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Contribution to the Characterisation of Urban Vegetation in Diffa (NIGER)

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Abstract
Trees in urban areas have become an essential element for a livable and sustainable environment. Located in the extreme east of Niger, the region of Diffa is subject to climatic hazards and insecurity from the Boko Haram sect. This study aims to assess the floristic diversity of the urban commune of Diffa in a context of insecurity in the Sahelian zone. The transect method with 2500 m² plots was used. In each plot, dendrometric measurements were taken on all woody species. The results obtained showed a floristic richness composed of 22 plant species distributed in families15. Meliaceae (41.68%) and Balanitaceae (13.84%) are the dominant families. The diversity indices of Shannon and the equitability of Piélou are respectively 2.89 bits and 0.65. Microphanerophyte biological type (95.80%) and Indian phytogeographic type (41.68%) are the most dominant. The relative abundance of species on the other phytogeographic types confirms the loss of local biodiversity in our urban environments. This study constitutes a database of urban floristic diversity and should also draw the attention of the authorities to the creation of green spaces in the city of Diffa.

Key Words: *Biological types, Phytogeographical types, Floristic diversity, Commune of Diffa, Niger.*

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I. Introduction

In Africa, biodiversity, especially plant biodiversity, is the primary source of human development and survival (Ouedraogo, 2009). It provides natural pasture for livestock feeding, fertilizes the soil and allows rural populations to meet their needs through the provision of various woody and non-woody products (Ganaba *et al*., 2005, Dan Guimbo *et al*., 2012). Through the services they provide, plants in cities help improve air, water, and soil quality. Trees absorb significant amounts of pollutants. They play a important role in the carbon cycle and have an tremendous impact on the temperature of neighborhoods, especially during heat waves. Indeed, the water taken by the roots and circulated to the leaves evaporates through the stomata. This conversion of liquid water into water vapour, which uses large quantities of solar energy, has a local cooling effect that is particularly appreciable in the summer.

Urban biodiversity also has cultural and educational benefits (Noumi, 2010). It provides an opportunity to raise awareness of environmental issues among a wide audience, starting with children. Recognized as an important issue for the future, its preservation is even included in the action plan of the 2010 Nagoya Conference on Biodiversity (Ahmed Djoghlaf, Introductory Speech). It becomes crucial to understand the factors that promote or hinder it development.

With the exception of a few inventories, bibliographic research has shown a significant deficit in the study of urban vegetation in Niger (Abdourahamane, 2016 ; Moussa et al., 2020), particularly with regard to the characterization of urban flora. This deficiency is due to many reasons, among which the reluctance of ecologists to take an interest in the city, and the purely aesthetic orientations that planners have in the vegetation to the detriment of the functional. An improvement in the knowledge of urban flora will contribute to the management of this spontaneous vegetation and will impulse changes in the practices of professionals, and serve as a tool for decision-making.

Furthermore, in some nigerien cities, the displacement of populations due to insecurity, has exacerbated the vulnerability of biodiversity in these urban areas. In Diffa region for instance, the populations bordering the Federal Republic of Nigeria have become the main victims of insecurity. Hence, the installation of refugee camps has caused profound changes in the landscape (Rabiou *et al*., 2019). The impact of refugee camps on the environment is of great concern in the Diffa region and communes, a region already affected by desertification and climate change (Rabiou et al., 2019). It is in this context that this study was conducted to serve as a baseline study on the floristic diversity of urban plants in the region of Diffa.

II. Methodology

Study area

The Diffa Region is located in the extreme east of Niger, between 13°04' and 18°00' north latitude and 10°30' and 15°35' east longitude (Figure 1). The climate is dry tropical and belongs to the Sahelian endemic center with an average annual rainfall and temperature of 306±103.1 mm and 27.2 °C respectively. The wettest months are July and August with annual averages between 82 and 147 mm. May is the hottest month and January the coolest.

