Diversity of Plant Communities Associated with Urban Green Spaces in Southwestern Algeria

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Abstract. Urban green spaces are essential to assuring the quality of life. This study aims to study the diversity of plant communities associated with urban green spaces in southwestern Algeria. Based on data collected from 57 phytocoenological surveys with an area of 1 m², plant communities were analyzed using diversity parameters (specific richness, biodiversity indices and similarity) and plant functional traits (life forms, morphological, phytogeographical and dispersal types). 32 species belonging to 31 genera in 13 families have been identified. According to the real spectrum (data based on abundance) of plant functional traits, plant species are mainly geophytes (48.27%) which adopt various dispersal strategies, including barochores (71.55%) and anemochores (17.24%). Phytogeographic analysis revealed the dominance of the cosmopolitan element (41.55%) which is well adapted to the Saharan climate. Agglomerative hierarchical clustering of species based on their abundance by Minitab 17 revealed six groups. This work provides important information that can serve as a basis for the management and conservation of biodiversity in southwestern Algeria.

Keywords. Plant communities, Diversity, Urban, Green spaces, Southwestern Algeria.

I. INTRODUCTION

In an urbanized environment, the need for green spaces has become necessary for aesthetic and ecological reasons [1,2]. Today, cities are home to a large number of cultivated or natural plant formations [3, 4]. These plant formations are represented by public gardens, alignment trees and green spaces [5-7]. Green spaces provide many services to humans called ecosystem services [8]. Ecosystem services include improving air quality, reducing energy consumption and regulating running water [9-11]. Urban people plant green spaces; this is called urban agriculture [12]. Urban agriculture is defined as the assembly of works that applies to the soil to produce plants of interest to humans [2]. Urban and peri-urban agriculture represents an important impact in terms of food security [13-15] and in terms of improving the environment and quality of life in cities [2]. It is necessary to understand the potential of urban centers in terms of green spaces in the context of climate change [16]. Green spaces with high ecological value are the subject of agricultural practices that lead to changes in the floristic composition and structure of plant formations [17]. Integrating agriculture under trees into the urban landscape can improve food security and complement traditional food security strategies [15].

In southwest Algeria, the green spaces are home to remarkable plant formations and a rich heritage that offer attractive landscapes. Therefore, it is necessary to make an inventory of urban green spaces in order to know the floristic diversity and the characteristics of plant communities associated with urban green spaces.

The objective of the study is to (i) establish phytocoenological groups of vegetation associated with urban green spaces; (ii) determine floristic diversity (specific richness, biodiversity indices and similarity); (iii) explore various functional traits of plants (life forms, morphological, phytogeographic and dispersal types).

II. MATERIAL AND METHODS

• Study Area

The study area is part of the Wilaya of Adrar (southwest Algeria). It is limited on the north by the municipality of Aougrout, on the south by the municipality of Fenoughil, on the east by the municipality of Timokten and on the west by the municipality of Adrar (Fig. 1).

The climate of Tamentit is the same as that of the city of Adrar, which is characterized by a hot climate and rare precipitation [18- 20]. Based on meteorological data collected between 2004 and 2014, the average climate data for the Adrar
region are as follows: Summer temperatures are high (46.4°C) in July. In winter, it is (5.53°C) in January. Precipitation is low and irregular with an average of 15.72 mm. The winds are very frequent and their speed can reach 24.5 m/s in May.

![FIGURE 1. Location of the study area.](image)

- **Collection of Data**

We have delimited plots with a fixed surface (1 X 1 m²), which are sufficient to obtain exhaustive representativeness of the plants. The choice of this surface was based on studies of plant communities in urban and cultivated areas [21, 22]. In each plot, the name of the species and the number of individuals of each species were determined. A total of 57 surveys were carried out during the month of August 2021.

Plant species were identified and named according to the flora of Algeria [23]. Biological types of the plant species inventoried were determined according to Raunkiaer (1934) [24] which is based on the position of the renovation buds in relation to the soil surface during unfavorable periods.

The biogeographical origin of the species was established from the flora of Algeria [23]. The dispersal of species was determined according to the classification of van der Pijl (1982) [25] who classified plants into anemochores, barochores, hydrochores, zoochores and autochore. Plants are classified as perennial or annual, depending on the persistence of the aerial vegetative part during the unfavorable season [20].

- **Data Analysis**

The agglomerative hierarchical clustering (AHC) using Minitab 17 software was applied to obtain floristically homogeneous ecological groups. AHC was carried out on the basis of abundance in order to highlight the main groups of surveys that appear. The AHC takes into account the similarities between surveys of the same group to accurately distinguish between similar subgroups of surveys [26]. For each phytocological group characterized by using the raw biological spectra (qualitative data: specific richness) and real biological spectra (quantitative data: abundance). The raw spectrum takes into account proportions of specific richness, while the real spectrum uses the cumulative abundances of these species in the group [20].

