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Influence of anthropogenic and ecological factors on stand structure of *Pterocarpus erinaceus* Poir. in Sudanian and Sahelian zones of Burkina Faso and Niger

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Pterocarpus erinaceus **is a popular tree for medicinal and fodder uses in the Sudano-Sahelian belt of West Africa. It is also used for its wood.** ***P. erinaceus*** **is one of the most exploited tree species in many countries in West Africa. Planks and logs have been exported towards the South-West Asian countries for ten years. This paper analysed the demographic structure, the ecological characteristics of natural stands of** ***P. erinaceus*** **and level of human pressure they suffer in two agro-ecological zones of Burkina Faso and Niger. Transects were installed in four forests of which two were in the Sahelian zone of Niger and two were in the Sudan region of Burkina Faso. Measurements and observations focused on the dendrometric parameters, soil type, vegetation type and the presence of termite mound. The traces of debarking and pruning were noted. Trenching traces have been categorized into 3 classes according to their intensity. The Sudanian zone shows higher densities than the Sahelian zone. The largest individuals of** ***P. erinaceus*** **(the mean diameter and the highest average height) are observed in the W regional park (57.7 ± 18.6 cm and 10.8 ± 2 m) although this park belongs to the Sahelian zone. In all areas, distribution of diameter classes are bells, characteristics of aging stands with predominance of older individuals. Dendrometric characteristics vary according to the agro-ecological zones, soil type and vegetation. Twenty-one percent of** ***P. erinaceus*** **inventoried in the Sahelian zone and 13% in Sudanian area are close to an anthill.** ***P. erinaceus*** **is a species of Sahelo-Sudanese areas, analysis of its demographic structure shows that individuals of small diameter are very poorly represented in all forests. The species is exploited much more in Sahelian zones for feed supplements. The soil type and vegetation type influence the growth of** ***P. erinaceus*****. Indeed, the strongest individuals were observed on soil clay loam, sandy loam soil and woodland.**

Key word: *Pterocarpus erinaceus*, demographic characteristics, Sahelian and Sudanian zones, Niger, Burkina Faso.

INTRODUCTION

In Africa, natural resources play a very important role in the lives of particularly rural populations (Ouedraogo et

al., 2006). The Sahelo-Sudanian band in West Africa faces serious problems of imbalance in natural ecosystems and accelerated degradation of natural resources. The most important degradation observed in these ecosystems results in a reduction of their surface area and, above all, an increase in the mortality rate or even the extinction of certain woody species, resulting in a significant modification of the vegetation structure (Bationo et al., 2001a, 2005; Rabiou et al., 2015).

The increase in demand for woody species for various uses (food, pharmacopoeia, firewood, handicrafts, fodder, etc.) is increasing rapidly in many localities due to rapid growth of human population and livestock (Ouédraogo, 2007). Although *Pterocarpus erinaceus* Poir. is widely appreciated for its wood, fodder and medicinal products (Ouedraogo et al., 2006; Sylla et al., 2002; Rabiou et al., 2015) it is belong to the species currently threatened in West Africa. The species is particularly threatened in Burkina Faso and Niger where it undergoes severe pressure, affecting its capacity for natural regeneration (Touré, 2001; Ouedraogo, 2007). During the dry season, *P. erinaceus* foliage is the most widely sold forage in Niger and Burkina Faso (Sanou et al., 2011). In 1990, more than 1,400 tons of fresh foliage, 78% of which were obtained from *P. erinaceus*, was sold in Bamako (Mali) as feed for small ruminants (Duvall, 2008). In Burkina Faso, the species represents more than 10% of the eleven main woody species used in handicrafts. In Niger, according to the forestry service responsible for the control and repression of offenses in the Tamou reserve, during the dry season (April to June), more than 90% of fines concern the mutilation of *P. erinaceus* by transhumant shepherds. The species is the subject of a hay exploitation by the shepherds especially in the dry season at the moment when the herbaceous fodder begins to miss. The constant pruning operates as a hindrance to the development of buds towards flowers and fruits and dangerously compromises the ability of the species to disseminate its seeds and possibly the regeneration in natural condition (Rabiou et al., 2015).

In the Sahelo-Sudanian countries, local species still face socio-cultural constraints such as use and clearing, and insufficient scientific knowledge about the ecology of these species (Bationo et al., 2001a, 2010). This paper analyzes the influence of pruning and debarking on the demographic structure of *P. erinaceus* natural stands in the Sahelo-Sudanian belt of Burkina Faso and Niger. It is also a question of analyzing the dendrometric and ecological characteristics as well as the level of pressure depending not only on the agro-ecological zones but also on the status of the forests that harbor the natural stands of this species. The results will allow better decision-making regarding the regeneration and exploitation of the species.

