Original Research Article

Structure of the woody stands of the future pre-release site of North African ostrich (*Struthiocameluscamelus*(Linnaeus, 1858)) in Koutous, Niger

ABSTRACT

This study aims to investigate the composition and Important Value Index (IVI) of the woody stands of Tchillala, a 130-ha area selected forfutureNorth-African ostriches (*Struthiocameluscamelus*) prerelease in the Koutousregion in Niger. The forest inventory methodwas implemented in 42 plots of 50 m x 20 m (1000m²)for tree-level observation,using stratified random sampling. For each woody specimen, the trunk diameter, total height and crown diameter have been recorded;the specimens with a trunk diameter smaller than 5 cm are considered as regenerations. A total of 17 woody species distributed across 10 families have been identified and most of them belongs either to the Mimosaceae (4 species) or theTiliaceae (3 species). The plants density, domination and frequency were used to determine the IVI:*Acacia tortilis* and *Balanitesaegyptiaca* are the species with the highest IVI(118.43 and 88.28 respectively). The woody plants condition assessment has emphasized that trees have been facingnatural (uprooting) and anthropogenic (cutting, pruning) threats. Consequently, the diameter class structures within the whole woody species community of Tchilala, as well as of the*Acacia tortilis* and *Balanitesaegyptiaca*,are mainlysmall size trees. The results of this study informsilvicultural management actions that would benefit to the North-African ostrich'establishment in Tchilala and the data collected are considered as possible indicators for long-term monitoring of habitat.

Keywords: Tree inventory, Struthiocameluscamelus, prerelease, habitat, dendrometry, Koutous, Niger

1. INTRODUCTION

The relationship between species and their habitat is one of the central themes inanimal population ecology [1].The habitat assessment is therefore a key stepin anyreintroduction planning. In particular, plants fulfill the important ecological function of producing organic compounds for herbivores in the bottom of the food web, but they can also play the roles ofrefuge for fauna or soil modifiers. Within the plant community, the woody species represent good indicators as they are persistent components of the macro-habitat.

According to GleléKakai et al. [2], a methodological approach of the tree diameter distribution is a good alternative to the study of the woody stands life history [3, 4] and would allow to infer the needed landscaping actions to restore or protect the natural habitat [5] when long-term monitoring is not available.

Additionally, as the animal species respond to their environment features, the vegetation characteristics such as taxonomic composition, size, condition and distribution,influence the occupation of the habitat[1]. The physical conditions (e.g., altitude, substrate) also often impact on the plant formations, and indirectly on the animal density[6]. The North African ostrich (*Struthiocameluscamelus*) is a giant flightless bird that was formerly widely distributed in the Sahelo-Saharan region: it was endemic in Niger but has disappeared from its natural environment since 2004 when the last male located in the AïrandTénéréNatural Reserve died [7].

An ongoing national conservation program supports captive breeding of North-African ostriches in threelocations, namely Kellé, Iferouane and Mainé-soroa,managed by non-governmental organizations (NGOs) or citizens. Theseslowly-growing captive populationsconstitute a hope for the sub-species' possible return to areas where it previously existed in Niger.

However, captive-raised animals of many species have had poor success after reintroduction into their natural habitat [8, 9, 10, 11] To maximize survival, reintroduction candidatesmust be able to procure food and shelter, develop antipredator skills, interact properly with conspecifics, and orient (navigate, migrate, and/or disperse) in a structurally complex environment [11, 12].

The prerelease phasemay alter behaviors in ways assumed to be beneficialto survival [14, 15, 16, 17, 18]. During this preliminary phase, the animals to be released can be actively trained, as demonstrated with birds trained forphysical fitness and anti-predatory behaviors that survivedbetter than untrained birds [19]. The soft-release methodis another strategy that allows to progressively expose the animals to the new challenges they will have to face to survive in the wild. This is particularly indicated for endangered species of which the ecology is little known, because the project managers will be able to monitor the animals' behavior and implement ad-hoc mitigation solutions when needed.

The North-African ostriches exhibit low population growth rates with high variance, are subject to high environmental variation (e.g., annual fluctuations in hatching or chicks mortality), and have little genetic variability relative to their population size. Thus, ostrich reintroduction presents many challenges. Therefore, the two NGOs involved the species conservation program in Niger, the Sahara Conservation Fund (SCF) and the Cooperative of Exploitation of Natural Resources of Koutous (CERNK), have agreed to prepare a 130-ha prerelease area, named Tchillala, in the Koutous.

In accordance with the IUCN's recommendations for reintroduction, this study comes in line with the preliminary assessment of a prerelease site, focusing on the woody species. Indeed, the treesrepresent an important component of the habitat features, particularly in the Sahel, where they providepermanent source of food and shade benefiting to herbivores, small fauna (birds and arthropods) and annual plants. We aim to determine baseline data that will help to implementa long-term monitoring program of the woody stands in Tchilalaand informthe development of habitat management activities for the return of the North-African ostrich in the Koutous.

2. MATERIAL AND METHODS

2.1. Study site

The site of Tchilala belongs to the Municipality of Kéllé, department of Gouré, Region of Zinder (Figure 1). It is a 132.4-ha area surrounded by hills in the form of mounds of the Continental Terminal, located between N13°51'40'' and N14°53'40'' and E9°51'40'' and E11°14'20''. As described by Saadou[20], it is located in the North Sahelian oriental sectorphytogeographic subdivision of Niger. The area is characterized by a long dry season of 8 to 9 months and a short rainy season of 3 to 4 months. The average annual temperature fluctuates between 25 and 30 °C and the cumulative annual rainfall is around 300 mm. The vegetation in the area is a shrub-to-tree steppe and forest galleries along the rivers.

