Journal of Phytology 2023, 15: 70-79
doi: 10.25081/jp.2023.v15.8387
https://updatepublishing.com/journal/index.php/jp

Research Article

ISSN: 2075-6240

Inselbergs: potential conservation areas for plant diversity in the face of anthropization

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ABSTRACT

Faced with the loss of biodiversity, particularly plant diversity, due to anthropogenic pressure, particular ecosystems such as inselbergs can constitute refuge areas. The objective of this study is to determine the conservation potential of plant biodiversity on inselbergs in Burkina Faso. A comparative study was carried out between inselberg's vegetation and the surrounding plains vegetation. In each of these vegetation types, stratified and random sampling was adopted and data were collected in plots of 900 m^2 for the woody stratum and 100 m^2 for the herbaceous stratum. The specific diversity was evaluated through the effective numbers of Hill of order $Q = 0; 1; 2$. The Hill index does not vary between inselbergs and plains and thus reflects a strong similarity in floristic diversity between the two ecosystems. Sorensen's similarity coefficient also shows a similarity in terms of floristic composition between inselbergs and surrounding plains. In inselbergs, relict species that have disappeared from the surrounding plains of some phytogeographic sectors occur. The flora of inselbergs is also characterised by indicative species of anthropized ecosystem absence. However, these species are present on the surrounding plains. Indeed, the flora of inselbergs is characterised by 11 endemic species. Inselberg's vegetation is characterised by unique plant communities such as rock pools and *Afrotrilepis pilosa* mats. The exploitation and mortality rates of woody plants are significantly higher on the surrounding plains than on the inselbergs. The flora and vegetation of inselbergs show the absence of indicator species of disturbed ecosystems. They present endemic and relict species and stable woody stands. Due to the steep slope, lack of suitable soil for agriculture and sacred status of someones, the inselbergs constitute a refuge for plant species and thus contribute to the conservation of biodiversity like the protected areas.

Received: October 28, 2022
Revised: May 15, 2023
Accepted: May 17, 2023
Published: May 27, 2023

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KEYWORDS: Anthropization, Biodiversity, Conservation, Rock outcrop, Burkina Faso

INTRODUCTION

Due to the anthropogenic degradation of most ecosystems, the degree of phytodiversity loss in Africa has reached an unprecedented rate (Sinsin & Kampmann, 2010; Mouhamadou *et al.*, 2013; Gillet *et al.*, 2016). Africa is the continent with the highest annual net loss of deforestation. Indeed, the rate of land cover degradation in Africa is four times higher than the global average (FAO, 2015). Between 2000 and 2010, Africa reached a net loss of 3.4 million hectares per year of land cover (FAO, 2010). Among the ten countries in the world with the highest deforestation, six are African (Deltour & Bigant, 2019). In West Africa, the loss of vegetation cover is estimated at nearly 19% between 2000 and 2010. About 870,000 hectares are lost each year. In Burkina Faso, the degradation of vegetation cover and woody species populations regression are perceptible with a reduction rate of 1% per year (Kambiré *et al.*, 2015). The causes of this degradation are physical, climatic and anthropogenic. The main causes are extensive agriculture, overgrazing, overexploitation of plant resources, human population growth and climate change (Traoré *et al.*, 2012b; Baggnian *et al.*, 2013; Akognongbe *et al.*, 2014). In West Africa, the decline in rainfall from 1970 to 1990 caused a 25-35 km shift of isohyets southwards in the Sahelian, Sudanian and Guinean zones during the 20th century (Gonzalez, 2001). More than 50% of woodland vegetation has been transformed into agriculture zones (Chidumayo, 2011). In some areas, excessive pruning has reduced many trees to skeletons in ecosystems (Muoghalu, 2014).

Certain landscape elements which are less degraded by human activities could act as refuges for plants. Under certain circumstances rock outcrops, such as inselbergs could thus play an important role in the conservation of biodiversity. Inselbergs are isolated mountains that rise ubruptly from their surroundings. They consist of various rock types (e.g. granite, gneiss, sandstone) and are characterized by a preponderance of seemingly bare, open slopes. Growth conditions on inselbergs are harsh (e.g. high temperatures, lack of water) and their vegetation comprises many specialized plant species which do not occur in the surrounding landscape.

This study aims to highlight the conservation potential of inselbergs in Burkina Faso and to provide an overview of the major plant communities.

MATERIALS AND METHODS

Study Area

The study was conducted in Burkina Faso, a country located in central West Africa.The country is subdivided into four phytogeographic sectors based on climate, vegetation and flora by Fontès and Guinko (1995). The inselbergs, which are the subject of this study, occur in all phytogeographic sectors of the country (Figure 1). The different types of inselbergs found in Burkina Faso are granitic, gneiss and sandstone inselbergs.

Sampling and Data Collection

Floristic surveys were carried out on inselbergs and in their surroundings following stratified and random sampling. Data were collected in plots of 900 m² for the woody stratum and 100 m² for the herbaceous stratum (Kouassi *et al.*, 2009; Tindano *et al.*, 2015; Zerbo *et al.*, 2017). The area of the plots in the micro-habitats of inselbergs varied from 0.25 m² to 9 m² depending on the size of the micro-habitat (Büdel *et al.*, 1997; Porembski, 2000; Kouassi *et al.*, 2014b). Surveys of the surroundings were conducted at a distance of 500 m from the piedmonts to avoid edge effects.

