Vol. 12(1), pp. 33-45, January-March 2020
DOI: 10.5897/JENE2020.0818
Article Number: CAC476463344
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and The Natural Environment

Full Length Research Paper

Structure of *Acacia senegal* (L.) wild settlements in southwest Niger: Case of the gum tree site in the rural district of Guéchémé

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Received 15 January, 2020; Accepted 17 March, 2020

This study conducted in the rural district of Guéchémé (Tibiri county, Dosso region, Niger) aims at characterizing *Acacia senegal* settlements of the village of Lido. The methodology consisted in floristic sampling of 1000 m^2 plots, measuring diameters 20 cm off the ground for shrubs and 1.30 m for trees. The results made it possible to determine the structure of *A. senegal*, representing significant densities (238.75 plants/ha). The species represent a high regeneration rate on the site (24.71%) but with an increasing mortality rate over time. The diameter variations and average heights among plants of different plantation years are not significant. In contrast, the average annual growth variations in terms of diameter and height are not significant ($p = 0.005$). The settlements represent a shrubby structure, the C-shape parameter valued at 3.6 ($1 < C < 3.6$), feature a positive or right asymmetric distribution of monospecific settlements with dominant younger plants or plants with smaller diameters.

Key words: *Acacia senegal*, Guéchémé, Niger, structures.

INTRODUCTION

Tropical ecosystems constitute the basis for the existence of the majority of our planet's population. In fact, in the world, approximately one million people get their revenues from using wild natural resources (Garba et al., 2019). Africa is one of the richest continents in terms of biodiversity (Wieringa and Poorter, 2004). Forest exploitation is the main sources of revenue in the economies of several African countries. The intensive practice of this activity leads to the degradation of many forests and natural habitats as well as the rarefaction of several species (FAO, 2018). In Africa, 25 to 42% of plant species could be at risk of extinction due to the loss of 81 to 97% of favorable habitats by 2085 (Fandohan et al., 2013). The Sahel region is experiencing profound

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changes. With recurrent droughts, we observe a gradual degradation of ecosystems (Grouzis and Albergel, 1991) and a decrease of natural grazing lands. In Niger, the Sahelian zone corresponding to the forest and pastoral area is featured by steppes and savannahs with shrubs and trees dominated by spiny plants, essentially the Acacias. These woody settlements play a key role in the lives of populations in the Sahel. In Niger, the survey found and estimated annual production of 139.960 tons of arabic gum value at near 119 million CFA francs (Seybou et al., 2016).

In addition to the fodder relay that these woody settlements represent during the dry season, they constitute a dietary supplement and are used as service wood, lumber, medicines by local populations (Lykke et al., 2004). Nonetheless, these plant resources have been undergoing a significant degradation because of climate pejoration and anthropism for decades now (Sarr, 2008). These changes have triggered an ecological imbalance in the ecosystems, namely the activation of dunes previously fixed by vegetation (Pierre, 2004). Among these main fruit trees highly appreciated by local populations we have: *Ziziphus mauritiana* Lam., *Balanites aegyptiaca* (L.) Del., *Sclerocarya birrea* A. Rich., *Diospyros mespiliformis* Hochst. ex A. DC., *Boscia senegalensis* (Pers.) Lam. Ex., *Tamarindus indica* L., *Acacia senegal* (L.) *Willd., Grewia tenax* Forsk*, Adansonia digitata* L., *Vitellaria paradoxa* C.F. Gaertn. Etc. These spontaneous plants, by their diverse production, occupy an important place in the socio-economic life of local populations. Nowadays, these forest essences continue to play a key role in satisfying the essential needs of the poor, but still via the informal sector. Overexploited, these plants are now at risk of extinction. Their weak natural regeneration coupled with non-sustainable harvest practices accelerates the process (Abdoulaye et al., 2017). *Acacia senegal* (L.) Willd, commonly called « gum tree » is the subject of this study. This species, belonging to the family of Fabaceae-Mimosoideae, produces the Arabic gum, a very important non-wood forest product (NWFP) for the populations. The gum is used in diverse food and cosmetic industries, human medicine, and arts and crafts (FAO, 2010; Daniele et al., 2011). The interest in this non-wood forest product led to the drafting of a document of national production and trading boost strategy of the Arabic gum via executive order 2003-196-PRN-MHE-LCD of 24 July 2003 in Niger. This program of boosting the Arabic gum sector helped establish several thousands of acres of gum tree sites across the country.

Nevertheless, the expectations for these gum production plantations and carbon fixation proved to be very optimistic. The degradation of these resources under the influence of intense human and animal pressure has not entirely been stopped. A better management of these forest and pastoral reserves would require that these degraded ecosystems be restored from human and animal pressure (Akpo and Grouzis, 1996). This restoration ought to be based upon knowledge of the current state of these resources (Diallo et al., 2012), hence the interest of this study that aims at characterizing the *Acacia senegal* site of the cluster (cluster of the villages of Lido, Fada Wassangou, Bayawa, Rouga Peulh) of Lido in the rural district of Guéchémé (Tibiri country, Dosso region, Niger) called biocarbon site. This study is part of a perspective of sustainable management of this resource for the well-being of the Lido cluster populations.

MATERIALS AND METHODS

Description of study area and species

This study was conducted on the *A. senegal* plantation site of the cluster of Lido, located in the rural district of Guéchémé (Figure 3). This cluster consisted of five blocks of plantation of different ages: the 2006 block (13 years old), the block of 2007 (12 years old), the 2008 block (11 years old), the 2010 block (9 years old), and the 2011 block (8 years old). This was a land restoration site with forest half-moons. The site area was 506 ha. The settlement density was 317 plants/ha. After the plantation, each block was protected from wandering animals over the course of two years by means of caretaking ensured by the population Figures 1 and 2.