MATERIALS AND METHODS

Study areas

Sahelian zone (Niger)

In Niger the study was conducted in the Tamou Wildlife Reserve and in the Regional Park of W. The Tamou Wildlife Reserve is a pastoral reserve. It is located between 12°28 'and 12°50' N and 2°06'and 2°24' E (Figure 1) (Diouf et al., 2010). It covers an area of 76,000 ha. The mean annual rainfall is 606 mm (average from 1988 to 2007) at the Tamou rainfall station. The average annual temperature is about 28.9°C. The highest average monthly maximum temperatures are recorded in April (39.5°C) while the minimum temperatures are observed in December and February (16.1°C). The vegetation of the Tamou Fauna Reserve is a mosaic of clear forests often formed by *Anogeissus leiocarpus* and *P. erinaceus*, tree savannahs, shrub savannahs and grass savannas. The woody flora is composed mainly of the Combretaceae which dominant species include *Guiera senegalensis, Combretum nigricans* and *Combretum micranthum* (Mahamane et al., 2007). The W regional park is a transboundary protected area straddling Benin, Burkina Faso and Niger. The study was conducted in the Niger portion between 11°00'and 12°35' N and 2°00'and 3°50' E (Figure 1). The average annual temperature is 30°C over a period of 20 years and an average annual rainfall of 704.7 mm (Diouf et al., 2010).

Sudan (Burkina Faso)

In Burkina Faso, the study was conducted in Cassou and Laba forests (Figure 1). The Cassou forest is located in the province of Ziro with an area about 29 515 ha. The average temperature is of 29°C, the average annual rainfall is around 900 mm between mid-June and the end of September (Sawadogo, 2009). The vegetation of the area is made up of savannah woodland, savanna with islands of clear forest and gallery forest along streams. The classified forest of Laba is located in the province of Sanguié and is coordinated 11°40' N and 2°50'W (Figure 1). The average annual rainfall is about 907±157 mm. The average annual temperature is 24°C with a thermal amplitude of 15°C. The vegetation is dominated by the shrub savannah and wooded riparian formations along the rivers (Sawadogo, 2009).

Characterization of the demographic structure

Sampling

Given the low density of *P. erinaceus* in these areas, the sampling in this study focuses on the band transect method (Rabiou et al., 2015). Two perpendicular transects of north-south and west-east direction, each about 200 m in width, have been established in each forest in order to characterize stands of *P. erinaceus* (Figure 2). The crossing point of these two transects corresponds to the center of the forest. The use of two transects makes it possible to take into account the heterogeneity of the forests studied and to inventory enough individuals of *P. erinacus* for estimating their

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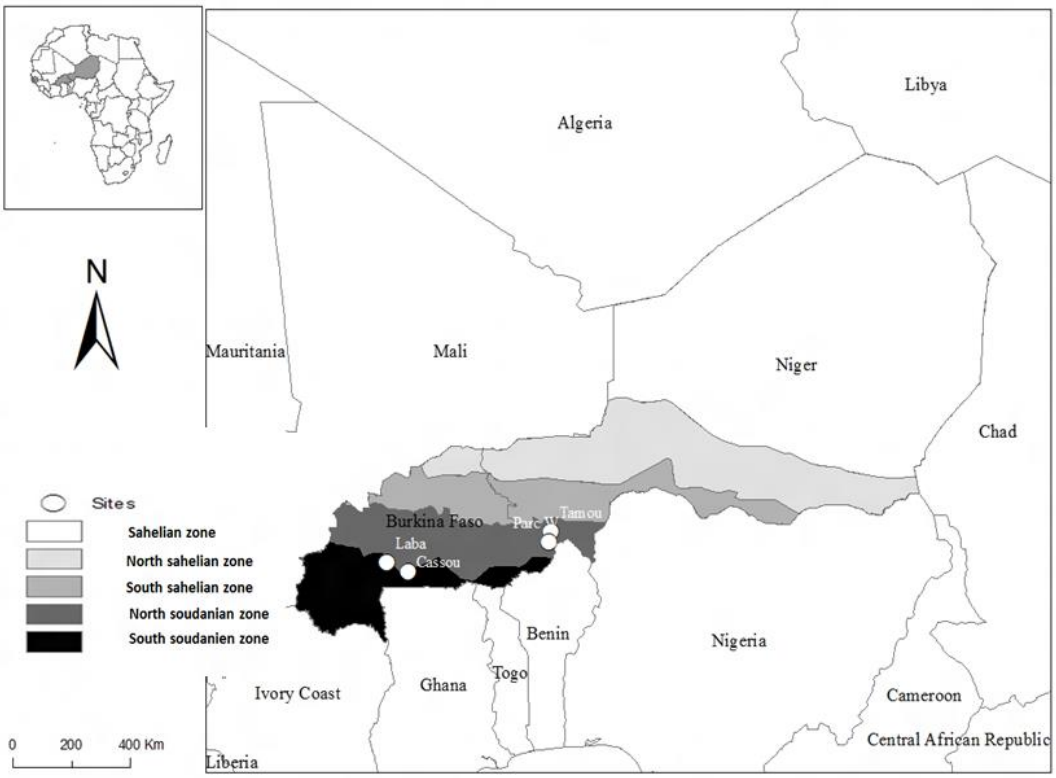

Figure 1. Location of study sites.