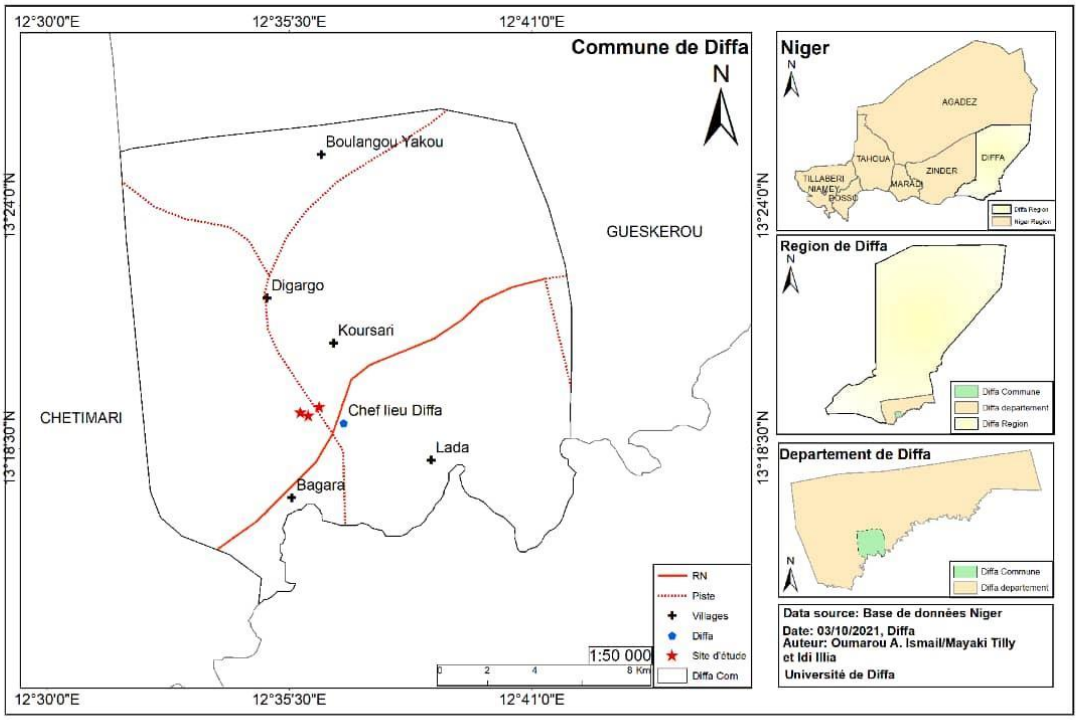

Figure 1: Location of the study area

Phytogeographically, Diffa is located in the eastern North-Sahelian C3 compartment (Saadou,1990), characterized by steppe vegetation on different types of substrates. These are dunes flattened by lacustrine transgressions, ancient ergs with transverse dunes, dune strips and perilacustrine perched beaches, and clay terraces overlooking the Komadougou-Yobe valley. The flora is composed essentially of *Acacia tortilis, Salvadora persica, Commiphora africana, Ipomoea kotchyana, Coccinia grandis, Astenatherum forskalaei, Corallocarpussp., Commicarpus helenae, Pennisetum violaceum* (Ada and Mahamane, 1999).

Sampling and data collection

Transect sampling was used to collect dendrometric parameters in 50m*50m plots (2500m²) along transects. In total, 45 plots were sampled. In each plot, dendrometric parameters were measured on all trees. These are the total height, the diameter of the stems at 1.3 m from the ground for the adult individuals, and the two perpendicular diameters of the crown of each tree.

Data analysis and processing

Biological types

Biological types or biological forms designate the adaptive behavior of the species to the environment. It provides information on the plant formation, its origin and its transformations. The classification used in this study, is that of Raunkiaer (1934) as used by several authors Mahamane (2005), Moro (2010), Soumana (2011), Karim (2013), Abdourahamane (2016), Rabiou (2016) and Alhassane (2019). These are for:

The woody state,

- Phanerophytes (Ph): higher plants whose renovation buds are located at more than 50 cm from the ground.

- Nanophanerophytes (np): from 50 cm to 2 m in height;
- Microphanerophytes (McPh): from 2 to 8 m in height;
- For the herbaceous stratum, the types used are:
- Chamephytes (Ch): Woody or suffrutescent perennial species, whose renovation buds are located at a maximum of 50 cm from the ground;
- Gr: Rhizomatous geophytes;
- Hydrophytes (Hy): Aquatic plants whose persistent buds are located at the bottom of the water;
- Hemicryptophytes (H): Perennial plants whose renovation buds are outcropping on the soil surface;
- Therophytes (Th): These are annual plants that form their spores or seeds during a single life period;
- LTh: Therophyte lilies;
- LCH: Chamephyte lilies.