2.2. Data collection

The tree inventory was carried out in 1000m² (50m x 20m) plots following a stratified random distribution based on geomorphology (dune peaks, dune slopes and depressions). A total of 42 plots were installed.

In each plot, the following parameters have been measured foreach woody plant: the circumference of the trunk (in cm) with a tape measure, the diameter of the crown on the two perpendicular axes with a tape measure, the total height (m) with graduated poles. The diameter (D) was then calculated by the formula D = circumference / π. These measurements were taken on individuals with a trunk diameter greater than or equal to 5 cm.The individuals thinner than 5cm have been considered as juveniles andcountedfor regeneration rate.

The condition of the individuals encountered has been also classified in the following categories: cutting, pruning and heaving.

2.3. Data analysis

Dendrometric parameters

The following dendrometric parameters were calculated:

- Importance value index (IVI):

The importance of the different woody species in the site was assessed with the IVI [21]. This index is expressed according to the following formula:

IVI = FR (%) + RBA (%) + DR (%), with:

FR: is the relative frequency of a species, it is the ratio of its specific frequency (number of plots in which it is present) to the total of specific frequencies;

RBA: relative basal area, it is the quotient of its basal area (basal area) by the total of the basal areas of the species;

DR: the relative density of a species; it is the ratio of its absolute density to the total of the absolute densities.

- The recovery rate (R) of woody species in percentage (%) was obtained by the following formula:

$$R(\%) = \frac{r \times 100}{S} with r = \frac{\pi}{4} \sum_{i=1}^{n} di^2$$

r = recovery of all individuals in the plot (m²); di = mean diameter of the crown of the individual i (m); s = area of the plot (m²).

The density of stems (N) expressed in stems per hectare (Stems / ha) was determined by the total number of stems in each plot according to the formula:

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

n = total number of stems inventoried in the plot; s = area of the plot in hectare.

- The regeneration density (Nr) was expressed in stems per hectare (Stems / ha) by the following formula:

$$\mathrm{Nr} = \frac{\mathrm{nr}}{\mathrm{s}}$$

nr = total number of rejects recorded in the plot; s = area of the plot in hectare.

- The average diameter (Dg) expressed in centimeters (cm) was determined for each plot by the formula:

$$D_g = \sqrt{\frac{1}{n} \sum_{i=1}^{n} d_i^2}$$

n = total number of stems encountered in the plot and di = diameter of the stem i (cm).

- The basal area of the stand (G), expressed in m² / ha, is given by the formula:

$$G = \frac{\pi}{40000\ s} \sum_{i=1}^{n} d_i^2$$

s = area of the plot in hectare and di = diameter of the stem i (cm).

- TheLorey's mean height (HL) is the weighted meanheight (in meters) whereby individual trees are weighted in proportion to their basal area [22]. The formula is as follows:

$$HL = \frac{\sum_{i=1}^{n} gi\ hi}{\sum_{i=1}^{n} gi} \quad with\ gi = \frac{\pi}{4} di^2$$

Where gi and hi are the basal area and the total height of individual i, respectively.

Demographic structures

For the structure in diameter and height classes of woody individuals, the diameter greater than 5 cm were divided into seven classes of diameter of amplitude 5 cm and seven classes of height of amplitude 1 m. The structures were adjusted to the Weibull model, chosen for its great flexibility [23]. To ensure a good fit of the observed structure to the theoretical Weibull distribution, a fit test based on a log-linear analysis with SAS software was carried out. The probability density function of the Weibull distribution is presented in the form of the following equation [3]:

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

Where x is the diameter or height of the trees and F (x) its probability density value;

a is the position parameter; it is equal to 0 if all the categories of trees are considered (from seedlings to seeders) during the inventory; it is not zero if the trees considered have a diameter or a height greater than or equal to a;

b is the scale or size parameter; it is linked to the central value of the diameters or heights of the trees in the stand considered;

c is the shape parameter linked to the diameter or height structure considered.

This Weibull distribution can take variousforms depending on the value of the shape parameter (C) related to the diameter structure, as shown in Table 1.

3. RESULTS

3.1. Floristic composition and specific importance

The woody communities of the site comprise 17 species belonging to 10 families. 23.52% of these species belong to the Mimosaceae family followed by the species of the Tilliaceae family (17.64%), Asclepiadaceae (11.76%) and Capparaceae (11.76%). The other families are represented by only one species (Figure 2).

Analysis of the Importance Value Indices shows that *Acacia tortilis* has the largest importance value index (IVI = 118.43) followed by *Balanitesaegyptiaca* (IVI = 88.28) (Table 2). These first two species represent 68.9% of the importance value index of all the inventoried species and mark the physiognomy of the woody stratum of the site.

3.2. Degradation of woody species

The assessment of the woody plants condition in Tchilalahighlights that 28.4% of the surveyed woody plants have been pruned or over pruned, and 15.2% show signs of debarking (Figure 3a). Other 21.7% has suffered from partial or full uprooting by water of wind, including fallen trees because of soil erosion action (Figures 3b and 3c).

In summary, about65% of the woody plants have been suffering from anthropogenic or natural damages.