For the floristic data, all plant species were recorded in each plot. The scientific name of each plant species is accompanied by its abundance-dominance coefficient according to Braun-Blanquet, (1932). For species that were not identified in the field, specimens were collected for determination in the laboratory. Some characteristics of the environment such as anthropogenic actions (grazing, fires, use/exploitation of rocks) were noted.

The reason for taking the woody stratum into account is that it reflects the physical dynamics of the environment in a more perceptible way. Trees and shrubs have an interesting ecological indicator value, as their populations respond to long-term trends of change in environmental factors (Ouedraogo, 2006). Woody plants are the most important determinants of the stability of plant ecosystems and can provide, on their own, sufficient information on the dynamics of phytocenoses. Dendrometric data were also collected namely the number of individuals of each woody species, the trunk diameter at 30 cm from the ground of woody plants with a diameter greater than or equal to 5 cm (Ouédraogo & Thiombiano, 2012; Traoré *et al.*, 2012b). The trunk diameter was measured at 30 cm from the ground because of the strong branching of plants in the Sahelian zone due to anthropic pressure (Diallo *et al.*, 2011). The vitality of the woody plants was assessed according to the following codes: 0 for individuals with no visible trace of exploitation; 1 for individuals bearing a trace of human exploitation; 2 for partially desiccated individuals; 3 for totally desiccated or dead individuals. Young individuals (seedlings) of woody species with

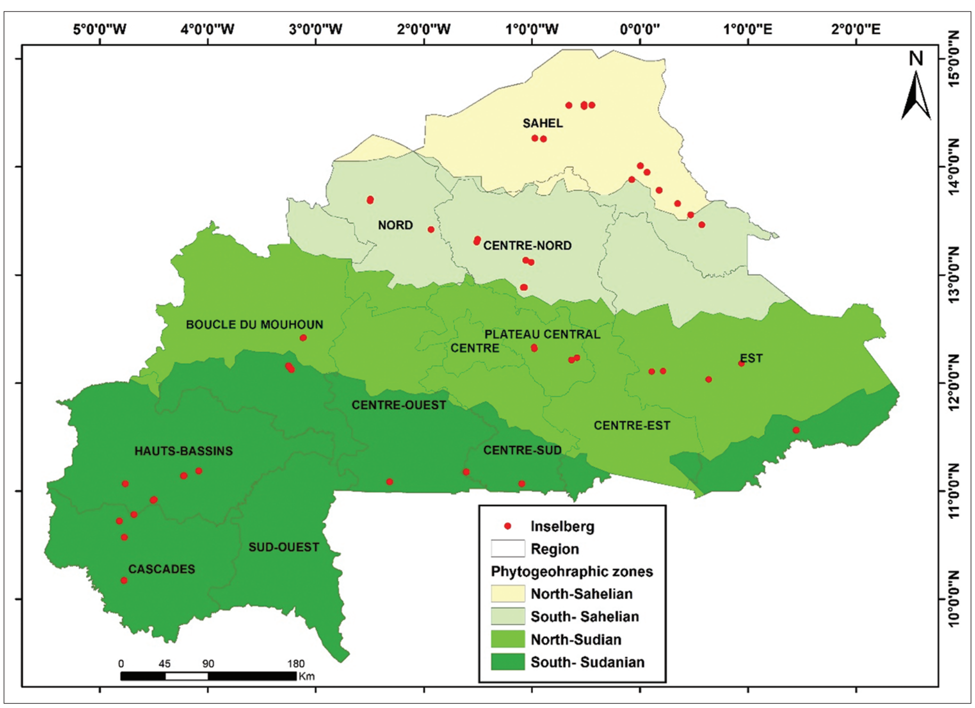

Figure 1: Study area showing the presence of inselbergs

a diameter of less than 5 cm, were recorded and used to calculate the regeneration rate.

Data Analysis

Floristic data

Species that could not be identified in the field were identified with the help of floristic literature (Hutchinson & Dalziel, 1954, 1958, 1963, 1968, 1972; Bérhaut, 1976; Akoegninou *et al.*, 2006). Authentication of the scientific names of all the species inventoried was done by comparison with specimens in the herbarium of Université Joseph KI-ZERBO and the Centre National de la Recherche Scientifique et Technologique (CNRST). The nomenclature adopted was based on the catalogue of vascular plants of Burkina Faso by Thiombiano *et al.* (2012).