Prior to each plantation, the cluster consisting of five villages, including Lido, Fada Wassangou, Bayawa, Rouga Peulh, got assistance from environmental services in terms of anti-erosive half-moons (HM) whose density was 313 HM/ha. During the first year of plantation, each block was protected for two years followed by caretaking from members of the cluster against wandering animals in order to allow a better restoration of the degraded ecosystem. The following year, the site was left for animal grazing and for farming activities. The gum production started with a few trees of *A. senegal* following bleating by members of the cluster's surveillance committee. The district of Guéchémé is located southwest of Tibiri, Dosso region, Niger between longitudes 12° 45' 09'' and 13 °04' 06'' North and latitudes 03° 47' 03'' and 03° 54' 39'' East. The district is limited to:

(i) The north by the rural district of Koré Mairoua (Dosso region) and that of Sakadamna (Dosso region);
(ii) The south by the Federal Republic of Nigeria;
(iii) The east by the districts of Tibiri and Douméga (Dosso region);
(iv) The west by the districts of Kargui Bangou and Kara Kara (Dosso region).

Its area is estimated at 1265 Km^2, with a population of 125,263 people (INS, 2012). It is essentially composed of Hausas (majority), Fulanis and Djermas. Farming, cattle breeding and trading constitute the main economic activities of the district population (PDC, 2014). The landscape of the area is characterized by landscape units such as Dallol Maouri, dunes and plateaus.

The climate is of Sahelian type mainly characterized by two big seasons:

(i) A long dry season lasting eight months, from October to May and divided into two distinct periods: a dry and cold period (November – February) and a dry and hot period (March – May);
(ii) A rainy season from June to September.

The soil is subdivided into four types:

(i) More dominant sand area, located in areas with dunes and other plateau enclaves;
(ii) Sandy loam area in the major part of the Dallol bed;

Figure 1. Site prior to plantation.

Figure 2. State of site in 2019.

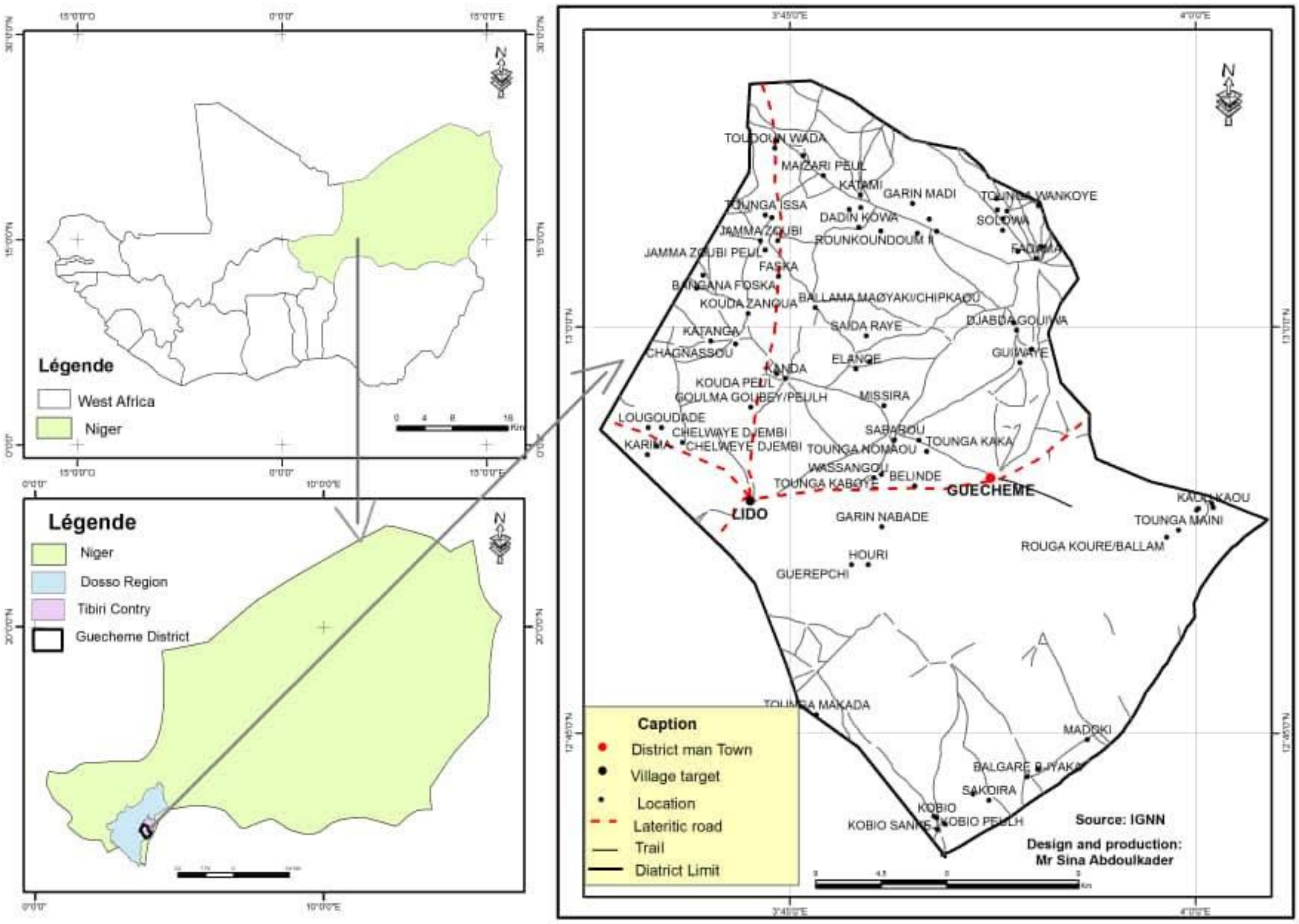

Figure 3. Geolocation of the rural district of Guéchémé.

(iii) Scattered hydromorphic lands in the Dallol bed;
(iv) Lateritic lands (ferruginous and tropical) on plateaus.