Alpha diversity was determined by calculating of:

Specific richness (S) is the total number of species present in each phytocological group and the study area in general; Shannon diversity index (H') was calculated using the formula:

\[ H' = - \sum p_i \log_2 p_i \]

where \( p_i = n_i/N \) is the relative abundance of species \( i \) in the sample;

\( n_i \) is the number of individuals of a given species, \( i \) ranging from 1 to \( S \) (total number of species) and \( N \) is the total number of individuals [27].

Pielou’s equitability (E) was calculated using the formula:

\[ E = H' / H_{\text{max}} \]

\( H' \) represents the Shannon diversity index;

\( H_{\text{max}} = \log_2 S \) the theoretical value of the maximum diversity.

It varies between 0 and 1, with \( E = 1 \) when individuals are evenly distributed among species [28].

Simpson diversity index was calculated using the formula:

\[ SDI = 1 - \sum_{i=1}^{S} D_{ij} \]

\[ SDI = 1 - \sum_{i=1}^{S} \sum_{j=1}^{S} p_i^2 \]

The maximum diversity will then be represented by the value 1 and the minimum diversity by the value 0 [29].
III. RESULTS AND DISCUSSION

- **Floristic Composition**
  
  In total, 32 plant species belonging to 13 families and 71 genera were recorded (Table 1). The number of species recorded in green spaces is due to the types of agricultural techniques, the type of soil, the type and quality of irrigation water, and space management methods [30, 31]. According to [32, 33], that green spaces are highly invested environments and could constitute potential reservoirs of interesting species and environments.

  The most representative families were Asteraceae (21.87%) and Poaceae (18.75%). These two families have been reported as the most representative families in cultivated areas around the world [34]. They are also characterized by the capacity to produce high quantities of seeds in a way favorable to dispersal and the ability to colonize different environments [35, 36, 37].

  The majority of species were perennial species (63.79%) and annuals with (36.21%). The proliferation of perennial species is due to favorable conditions of the environment and the absence of herbicide treatments [30]. The presence of annual species may be related to their short life cycle, which allows them to resist maintenance labor [30, 38].

  Discrimination of Different Plant Formations

  The Agglomerative hierarchical clustering made it possible to discriminate the principal vegetation groups. Each vegetation group includes an ensemble of surveys with similar vegetation. The (AHC) individualized six different groups of plants (G1, G2, G3, G4, G5 and G6) (Fig. 2).

| Family       | Species                          | Forme life | Dispersal types | Morphological types | Phytogeographical type |
|--------------|----------------------------------|------------|-----------------|---------------------|------------------------|
| Cyperaceae   | Cyperus rotundus L.              | Geophytes  | Barochore       | Perennial           | Subtropical            |
|              | Zygoelium album L. f.           | Chamephyte | Barochore       | Perennial           | Saharo-Arabian.        |
|              | Tribulus terrestris L.           | Therophytes| Zoochrome       | Annual              | Old World              |
|              | Phragmites communis Trin.       | Geophytes  | Anemochore      | Perennial           | Cosmopolitan           |
|              | Phalaris brachystachys Link.    | Therophytes| Zoochrome       | Annual              | Mediterranean           |
|              | Dactyloctenium aegyptium (L.)   | Therophytes| Barochore       | Annual              | Pannotropical          |
| Poaceae      | Wild                             | Therophytes| Zoochrome       | Annual              | Temperate Subtropical  |
|              | Setaria viridis (L.) P. Beauv.   | Geophytes  | Barochore       | Perennial           | Cosmopolitan           |
|              | Cynodon dactylon (L.) Pers.     | Geophytes  | Barochore       | Perennial           | Cosmopolitan           |
|              | Imperata cylindrica (L.) Rüssch.| Geophytes  | Barochore       | Annual              | Cosmopolitan           |
|              | Chenopodium album L.            | Therophytes| Barochore       | Annual              | Saharo-Mediterranean   |
|              | Salsola vermiculata L.          | Chamephyte | Anemochore      | Perennial           | Saharo-Mediterranean   |
| Asteraceae   | Amaranthus retroflexus L.       | Therophytes| Zoochrome       | Annual              | North American         |
|              | Bassia maricata (L.) Asch.      | Therophytes| Zoochrome       | Annual              | Saharan                |
|              | Suaeda fruticosa L.             | Chamephyte | Hydrochore      | Annual              | cosmopolitan           |
|              | Sonchus oleraceus L.            | Therophytes| Barochore       | Annual              | cosmopolitan           |
|              | Erigeron bonariensis L.         | Therophytes| Anemochore      | Annual              | American               |
|              | Pulicaria arabica (L.) Cass.    | Hemicryptophytes | Anemochore | Perennial           | North African          |
|              | Launaea nudicaulis (L.) Hook. f.| Therophytes| Anemochore      | Annual              | Mediterranean Saharo Arabian |
|              | Launaea resedifolia O.K.        | Therophytes| Anemochore      | Annual              | Mediterranean Saharo Arabian |
|              | Lactuca Serriola L.             | Therophytes| Anemochore      | Annual              | Pale-o-temperate       |
| Polyanaeae   | Portulaca oleracea L.           | Therophytes| Barochore       | Annual              | Cosmopolitan           |
|              | Reichardia picroides (L.) Roth  | Therophytes| Barochore       | Annual              | Mediterranean           |
|              | Polygonum aviculare L.          | Therophytes| Barochore       | Annual              | Cosmopolitan           |
|              | Cynanchum acutum L.             | Geophytes  | Barochore       | Perennial           | Mediterranean-Asian     |
|              | Calotropis procera Act.         | Phanerophyte| Anemochore      | Perennial           | Sahelo-Saharan          |
|              | Euphorbia granulata Forsk.      | Therophytes| Barochore       | Annual              | Saharo-Arabian.        |
|              | Solanum nigrum L.               | Therophytes| Zoochrome       | Annual              | Cosmopolitan           |
|              | Hyoscyamus muticus L.           | Therophytes| Zoochrome       | Annual              | Saharo-Arabian.        |
|              | Cucurbitaceae colorocynthis vulgaris (L.) Schrad | Therophytes| Zoochrome       | Annual              | Tropical Mediterranean  |
|              | Malvaceae                       | Therophytes| Barochore       | Annual              | Mediterranean           |
|              | Malva parviflora L.             | Therophytes| Barochore       | Annual              | Mediterranean           |
|              | Apliaceae                       | Seseli tortuosum L. | Hemicryptophytes | Zoochrome           | Perennial              | Mediterranean           |
FIGURE 2. Dendrogram of the phytoecological groups of plant communities associated with urban green spaces in southwest Algeria.