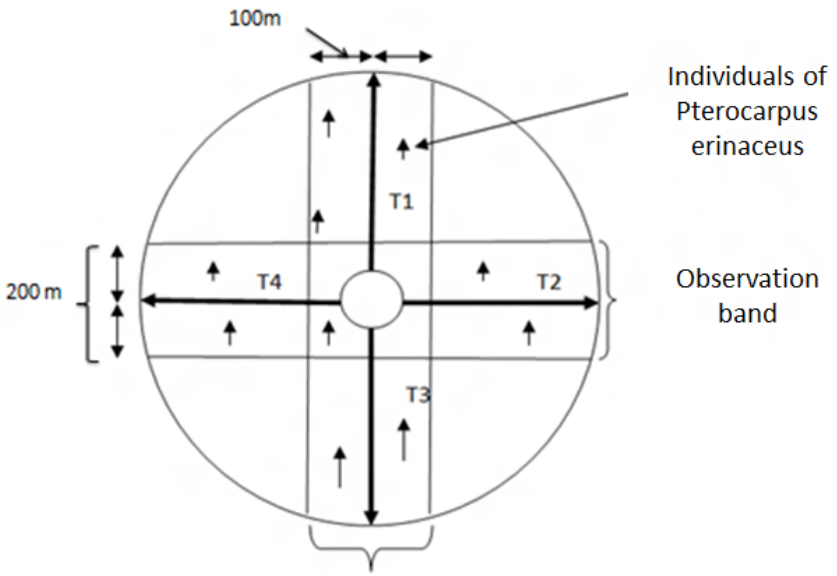

Figure 2. Device for collecting data on *P. erinaceus*.

density (Table 1).

Data collection

In each observation band an azimuth was fixed using a GPS. Along this azimuth, all individuals of *P. erinaceus* with a diameter of 1.30 m greater than or equal to 5 cm are measured. The distance between the individual and the direction perpendicular to the azimuth was estimated using a laser rangefinder to not exceed 100 m on either side of the azimuth. Measurements were carried out on the diameter at 1.30 m from the ground, the total height, the height

Table 1. Characteristics of observation bands.

Characteristics of strip transects	Sudanian zone (Burkina Faso)		Sahelian zone (Niger)	
	Laba	Cassou	Tamou	Parc W
Total length (Km)	3.1	1.7	9.8	6.4
Area covered (ha)	63.24	34.04	197.3	128.02

of the stem, the two perpendicular diameters of the crown respectively using a forest compass for large diameters, a graduated rod and a meter ribbon. The threat to the individual (trace of pruning or debarking), the type of soil and vegetation formation in which the individual is found, and its presence on a termite mound or not have been noted. The texture of the soil by the tactile method (Ambouta, 1984) in the first 20 cm was determined using the tactile method. Table 1 summarizes the distances travelled and the areas covered.

Data analysis

Dendrometric characteristics

The data collected on the stand of *P. erinaceus* were subjected to the analysis of variance in order to compare the dendrometric parameters according to the types of vegetation formation, the type of soil and the threats. The general linear model was used using R and Minitab softwares. The density (N), the basal area (G) and the stand Lorey height (H) were calculated.

$$N = \frac{n}{s}$$

With n: the total number of individuals and s the area covered in ha.
The basal area G is the sum of the cross-sections of all individuals of *P. erinaceus* returned in m^2/ha:

$$G = \frac{\pi}{4s}\sum_{i=1}^{n} di^2$$

Where di: the diameter in m of the individual i and s the area covered in ha.
The mean height of Lorey (HL) is the average height of individuals weighted by their basal area, expressed in m (Philip, 2002).

$$H_L = \frac{\sum_{i=1}^{n} gi\ hi}{\sum_{i=1}^{n} gi} \qquad \text{avec } gi = \frac{\pi}{4} di^2$$

Where gi: the basal area of the individual i in m^2,
h: the height of the individual i in m and
di: the diameter of the individual i.

Demographic structure

Minitab 16 software was also used to estimate the parameters of the Weibull theoretical distribution from the observed diameters and heights data. To ensure a good fit of the observed structure to the Weibull theoretical distribution, the SAS software was used for an adjustment test based on log-linear analysis.