The floristic diversity of inselbergs and surrounding plains were characterised by determining alpha and beta diversity. The alpha diversity includes species richness (Q0), exponential of Shannon index (Q1), inverse of Simpson index (Q2), Hill index and Piélou equitability index (E). These parameters were calculated from the following formulae:

- Q0 = S, S being the specific richness;
- $Q1 = e^{H}$, with $H = -\sum_{i=1}^{s} Pi \ln Pi$, Pi is the relative abundance of the second species in a plot. Q1 is the number of abundant species;
- $Q2 = \sum_{i=1}^{S} P_i^2$, where P_i is the relative abundance of species i in a plot. Q2 is the number of highly abundant species;
- $Hill = \frac{Q2}{Q1}$, Hill index seems more relevant because it

integrates the two other diversity indices (Shannon and Simpson) and allows comparisons between plant communities in different ecosystems (Traoré *et al.*, 2012b).

$$E = \frac{H}{\ln S}$$

Beta diversity complements the study of alpha diversity (species richness and diversity indices) and provides an account of diversity at the scale of an ecosystem or region. In this study, Sorensen's similarity coefficient (Cs) was used to measure beta diversity.

$Cs = \frac{2c}{2c + b + a}$, c: number of common species; a = number of species found in site A; b = number of species found in site B.

Species richness, exponential of Shannon index and the inverse of Simpson index, were calculated with R 4.0.5 through the BiodiversityR package (Kindt & Coe, 2005). The package ggplot2 (Wickham, 2016) was used to generate the graphs. These different diversity indices were compared between inselbergs and surrounding plains and the differences were tested by univariate analyses (Kruskal-Wallis Anova) with R package Commander (Fox, 2005).

The life forms used are those defined by Raunkiaer (1934) and phytogeographical types were derived from the chorological subdivisions of White (1986). Proportions have been calculated to highlight the abundance of life forms and phytogeographical types (Oumorou & Lejoly, 2003; Kouassi *et al.*, 2009). The proportion is the percentage ratio of the cumulative number of species of a life form or phytogeographical type to the total number of species.

Dendrometric data

The parameters that have been calculated for the description of woody vegetation of inselbergs and in surrounding plains are:

- Density, $D = \frac{N}{S}$, N: total number of woody individuals, S: area in hectares
- Average diameter (Di)
- Basal area, $Ba = Di^2_{30cm} \frac{\pi}{4}$, Di: diameter
- Exploitation rate (Ex), which is given by the ratio between the number of woody individuals bearing a trace of human exploitation on the total number of woody individuals inventoried (Tindano *et al.*, 2011, 2015).

$$Ex = \frac{\text{Total number of individuals with evidence of exploitation}}{\text{Total population of the stand}} \text{x100}$$

- Mortality rate (Mo), which is given by the ratio of the number of dead woody individuals to the total number of woody individuals surveyed (Tindano *et al.*, 2014).

$$Mo = \frac{\text{Number of dead woody individuals}}{\text{Total number of woody individuals surveyed}} \text{x100}$$

- Regeneration rate (Re) is given by the ratio of the total number of young plants to the total number of plants in the stand (Ngom *et al.*, 2013).

$$Re = \frac{\text{Total number of young individuals}}{\text{Total number of the survey}} \text{x100}$$

The demographic trend of woody species populations threatened in Burkina Faso according to Thiombiano and Kampmann (2010), found both on inselbergs and on surrounding plains, was assessed. For this purpose, individuals of each species were divided into diameter classes of 5 cm interval (Traoré *et al.*, 2012a) and the three-parameter Weibull distribution (a, b, c) was used to assess the status of populations (Kakaï *et al.*, 2016; Agbani *et al.*, 2018; Félix *et al.*, 2019). Four woody species were selected for this study (*Lannea microcarpa* Engl. et K. Krause, *Pterocarpus lucens* Guill. et Perr., *Pterocarpus erinaceus* Poir, and *Stereospermum kunthianum* Cham.).

The demographic trend was also analysed through a log-linear regression (Obiri *et al.*, 2002). For each species, the log-linear regression was calculated with the median class as the independent variable and the number of individuals in this class as the dependent variable. The log-linear regression allows to obtain the stability parameters which are the values of the slopes (a) from the regression equations and the correlation r^2. These two parameters are considered as an indicator of the population structure of woody species (Condit *et al.*, 1998). A zero slope indicates that the numbers of small and large trees are equal. A positive value of the slope indicates that large individuals are the most important and characterize a disturbed or unstable population. While the negative value of the slope indicates that small individuals are more numerous and indicates a stable population. To obtain the stability parameters, Ni (the number of individuals in each diameter class) was log-transformed using ln(Ni+1) because some diameter classes do not contain any individuals (Sop *et al.*, 2010). The regression was run between ln(Ni+1) and ln(mi) (with mi as the median class).

Different parameters of woody vegetation structure were compared between inselbergs and surrounding plains and the differences were tested by univariate analyses at the 5% threshold (Kruskal-Wallis Analysis Of Variances) with the R Commander package (Fox, 2005).

RESULTS

Floristic Composition and Diversity

On the surrounding plains, the floral is composed of 535 species distributed in 295 genera and 84 families against 467 species distributed in 273 genera and 83 families on the inselbergs. The Poaceae, Fabaceae-Faboideae, Fabaceae-Mimosoideae and Rubiaceae are the dominant families on inselbergs. The dominant families on the plains are Poaceae and Fabaceae-Faboideae, followed by Malvaceae and Rubiaceae. The Hill index does not vary ($p = 0.494$) between inselbergs and plains and thus reflects a strong similarity in floristic diversity between the two ecosystems (Table 1). Sorensen's similarity coefficient (Cs = 87.95%) also shows a similarity in terms of floristic composition between inselbergs and surrounding plains.