3.3. Dendrometric characteristics

~~The t~~Table 3 presents the average values of the dendrometric parameters for the whole woody species community and for each of the two dominant species (*Acacia tortilis* and *Balanitesaegyptiaca*). The density of adult woody trees is 83.33 ± 42.80 trees / ha lower than the density of regeneration 227.54 ± 129.87 stems / ha. The overall basal area of all woody species is 0.52 ± 0.51 m² / ha (Table 3). Populations of *B. aegyptiaca* have a higher mean diameter (Dg), while populations of *Acacia tortilis* have higher values for all other dendrometric parameters.

3.4. Demographic structures of woody species

According to the classification presented in Figure 4a, the diameter structure of the whole woody species community shows a distribution dominated by individuals of the diameter classes of 5 to 10 cm, with a C shaped parameter less than. The distribution in diameter classes of the two dominant species on the site, *Acacia tortilis* and *Balanitesaegyptiaca* also shows the same distribution in “inverted J” with a shape parameter less than 1. The diameter class 5 to 10 cm represents 44.44% and 41.58% of the sampling effortrespectively for *Acacia tortilis* (Figure 4b) and *Balanitesaegyptiaca* (Figures 4c).

The distribution of woody trees in height classes also shows a shape parameter characteristic of a young stand with a predominance of individuals in the middle classes (3 to 5 m) (Figure 5a).

As for the height structures of *Acacia tortilis* and *Balanitesaegyptiaca* populations, it is also the individuals of the middle classes who predominate (Figures 5b and 5c). The results of the log-linear analysis show that the distributions observed in diameter and height classes fit globally with the theoretical Weibull distributions (P <0.05).

4. DISCUSSION

With only 17 species encountered, the woody flora of the future ostrich’ pre-release site show a low diversity, and dominated by the Mimosaceae family. While low-diverse single-dominant forests are not rare [25],this number of species is lower than those found in similar work carried out in other Sahelian areas of Niger [26, 27]. This difference could be related to the fact that the site is confined by the chain of hills which surrounds it; the latter could constitute an obstacle to the flow of seeds, particularly for species with modes of anemochore and hydrochore dissemination.

The species with the greatest importance value indices (IVI), i.e. those which are ecologically important in terms of their overlap, frequency and density are *Acacia tortilis* and *Balanitesaegyptiaca*, two species with high resistance to drought [28]. These species represent 74.6% of the overall density of all woody species encountered in Tchilala. These two species also dominate in number of juvenile individuals. These results reflect the strong capacity of these species to regenerate, since the latter have shown a strong capacity for germination [29, 30]. In addition, the fruits of these species are very appreciated by animals: the site currently having a pastoral vocation, the frequentation by the herds can favor the propagation of their seeds in the site.

Acacia tortilis pods are known to be highly valued by captive ostriches at the Kellé breeding center [31]. Its palatability for the ostrich is also reported by Issoufou[32] and Ibrahim [33], as well as for *Maeruacrassifolia*. In the absence of herbaceous species during the dry season, these species will represent one of the main food sources for the ostrich.

The intensity of logging could be explained by the fact that the site has no legal protection status. In the dry season, when herbaceous fodder is scarce, the pastoralists who roam the site prune the woody species to feed their live stock or make some fires. This harmful practice could jeopardize the dynamics of woody stands in the long term if no protective measure is taken, since cutting and pruning generally happen on the biggest trees. These actions could have repercussions on the lives of ostrich individuals who will be pre-released, in the Sahel; the woody species constitute the perennial component of the vegetation. In addition to the nutritional role of the ostrich, the woody plants will serve as a resting area during the hottest hours of the day and will allow the animal to perform certain biological functions.

The diameter structures of all woody species and two dominant species, *Acacia tortilis* and *Balanitesaegyptiaca* show the predominance of individuals of small diameter. Similar structures have already been observed in previous work on woody species [34, 35]. These structures reflect a regeneration capacity of the stand. The low representation of individuals of large diameters could be explained by the inability of young subjects to cross the adult stages due to climatic and anthropogenic disturbances. The latter would cause trauma and slow growth in height and diameter. Individuals of small diameter ensure the future of natural formation while those of large diameters resulting from natural selection are seeders that ensure the sustainability of the stand through the production of seeds [36, 37]. As for the structures in height, they show the dominance of individuals of middle classes (2 to 5m), these structures confirm the characteristic of a Sahelian vegetation essentially made of shrubs. the North African ostrich is the tallest subspecies of ratites [38, 39]and so, they will be able to feed on the highest parts of the trees (including fruits, leaves, flowers): this would be a factor in favor of the establishment of sedentarygroups in these wooded areas, ~~as long~~ as long-term monitoring is performed to evaluate the impact of this new form on grazing on this Sahelian steppe.

5. CONCLUSION

This study shows that Tchilala area has a low diversity of woody species (17 species), and a physiognomy of the woody stratum marked by *Acacia tortilis* and *Balanitesaegyptiaca*. The dendrometric parameters and the demographic structures of the trees match the characteristics of a regenerating ecosystem, despite continuing natural (soil erosion, wind) and anthropogenic (cutting and pruning) damages. This suggests that further recovery will happen when the site will be protected.Additionally, in arid climates, the woody species play an important role not only in the structure of the habitat (perennial source of food, shade) but also in the development of biodiversity (e.g., habitat for microfauna, microclimate for annual plant species): they are good biodiversity indicators. This study shows that the site has qualitative and quantitative characteristics consistent with the Sahelian habitat in which North African ostriches used to live naturally before having been extirpated by over-hunting. The study also suggests that implementing a long-term monitoring on the prerelease site to counteract the harmful effects of anthropogenic activities and animal grazing on the woody species will be instrumental for a comprehensive silvicultural management.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

REFERENCES

1. Morrison ML, Marcot BG, &Mannan, R.W. Wildlife-habitat relationships: concepts and application. Island Press. *In* Dénis.2006.
2. GleleKakaï RL, Bonou, W &Lykke, AM. Approche méthodologique de construction et d’interprétation des structures en diamètre des arbres. Annales des Sciences Agronomiques. 2016, 20. 99-112.