The woody and herbaceous vegetation was very diversified. In the woody stratum there were species such as: *Guiera senegalensis* J. G. Gmel*., Piliostigma reticulatum* (DC.) Hochst.*, Ziziphus mauritiana* Lam.*, Combretum glutinosum* Perr. Ex DC.*, Sclerocarya birrea* (A. Rich.) Hochst., *Khaya senegalensis* (Desv.) A. Juss*., Balanites aegyptiaca* (L.) Del*., Acacia nilotica* (L.) Willd. Var. adansonii (Guill. & Perr.) O. Ktze*, Acacia seyal* De, *Diospyros mespiliformis,* Hochst. ex A. Rich*, Combretum micranthum* G. Don., *Combretum nigricans* Engl. Ex Diels, *Tamarindus indica* L*., Vitellaria paradoxa* C.F. Gaertn., etc.

The herbaceous stratum was composed of species such as: *Cassia italica* (Mill.) F.W. Anders*., Commelina benghalensis* L*, Commelina forskalaei* Vahl*., Jacquemontia tamnifolia* (L.) Griseb., *Merremia pinnata* (Choisy.) f., *Merremia tridentata* (L.) Hallier. f., *Cyperus amabilis* Vahl, *Cyperus rotundus* L., *Fimbristylis hispidula* (Vahl.) Kunth.subsp, *Phyllanthus pentandrus* Schum. and Thonn*, Alysicarpus ovalifolius* (Schum. Et Thonn.) J. Léonard, *Indigofera hirsuta* L. var. hita, *Sesbania pachycarpa* DC, *Zornia glochidiata* Reichb. Ex DC., *Sida cordifolia* L. etc*.* These resources face diverse anthropogenic and climate pressures that could lead to their degradation if appropriate measures are not undertaken. The fauna is almost nonexistent in the area because of the degradation of its habitat. Nevertheless, we find a few reptiles, rodents (rats and squirrels etc..), lagomorphs (rabbits) and birds (Figure 3).

Data collection

Sampling

The gum site of Lido was divided into five blocks of plantations with different ages. Taking into account the density and age of the plantations of the different blocks, a stratified random sampling was chosen. A pre-inventory permitted to determine the average variation coefficient of 41%. On the basis of the coefficient and for a margin of error of 15%, the number of plots n was = $t^2 * cv^2/E^2$ (t =1.96, Cv coefficient of variation and E = margin of error). The minimal number of plots inventoried was 28.70. This number was rounded to 30 plots. Thus, circular plots of 1,000 m^2 (35.84-meter diameter) were marked out in each block in order to obtain at least twenty *A. senegal* plants. The division of three plots per plantation block was performed proportionally based on their area. The random sampling tool of the software ArcGIS 10.4® was used to determine the grids of the plots. The sampling rate was 3 ha/506 ha; which was, 0.6%.

In each circular plot, all the *A. senegal* plants as well as the other woody species with a minimum diameter more than or equal to two centimeters (d > 2 cm) were measured. Those with a diameter of less than 2 cm were deemed rejected. The summarized dendrometric parameters were:
(i) Diameter of 1.30 m off the ground by means of a forest compass for trees and 20 cm off the ground for all the shrubs by means of a grout;

(ii) The total height by means of a graduated pole;
(iii) The average crown diameter by means of a measuring tape;
(iv) The number of rejections or stalks with less than two centimeters.

Data related to stational factors such as soil texture, terrain geomorphology, plot center grids, and soil occupation type were also recorded. Collected data were handled and processed via Excel spreadsheet in order to compute structure parameters such as density, basal area, distribution, etc.

Actual density

It corresponds to the actual number of trees on the plot, estimated in hectares and calculated following the following formula:

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

N is the average number of plants per hectare; **n**, the number of trees in the plot, and s, the area per hectare.
(i) The index value of importance (IVI) of CURTIS and MACINTOSH (1951).

This index was determined via the formula: IVI= ∑[(rf + rd +rdom)]
rf is the relative frequency of the species, *rd* the relative density (number of trees/ha) of the species and *rdom* is relative dominance referring to the basal area of the species. The index value of importance is a quantitative index that helps identify the species that are ecologically important within the plant community (Adomou et al*.,* 2009; Dossou et al*.*, 2012). It varies from 0 (absence of dominance) to 300 (mono-dominance). The relative frequency of a species is the sum of its specific frequency divided by the total specific frequencies of all the species, multiplied by 100.

$$\mathrm{rf} = \frac{specific\ species\ frequency}{total\ species\ frequcny} \times 100$$

The specific frequency (SF) is equal to the figure expressed in percentage of the number (ni) of times the species **i** is present in the floristic list divided by the total number of trees inventoried.

$$\boldsymbol{Fs} = \frac{\mathrm{ni}}{N} \times 100$$

The relative dominance of a species is the quotient of its basal area with the total basal area of all species;

$$rdom = \frac{\text{Species basal area}}{\text{Total basal area of all species}} \times 100$$

The basal area is determined by following the formula:

$$\boldsymbol{G}(\mathbf{m^2}/\boldsymbol{ha}) = \frac{\pi}{40000S} \sum_{i=1}^{n} \mathrm{di}^2$$

di stands for diameter (in centimeter) of the tree **i** of the plot and s the area of the plot (in ha).
(i) The relative density of a species is the sum of its absolute density divided by the total absolute densities of all the species multiplied by 100.

$$\mathrm{rd} = \frac{Number\ of\ plant\ species}{Total\ number\ of\ plants} \times 100$$

The settlement recovery is the sum of crown areas of all the plants of the settlement. This area is obtained by means of the average tree foliage diameter assimilated to a circle by projection to the ground. It is obtained via the following formula (Rondeux, 1999):

$$\mathrm{SC} = \sum \frac{\pi\, \mathrm{D}^2}{4}$$

Sc = Crown surface in (m^2); D = average diameters to East/West and North/South.