Weibull distribution of diameters

The Weibull distribution with 3 parameters (a, b and c) is characterized by great flexibility of use and a great variability of form. Its probability density function, f (x) is presented as follow (Rondeux, 1999).

$$f(x) = \frac{c}{b}\left(\frac{x-a}{b}\right)^{c-1} exp\left[-\left(\frac{x-a}{b}\right)^{c}\right]$$

Where x is the diameter or height of the trees and f (x) its value of the probability density function.
a = is the position parameter
b = is the scale or size parameter
c = is the shape parameter related to the observed structure.

RESULTS

Dendrometric characteristics and stand structure

The findings are made to establish the dendrometric characteristics of *P. erinaceus* according to the agro-ecological zones (Table 2). The analysis of this table shows that the largest individuals of *P. erinaceus* (the mean diameter and the highest average height) are observed in the W regional park (57.7±18.6 cm and 10.8±2 m) although this park belongs to the Sahelian zone. Trees in the Tamou Wildlife Reserve, which is a buffer zone of Park W, have an average diameter of 36.8±12.6 cm and an average height of 9.20±2.3 m, much lower than those recorded in the Park W ($P < 0.001$) although the climatic and ecological conditions appear to be the same. In the Sudanian zone, the density is higher with 9.41 trees/ha in the Cassou forest and 2.84 trees/ha in the Laba forest, compared to only 1.82 individuals / ha in the Park W and 0.75 tree/ha in the Tamou fauna reserve in the Sahelian zone.

The structure of stands of *P. erinaceus* shows that the best represented individuals are in the diameter classes between 15 and 45 cm and between 35 and 65 cm in Sudanian zone and Sahelian zone respectively (Figure 3). Young stands are almost absent. In general, the distributions of diameter classes in all plant recorded are adjusted to the theoretical Weibull distribution ($P > 0.05$) with $c > 1$ form parameters, showing thus the characteristic of stands with predominantly elderly individuals.

The height structure of *P. erinaceus* stands shows a bell distribution in the Sudanian and Sahelian zones

Table 2. Dendrometric characteristics stands of *P. erinaceus.*

Parameter	Sudanian zone (Burkina Faso)		Sahelian zone (Niger)		Probability
	Cassou	Laba	Parc W	Tamou	
Diameter (cm)	25.49±7.8^{b}	33.63±10^{a}	57.7±18.6^{c}	36.89±12.6^{a}	<0.001*
Height (m)	8.07±1.6^{b}	9.29±2.08 ^{a}	10.8±2.02^{b}	9.20±2.3^{a}	<0.001*
Commercial height (m)	3.53±1.05^{a}	3.95±1.42^{b}	4.35±1.5^{c}	3.65±0.9^{ab}	<0.001*
Basal area (m^2/ha)	0.54	0.286^{a}	0.524	0.089^{a}	<0.001*
Height of Lorey (m)	8.68	9.99a	11.62	10.24^{a}	<0.001*
Crown (m)	6.3±2.15^{ab}	6.25±2.48^{ac}	10.18±3.05	5.65±2.42^{bc}	<0.001*
Densityé (trees/ha)	9.401	2.84	1.82	0.75	<0.001*

Means ± standard deviation in a column followed by the same alphabet are not significantly different (P>0.05) according to Turkey's test.