Species richness ($p < 0.001$), exponential of Shannon index ($p < 0.001$), inverse of Simpson index ($p < 0.001$) and Piéou's equitability index ($p < 0.05$) vary significantly between inselbergs and surrounding plains (Table 1 & Figure 2). The Q0 value is high in the plains compared to the inselbergs, showing that the species richness of the plains' flora is higher than the flora of inselbergs. The values of Q1 and Q2 showed that the number of abundant and very abundant species are higher in the lowland vegetation than in the inselberg vegetation. Pielou's equitability index confirms the existence of species dominance in both ecosystems despite the fact that almost all plant species are represented.

On inselbergs, relict species that have disappeared from the surrounding plains of some phytogeographic sectors occur. During this study, two relic species were found on inselbergs in the North Sahel phytogeographical sector (Table 2). The flora of the inselbergs is also characterised by the absence of indicative species of anthropized ecosystems. However, these species are present on the surrounding plains. Indeed, the flora of inselbergs is characterised by endemic species. 11 species endemic to inselbergs in Burkina Faso were recorded during this study (Table 2).

Inselberg's vegetation is characterised by unique plant communities such as rock pools and *Afrotrilepis pilosa* mats.

As their name suggests, pools on rocks are small reservoirs of water on inselbergs. They occur both on granitic and sandstone inselbergs. Species that is subject to this habitat is *Dopatrium longidens* Skan (Figure 3). The main characteristic species of *A. pilosa* mats is *A. pilosa*. With the help of its roots, this species colonizes bare rock surfaces and traps the soil (Figure 4).

Life Forms

Therophytes (42.60%; 42.72% respectively) and Phanerophytes (39.08%; 39.17% respectively) have the same dominance trend in inselbergs and in surrounding plains (Figure 5). Hemicryptophytes (6.15%) and Lianas-phanerophytes (5.42%) are more abundant on the inselbergs than on the surrounding plains. Chamaephytes (5.80%) and Geophytes (2.43%) are more abundant on the surrounding plains than on the inselbergs (Figure 5).

The vegetation of inselbergs is characterised by hemicryptophytes abundance and the low presence of chamaephytes. Conversely, chamaephytes are more abundant on the surrounding plains and hemicryptophytes are poorly represented.

Phytogeographic Types

The proportion of phytogeographic types shows that species with a Sudano-Zambezian (28.37%), Afro-tropical (21.73%) and Sahelo-Saharan (2.31%) distribution are more abundant on the

Table 1: Floristic diversity of inselbergs and surrounding plains

	Diversity parameters								
	Families	Genera	Species	Q0	Q1	Q2	Hill	E	Cs
Inselbergs	83	273	467	21.26±9.14	10.37±4.36	7.59±3.19	0.74±0.09	0.76±0.09	87.95
Plains	84	295	535	27.09±10.03	13.15±4.42	9.69±3.27	0.74±0.05	0.78±0.06	
Analysis of variance									
d.f.	-	-	-	1	1	1	1	1	-
F	-	-	-	30.67	32.07	33.95	0.468	6.309	-
P	-	-	-	<0.001***	<0.001***	<0.001***	0.494	<0.05*	-

Significant difference codes $p<0.05$*, $p<0.01$**, $p\leq0.001$***

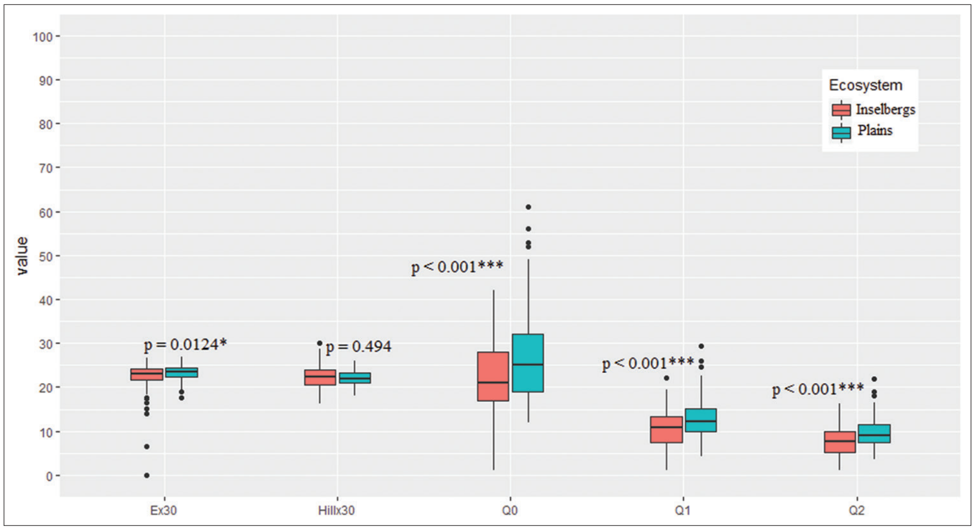

Figure 2: Comparison of species diversity indices between inselbergs and the surrounding plains (Significant difference codes $p < 0.05^*$, $p < 0.01^{**}$, $p \leq 0.001^{***}$)

Figure 3: Temporary rock pools, province of Comoé (Takalédougou). Photo E. Tindano.