Phytogeographic types

The types used are those of the world chorology according to White (1983) and Saadou (1990). These are:

- African (A): These are species found only in Africa;
- Paleotropical (Pal): These are species common to Africa, tropical Asia and some islands of the Indian Ocean;
- Pantropical (Pan): These are species found in all tropical regions of Africa, Asia and America;
- Cosmopolitan (Cos): These are species that are widely distributed on the surface of the earth;
- Afro-Malagasy (AM): which are common to Africa, Madagascar, Comoros, Mascarene Islands and Seychelles;
- Afroneotropical (AN): They are common to Africa and tropical America.

Identification of plant groups

For the identification of the different plant groups, a matrix of 32 species 45 polts was subjected to a multidimensional positioning (MNDS) with the PCORD 5 software. The resulting plant groupings were subjected to an Ascending Hierarchical Classification (AHC). Indicator values for each plant community species were calculated based on Indicator Species Analysis (ISA) of the same software (Bio *et al*,.2021).

Floristic diversity

To measure diversity, several parameters must be calculated. These are:

- Alpha diversity (α): It is composed of parameters such as species richness, Shannon index (H') and Piélou equitability (E).
- Species richness (S): It is defined as the number of species that a community contains;
- Shannon index (H') calculated by the following formula: $\mathbf{H' = - \Sigma P_i * Log_2 P_i}$

p i= n/Ni: Relative proportion of the average cover of species i in the community; ni: average recovery of species i and N: total recovery of all species; H'= 0 if all individuals in the stand belong to a single species, H' is also minimal if, in a stand each species is represented by a single individual, except for one species that is represented by all other individuals in the stand. The index is maximal when all individuals are equally distributed over all species (Frontier, 1983; Karim, 2013).

- The Piélou equitability (E) calculated by the following formula: $\mathbf{E = \frac{H'}{Hmax} = \frac{H'}{\log_2 S}}$

With S: Total number of species. The Piélou equitability index can vary from 0 to 1 ($0 < E < 1$). It is maximal when species have identical abundances in the stand and minimal when a single species dominates the entire stand.

The dendrometric parameters were subjected to a non-parametric test (KrulKal-Wallis) to compare the mean values since they did not meet the conditions to apply an ANOVA.

III. Results

Individualization of plant groups

The analysis of the dimensional positioning (NMDS), the Ascending Hierarchical Classification (CHA) and the Canonical Correspondence Analysis allowed to discriminate two (2) plant groupings (Figure 1). These are the:

Citrus limon and Mangifera indica group (G1): This group is composed of 29 records. The species that characterize it are *Citrus limon* (Lin.) Burn. f., *Mangifera indica* L. *Combretummicranthum* G.Don. *Moringaoleifera* Lam. and *Delonixregia* (Hook.) Raf.

***Vachellia tortilis* and *Prosopis juliflora* group (G2):** This grouping is composed of 16 records characterized by species such as *Vachellia tortilis* subsp. raddiana, *Prosopis juliflora* (Sw.) DC., *Balanites aegyptiaca* (L.) Del. and *Faidherbia albida* (Del.) A. Chev.