Structure in diameter and height

In order to better analyze the data, the observed structure was modeled from the Weibull theoretical distribution parameters whose density probability function (Rondeux, 1999) is expressed through the formula:

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

x stands for the diameter of trees and **f(x)** its value; **a** represents the position parameter; **b** is the parameter of scale or size and c is the parameter of shape as it relates to the structure in diameter or in height given. In this study, the position parameter **a** is set at 2 centimeters for the minimum diameter of *A. senegal* trees. The software Minitab 14 was used to adjust the different histograms constructed via the Weibull (Husch et al., 2003) theoretical distribution. Based on the parameter value **C**, the main shapes of the Weibull theoretical distribution were interpreted as follows : (a) C < 1 indicated a distribution in « Inverted J», featuring the multi-specific or uneven-aged settlements; (b) C = 1 indicated an exponentially decreasing distribution, a feature of settlements in extinction ; (c) 1 < C < 3,6 implied a positive asymmetric distribution or right asymmetric, a feature of monospecific settlements with predominant young plants or plants with smaller diameters; (d) for C = 3,6 : the distribution was asymmetric; normal structure, feature of uneven-aged settlements or monospecific with the same cohort ; (e) C > 3,6 negative asymmetric or asymmetric left, feature of monospecific settlements with predominant older trees.

The regeneration rate of the settlement (RRS) which was the difference between the total number of young plants (Ø < 4 centimeters for shrubs, or 10 centimeters for trees) and that of all the tree settlement (Poupon, 1980). According to Poupon, a 50% rate indicated a balanced settlement where there were as many young trees as adult trees ; a rate that was less than 50% (< 50%) represents an ageing settlement, the density of whose young plants is less than that of adult plants; a rate higher than 50% (> 50) characterized a settlement in full expansion following a significant regeneration; young plants were more important than adults.

RESULTS

Specific abundance

The gum site inventory of the Lido cluster permitted to inventory a total number of ten woody species classified

Table 1. Number of woody species inventoried on the Lido gum site.

Species	Number	Family	Total	Frequency
Acacia ataxacantha DC.	1	Fabaceae-Mimosoideae	1	10
Acacia nilotica (L.) Willd. ex Del.	2	Fabaceae-Mimosoideae	1	10
Acacia senegal (L.) Willd.	191	Fabaceae-Mimosoideae	1	10
Boscia senegalensis (Pers.) Lam. ex Poir.	1	Capparaceae	1	10
Cassia sieberiana DC.	18	Fabaceae-Ceasalpinoideae	1	10
Combretum micranthum G. Don	14	Combretaceae	1	10
Guiera senegalensis J.F. Gmel.	47	Combretaceae	1	10
Maerua crassifolia	4	Capparaceae	1	10
Piliostigma reticulatum (DC.) Hochst.	20	Fabaceae-Ceasalpinoideae	1	10
Ziziphus mauritania Willd.	2	Rhamnaceae	1	10
Total	300		10	100

Table 2. Average *A. senegal* diameters and heights based on plantation years.

Blocks	Average diameters (cm)	VC	Average heights (m)	VC
2006	10.1± 4.39	43.22	3.06±1.16	38.09
2007	8.34±3.25	39.04	2.44±0.76	31.29
2008	6.96±3.82	54.98	2.42±1.28	52.88
2010	10.84±2.84	26.25	4.16±1.47	35.43
2011	7.69±3.37	43.86	2.52±0.95	37.97
	P* = 0.479		p* = 0.937	

CV = Variation coefficient.

into ten families (Table 1), the most significant of which were the Fabaceae-Mimosoideae representing (30%), followed by the Capparaceae, the Combretaceae, and the Fabaceae-Caesalpinioideae, each of which represented (20%), and the Rhamnaceae (10%).

Actual density, importance value index and recovery

Table 3 shows the structural parameters of woody species inventoried at the *A. senegal* gum site. This table shows that the actual *A. senegal* is 238.75 trees/ha with an importance value index of 220.38%, and a recovery of 1329.37 $m^{2.}$

Average diameters and heights of Acacia senegal based on plantation years

Table 2 summarizes the average diameters and heights of *A. senegal* based on plantation years. The results analysis of the results showed that there was a variation.
relatively to these two structural parameters of *A. senegal* based plantation years. The statistical test of ANOVA One-Way proved that this variation between average diameters and heights based on plantations years was not significant (P = 0.479) for average diameters, (P = 0.937) for average heights.

Structure of *Acacia senegal* settlements

Structures in terms of diameter

Chart 4 illustrates the structure in terms of diameter of *A. senegal* plants based on plantation age. The distribution of trees in classes of diameter of the plantation year 2008 presented an inverted "J" trend for (Figure 4c). The observed distribution adjusted to the Weibull theoretical distribution in a C-shape = 1.349. For plantations of the years 2006, 2007, 2010 and 2011, the distribution of trees in classes of diameter showed a bell-shape distribution. The observed distribution adjusted to the Weibull theoretical distribution with the values of the C-shape parameter, which were equal to 1,969 for the 2006 site, 1, 981 for the 2007 site, 3,157 for the 2010 site, and 2,088 for the 2011 site (Figure 4a, b, d and e). The Kolmogorov Smirov testing between the observed distributions and the Weibull theoretical distributions resulted in P-values greater than 0.05, which indicates that the two types of distributions did adjust.

Structures in terms of height

Figure 5 displays the *Acacia senegal* plants in terms of height. The distribution in classes of height presented an « inverted J » distribution. It adjusted to the Weibull

Table 3. Structural value parameters of inventoried species on the Lido gum site.

