SPECIES DIVERSITY IN SOME ZAMBIAN FORESTS

Diversité spécifique dans quelques forêts zambiennes

E.N. CHIDUMAYO *

RESUME

La structure spécifique de quatre types de forêts zambiennes a été étudiée en seize stations. La diversité spécifique s'est avérée similaire pour les forêts de type Brachystegia, Marquesia *et chipya, bien que la densité spécifique de 13.0,1 ha^{-1} pour le type chipya soit nettement moindre que celles de 23 et 24 pour les sites à forêt de* Brachystegia *et* Marquesia *respectivement. La forêt marécageuse présente les valeurs les plus basses pour la densité spécifique (5.0,1 ha^{-1}) et l'index de richesse spécifique (0,434), bien que les index de dominance spécifique et d'égale répartition entre les espèces, respectivement de 0,593 et 3,010 soient plus élevés que pour les trois autres forêts. Comme les forêts à* Brachystegia *et chipya représentent des stades de régression de la forêt à* Marquesia *, on peut en conclure que le processus de régression n'est pas accompagné par des changements significatifs de la diversité spécifique.*

ABSTRACT

Species structure of four Zambian forests was studied at sixteen sites. species diversity was similar among Brachystegia, Marquesia *and chipya forests, although the species density of 13.0,1 ha^{-1} at the chipya forest site was much lower than that of 23 and 24 at* Brachystegia *and* Marquesia *forest sites, respectively. Swamp forest had the lowest species density (5.0,1 ha^{-1}) and species richness index (0.434) although the indices of species dominance and evenness of 0.593 and 3.010, respectively, were higher than in the other three forest types. Since* Brachystegia *and chipya forests represent regressive stages from* Marquesia *forest, it was concluded that this process of regression is not accompanied by significant changes in species diversity.*

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* Biology Department, University of Zambia, Box 32379, Lusaka, Zambia.

INTRODUCTION

Although species checklists of Zambian vegetation types have been published (FANSHAWE, 1971), site-specific species diversity is not well documented. Recently CHIDUMAYO (1987 a) has discussed species diversity in Zambian miombo woodlands but similar studies in forest vegetation types have not been published. Eight forest types are recognized in Zambia and of these six are climate controlled and the remaining two (swamp and riparian) are edaphic. Apart from the montane forest, climate controlled forests are divided into evergreen and deciduous (FANSHAWE, 1971). Among the evergreen forests, FANSHAWE (1971) recognized *Cryptosepalum*, *Marquesia* and *Parinari* forests. Apparently, partial destruction of all these forests leads to invasion by *Brachystegia* forest in which *B. spiciformis* Benth replaces some semi-evergreen and deciduous dominants. According to FANSHAWE (1971) fire and concomitant soil changes may also induce regression of *Cryptosepalum*, *Marquesia* and *Parinari* forests to chipya forest. The two deciduous forests are *Baikiaea* and itigi.

This paper discusses species structure in four forest types : *Brachystegia*, *Marquesia*, chipya and swamp. MALAISSE (1984) has defined forest on the basis of basal area : open and closed forests have 15-25 m^2 and 30-40 m^2 basal area at breast height per ha, respectively. However, some Zambian miombo woodland stands may attain a basal area of 18.0 m^2 ha^{-1} (CHIDUMAYO, 1987 b). Therefore forest in this paper has been defined as woody vegetation with basal area at breast height equal to or greater than 20.0 m^2 ha^{-1} .

Nomenclature of woody plants follows WHITE (1962) and FANSHAWE (1971).

STUDY AREAS AND SAMPLING METHODS

Zambia extends over latitudes 8° - 18° south and longitudes 22° - 34° east in southern Africa and has a tropical sub-humid climate with alternating dry and wet seasons. Annual rainfall varies from 700 mm in the south and southeast to 1,500 mm in the north and northwest of the country. Most of the rain falls between November and April.

The study was conducted in six areas (Fig. 1) and rainfall and sampling effort in these areas are shown in table I. Except Mongu, all

the study areas are in the high rainfall (over 1,100 mm mean annual rainfall) region.