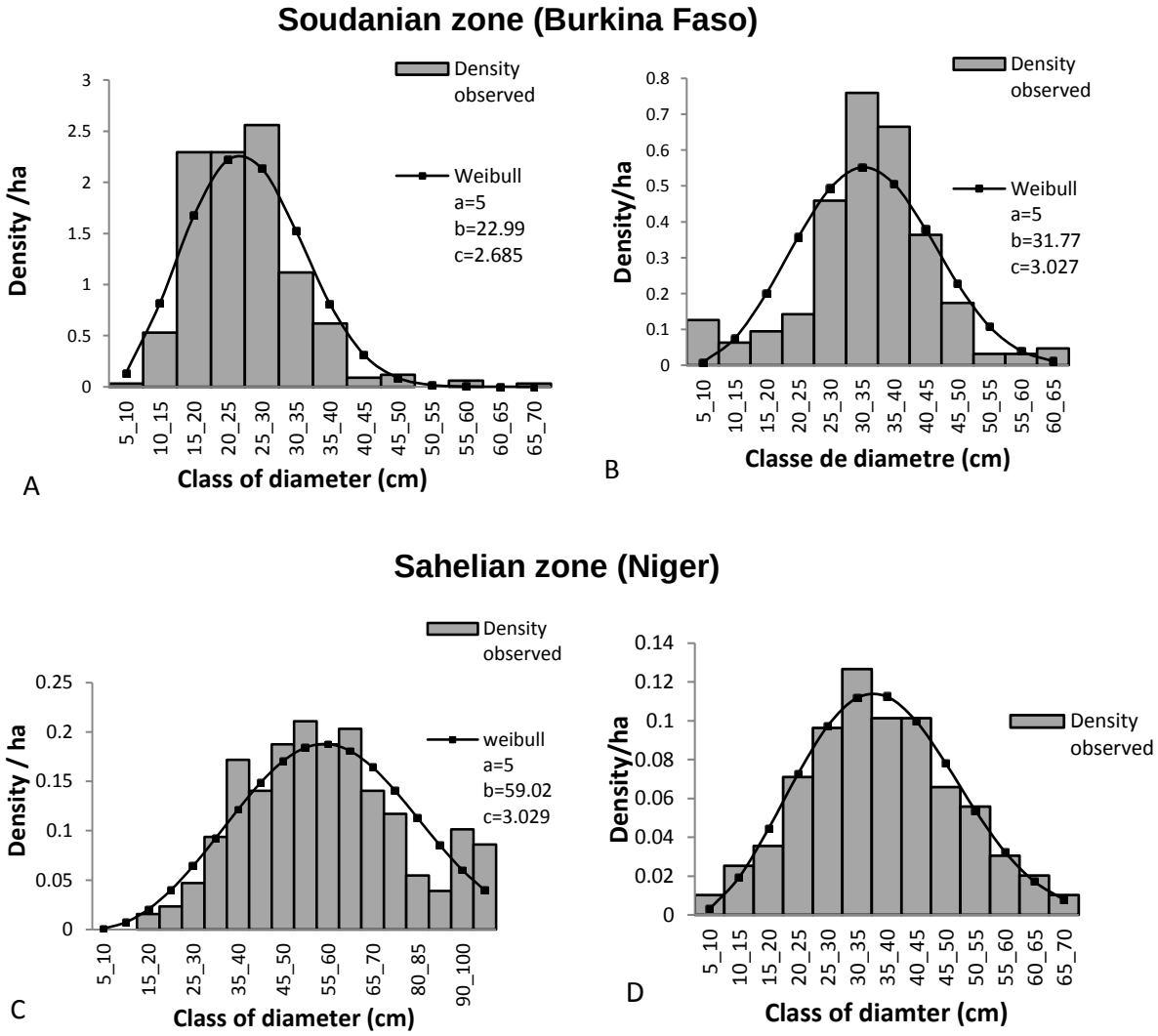

Figure 3. Diameter structure of *P. erinaceus*: forests of Cassou (A); Laba (B); Park W (C) and Tamou (D).

(Figure 4). The weak form parameter is observed in Cassou forest with c=2.785; on the other hand, the Park W where the largest individuals were recorded has a parameter of form c=5.522 of the theoretical distribution of Weibull. The variation of the parameer of form c expresses the frequency of young individuals. Indeed, the

