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Original Article

Factors determining floristic composition and functional diversity of plant communities of Mount Oku forests, Cameroon

Marie Caroline Momo Solefack [a], Evariste Fongnzossie Fedoung [b,*], Lucie Félicité Temgoua [a]

[a] University of Dschang, Faculty of Science, Department of Plant Biology, P.O.Box 67, Dschang, Cameroon
[b] University of Douala, Higher Technical Teacher's Training School, PO BOX 1872 Douala, Cameroon

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ABSTRACT

Mount Oku, in north-western Cameroon, holds many endemic and restricted-range species. This study identifies factors influencing the species and functional diversity of plant communities in Mount Oku forests. We specifically look at whether the altitudinal gradient, which classically structures the mountain vegetation, has shifted in response to the influence of human activities. To explore variations in the vegetation composition of the study area, we realized 102 floristic plots along an altitudinal gradient and environmental conditions records (abiotic and biotic variables, human proximity indexes, and land uses at certain periods). Plant species identified were also characterized by a series of life traits (biological type, type of diaspore, leaf size, phytogeography, dispersal pattern, and altitudinal distribution). Multivariate analyses (nonmetric multidimensional scaling and coinertia) have identified the main types of forest vegetation and link functional diversity to environmental factors. The results show that humans have altered the functional composition of vegetation by rearing domestic animals in the understorey forest near the summit. The results also show that it is sometimes difficult to separate the effect of the altitude from the effect of human presence on the plant composition. Greater efforts of biodiversity conservation in high species-rich areas in Mount Oku should be made.

Introduction

Tropical forests of West and Central Africa have long been recognized as being biologically diverse (Bergl et al 2007, Burgess et al 2007, Myers et al 2000). The Kilum Mountain Range and the Ijim Ridge commonly known as Mount Oku are part of the Western Highlands of Cameroon, commonly referred to as the Bamenda Highlands, and are among the sites possessing the highest rate of endemism in the region (Cheek et al 2000; Asanga 2002). This area contains the largest remaining patches of Afromontane forests in Central Africa, with threatened fauna and flora. The World Wildlife Fund for Nature has defined it as one of its top 200 worldwide ecoregions. It contains 35 restricted-range endemic bird species, which makes it the third richest ecoregion for birds in mainland Africa. It is home to 10 endemic reptiles, 55 endemic amphibians, 6 endemic mammals, and around 100 rare/endemic plant species.

The vegetation of this area consists of a mosaic of gallery forest, Afromontane forests, Raphia forests, and savannah grasslands. Although the mountain forests are naturally geographically isolated because of their mountainous characteristics, they are now highly fragmented by the expansion of agricultural land and fire and timber exploitation (Gardner et al 2001).

There has been a growing interest of ecological research in ascertaining the processes underlying the assembly, dynamics, and structure of ecological communities. Such information is useful not only in understanding plant community structure and species distribution variability at a spatial scale but also in providing insight into the environmental requirements of the tree species needed for successful ecological restoration and biodiversity protection (Maréchal et al 2014). Historically, some influential theoretical models have been developed for studying plant community assembly. The niche theory expresses the relationship of an individual or a population to all aspects of its environment (Khatibi and Sheikholeslami 2016). According to this theory, species live together in a community only when they differ from one another in

* Corresponding author. Tel.: +237 677207532.
E-mail address: fong_nzossie@yahoo.com (E. Fongnzossie Fedoung).
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resource uses. But, this theory showed some difficulties in explaining the diversity often observed in specie-rich communities such as tropical forests. As an alternative, Hubbell introduced the neutral model and argues that the number of species in a community is controlled by species extinction and immigration or speciation of new species (Zhou and Zhang 2008). This theory assumes that highly diverse communities of equivalent species arise because chance extinctions are balanced by speciation. Contrary to the neutral model, negative density dependence mechanisms have been advocated by other researchers such as Xiaoguang Du et al (2011) who argued that a species' relative abundance is positively related to its competitive ability. The debate over these two extremes of pure niche theory and neutral theory is still ongoing, and recent developments are attempting to unify neutral- and niche-based approaches to ecology.

The composition and functional diversity are among the most significant ecological attributes of a particular ecosystem, which show variations in response to environmental and anthropogenic factors, and elucidating how these factors drive the assemblage of plant communities remains an important challenge in ecological research (Mason and de Bello 2013). In fact, a variety of environmental processes including topography, edaphic, and disturbance factors have been reported to influence vegetation composition and functional traits of plant communities (Fensham et al 1992; Williams et al 1996; O'Grady et al 2000; Pekin et al 2009; Molina-Venegas et al 2016). In Mount Oku area, a very general typology of the milieu and a nonexhaustive list of species were established by Hawkins and Brunt (1965) and Cheek et al (2000). Very few studies have focused on the drivers of variations of floristic composition of plant communities.