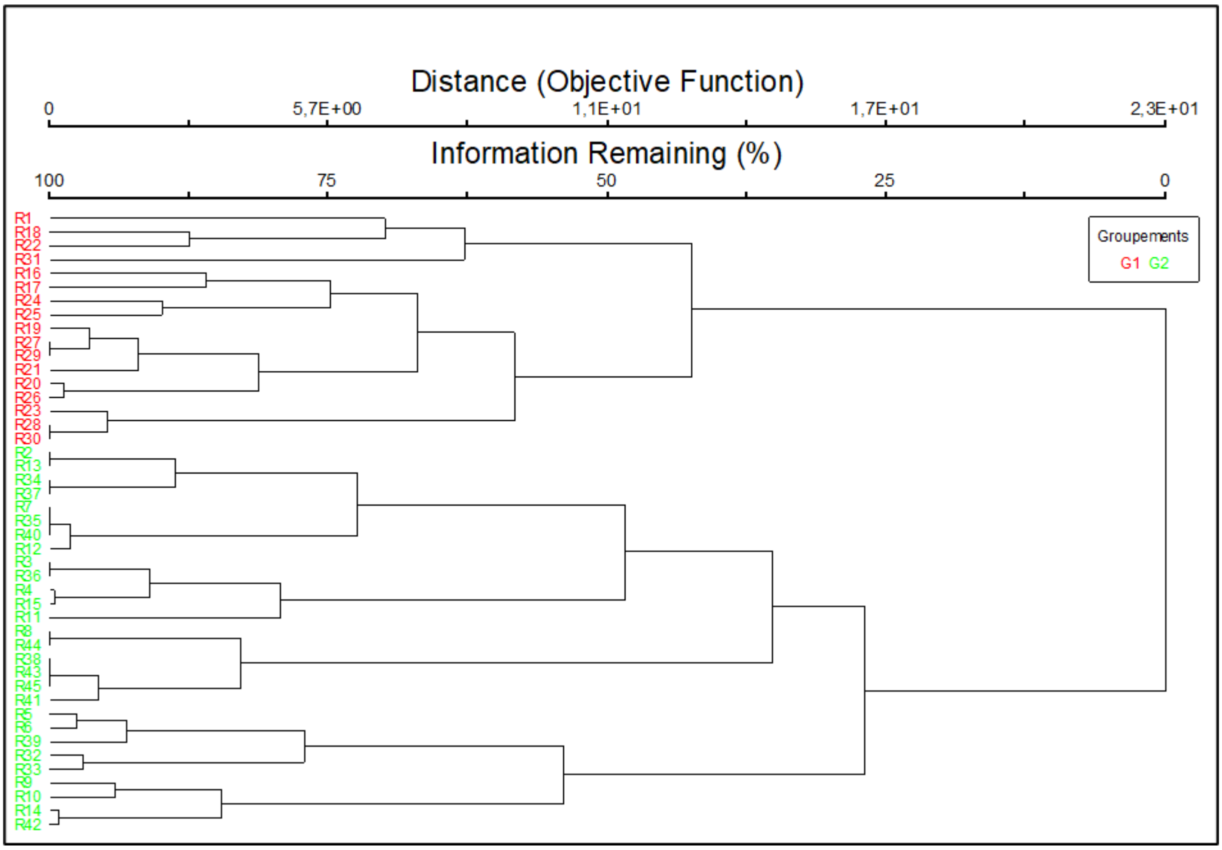

Figure 2: Ascending Hierarchical Classification (AHC)

Global floristic analysis

Theanalysisofthefloristiccharacteristicsshowsgloballythatthestudyareacounts 15families distributedin22species(Table 1).ThemostrepresentedfamiliesareMeliaceae(238 individuals or 41,68%),Fabaceae-Mimosoideae(124individualsor21.72%)andBalanitaceae(79individualsor 13,84%).

Table 1: Listof families surveyed

Scientificnames	**Families**	**G1**		**G2**		**Global**	
		N	**F**	**N**	**F**	**N**	**F**
*Adansonia digitata*L.	Bombacaceae	1	0.95	0	0	1	0.18
Annona squamosa L.	Annonaceae	1	0.95	0	0	1	0.18
Azadirachta indica A. Juss.	Meliaceae	36	34.29	202	43.16	238	41.68
Balanites aegyptiaca(L.)Del.	Balanitaceae	9	8.57	70	14.96	79	13.84
*Bauhinia rufescens*Lam.	Caesalpiniaceae	0	0	3	0.64	3	0.53
Citrus limon(Lin.) Burn.f.	Rutaceae	16	15.24	1	0.21	17	2.98
*Combretum micranthum*G.Don.	Combretaceae	4	3.81	0	0	4	0.70
Delonixregia(Hook.) Raf.	Caesalpiniaceae	3	2.86	0	0	3	0.53
*Eucalyptus Camaldulensis*Dehnh	Myrtaceae	4	3.81	44	9.4	48	8.41
Faidherbia albida(Del.)A. Chev.	Fabaceae-Mimosaceae	1	0.95	39	8.33	40	7.01
Hyphaenethebaica (L.)Mart.	Arecaceae	0	0	21	4.49	21	3.68
Mangifera indica L.	Anacardiaceae	10	9.52	1	0.21	11	1.93
Moringa oleifera Lam.	Moringaceae	11	10.48	2	0.43	13	2.28
Olea europaea L.	Oleacaceae	1	0.95	0	0	1	0.18
*Phoenix dactylifera*L.	Arecaceae	1	0.95	0	0	1	0.18