3. Rondeux J. La mesure arbres et des peuplements forestiers. *Presses agronomiques de Gembloux*, Gembloux, Belgique. 1999, 522p.
4. Feeley JK, Davies SJ, NurSupardi Noor MD, Kassim AR& Tan S. Docurrent stem size distributions predict future population changes? An empirical test of intraspecific patterns in tropical trees at two spatial scales. Journal ofTropicalEcology. 2006, 23: 191-198.
5. Van Laar A. &Akça A. Forest mensuration. Springer, Dordrecht. 2007.
6. Freycon V, Sabatier D, Paget D, Ferry B. Influence du sol sur la végétation arborescente en forêt guyanaise: état des connaissances. RFF numéro spécial "Connaissance et gestion de la forêt guyanaise": 2003, 60-73.
7. Abdou MI, Abdoulaye H, Hamidine S. Stratégie et plan d'action pour l'élevage et la réintroduction des espèces menaces de disparition dans la RNNAT. Projet de cogestion des ressources naturelles de l'Aïr et de Ténéré (COGERAT). 2007, 71p.
8. Wemmer C, Derrickson S. Reintroduction: the zoologists dream. In: Annual Proceedings, American Association of Zoological Parks and Aquariums, Wheeling, W. Virginia, pp. 1987, 48-65.
9. Griffith B, Scott JM, Carpenter JW, Reed C. Translocation as a species conservation tool: Status and strategy. Science, 1989 345, 447-480.
10. Beck BB, Rappaport LG, Stanley Price MR, Wilson AC. Reintroduction of captive-born animals. In: Olney, P., Mace, G., Feistner, A. (Eds.), Creative Conservation: Interactive Management of Wild and Captive Animals. Chapman and Hall, London.1994 pp.265-286.
11. Wilson AC, Stanley-PriceMR. Reintroduction as a reason for captive breeding. In: Olney, P., Mace, G., Feistner, A. (Eds.), Creative Conservation: Interactive Management of Wild and Captive Animals. Chapman and Hall, London. 1994, pp. 243-264.
12. Kleiman DG. Reintroduction of captive mammals for conservation. Bioscience. 1989, 39, 152-161.
13. Box HO. Training for life after release: simian primates as examples. In: Gipps, J.H.W. (Ed.), Beyond Captive Breeding: Re-introducing Endangered Mammals to the Wild. Clarendon Press, Oxford, U.K. 1991, pp. 111-124.
14. Kleiman DG, Beck BB, Dietz JM, Dietz LA, Ballou JD, Coimbra-Filho AF. Conservation program for the golden lion tamarin: Captive research and management, ecological studies, educational strategies, and reintroduction. In: Benirschke, K. (Ed.), Primates: The Road to Self-sustaining Populations. Springer-Verlag, New York. 1986 pp. 959-979.

15. Stanley-Price MR. Animal reintroductions: The Arabian oryx in Oman. Cambridge U. Press, 1989, Cambridge, U.K.
16. Phillips MK. Measures of the value and success of a reintroduction project: Red wolf reintroduction project in Alligator River National Wildlife Refuge. Endangered Species Update, 1990, 8, 24-26.
17. SoderquistTR, Serena M. An experimental reintroduction program for bush-tailed phascogales (Phascogale tapoatafa): the interface between captivity and the wild. In: Olney, P., Mace, G., Feistner, A. (Eds.), Creative Conservation: Interactive Management of Wild and Captive Animals. Chapman and Hall, London, 1994, pp. 431-438.
18. Biggins, D. E., Vargas, A., Godbey, J. L., & Anderson, S. H. Influence of prerelease experience on reintroduced black-footed ferrets (*Mustelanigripes*). Biological conservation.1999, *89*(2), 121-129.
19. Ellis DH, Dobrott SJ, Goodwin JrJG. Reintroduction techniques for masked bob-whites. In: Temple, S.A. (Ed.), Endangered Birds. U. Wisconsin Press, Madison. 1978, pp. 345-354.
20. Saadou M. Végétation des milieux drainés nigériens à l'Est du fleuve Niger. Thèse de doctorat ès Sciences Naturelles, Université de Niamey.1990, 395p.
21. Curtis JT & Macintosh RP. An upland forest continuum in the prairie-forest border region of Wisconsin. *Ecology*, 1951, 32(3): 476-496.
22. Philip SM. Measuring Trees and Forests. 2nd edition. Londres, Royaume-Uni, CABI, 2002, 310 p.
23. Bonou W, Glélé KR, Assogbadjo AE, Fonton HN, Sinsin B. Characterisation of *Afzelia Africana* Sm. Habitat in Lama forest reserve of Benin. *Forest Ecology and Management*, 2009, 258: 1084-1092.
24. Husch B, Beers T. & Kershaw JJr..Forest Mensuration. John Wiley, New York. 2003.
25. Connell JH and Lowman MD. Low diversity tropical and subtropical forests. American Naturalist, 1989, 134: 88-119.
26. Laminou MO, Bachir OG, Morou B, Karim S, Mahamane A. Etat de la végétation ligneuse au Sahel : cas de GuidanRoumdji au Sahel central du Niger. *Journal of Animal & Plant Sciences*, 2017, 31(3): 5033-5049. DOI: http://www.m.elewa.org/JAPS.
27. Ali A, Morou B, Inoussa MM, Abdourahamane S, Mahamane A, Saadou M.Caractérisation des peuplements ligneux des parcs agroforestiers à *Diospyrosmespiliformis* dans le centre du Niger. *Afrique Science*, 2017, 13(2) : 87-100. http://www.afriquescience.info