The aim of the study is to identify factors influencing the species composition and functional diversity of plant communities in Mount Oku forests and to evaluate the relative influence of these factors using appropriate analyses.

Materials and methods

Study site

The Kilum Mountain Range and the Ijim Ridge are commonly called Mount Oku and are situated in the North-West region of Cameroon, in Bui and Boyo divisions, respectively. The contiguous Kilum and Ijim mountain forests are located between latitude 6°07′N and 6°17′N and longitude 10°20′E and 10°35′E in Universal Transverse Mercator (UTM) 32N reference—World Geodetic System (WGS) 84. The Ijim ridge possesses a lake (Lake Oku) which is located at 6°12′N and 10°27′E.

Mount Oku (3,011 m a.s.l. (above sea level)) is located in the northern section of the Bamenda Highlands close to the montane forest and savannah transition zone. The area includes a mixture of montane forest, montane grassland, and subalpine habitats. Mount Oku is also among the largest areas of endemism in Africa for plants and animals (McLeod 1987; Cheek et al 2000; Asanga 2002).

The climate of Mount Oku presents the characteristics of a subequatorial climate with a rainy season between May and September and a dry season between October and April. The soils are humic ferralitic, derived from tertiary lava parent material and may contain appreciable quantities of concretionary rubble (Hawkins and Brunt 1965). The land used in subsistence farming consists of sun crops predominately maize grown with beans, pumpkins, and shade crops of coffee, banana, kola nut, avocado, sour plum, and other trees. Most farmers rear poultry, goats, sheep, pigs, and fish (the latter two sometimes combined with pig sheds above fish ponds). Grasslands are often used for grazing of livestock (cattle, sheep, and goats) (Doherty-Bone & Gvoždík 2017).

Vegetation sampling

A total of 102 floristic plots were arranged randomly in the forest along an altitudinal gradient spanning from 1800 to 2749 m. Each plot consisted of a system of nested quadrats of 1600 m^2 for the inventory of tree species >10 cm in diameter and shrub of 2–10 cm in diameter; 800 m^2 for the inventory of subshrub species <2 cm in diameter and tall grasses >1 cm in diameter; and 400 m^2 for the low herbaceous species <1 cm in diameter. In each stratum of each plot, the vascular plants cover was estimated using the Braun-Blanquet cover-abundance coefficients transformed to frequency index (i = 0.1; += 0.5; 1 = 3; 2 = 15; 3 = 37.5; 4 = 62.5; 5 = 87.5). The nomenclature of species follows that of Lebrun & Stork (1991–1997). To estimate the density of woody species on our surveys, we estimated the number and measured the height of individuals present in the tree and shrub strata.

Sampling of environmental variables

To link changes in species composition to changes in environmental conditions, we measured 27 variables characterizing the environment of each plot (Table 1). These environmental variables can be classified into three categories: local biotic and abiotic variables (tree height, elevation ...), the variables describing the human impact (density of population, distance from homes ...), and landscape variables (changes in soil occupation around plots between different dates).

Functional characterization of species

To study the functional diversity of plots, we classified each species according to various traits that may represent a response to a changing environment. The biological types and location of species in the vertical stratification of the ecosystem indicate the

Table 1. List of environmental variables and their codes.

Biotic and abiotic local variables	CODES
Maximum height of the ligneous plant (cm)	Hmax
Mean height of the ligneous plant (cm)	Hmoy
Density of trees (number of stems/ha)	DA
Density of shrubs (number of stems/ha)	Dar
Coverage of the tree stratum (>10 m) (%)	ARBO
Coverage of the shrub stratum (2 m < H < 10 m) (%)	ARBU
Coverage of subshrub stratum (1 m < H < 2 m) (%)	SARBU
Coverage of herb stratum (%)	HERB
Coverage of bare soil (%)	SOL
Number of death trees	MORT
Number of traps	PIEG
Altitude (m)	ALTI
Human presence variables	
Number of villages in a radius of 5 km	Vil5km
Distance from the nearest village (m)	DVIL
Number of inhabitants within a radius of 5 km	Hab5km
Lanscape variables	
Forest area within a radius of 500 m in 1978 around the plot	F78
Savannah area within a radius of 500 m in 1978	S78
Crop area within a radius of 500 m in 1978	C78
Bare soil area within a radius of 500 m in 1978	Sol78
Forest area within 500 m in 1988	F88
Savannah area within 500 m in 1988	S88
Crop area within 500 m in 1988	C88
Bare soil area within 500 m in 1988	Sol88
Forest area within 500 m in 2001	F01
Savannah area within 500 m in 2001	S01
Crops area within 500 m in 2001	C01
Bare soil area within 500 m in 2001	Sol01