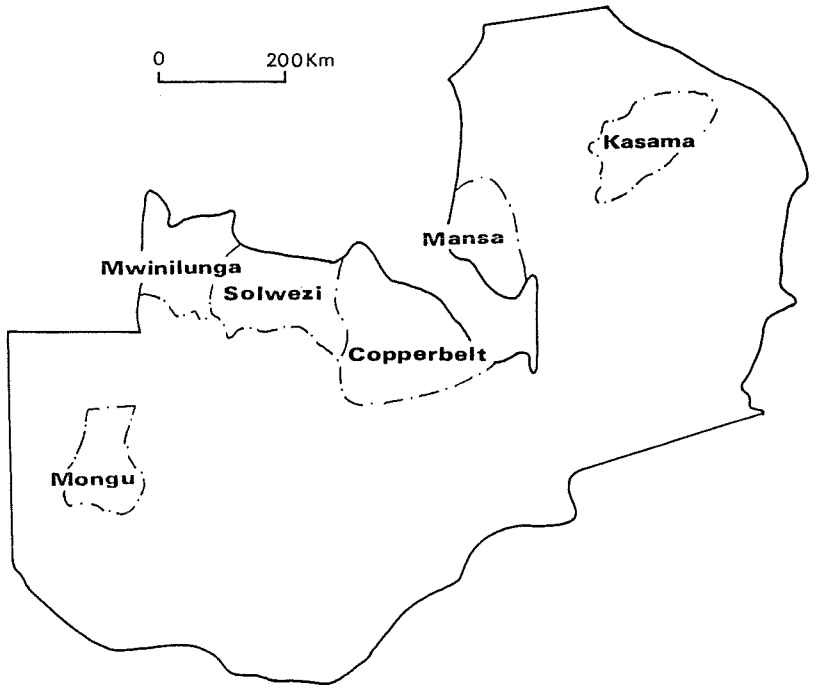

Fig. 1 : Map of Zambia showing the location of study areas.

Study area	Mean annual rainfall (mm)	Distribution of sample sites by forest type			
		Brachystegia	*Marquesia*	Chipya	Swamp
Mongu	972	-	-	1	-
Copperbelt	1171	2	-	-	1
Mansa	1114	2	-	-	-
Kasama	1274	-	2	-	-
Solwezi	1350	3	4	-	-
Mwinilunga	1402	1	-	-	-
All together		8	6	1	1

Tab. I : Rainfall and distribution of sample sites in the study areas.

Each sample site was 20 x 50 m (0.1 ha) and all stems over 9.0 cm girth at 0.3 m above ground were identified, enumerated and girth at 0.3 m and 1.3 m (breast height or BH) above ground measured and recorded. Stems were also classified into four height classes : under 2 m, 2-5 m, 5-10 m and over 10 m. The determination of height classes was based on experience gained from felled stems whose height was measured. Sample stands showed little or no recent human disturbance. Fieldwork was conducted during 1982-1986.

A. *Brachystegia* forest

Brachystegia spp.
Julbernardia spp.
Isoberlinia angolensis

B. Chipya forest

Acacia albida
Afzelia quanzensis
Albizia antunesiana
Burkea africana
Combretum mechowianum
Erythrophleum africanum
Ficus sycomorus
Parinari curatellifolia
Pericopsis angolensis
Pterocarpus angolensis
Sclerocarya caffra
Terminalia sericea
Guibourtia coleosperma
Syzygium guineense subsp. *afromontanum*

C. *Marquesia* forest

Anisophyllea pomifera
Entandrophragma delevoyi
Erythrophleum suaveolens
Parinari excelsa
Podocarpus milanjianus
Marquesia spp.
Syzygium guineense subsp. *afromontanum*

D. Swamp forest

Bridelia micrantha
Diospyros mespiliformis
Ilex mitis
Khaya nyasica
Mitragyna stipulosa
Parinari excelsa
Raphia spp.
Syzygium cordatum
Syzygium owariensis
Uapaca guineensis
Xylopia spp.

Tab. II : Forest canopy species-groups in the study forests (after FANSHAWE, 1971).

RESULTS

Following FANSHAWE (1971), Table II shows the dominant canopy (over 10 m high) species-groups of the four forest types that were studied. The species-groups that contributed the highest proportion to to-

tal basal area at BH was used to identify the different forest types (Tab. I).

Canopy species	BF	MF	Understorey species	BF	MF
Albizia antunesiana	II	-	*Anisophyllea boehmii*	II	II
Brachystegia boehmii	-	I	*Baphia bequaertii*	II	-
B. floribunda	I	-	*Combretum* sp.	I	-
B. glaberrima	I	-	*Diospyros* sp.	I	-
B. longifolia	II	-	*Diplorhynchus condylocarpon*	I	IV
B. Spiciformis	III	III	*Hexalobus monopetalus*	I	I
B. utilis	I	-	*Hymenocardia acida*	II	I
B. wangermeena	I	-	*Lannea* sp.	-	I
Erythrophleum africanum	II	-	*Maprounea africana*	-	I
Isoberlinia angolensis	III	I	*Monotes* sp.	I	-
Julbernardia globiflora	I	-	*Ochna* sp.	I	-
J. paniculata	II	-	*Phyllocosmus lemaireanus*	I	III
Marquesia macroura	I	IV	*Pseudolachnostylis maprouneifolia*	I	-
Parinari curatellifolia	II	II	*Salacia rhodesiaca*	-	II
Pericopsis angolensis	I	I	*Strychnos* sp.	I	I
Pterocarpus angolensis	I	-	*Swartzia madagascariensis*	I	-
			Syzygium guineense subsp. *macrocarpum*	I	I
			Uapaca kirkiana	-	II
			Viridivia suberosa	-	I

Tab. III : Dominant (over 4 % of total stems per site) species in *Brachystegia* forest (BF) and *Marquesia* forest (MF). Species that were dominant at 1-24 % (I), 25-49 % (II), 50-74 % (III) and 75-100 % (IV) of the sites.

