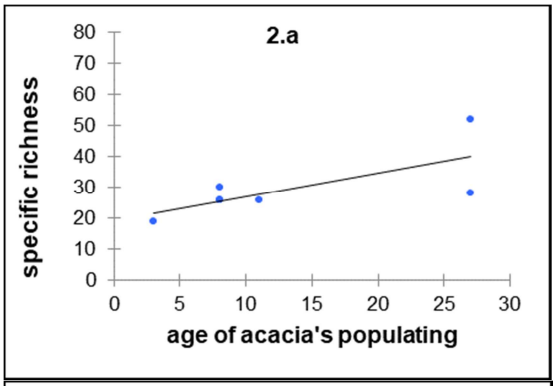
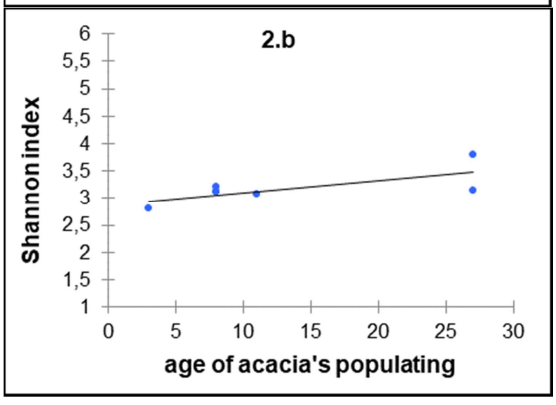


Fig. 1. Families spectre of species inventoried in the populatings of acacias.

The relationship between floristic richness and the populating's age was significant and positive (R^2 = *0,50* ; *p=0,004*). Floristic richness increased with populating's age (Fig. 2.a). The indexes of diversity and equitability were significantly and positively related to populating's age (H: R^2 = *0,51*; *p=0,010* and *J':* R^2 = *0,03*; *p=0,028*). The relationship was medium for Shannon index (Fig. 2.b) and low for Piélou index (Fig. 2.c). We observed a significant and negative relationship between ligneous regeneration and populating's age (R^2 = *0,58*; *p=0,027*). In fact, the ligneous regeneration decreased when populating's age increased (Fig. 2.d).





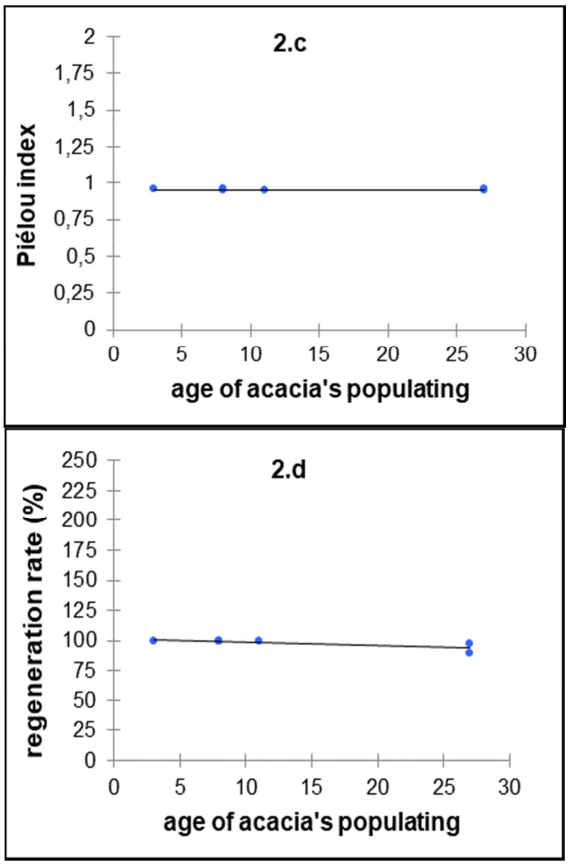


Fig. 2. Linear regressions between floristic parameters and populating's age.

The ligneous regeneration according to acacia's species are significantly different (*F=114,588*; *P=0,000*). There was two categories of populating (Table 3). This ligneous regeneration is statistically highest under populatings of *Acacia mangium* (TR=100,00±0,45%) and *A.auriculiformis* (TR=98,90±0,55%) than under populating of *A.crassicarpa* (TR=89,76±0,55 %).