Species	Total	Rf (%)	Rd (%)	RBA (%)	IVI (%)	CS (unit)
Acacia ataxacantha DC.	1	0.33	0.33	0.064	0.73	2.51
Acacia nilotica (L.) Willd. ex Del.	2	0.67	0.67	0.71	2.04	10.52
Acacia senegal (L.) Willd.	191	63.67	**63.67**	93.06	**220.39**	**1329.37**
Boscia senegalensis (Pers.) Lam. ex Poir.	1	0.33	0.33	0	0.67	0
Cassia sieberiana DC.	18	6	6	1.037	13.04	73.61
Combretum micranthum G. Don	14	4.67	4.67	0.74	10.07	52.05
Guiera senegalensis J.F. Gmel.	47	15.67	15.67	0.68	32.01	32.7
Maerua crassifolia Forsk.	4	1.33	1.33	0.024	2.69	0.016
*Piliostigma reticulatum (*DC.) Hochst.	20	6.67	6.67	1.62	14.95	22.96
Ziziphus mauritania Willd.	2	0.67	0.67	0	1.33	0
Total	300	100	100	97.935	297.94	1523.736

Rf = relative frequency, Rd = relative density RBA = relative basal area, CS = crown surface.

theoretical distribution with the C-shape parameter c = 1, 887; c = 2.271; c = 1.349; c = 1.849, respectively for the plantations of the years 2006; 2007; 2008 and 2011 (Figure 5f, g, h, j). The distribution in classes of height of the 2010 plantation showed a bell distribution. It adjusted to the Weibull theoretical distribution with the C- form parameter c = 2.221 (Figure 5i) (Table 3).

Average annual growth and mortality rate of *A. senegal* based on plantation years

Table 4 illustrates the variation of average annual growth (AAG) in terms of diameter and height of *A. senegal* plants in 2019. The results indicated that the highest average growth rate in terms of diameter and height were recorded in 2010, and then in 2011. This growth rate varied depending on the year. The significance of this variation between plantation years was certified via the ANOVA one-Way statistics test with a probability P = 0.001.

The curve in chart 6 shows the global mortality rate of *A. senega*l plants based on plantation year. This curve indicates that the highest plant mortality rate was recorded in 2009 (Mr =17%), then 2008 and 2010 recording proportionally equal mortality rates (Mr = 15%). In 2011, when we recorded a mortality rate of A (Mr = 10%), mortality rate values of the other years decrease continuously until they reached (Mr = 0). The ANOVA one-way statistics test confirmed that the mortality rate. variation in terms of year was highly significant (P = 0.005) (Figure 6).

Regeneration capacity of woody species

Figure 6 illustrates the regeneration rate of species inventoried on the *A. senegal* site. The analysis of the chart shows that the regeneration of the settlement was 80%. The species that contributed the most to this rate were the *A. senegal* and *Guiera senegalensis* representing equal proportions, the highest rejection rate (24.71%), followed by the *Combretum micranthum*, *Cassia sieberiana* and *Piliostigma reticulatum* in relatively respective equal proportions of 15.04; 7.21 and 5.87%. In this contribution, species like *Maerua crassifolia, Bossia senegalensis, Acacia nilotica* and *Zizipus mauritiana* represented the lowest regeneration rate (Figure 7).

DISCUSSION

The study of the current structure of *A. senegal* settlements on the gum site of Lido permitted to record an actual density, an important recovery and regeneration rate. However, the study also helped to show the presence of a consequential mortality rate related to the species. This mortality rate observed with the species was likely linked to anthropogenic pressures (abusive cutting), intensive grazing of animals on the site without the surveillance committee knowing. The usage of this species for the reconstitution of the degraded ecosystem permitted the creation of a microclimate favorable to the regeneration of certain species such as *Guiera senegalensis, Combretum micranthum*, *Cassia sieberiana* and *Piliostigma reticulatum* whose contributions to the reconstitution of the plant cover is quite significant. They contribute up to 52.83% to the settlement recovery. These species regenerated either by zoochory or anemochory. *A. senegal* is a legumin whose leaves are eaten perpetually by animals while the grains are highly demanded in feeding cattle. This trend was reported by previous studies (Alassane, 2006; Diallo et al., 2011). According to Tybirk the absence of a significant number of younger plants observed with *A. senegal* (Tybirk (1991) might be linked to the usage of grains and fruit in feeding cattle, and/or the competition