Dominant species in *Brachystegia* and *Marquesia* forests are given in table III. *B. spiciformis*, *Parinari curatellifolia* and *Pericopsis angolensis* among canopy flora and *Anisophyllea boehmii*, *Hexalobus monopetalanthus*, *Strychnos* spp. and *Syzygium guineese* spp. *macrocarpum* among understorey taxa had equal frequency ranks in the two forest types. Canopy species at the swamp forest site were *Ilex mitis*, *Mitragyna stipulosa*, *Raphia farinifera* and *Syzygium owariense* with a single unidenti-

fied understorey species. The chipya forest stand in Mongu was dominated by *Guibourtia coleosperma*, *P. curatellifolia* and *S. guineense* ssp. *afromontanum* among canopy taxa and *Combretum* sp. and *Maprounea africana* among the understorey taxa.

The basal area at BH in chipya and swamp forests was 20.0 m^2 and 22.6 m^2 ha^{-1} . Mean basal area of *Brachystegia* forest stands was 24.6 m^2 (standard error (SE) = 0.74) ha^{-1} while that in *Marquesia* forest stands was 79.8 m^2 (SE = 30.12) ha^{-1} . These mean basal area values were significantly different ($t = 3.142$, $P = 0.01$). The very high basal area density in *Marquesia* forest was attributed to the numerous very large buttressed *M. macroura* stems which accounted for 66-82 % of total basal area. Among *Brachystegia*, chipya and swamp forest stands basal area ranged 20.0-26.0 m^2 ha^{-1} , except the Mwinilunga *Brachystegia* forest sample that had 43.0 m^2 ha^{-1} .

Measure of diversity	Forest type			
	Brachystegia	*Marquesia*	Chipya	Swamp
Species 0.1 ha^{-1}	23.88	23.00	13.00	5.00
	(3.95)	(2.27)		
Species dominance : $c = \Sigma (ni/N)^2$	0.115	0.136	0.177	0.593
	(0.001)	(0.001)		
Species richness : $d = S/\sqrt{N}$	2.313	2.012	1.876	0.434
	(0.020)	(0.032)		
Shannon index : $H' = -\Sigma (ni/N)\ln(ni/N)$	2.170	2.230	1.813	2.102
	(0.003)	(0.010)		
Species evenness : $e = H'/\ln S$	1.592	1.650	1.627	3.010
	(0.004)	(0.004)		

Tab. IV : Species diversity in four Zambian forests. For *Brachystegia* and *Marquesia* forests figures represent mean values and those in parentheses show standard error. Definitions of indices of dominance and species diversity follow ODUM (1971). ni = stems per species; N = stemps per sample; S = total species per site. H' was calculated using natural logarithme.

Table IV shows the indices of species diversity in the four forest types. Statistical comparison of species diversity and number of canopy and understorey species between *Brachystegia* and *Marquesia* forest types revealed no significant differences ($\pm < 0.652$, $P > 0.05$). Species diversity in *Brachystegia* and *Marquesia* forests was similar to that found at the chipya forest site, except for the much lower species density in

the latter. Swamp forest was different from the other forests in four aspects. Species dominance and evenness are much higher while species density and richness are much lower than in the other forests (Tab. IV). This may be due to the fact that swamp forest is edaphically controlled while the other three forests are climate controlled. FANSHAWE (1971) also observed that swamp forest has a low species diversity.

DISCUSSION

Brachystegia and chipya forests represent regressive stages from *Marquesia* forest (FANSHAWE, 1971). It is apparent from table IV that although the regression from *Marquesia* forest to either *Brachystegia* or chipya forest is accompanied by changes in floristic composition (FANSHAWE, 1971; LAWTON, 1978) there are no significant changes in species diversity. Species diversity in *Brachystegia* and *Marquesia* forests found in this study is similar to that found in wetter miombo woodland in the same high rainfall region of Zambia (CHIDUMAYO, 1987 a), except for the lower species density (18-19 0.1 ha^{-1}) in the miombo woodland than in *Brachystegia* and *Marquesia* forests (Tab. IV). Thus apart from basal area, species density may be useful in distinguishing wetter miombo woodland from *Brachystegia* forest.

According to the present study, the dry evergreen forest studied by MALAISSE (1984) near Lubumbashi in southern Zaïre can be classified as a *Brachystegia* forest. Although MALAISSE (1984) only enumerated stems with over 31.0 cm girth at BH analysis of his data gives the following species diversity indices : c = 0.111, d = 1.752, H' = 2.271 and e = 0.803 (symbols are defined in table IV). The H' and c values are similar to those found in *Brachystegia* and *Marquesia* forests in the present study, although the d and e values are somewhat lower.

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