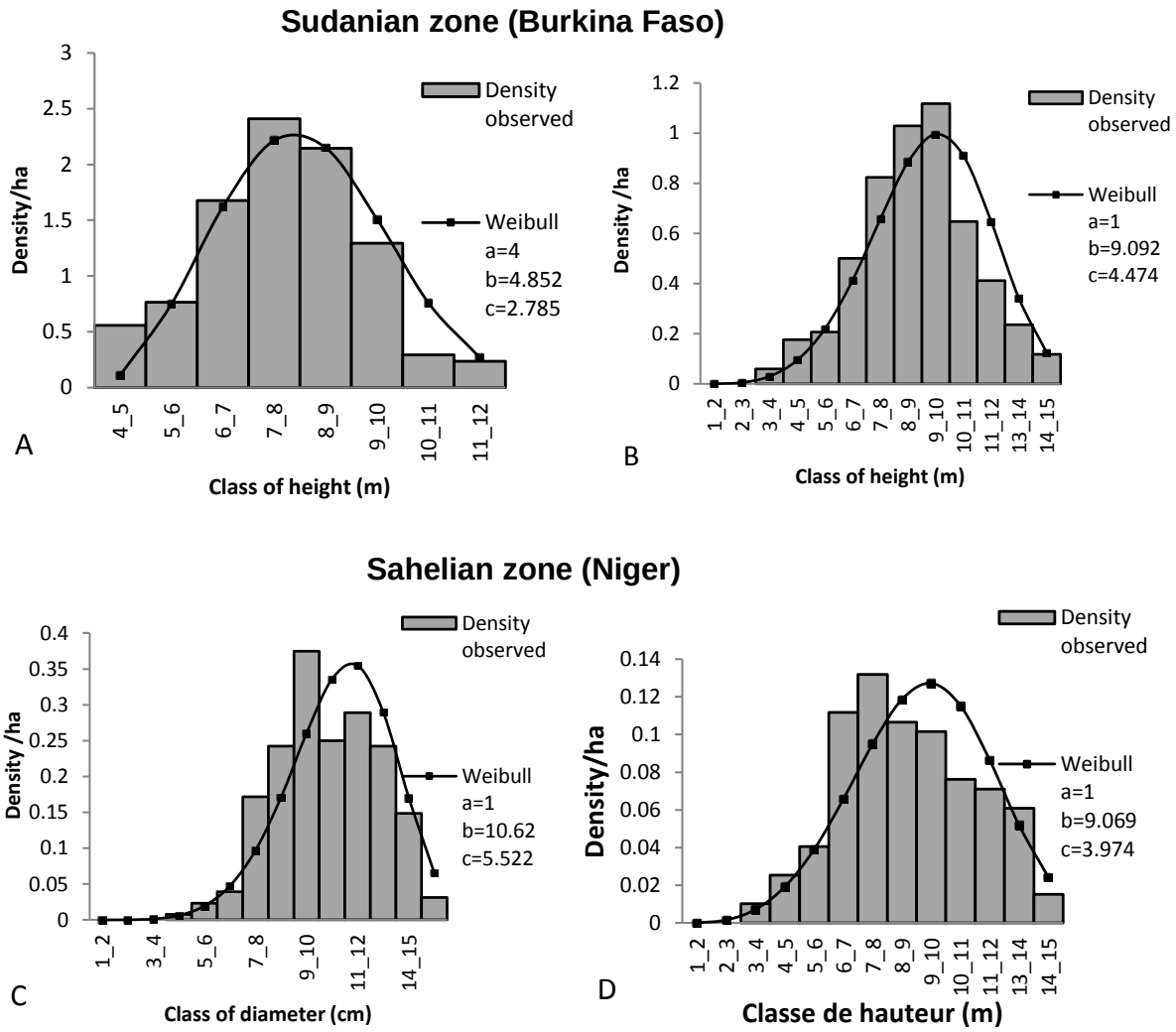

Figure 4. Structure in height of *P. erinaceus*: The forests of Cassou (A); Laba in (B); The Park W (C) and Tamou (D).

more c increases the more frequency of elderly individuals increases.

Effect of soil types on the variation of dendrometric parameters

Soil type appears to play an important role in the diameter and height growth of *P. erinaceus*. Clay loam soil and sandy loam soil are the best ecological preference of this species. Individuals growing on these soils are distinguished by their high dendrometric parameters (diameter, height and height); in contrast to clayey soil and sandy soils that have individuals of *P. erinaceus* whose dendrometric parameters are very low with statistically significant differences. Individuals of this species growing on laterite soil found only in the Sahelian zone, that is, in Niger, has an average diameter of 36.2 cm and an average height of 8.4±2.2 m (Table 3).

The sandy loam soil and the silty-clay soil also optimize the growing in height of the stem. These soils stand out with high values of mean stem heights respectively with 4.05±1.3 m and 3.97±1.3 m. The lowest height of the drum is observed from individual growing on clay soil. This result shows that the height growth of the stem is sensitive to the compactness of the ground. The observed difference is statistically significant ($P<0.001$) in general. The test, however, indicates that there are no statistically significant differences between the mean height of the *P. erinaceus* stem on clay loam and sandy loam soils. The difference is clearly significant between these soils and the group of silty, sandy lateritic and clayey soils in which there are no significant differences in mean height of the stems (Table 3).

Analysis of the effect of the soil type on the dendrometric parameters reveals that higher values were observed in Sahelian zone. These differences are strongly influenced by the stands aging in Park W with values on

Table 3. Variation of the dendrometric parameters stands of *P. erinaceus* as a function of the soil type.

Soil texture	Diameter (cm)	Height (m)	Commercial height (m)
Clay soil	23.9±13[b]	7.6±2.9[b]	2.8±1.1[b]
Laterite	36.2±12a	8.4±2.2[b]	3.5±0.6[b]
Limestone	29.4±7.5[b]	8.3±1.4[b]	3.5±1.1[b]
Silty clay	42.2±19.1[a]	9.7±2.2[a]	3.9±1.3[a]
Sandy	20.4±5.9[b]	7.2±1.6[b]	3.3±1.0[b]
Sandy-loam	38.9±17.5[a]	9.3±2.1[a]	4.0±1.3[a]
Probabilité	<0.001*	<0.001*	<0.001*

Means ± standard deviation in a column followed by the same alphabet are not significantly different (P>0.05) according to Turkey's test.