Figure 4: *Afrotrilepis pilosa* mats, province of Houet (Koro). Photo E. Tindano

inselbergs than on the surrounding plains (Figure 6). However, broadly distributed species such as Pantropical (23.27%), Palaeotropical (10.83%) and African Pluriregional (5.55%), are more abundant in surrounding plains (Figure 6).

Table 2: Relic and endemic species of inselbergs, indicative species of anthropized ecosystems

Families	Species	Inselbergs	Plains
Euphorbiaceae	*Acalypha ciliata* Forssk	-	+β
Cyperaceae	*Afrotrilepis pilosa* (Boeckeler.) J. Raynal	+*	-
Amaranthaceae	*Amaranthus viridis* L.	-	+β
Poaceae	*Aristida hordeacea* Kunth	-	+β
Rubiaceae	*Batopedina tenuis* (A.Chev. ex Hutch. & Dalziel) Verdc.	+*	-
Begoniaceae	*Begonia rostrata* Welw. ex Hook.f.	+*	-
Acanthaceae	*Blepharis linariifolia* Pers	+§	-
Capparaceae	*Cadaba glandulosa* Forsk.	+§	-
Asteraceae	*Chrysanthellum indicum* DC.	-	+β
Commelinaceae	*Commelina benghalensis* L.	-	+β
Apocynaceae	*Cynanchum hastifolium* N. E. Br.	+*	-
Plantaginaceae	*Dopatrium longidens* Skan	+*	-
Poaceae	*Eleusine indica* (L.) Gaertn.	-	+β
Euphorbiaceae	*Euphorbia sudanica* A. Chev.	+*	-
Eriocaulaceae	*Eriocaulon fulvum* N.E.Br.	+*	-
Convolvulaceae	*Ipomoea dichroa* Choisy	-	+β
Isoetaceae	*Isoetes jaegeri* Pilot	+*	-
Cyperaceae	*Kyllinga squamulata* Thonn. ex Vahl	-	+β
Linderniaceae	*Lindernia exilis* Philcox	+*	-
Linderniaceae	*Lindernia schweinfurthii* (Engl.) Dandy	+*	-
Plantaginaceae	*Scoparia dulcis* L.	-	+β
Orobanchaceae	*Striga aspera* (Willd.) Benth.	-	+β
Xyridaceae	*Xyris straminea* L.A.Nilsson	+*	-

+=Presence; -=Absence; §=Relict species;
β=Indicator species of disturbed ecosystems; *=Endemic species

Structural Parameters of Woody Vegetation

Mean density, mean diameter and mean basal area ($p < 0.001$) vary significantly between inselbergs and surrounding plains. Mean density, mean diameter and mean basal area values are higher in plains than in inselbergs (Table 3 & Figure 7). The exploitation and mortality rates of woody plants also vary significantly ($p < 0.001$) between inselbergs and surrounding plains with higher values in the surrounding plains (Table 3 & Figure 7). As for the natural regeneration rate, the difference is not significant (p = 0.571) between inselbergs and the surrounding plains.

Population Trends of Threatened Woody Species

L. microcarpa, *P. lucens*, *P. erinaceus* and *S. kunthianum* show stable population structures on the inselbergs, characteristic of populations with high regeneration rates. However, these same species show unstable structures on the surrounding plains, indicating difficulties in regeneration (Figure 8). The stability of the populations of the four species on inselbergs is confirmed by the negative slopes and high r^2 correlation coefficients of the regression equations. However, the instability of populations of these species on the surrounding plains is illustrated by the low r^2 correlation coefficients and the positive slopes of the regression equations (Table 4).

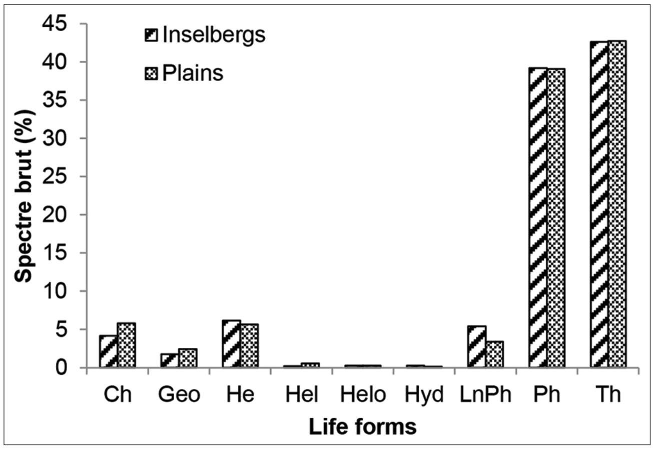

Figure 5: Life forms of inselbergs and surrounding plains
Ch: Chamaephytes, Geo: Geophytes, He: Hemicryptophytes, Hel: Helophiles, Helo: Helophytes, Hyd: Hydrophytes, LnPh: Lianas-phanerophytes, Ph: Phanerophytes, Th: Therophytes