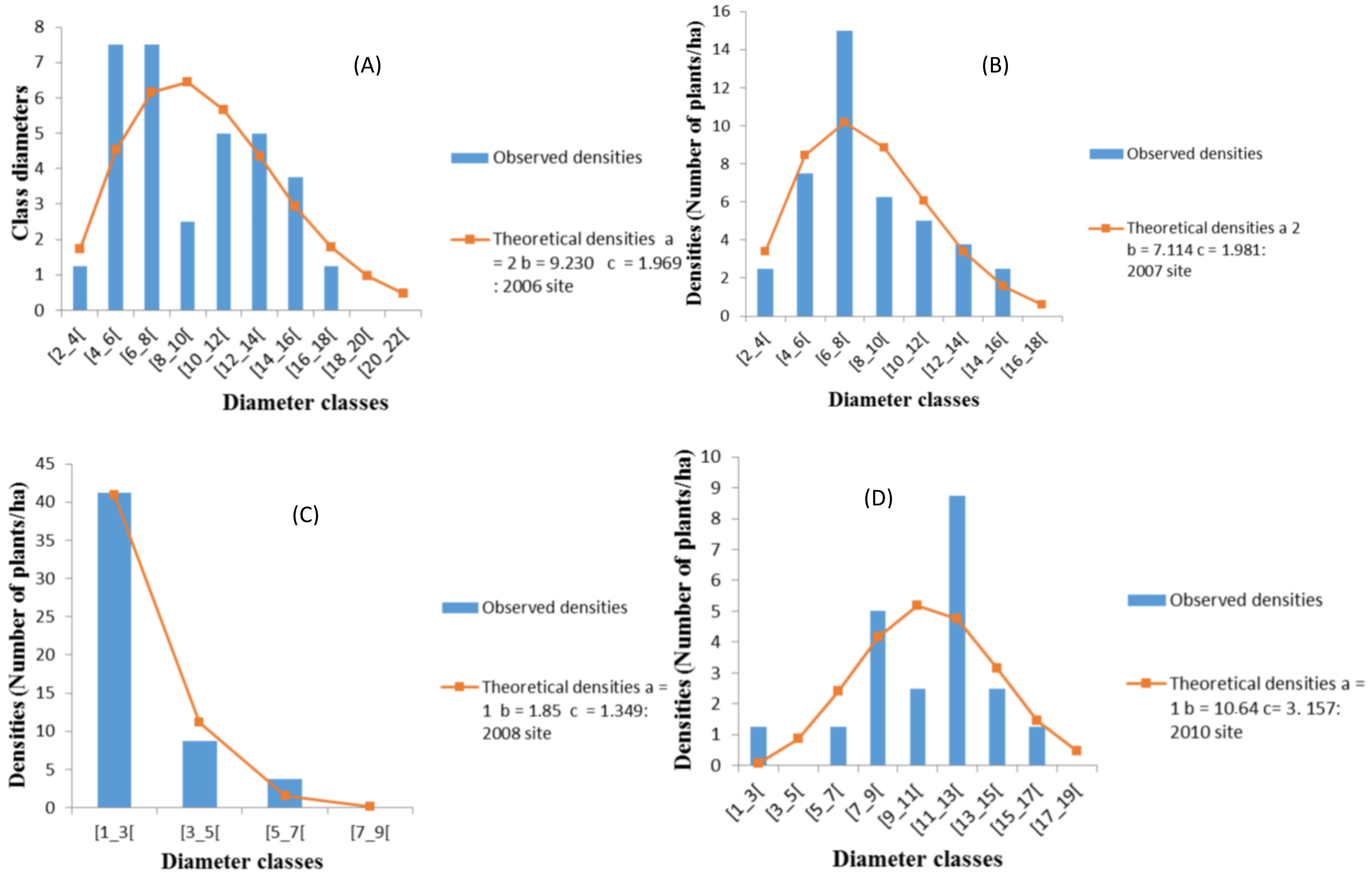

Figure 4. Structure of classes in diameters of *A. senegal* settlements based on plantation year.

on the stock of water available with grasses (Sharman, 1987). In addition to this, we have the impact of overgrazing through the selection of young plants eaten on the growth rate of young plants (Miehe, 1990; Diallo et al., 2012). The different average diameter and height variations

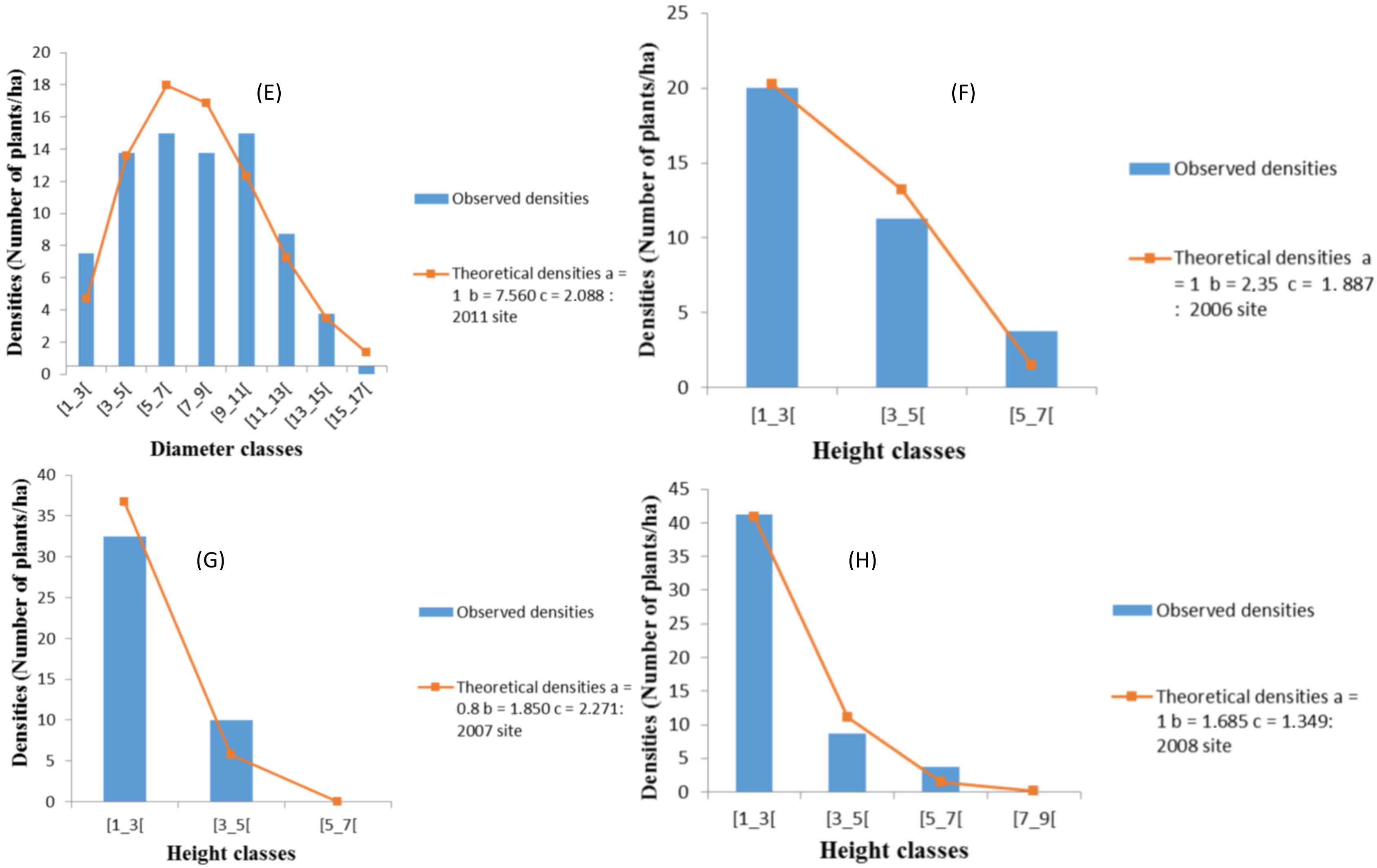

Figure 4. Contd.