Table 4. Variation of dendrometric parameters according to soil type and agroecological zones.

Soil texture	Zones	Diameter (cm)	Height (m)	Commercial height (m)
	Niger	49.21±20.1[a]	10.214±2.2[a]	4.01±1.3
Silty clay	Burkina Faso	30.759±9.14[b]	8.982±1.8[b]	3.904±1.3
	Probability	<0.001*	<0.001*	0.416*
	Niger	56.25±16.03[c]	10.726±1.88[a]	4.548±1.55
Sandy-loam	Burkina Faso	29.975±10.07[b]	8.71±1.9[b]	3.8±1.08
	Probability	<0.001*	<0.001*	<0.001*

diameter, height and stem height of 57.7±18.6 cm, 10.84±2, (P <0.001) than those observed at Tamou with 37.04±12.85 cm, 9.38±2.29 m and 3.66±0.97 m respectively for the diameter, height and height of the stem. In the Sudanian zone, the difference between stands on sandy loam and silty-clay soils is not statistically significant (Table 4). Only these two types of soil have been observed both in the Sudanian zone and in the Sahelian zone. Stands on laterite soil are only observed in the Sahelian zone and on clay soil in the Sudanian zone.

Effect of the termite mound on the dendrometrics characteristics

Twenty-one percent of *P. erinaceus* inventoried in the Sahelian zone and 13% in the Sudanian zone were found in the environment of a termite mound. This environment influences the growth in diameter and height of trees. The differences are significant between individuals on termite and non-termite mounds in the same zone and between areas (P <0.05) except for the total diameter and height in Sahelian zone where the difference is not significant between (Table 5).

Exploitation of the resource

Table 6, shows the percentages of individuals pruned and individuals barked according to agro-ecological zones. Depending on the area, there are tracks of barking and pruning on the same individuals. In Park W where protection is integral, any track of debarking or pruning has been found. In Tamou Wildlife Reserve, which is adjacent to Park W, "85%" of individuals are pruned and 23% are barked. More than 60% of the individuals pruned are more than 50% of their crown. In the Sudanian zone in Burkina Faso debarking is not significant, but pruning remains the most widespread form of exploitation. Table 6 shows the summary of harvesting tracts, the average of the total height and the tree trunk varies according to the type of vegetation formation. The highest averages were recorded in the open forest. The differences are statistically significant (P <0.001) between light forest and other vegetation units but not significant between cultivated fields and savanna according to the test (Table 7).

DISCUSSION

The study of the natural stands of *P. erinaceus* conducted in Sahelian zone of Niger and in Sudanian zone of Burkina Faso shows that in addition to the ecological characteristics of the stations, protection is essential to ensure the development of species. Park W, because of its protected area status, while it is the least watered site, is home to the populations of *P. erinaceus*

Table 5. Variation of the dendrometric parameters of *P. erinaceus* on and off the termite mound.

Parameter	Sudanian zone (Burkina Faso)		Probability	Sahelian zone (Niger)		Probability
	On eroded termite mound	Outside eroded termite mound		On eroded termite mound	Outside eroded termite mound	
Height (m)	9.9±2.01	9.04±2.06	0.007*	10.8±1.8	10.02±2.3	0.005*
Diameter (cm)	36.9±9.82	33.03±9.4	0.014*	48.2±16.5	50±20.17	0.479
Commercial height (m)	4.33±1.47	3.80±1.38	0.027*	4.07±1.16	4.08±1.4	0.950

Table 6. Summary of operating traces.

Zone	Site	Debarking (%)	Pruning (%)	Intensity of pruning	
				25 - 50%	>50%
North sudanian	Cassou	2.5	70.5	31.5	68.4
	Laba	7.2	81.2	31.29	68.7
South sahelian	ParcW	0	0	0	0
	Tamou	24.3	85.2	39.37	60.62

Table 7. Influence of vegetation type on total height and stem height of *P. erinaceus.*

Land use type	Total height (m)	Commercial height (m)
Fields	8.3±1.3^{b}	3.31±1.0^{b}
Clear forest	9.5±1.8^{a}	3.96 ±1.3^{a}
Savannah	8.1±1.7^{b}	3.41±1.1^{b}
Probability	<0.001*	<0.001*

Means ± standard deviation in a column followed by the same alphabet are not significantly different (P>0.05) according to Turkey's test.

with the largest diameters and heights. The contribution of protection in the conservation of endangered species in the Sahelian and Sudanian zones was also reported by Traoré (2013) in Burkina Faso. However, the highest densities of *P. erinaceus* observed in the Sudanian zone are due to the best ecological conditions which are favorable to the establishment of the species. Indeed, the Sudanian zone corresponds to the most watered zone of our study zone, with a rainfall much higher than that observed in the Sahelian zone. The Cassou forest has a density of 9.4 trees / ha followed by the Laba forest with 2.8 trees per ha, far in front of the W Park and the Tamou Wildlife Reserve. These densities are considerably lower than those found by Glee et al. (2008) in the Wari Maro forest in Benin (22.8 trees / ha in the savanna and 23.3 trees / ha in the open forest), which are much lower than those found by Adjonou et al. (2010) in the central plain of Togo (114±1.1 trees / ha in harvested areas and 136±1.6 trees/ha in fully protected areas).