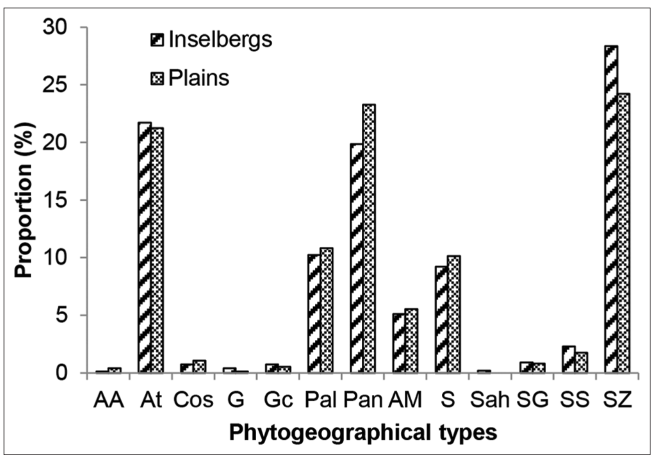

Figure 6: Phytogeographic types of inselbergs and surrounding plains
AA: Afro-american, At: Afro-Tropical, Cos: Cosmopolitan, G: Guinean, GC: Guineo-Congolese, Pal: Paleotropical, Pan: Pantropical, AM: African Multiregional, S: Sudanian, SG: Sudano-Guinean, SS: Sahelo-Saharan, SZ: Sudano-Zambesian

DISCUSSION

Floristic Composition and Diversity

The flora of surrounding plains is marked by the presence of characteristic species of anthropized environments and disturbed areas. These species are absent from inselbergs and this indicates that the vegetation of inselbergs is better protected from human impacts (Akoegninou *et al.*, 2006). It is in this sense that Wittig *et al.* (2000) referred to the relative intactness of the vegetation of inselbergs in Burkina Faso because of its lesser exploitation compared to the vegetation of surrounding plains. This could be due to their inaccessibility because of the steep slopes, the lack of suitable soil for agriculture and the sacred nature of some of them (Tindano *et al.*, 2015). The presence of relic species on inselbergs in Burkina Faso corroborates the results of Kouassi *et al.* (2014a) in the Ivory Coast and attests to the relatively natural state of inselberg vegetation. These authors reported that inselbergs harbour relic species testifying their refuge character for plant diversity resisting negative human influences. The results obtained concerning life forms reflect the conservation status of vegetation at the level of each ecosystem.

The more the vegetation of an ecosystem is disturbed, the greater the relative importance of chamaephytes and the more hemicryptophytes are in decline (Nacoulma *et al.*, 2011; Gamoun *et al.*, 2012). The abundance of hemicryptophytes and the low presence of chamaephytes on inselbergs reflect the low disturbance of the vegetation of these ecosystems compared to the surrounding plains where chamaephytes become more abundant and hemicryptophytes are weakly represented. The proportion of phytogeographic types showed that widely distributed species are more abundant on the surrounding plains than on inselbergs. This reflects strong disturbance on the surrounding plains (Miabangana & Ayingweu, 2015; Folahan *et al.*, 2018).

Table 3: Mean (±SE) structural parameters of woody vegetation on inselbergs and surrounding plains

	D (N/ha)	Ba (m²/ha)	Di (cm)	Ex (%)	Re (%)	Mo (%)
Inselbergs	670.10±356.23	3.51±2,59	12.25±8.52	5.54±4.91	65.94±14.50	3.29±3.83
Plains	1731.26±1362.61	10.71±9.59	13.14±12.69	64.88±130.09	70.47±4.35	7.76±15.36
Analysis of variance						
d.f.	1	1	1	1	1	1
F	111.6	40.28	12.9	37.99	0.359	7.406
P	<0.001***	<0.001***	<0.001***	<0.001***	0.571	<0.01**

D=Density; Ba=Basl_area; Di=Diameter; Ex=Exploitation; Mo=Mortality; Re=Regeneration
Significant difference codes p<0.05*, p<0.01**, p≤0.001***