There was a significant differences (F=13,752; P=0,016) between specific richness averages according to acacia's species (Table 3). It was highest for *A.crassicarpa* (20,60±1,56) than for *A.auriculiformis* (11,90±1,56) and *A.mangium* (11,40±1,28). There was also a significant differences (Table 3) concerning Shannon index (*F=27,428; P=0,005*) and Piélou index (*F=13,798; P=0,016*).

In fact, the average values of these diversity's indexes were highest for *A.crassicarpa* (H : 3,80±0,09 ; J' : 0,96±0,01) than for *A.auriculiformis* (H: 3,18±0,09; J' : 0,95±0,01) and *A.mangium* (H: 3,00±0,07; J': 0,95±0,01).

Table 3. Average compared values of floristic diversity and ligneous regeneration according to acacia's species.

	A.auriculiformis	*A.crassicarpa*	*A.mangium*	Statistical parameters
Average richness	11,90±1,56b	20,60±1,56a	11,40±1,28b	F=13,752; *P=0,016*
Shannon index	3,18±0,09b	3,80±0,09a	3,00±0,07b	F=27,428; *P=0,005*
Piélou index	0,95±0,00b	0,96±0,00a	0,95±0,00b	F=13,798; *P=0,016*
Regeneration rate	98,90±0,55a	89,76±0,55b	100,00±0,45a	F=114,588; *P=0,001*

Discussion

The populatings of acaias create an ecological conditions that enable the appearance of the ligneous species. The presence of shrubby plants in an environment after disturbances constitutes a microsites that favorise the installation of first tree's seedling (Rameau, 1999). The symbiotic association formed by the leguminous trees with fixer bacteria of nitrogen is a model of facilitation of vegetable succession, according to the indirect mechanism of Van Andel *et al.* (1993). The ligneous regeneration is bound to the plant cover and nitrogen's fixation by the roots of acacias. Fixing the atmospheric nitrogen, these plant permit to control herbaceous flora and adventitious which are harmful to the growth of the ligneous flora. The augmentation of the number of ligneous species according to populating's age is confirmed by Puig (2001) who indicate that in an environment, the specific richness increases in time. Shannon index also evolves with the age. We can explain by the fact that this indication is bound to number of species. This increase of richness and diversity according to the age is named species turnover by ecologists (Van Gemerden *et al.*, 2003). The strong rates of regeneration are owed to the ascendancy of the individuals in the small diameters. The abundance of stalks in the classes of small diameters is synonymic of good natural regeneration (Puig, 2001). The regeneration rates are highest in the young populatings.

In the old populatings, the decrease of regeneration rate is induced by the diametric growth regenerated ligneous and their recruitment in the classes of superior diameters. This growth situation could be a preservation factor of ligneous flora under these acacia's populatings (Riéra *et al.*, 1998). The absence of individuals with large diameters is explained by the fact that the forest ecosystems engendered by the populatings of locust trees have not reached their climax. Indeed, the oldest populatings are twenty seven years old. This age is lower than the estimations of some authors concerning the resilience, that is the return duration of an ecosystem in her condition. So, Riswan *et al.* (1985) comparing secondary and primary forests of Dipterocarpaceae in Samarinda (East Kalimantan, Indonesia), consider that the forest regenerates in thirty five years ; when in SouthWest of Ivory Coast, De Namur and Guillaumet (1978) think that thirty nine years are necessary.

Conclusion

This work permited to show the effect of acacias on the ligneous biodiversity and ligneous regeneration in wet evergreen forest zone. Shannon index (between 2,81 and 3,80 bits) and Piélou index (0,95 and 0,96) attest that the ligneous biodiversity is diversified. Besides, the high rates of regeneration (between 89,76 and 100%) prove a very good natural regeneration of the ligneous. As populatings of acaias get older, Shannon, index and Piélou index increase while the rates of regeneration falls. It indicates the influence of legumineous trees on ligneous vegetation restoration concerning the dynamics of the vegetable successions.

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