28. Konaté PS. Structure, composition et distribution de quelques ligneux dans les provinces du Séno et du Yagha: proposition d'application à leur gestion. Mémoire de fin d'études d'ingénieur du développement rurale, Université Polytechnique de Bobo Dioulasso, 1999, 79p.
29. Jaouadi W, Hamrouni L, Souayeh N, Khouja ML. Étude de la germination des graines d'*Acacia tortilis*sous différentes contraintes abiotiques. *Biotechnol. Agron. Soc. Environ.,* 2010*,* 14(4) :643-652*.*
30. Abdou HMK, Rabiou H, Abdou L, Abdourahamane IS, Sanoussi IAZ., Soumana A, Mahamane A. Germination et croissance des plantules d'une espèce fruitière indigène au Niger : *Balanites aegyptiaca*(L.) Del. *Int. J. Biol. Chem*. *Sci.*, 2019, 13(2) : 693-703. DOI: https://dx.doi.org/10.4314/ijbcs.v13i2.10
31. SCF. Rapport d'activités. 2016.
32. Issoufou IA. Etude de faisabilité pour la création d'un site de pré-lâché ou lâcher de l'autruche à cou rouge (*Struthiocameluscamelus*) dans la zone de Kéllé à Zinder. Mémoire Master, Faculté des Sciences Agronomiques, Université d'Abomey Calavi, Bénin,2011, 48p.
33. Ibrahim MM. Analyse des forces et faiblesses de l'élevage de l'autruche à cou rouge (*Struthiocameluscamelus* (Linnaeus, 1858)) dans le site de Kellé (Zinder). Mémoire de Master, Université Dan DickoDankoulodo de Maradi,2015, 44p.
34. Rabiou H, Inoussa MM, Bakasso Y, Diouf A, Boubacar MM, Mahamane A., Saïdou IS, Saadou M, Lykke AM. Structure de la population de *Bosciasenegalensis* (Pers) Lam. Ex Poir suivant la toposéquense dans la commune de Simiri (Niger). *Journal of Animal & Plant Sciences*. 2014, 23(3) : 3657-3669.
35. Morou B, Ounani H, Amadou OA, Diouf A, Guéro C, Mahamane A. Caractérisation de la structure démographique des ligneux dans les parcs agroforestiers du terroir de Dan Saga (Aguié, Niger). *Int. J. Biol. Chem. Sci*., 2016, 10(3): 1295-1311. DOI :http://dx.doi.org/10.4314/ijbcs.v10i3.31
36. Adjonou K, Bellefontaine R, Kokou K. Les forêts claires du Parc national Oti-Kéran au Nord-Togo :structure, dynamique et impactsdes modifications climatiques récentes. *Sécheresse*, 2009, 20(1) : 1-10. DOI: 10.1684/sec.2009.0217.
37. Morou B. Impact de l'occupation des sols sur l'habitat de la girafe au Niger et enjeux pour la sauvegarde du dernier troupeau de girafes de l'Afrique de l'Ouest. Thèse de doctorat en Biologie appliquée, Université Abdou Moumouni de Niamey, 2010, 198p.
38. Cornette B, and Lebailly P. L'Autruche, élevage et rentabilité. Les presses agronomiques de Gembloux : Gembloux. 1998, 178 p.

39. Shanawany MM. and Dingle J. Ostrich production systems. Food and AgricultureOrganization of the United Nations (FAO): Rome, 1999, 256 p.

Table 1. Shapeof the Weibull distribution as a function of the value of the parameter c (Husch et al., 2003)

Value of parameter C	Interpretation
C<1	Distribution in "inverted J", characteristic of multispecific or uneven-aged stands.
C = 1	Exponentially decreasing distribution, characteristics of extinct populations.
1 <C < 3.6	Positive asymmetric or right asymmetric distribution, characteristic of monospecific stands with predominance of young or small diameter individuals.
C = 3.6	Symmetrical distribution (normal structure), characteristic of monospecific stands with individuals of unequal diameter.
C > 3.6	Negative asymmetric or left asymmetric distribution, characteristic of monospecific stands predominantly of elderly individuals.

Table 2. Importance value index (IVI) of ten predominant woody species in Tchilala (Koutous, Niger).

Species	DR (%)	RBA (%)	FR (%)	IVI
Acacia tortilis	41.14	47.13	30.16	118.43
Balanitesaegyptiaca	28.86	35.61	23.81	88.28
Maeruacrassifolia	9.14	3.89	13.49	26.53
Acacia senegal	8.86	5.67	11.90	26.43
Bosciasenegalensis	3.43	0.33	7.14	10.90
Commiphoraafricana	4.57	1.39	3.17	9.14
Leptadeniapyrotechnica	1.71	0.21	3.97	5.90
Sclerocaryabirrea	0.29	4.46	0.79	5.54
Ziziphusmauritiana	0.57	0.81	1.59	2.97
Faidherbiaalbida	0.29	0.23	0.79	1.31
Others	1.16	0.26	3.16	4.48
Total	**100**	**100**	**100**	**300**

DR: relative density RBA: relative basal area; FR: relative frequency.