Prosopis juliflora(Sw.)DC.	Fabaceae-Mimosaceae	1	0.95	36	7.69	37	6.48
*Saba sengalensis*Pers.	Apocynaceae	1	0.95	0	0	1	0.18
*Senegalia senegal*L.ensis (A. D. C.) Pichon.	Annonaceae	1	0.95	0	0	1	0.18
Terminalia mantaly H. Perr.	Combretaceae	1	0.95	2	0.43	1	0.18
*Vachellia tortilis*subsp. raddiana	Fabaceae-Mimosaceae	0	0	47	10.04	47	8.23
*Ziziphus mauritiana*Lam.	Rhamnaceae	2	1.9	0	0	2	0.35
Ziziphus spina-christi(L.) Desf.	Rhamnaceae	1	0.95	0	0	1	0.18
Total	**15**	**105**	**100**	**468**	**100**	**571**	**100**

Legend: N: *Number,* ***F:*** *Frequency,* ***G1:*** *Citrus limon and Mangifera indica group, G2: Vachellia tortilis and Prosopis juliflora group.*

Biological types

The overall analysis of biological types (Table 2) shows a perfect dominance of Microphanerophytes (95.80%). At the grouping level, this trend is observed with the highest value recorded for grouping G1.

Table 2: Biological Types

TP	**G1**		**G2**		**Global**	
	N	**F**	**N**	**F**	**N**	**F**
Mesophanerophytes	3	2.86	21	4.51	24	4.20
Microphanerophytes	102	97.14	445	95.49	547	95.80
Total	**105**	**100**	**466**	**100**	**571**	**100**

Legend: G1:*Citrus limon and Mangifera indica group, G2: Vachellia tortilis and Prosopis juliflora group*

Phytogeographic types

The global analysis of the phytogeographical types (Table 3) shows a dominance of Indian species (41.68%) followed by African species with 37.7%. At the group level, this trend is observed with a dominance of Indian and African species in group G2 with 43.35 % and 38.63 % respectively.

Table 3: Geographic Types

TP	**G1**		**G2**		**Global**	
	N	**F**	**N**	**F**	**N**	**F**
A	20	19.05	180	38.63	200	35.03
AM	1	0.95	36	7.73	37	6.48
As	10	9.52	1	0.21	11	1.93
At	4	3.81	44	9.44	48	8.41
Ind	36	34.29	202	43.35	238	41.68
M	5	4.76	0	0.00	5	0.88
N	1	0.95	0	0.00	1	0.18
Pal	17	16.19	1	0.21	18	3.15
Pt	11	10.48	2	0.43	13	2.28
Total	105	100	466	100	571	100

Legend: G1:*Citrus limon* and *Mangifera indica* group, G2: *Vachellia tortilis* and *Prosopis juliflora* group

Diversity analysis

The analysis of the diversity indices shows that the overall species richness S is 22 species with a Shannon diversity index of 2.89 and a Piélou Equitability of 0.65. The two (2) identified groups present a Shannon diversity index that varies between 2,52bits and 3,16 and a Piélou equitability index which varies between 0.51 and 0.76 (Table 4). The *Citrus limon* and *Mangifera indica* grouping has the highest species richness (19 species) with a Piélou Equitability of 0.75. The lowest species richness is observed in the *Vachelliatortilis* and *Prosopisjuliflora* grouping with 12 species and a Piélou Equitability of 0,7.

Table 4: Diversity of plant groups

Groupings	S	E	H'	H max
G1	19	0.75	3.16	1.66
G2	12	0.7	2.52	1.34
Global	22	0,65	2,89	1,53

Legend: G1:*Citrus limon* and *Mangifera indica* group, G2: *Vachellia tortilis* and *Prosopis juliflora* group

Dendrometric and environmental characteristics

The overall analysis of the table 5 shows that the town is located at an altitude of 320.850±26.750 m above sea level. The woody stand that characterizes it is formed by large individuals with an average diameter of 43.322±17.025 cm, an average cover of 21.887±17.521 m² and an average density 13±7.72 stems/ha. This stand is characterized by individuals with an average height of 7.802±2.769 m and a basal area of 0.011±0.004m²/ ha. At the grouping level, high values are observed in the Vachellia tortilis and Prosopis juliflora grouping (G2) for parameters such as height, cover and density.