On the different sites, the large *P. erinaceus* (diameters and heights) were observed on deep silty-clay and sandy loam soils generally located beside depressions where water conditions are favorable. The species is, however, not very present on hydromorphic soils rich in clay. Several authors have reported the relationship between soil type and growth (Goulard et al., 1995; Bationo et al., 2010) and its impact on the spatial distribution of woody species (Grimaldi and Riéra, 2001; Clark et al., 1998, Condit et al., 2000, Bationo et al., 2005). Twenty-one percent of *P. erinaceus* inventoried in the Sahelian zone and 13% in the Sudanian zone are in the environment of a termite mound. The individuals on these microsites are distinguished by total heights and larger stems especially in the Sudanian zone. Termite mounds are or have been former habitats of many rodent species that transport and store forest seeds (Bationo et al., 2010a). Soil tillage improves the porosity of the soil, which promotes the infiltration of water, thus creating an edaphic microclimate favorable to the establishment and development of woody vegetation (Diallo, 2001; Bationo et al., 2001).

In all the forests surveyed, both in the Sudanian zone and in the Sahelian zone, the distribution of diameter and height classes of *P. erinaceus* is bell-shaped. Young individuals are poorly represented at all sites, even in

protected areas such as Park W. This indicates that in addition to anthropogenic pressure, climate plays an essential role in the establishment and development of the species. The state of regeneration is however less critical in the Cassou forest with a shape parameter (c) 1 <c <3.6 compared to the other forests where c> 3.6 indicates stands with a predominance of elderly. However, the regeneration regime may have an impact on regeneration, especially late late-fires observed frequently in Park W. The same distribution of diameter classes was observed in the Burkina Faso part of Parc W by Nacoulma (2012), Glele et al. (2008) in the Wari Maro forest in Benin and on the central plateau in Togo (Adjonou et al., 2010). Yet some authors such as Camara (1997) and Ouédraogo et al. (2006) showed that the species has good germination capacity. The main constraint of *P. erinaceus* regeneration is the postabortion and development of juveniles into adulthood (Nacoulma, 2012; Bationo et al., 2001; Ouédraogo et al., 2006). The factors that are responsible of this lack of relay include herbivore pressure, vegetation fire and herbaceous competition. In addition, pruning and debarking for medicinal use are the main threats to *P. erinaceus* stands. In Tamou Wildlife Reserve 85% of individuals are totally or partially pruned. The untrimmed individuals are in tufts of *Acacia erythrocalyx*, a thorny vine that overcomes the tree crowns and renders them inaccessible to the shepherds. Repeated pruning of trees prevents fructification and therefore the production of seeds necessary for natural regeneration (Bationo et al., 2010b). *P. erinaceus* is the woody species which leaves are most sold as fodder in Bobo-Dioulasso in Burkina Faso (Sanou et al., 2011; Kiéma, 2007). Thus, the species that was dominant in the peri-urban forests of western Burkina Faso has either disappeared locally or has become rare (Fournier et al., 2001). These results show that *P. erinaceus* is threatened in the Sahelian zone and in the Sudanian zone.

Conclusion

Findings of the population structure of *P. erinaceus* according to the agro-ecological zones of Burkina Faso and Niger shows that the species is more adapted to Sudanian than Sahelian zones. *P. erinaceus* is threatened in its habitat, both in Sahelian and Sudanian zones due to anthropogenic pressure (late fire management, pruning for forage and debarking for various uses). All the distributions by class of diameter and height reveal a bell structure characteristic of the stands with predominance of elderly individuals. Small diameter individuals are virtually absent, posing a problem of species renewal in all long-term agro-ecological zones. Soil type and vegetation type control the growth rate of *P. erinaceus*. Indeed, the most vigorous individuals of the species were found on silty-clay soil, sandy loam soil and in the clear forests. The study also showed that mature individuals of this species remain only in the W Park, because of the integral protection measures that gave them a chance to reach the maximum of their growth but their regeneration is weak due to the occurrence of savannah management fire and the pressure of herbivores. National and international policies should be put in place for the rescue and conservation of residues of *P. erinaceus* stands that still exist as the species is critically endangered in all areas of this study.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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