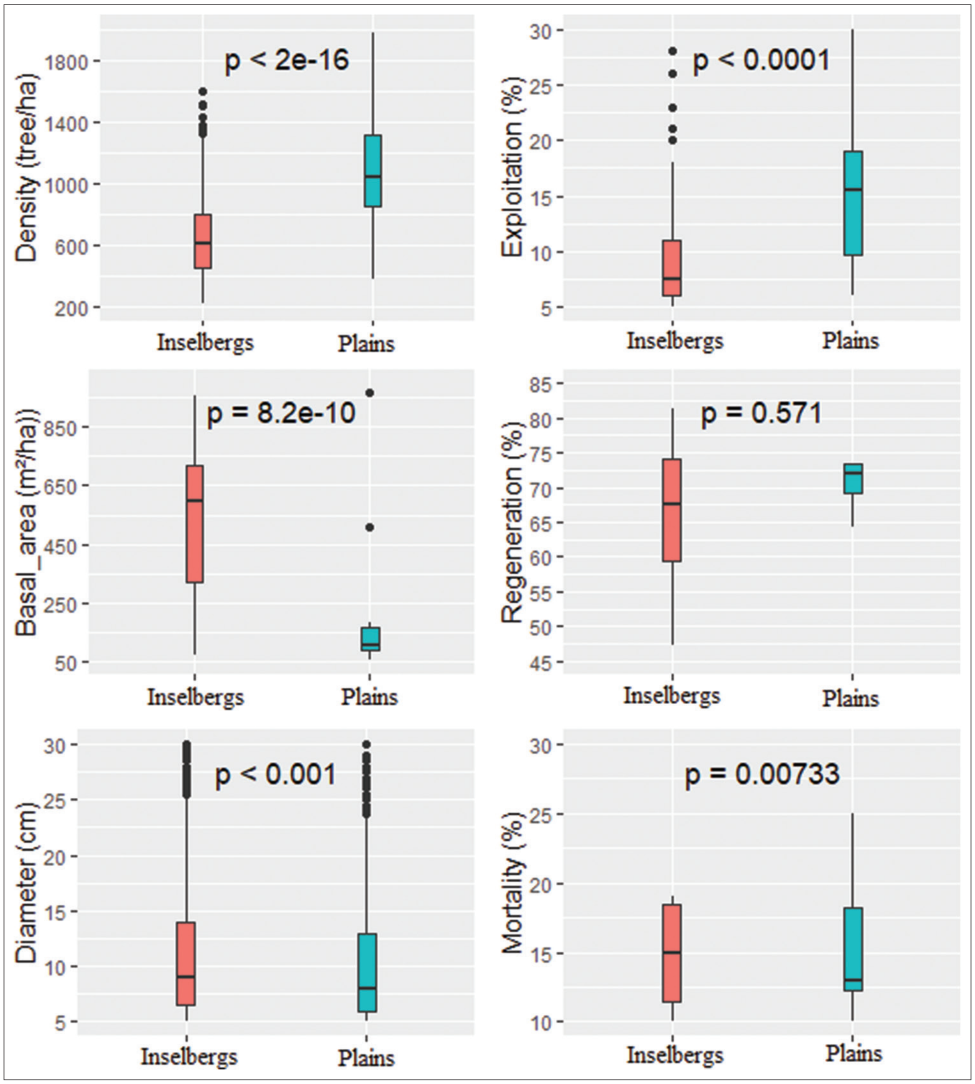

Figure 7: Comparison of structural parameters of woody vegetation between inselbergs and surrounding plains (Significant difference codes $p < 0.05^*$, $p < 0.01^{**}$, $p \leq 0.001^{***}$)

Table 4: Log linear regression equations showing the population trend of species on inselbergs and surrounding plains

Inselberg				Plain			
Species	Equations	r^2	p-value	Species	Equations	r^2	p-value
P. lucens	y=-0.28926x+3.67755	0.84	0.009721	*P. lucens*	y=-0.5883x+4.0022	0.28	0.07513
L. microcarpa	y=-0.26236x+3.22928	0.96	0.004035	*L. microcarpa*	y=0.02889x+3.44636	0.0	0.9501
S. kunthianum	y=-0.30377x+3.56055	0.88	0.006039	*S. kunthianum*	y=0.4545x+2.0421	0.28	0.3575
P. erinaceus	y=-0.56032x+3.84413	0.83	0.0005847	*P. erinaceus*	y=-0.2606x+3.7314	0.02	0.5968

The dominance of Poaceae, Fabaceae-Faboideae and Rubiaceae on inselbergs is consistent with the results of Oumorou and Lejoly (2003) in Benin and those of Kouassi *et al.* (2009) in Ivory Coast. Allegiance of A. *pilosa* to inselbergs in West African and in particular has been shown by several authors (Parmentier *et al.*, 2001; Oumorou, 2003; Banak, 2005; Akoegninou *et al.*, 2006; Kouassi *et al.*, 2014a, 2014b; Folega *et al.*, 2018).

State and Dynamics of Woody Vegetation

The low values of density, mean diameter and mean basal area of woody vegetation on inselbergs are related to the shallow depth and low moisture content of the soils as pointed out by Porembski (2005). However, the lowest rates of exploitation and mortality of woody vegetation are recorded on inselbergs and highlight the refuge character of these ecosystems for plant species. The low exploitation rate is explained by the difficult access conditions to inselberg vegetation as noted by Tindano *et al.* (2015) and Wittig *et al.* (2000).

Populations of species threatened by anthropization (*L. microcarpa*, *P. erinaceus*, *P. lucens* and *S. kunthianum*,) on the plains (Thiombiano & Kampmann, 2010), find refuge on