The overall analysis of the results in Table 6 highlights two species with high importance value indices (IVI) which are *Azadirachtaindica* (138,31%) and *Balanites aegyptiaca* (39.16%). This dominance of these two species is observed at the scale of the groups with the highest values observed in group G2 with 140.71% for *Azadirachtaindica* and 39.56% for *Balanitesaegyptiaca*.

Table 5: Dendrometric and stationary parameters

Parameters	Groupings	Averagevalues	P-value
Altitude(m)	G1	336.830±15.790[a]	*<0,001*
	G2	317.250±27.400[b]	
	Global	320.850±26.750	
Diameter(cm)	G1	46.440±23.380[a]	*>0,05*
	G2	42.620±15.177[a]	
	Global	43.322±17.025	
Height (m)	G1	6.699±2.239[b]	*<0,001*
	G2	8.051±2.818[a]	
	Global	7.802±2.769	
Coverage(m²)	G1	17.390±20.620[b]	*<0,001*
	G2	22.900±16.603[a]	
	Global	21.887±17.521	
Basal area (m²/ha)	G1	0.011±0.006[a]	*>0,05*
	G2	0.011±0.004[a]	
	Global	0.011±0.004	
Density (feet/ha)	G1	7.06±4.43[b]	*<0,001*
	G2	16.39±7.15[a]	
	Global	13±7.72	

Legend: G1:*Citrus limon* and *Mangifera indica* group, G2: *Vachellia tortilis* and *Prosopis juliflora* group

Table 6: Importance Value Indices

Species	G1	G2	IVI (%)
Adansonia digitata	1.82	0.00	0.34
annona sengalensis	1.48	0.00	0.27
Annona squamosa	2.04	0.00	0.38
Azadirachta indica	127.36	140.71	138.31
Balanites aegyptiaca	38.38	39.59	39.16
Bauhinia rufescens	0.00	2.00	1.66
Citrus limon	19.90	0.28	3.78
Combretum micranthum	8.01	0.00	1.48
Delonixregia	5.74	0.00	1.04
Eucalyptus spp Camaldulensis	9.43	25.82	22.99
Faidherbia albida	10.73	34.59	30.32
Hyphaenethebaica	0.00	9.40	7.69
Mangifera indica	37.97	0.75	7.14
Moringa oleifera	22.39	0.89	4.87
Olea europaea	1.82	0.00	0.34
Phoenix dactylifera	2.35	0.00	0.41
Prosopis Juliflora	1.64	18.13	15.23
Saba senegalensis	2.01	0.00	0.36
Terminalia mantaly	2.02	0.00	0.36
Vachellia tortilis	0.00	27.84	22.95
Ziziphus mauritiana	3.84	0.00	0.71
Ziziphus spina-christi	1.08	0.00	0.20
Total	**300**	**300**	**300**

Legend: G1:*Citrus limon* and *Mangifera indica* group, G2: *Vachellia tortilis* and *Prosopis juliflora* group

Woody stand structures

The diameter class structure of the overall stand in the area shows a predominance of individuals belonging to the 20-30 and 30-50 cm diameter classes (Figure 3 a). Large individuals (large diameter) are very poorly represented. As for the height class structure (Figure 3b), it shows a predominance of species with heights between 4 and 5 m followed by species in the 8_9 and 7_8 m classes.