and the average annual growth observed with *A. senegal* based on plantation year were linked to the variability of rainfall through the years. Thus, after a plantation, good rainfall surely offers pedoclimatic conditions suitable for the emergence of species. The inverted « J » distribution that the classes of plant diameter of the 2008 plantation structure represented, with the C-shape parameter of less than 3,6 value positive

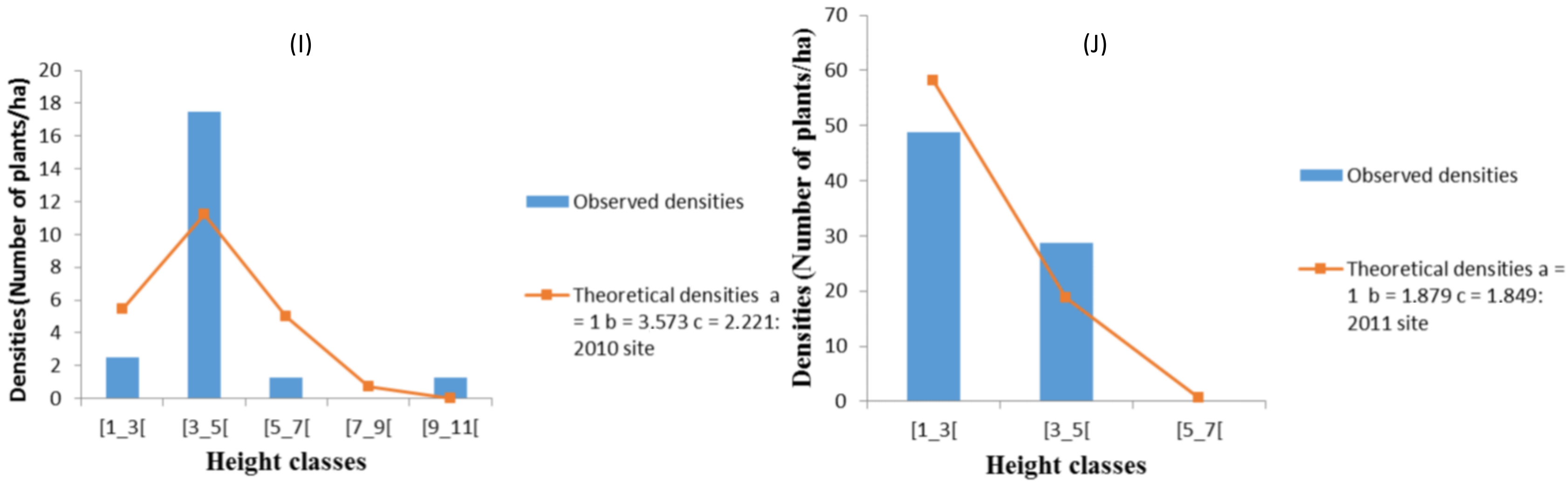

Figure 5. Structure height classes of *A. senegal* settlements based on plantation year.

Table 4. Average annual growth rate and mortality rate of *A. senegal* plants.

Blocks	Plant diameter based on plantation year (cm)	Average diameters in 2019 (cm)	AAG (cm)	Average plant height based on plantation year (m)	Average height in 2019 (m)	AAG(m)
2006	0.3	10.1	**0.75**	0.3	3.06	**0.21**
2007	0.3	8.34	**0.67**	0.3	2.44	**0.18**
2008	0.3	6.96	**0.61**	0.3	2.42	**0.19**
2010	0.3	10.84	**1.17**	0.3	4.16	**0.43**
2011	0.3	7.69	**0.92**	0.3	2.52	**0.28**

P* = 0001, AAG = Average Annual Growth.

asymmetric curve or right asymmetric, was characteristic of monospecific settlements with a predominance of younger plants or those with smaller diameters. This structure was dominated by plants of the first class belonging to the class diameter. The « crown » distribution representing the structures of diameter classes of plantations of other years with the C-shape parameter value of less than 3,6 (also features a positive asymmetric distribution or right asymmetric), was a feature of monospecific settlements with a predominance of younger plants or plants with smaller diameters. In contrast to plants of the 2008 plantation, these structures represented a smaller proportion of younger plants in the first classes of diameter and plants with larger diameters were scarce. The absence of trees of large diameters in these blocks of plantation implied the impact of the