Table 3. Averages and coefficient of variation of the dendrometric parameters of woody plants and two dominant species on the site

Dendrometric parameters		**M**	**CV (%)**
Density (stems/ha)	Global	83.33±42.80	51.36
	Acacia tortilis	34.28±29.80	86.93
	Balanitesaegyptiaca	24±28.03	115.44
Basal area(m²/ha)	Global	0.52±0.51	98.56
	Acacia tortilis	0.27±0.33	128.41
	Balanitesaegyptiaca	0.26±0.32	123.09
Lorey height(m)	Global	4.64±1.33	28.86
	Acacia tortilis	4.61±1.51	32.78
	Balanitesaegyptiaca	4.21±1.59	37.78
Diameter (cm)	Global	12.35±5.68	46.98
	Acacia tortilis	12.50±7.19	57.54
	Balanitesaegyptiaca	13.67±6.80	49.76
Recovery rate (%)	Global	17.07±13.21	77.44
	Acacia tortilis	9.26±10.05	108.54
	Balanitesaegyptiaca	3.90±4.88	125.17
Regeneration density (stems/ha)	Global	227.54±129.87	57.07
	Acacia tortilis	129.52±108.91	84.09
	Balanitesaegyptiaca	40.23±114.22	283.86

M: Mean; CV: coefficient of variation

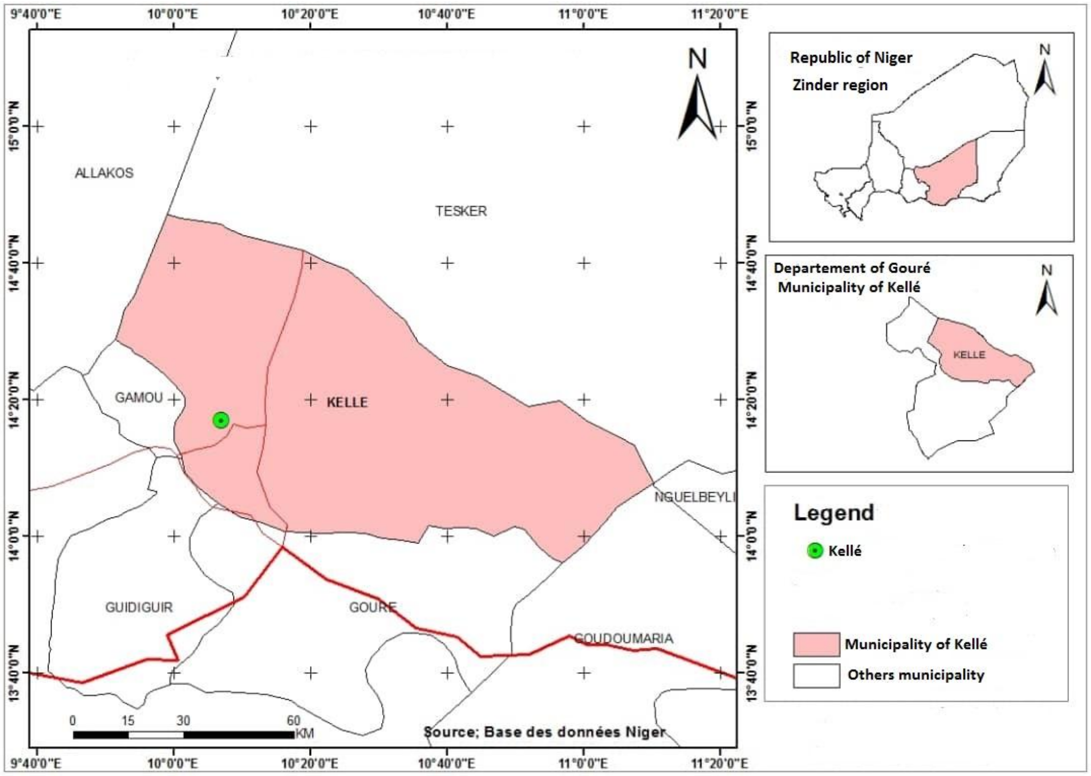


Figure 1. Location of the study area

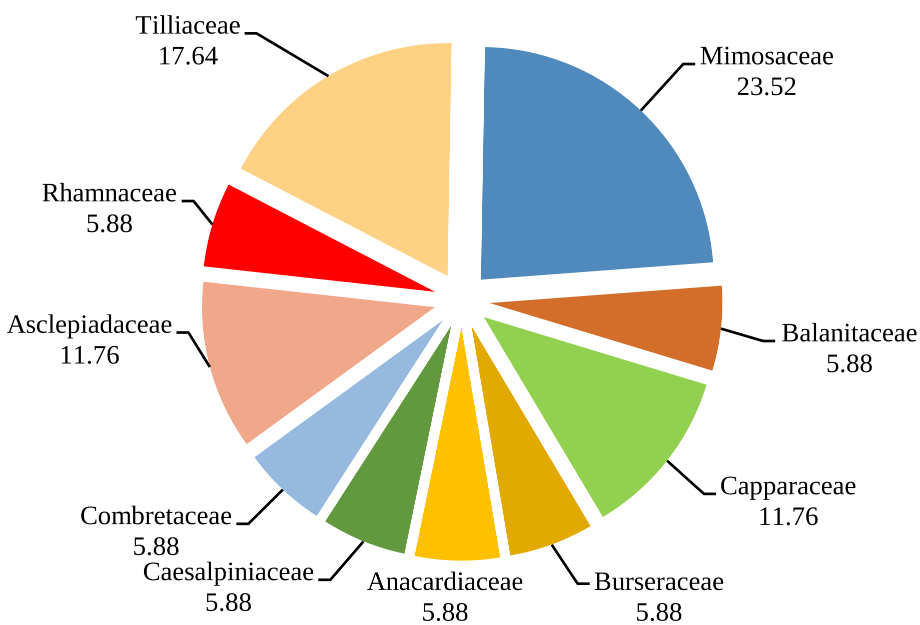


Figure 2. Spectrum of woody species families

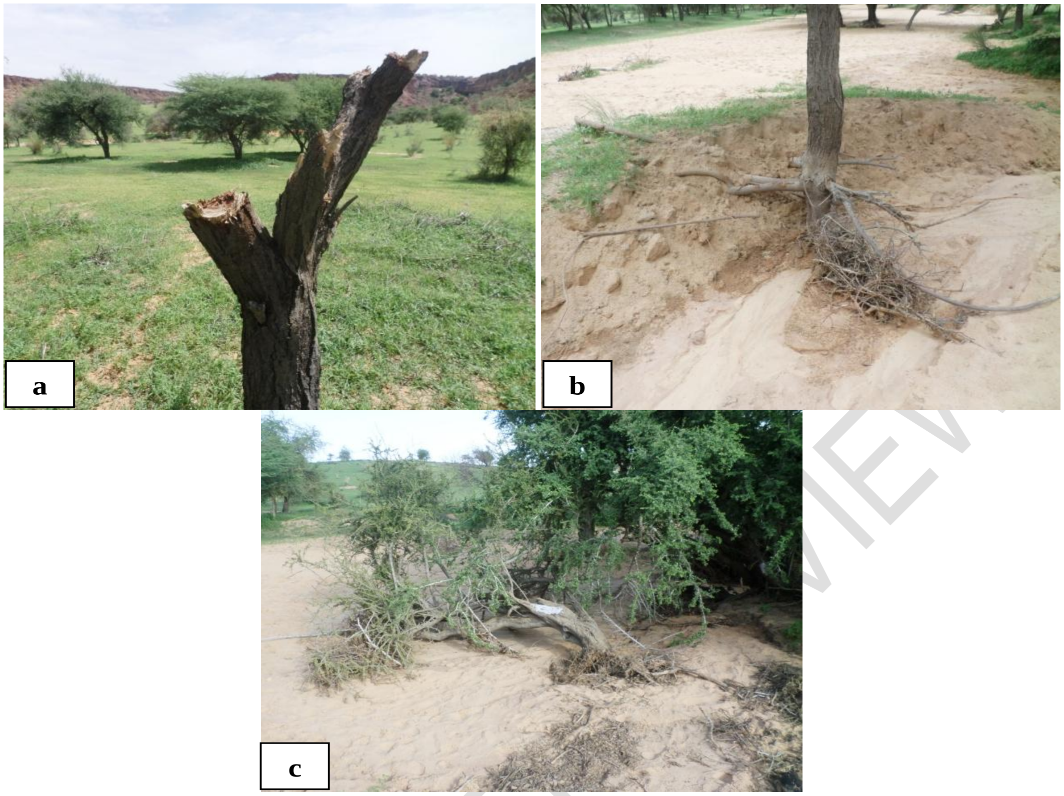
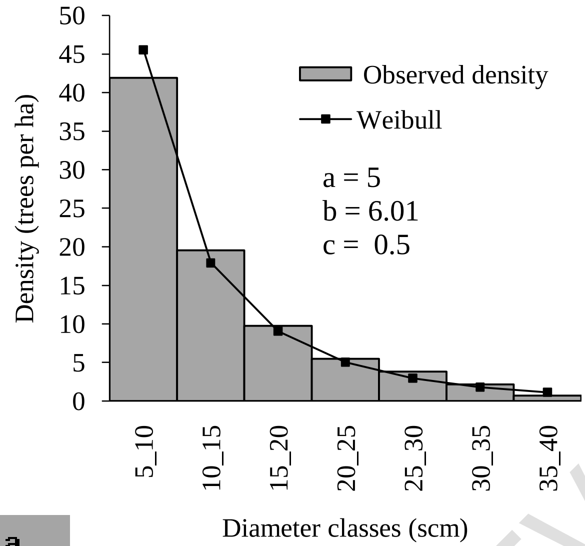
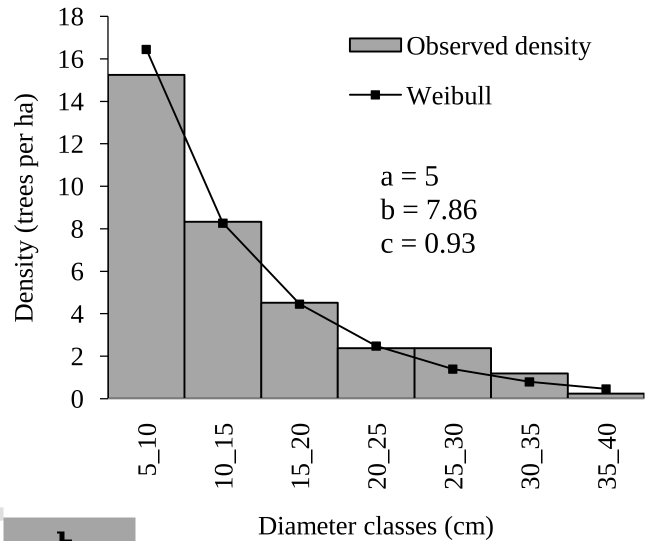