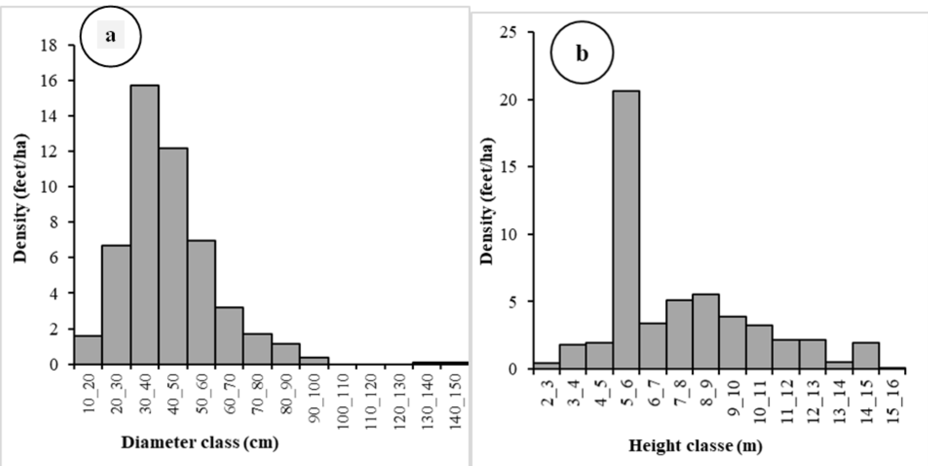

Figure 3: Plant stand structures: **a:** Diameter class; **b:** Height class

IV. Discussion

The floristic richness of the urban commune of Diffa is estimated at 15 botanical families and 22 species. This floristic richness is lower than that found by Bagalé (2021) who found 16 families in the commune of Chétimari in the Diffa region. This difference may be due to the fact that the population of the commune of Diffa has not put emphasis on the creation and preservation of green spaces. The vast majority of old trees are found along the main (asphalt) road and in a few concessions in the old districts of the commune. This is reflected in the dominance of a single species *Azadirachtaindica* commonly called "neem" which is an introduced species. This species is characterized by a high IVI value (Index of Importance 138.31 %), a density and a coverage superior to all the other species recorded in the commune since globally the density. The dominance of the *Azadirachtaindica*in Diffa is similar to that of other cities in Niger (Illiassou et al., 2016, Moussa et al., 2020)

The study took into account dendrometric parameters of the woody stand. However, species diversity is influenced by diameter limits (Sehoun *et al*., 2021), and taking into account smaller diameters maximizes the number of species studied in an area (Aimé et al., 2010). This low plant diversity in the study area also reflects the intensity of uncontrolled anthropogenic activities (settlement of displaced populations in the commune) that has had a severe impact on diversity, decreasing the number of species individuals and density (Sehoun *et al*., 2021).

Shade rows remain along the main road and the old neighborhoods that have the most floristic species with a large diameter. This result can be explained by the fact that the local authorities of the cities do not invest in these alignment trees that form shade rows because of their aesthetic, beautification and recreational role in urban spaces (Sehoun *et al*., 2021). The place of street trees in urban areas is limited to a simple decoration in many African cities (Clergeau, 2007; Sehoun *et al*., 2021). Indeed, reforestation is always guided by the choice of fast-growing species and also by the objective of reforestation (Sehoun *et al*., 2021). This situation leaves the possibility for planners to associate species in plantation in urban environments in order to avoid phytosanitary problems related to the use of a single species according to Bekkouch *et al*. (2011).

As for biological and phytogeographical types, the results show a strong domination of microphanerophytes in the city of Diffa. These results are in contradiction with those obtained by Kaou *et al*. (2017), Bio *et al*. (2021) and Bagalé (2021) who found that therophyte species are more abundant in communes close to Diffa. This result confirms Schmidt *et al*.'s (2005) assertion that biological types reflect not only structural parameters in a vegetation but also varied environmental conditions (Sehoun *et al*., 2021). The preponderance of these species has been favored by their promotion as urban-adapted species used during reforestation and regreening campaigns for the past three decades (Osseni *et al*., 2015; Sehoun *et al*., 2021). In order to settle down, humans' fragment and degrade or destroy natural spaces, making local or endogenous biodiversity disappear or be lost and introducing exotic species for their comfort (Boucher *et al*., 2010). According to Sehoun *et al*. (2021), the development of endogenous plant species in urban green spaces would greatly help the conservation of local plant diversity in urban ecosystems.

V. Conclusion

The present study made it possible to evaluate the floristic richness of the urban commune of Diffa. Thus, the floristic procession is composed of 15 families and 22 species. The Meliaceae family is by far the most dominant. As for the distribution of species, the biological type Microphanerophytes and the phytogeographical type Indian remain the most dominant in the city. The study noted the dominance of an introduced species (*Azadirachtaindica*) in the area characterized by large feet with a medium height. On the other hand, the density of the woody population of the city is low. With such, it is essential to plant and maintain trees in green spaces and public places for the welfare of the population and the fight against global warming.

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