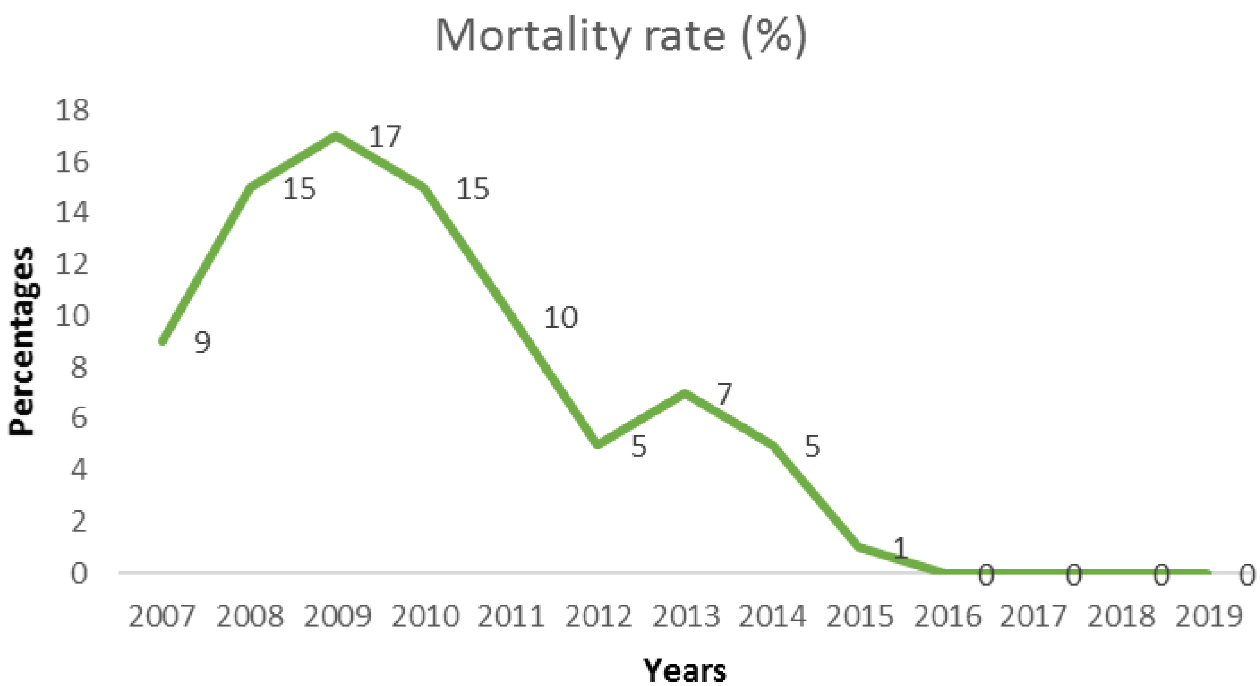

Figure 6. Mortality rate variation of Acacia *senegal* plants over the years.

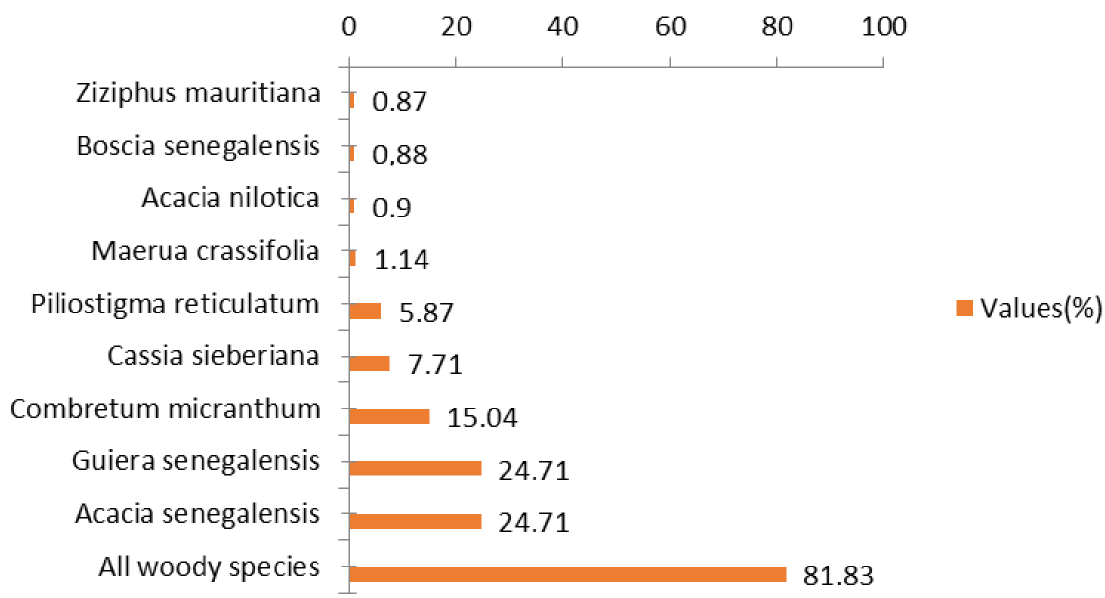

Figure 7. Regeneration variation rate of species on the site.

aridity of the Sahelian climate on the growth of species in diameter and thickness. This observation was signaled by Diallo et al. (2011). It might also be linked to the impact of anthropic factors such as bleating and pruning of plants of the species in these blocks. It may also be due to intensive grazing on the plants from their first age of growth by animals. The inverted « J » distribution representing the class structures in terms of height characterizes the Sahelian type of vegetation that was essentially shrubby. Thus, of all the plantation years, the plants of *A. senegal* of seven meters high were very scarce, often nonexistent. This situation was foremost due to the pressure of anthropogenic and climate factors, and also grazing. Overexploitation obviously led to stress and traumatism on the plants of these settlements with regard to these two dendrometric parameters (Kebenzikato et al., 2014; Ngarnougber et al., 2017). During the dry season, younger seedlings of *A.senegal* were highly appreciated in cattle feed (Dan Guimbo et al., 2010), which constituted a major constraint on the dynamic of future regeneration of this species.

Conclusion

For the development of non-wood forest products, namely the Arabic gum, this study provided additional information on the current state of the *A. senegal* settlements in the Lido terroir plantation site. The structure of these settlements, shrubby in nature, remains dominated by younger trees with smaller diameters. It was highly tributary to the pedoclimatic conditions and upset by anthropogenic, climate factors and the effect of grazing. The objective sought through these plantations, which was the production of Arabic gum, was therefore strongly compromised. These settlements represented a smaller regeneration rate (24.71%), which could compromise the long-term survival of the settlements of the species. For the sake of a sustainable conservation of this species for the well-being of populations, it is indispensable for the public interest to integrate afforestation actions, protection and restoration in the development of Sahelian and Sudan ecosystems of *A. senegal* across the gum sites of the country.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGMENTS

The authors appreciate the people of the village of Lido in particular the head of the village, for his support.

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