Figure 3. Threats on the woody sites of the site: *Acacia tortilis* pruned (a) and uprooting by water erosion (b), fallen*Maeruacrassifolia*after soil erosion or wind actions


50
45
40
35
30
25
20
15
10
5
0
Density (trees per ha)
Observed density
Weibull
a = 5
b = 6.01
c = 0.5
5_10
10_15
15_20
20_25
25_30
30_35
35_40
Diameter classes (scm)

a


18
16
14
12
10
8
6
4
2
0
Density (trees per ha)
Observed density
Weibull
a = 5
b = 7.86
c = 0.93
5_10
10_15
15_20
20_25
25_30
30_35
35_40
Diameter classes (cm)

b

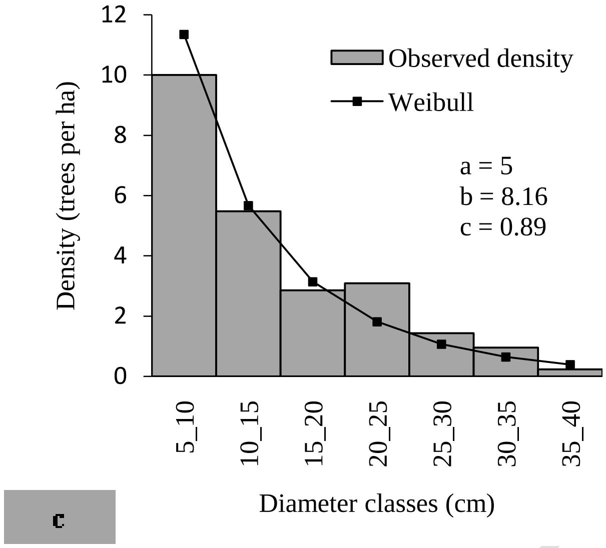


Figure 4. Diameter structure of all woody species together (a), *Acacia tortilis* (b) and *Balanitesaegyptiaca* (c) in Tchilala

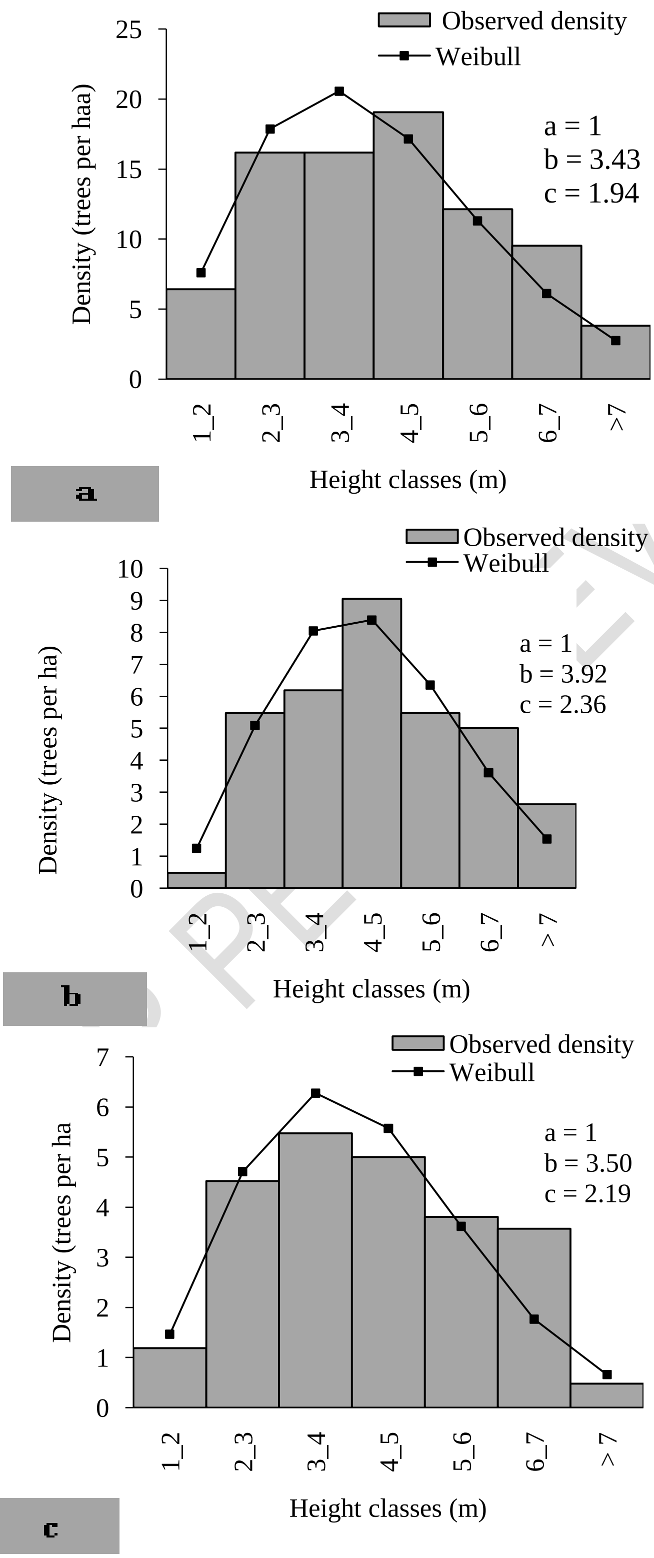


Figure 5. Height structure of all woody species together(a), *Acacia tortilis* (b) and *Balanitesaegyptiaca* (c) in Tchilala.