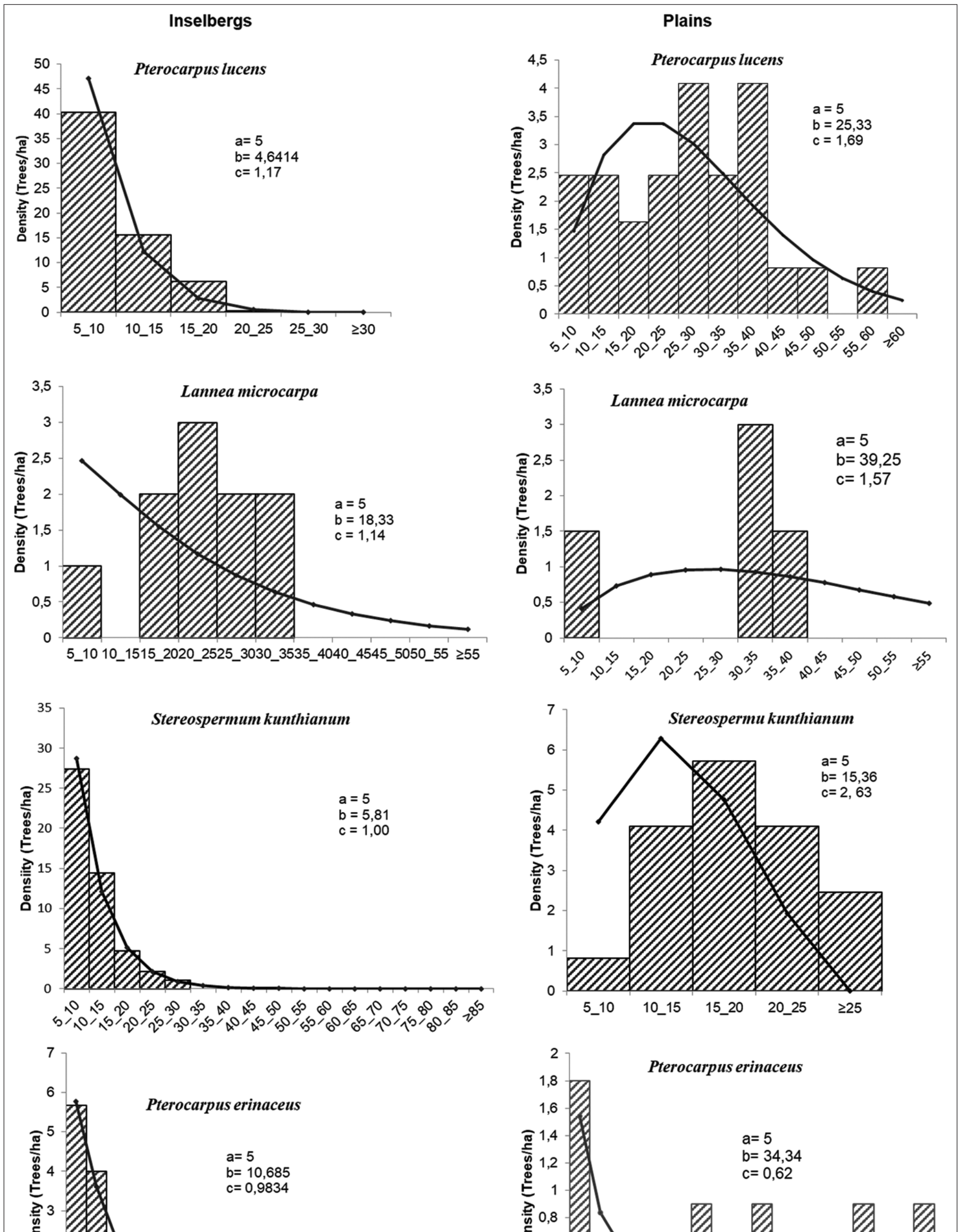

Figure 8: Structures of threatened woody species on inselbergs and surrounding plains

inselbergs. Indeed, on the inselbergs, the populations of these species are stable, whereas on the surrounding plains. The “J-inverted” demographic structures, the values of the shape parameter c, the negative slopes of the regression equations and the high correlation coefficients r^2 of the populations of these species on inselbergs are evidence of their stability. According to Gnoumou *et al.* (2011), Kebenzikato *et al.* (2014) and Kakaï *et al.* (2016) a “J-inverted” structure is characteristic of self-maintaining stable stands. According to Obiri *et al.* (2002) negative slopes and high correlation coefficients are characteristics of stable populations or stands. The stability of inselberg vegetation was demonstrated by Porembski *et al.* (1993). The vegetation of surrounding plains, on the other hand, is under the yoke of intensive anthropisation, the characteristic elements of which are agriculture, overgrazing and demographic growth (Traoré *et al.*, 2012a, 2012b; Baggnian *et al.*, 2013; Akognongbe *et al.*, 2014).

CONCLUSION

Vegetation of surrounding plains the inselbergs of Burkina Faso is under threat from increasing anthropisation characterised by agriculture, overexploitation of plant resources due to human population growth, overgrazing and urbanisation. In the face of this strong anthropic pressure, inselbergs constitute conservation areas where some plant species find refuge. The vegetation of inselbergs is less disturbed and comprises relict and endemic species and stable woody stands. The results obtained in this study show that the vegetation of inselbergs is better conserved than the vegetation of the surrounding plains. Inselbergs are therefore ecosystems that contribute to the conservation of plant biodiversity in the same way as protected areas. But, it should be mentioned that nowadays there are many threats such as quarrying, bushfires and grazing also affect inselbergs.

AUTHOR'S CONTRIBUTION

Elycée Tindano: Data ownership, data analysis and interpretation of results. Benjamin Lankoandé: Data analysis and interpretation of results. Stefan Porembski: Manuscript reading, orientation in ideas and English review. Adjima Thiombiano: Manuscript reading and orientation in ideas.

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