The characteristics of these six vegetation groups as well as the abundance of species for each group are given in Table 2; this table also includes the values of species richness, the Shannon index and the Simpson index.

| Species                          | Abundance of G1 | Abundance of G2 | Abundance of G3 | Abundance of G4 | Abundance of G5 | Abundance of G6 |
|----------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Cyperus rotundus L.              | 112             | -               | -               | -               | -               | -               |
| Zygoephylum album L. f.          | -               | -               | -               | 4               | 5               | 23              |
| Tribulus terrestris L.           | -               | -               | -               | -               | -               | -               |
| Phragmites communis Trin.        | 1               | 2               | 7               | 16              | 6               | 7               |
| Phalaris brachystachys Link.     | -               | -               | -               | 3               | -               | -               |
| Dactyloctenium aegyptium (L.)    | 4               | 5               | 43              | 2               | 2               | 53              |
| Willd.                           | -               | -               | -               | -               | -               | -               |
| Setaria viridis (L.) P. Beauv    | -               | 5               | -               | -               | -               | -               |
| Cynodon dactylon (L.) Pers.      | 16              | -               | 106             | -               | -               | -               |
| Imperata cylindrica (L.) Räusch. | 70              | -               | 3               | -               | -               | -               |
| Chenopodium album L.             | -               | 3               | -               | -               | -               | -               |
| Salsola vermiculata L.           | 2               | -               | -               | 8               | -               | -               |
| Amaranthus retroflexus L.        | 1               | -               | -               | -               | -               | -               |
| Howellia viridiflora L.          | 1               | 2               | 2               | 4               | 7               | -               |
| Nasturtium officinale L.         | -               | 1               | -               | -               | -               | -               |
| Gaiadina cauliformis L.           | -               | 1               | -               | -               | -               | -               |
| Erigeron annuus L.               | 1               | 1               | 2               | 1               | 1               | 1               |
| Puccinellia gracilis L.          | -               | -               | -               | -               | -               | -               |
| Launaea arvensis L.              | -               | 1               | -               | -               | -               | -               |
| Launaea nudicaulis L.            | -               | 2               | -               | -               | -               | -               |
| Lactuca Serriola L.              | 12              | -               | 2               | 5               | -               | -               |
| Reichardia picrosides (L.) Roth  | -               | -               | -               | 1               | -               | -               |
| Portulaca oleracea L.            | 5               | -               | 5               | 4               | 2               | 3               |
| Polygonum aviculare L.           | -               | -               | -               | -               | -               | -               |
| Euphorbia granulata Forsk.       | 2               | -               | -               | -               | -               | 3               |
| Solanum nigrum L.                | -               | 1               | -               | -               | 7               | -               |
| Datura stramonium L.             | -               | 2               | 1               | -               | 4               | -               |
| Hyoscyamus muticus L.            | -               | -               | -               | 1               | -               | -               |
| colocythis vulgaris (L.) Schrad  | -               | -               | -               | 1               | 4               | -               |
| Malva parviflora L.              | -               | -               | -               | 2               | -               | -               |
| Seseli tortuosum L.              | -               | -               | 1               | -               | 4               | -               |
| Species richness                 | 13              | 10              | 16              | 13              | 13              | 13              |
| Shannon index                    | 2.10            | 2.79            | 2.32            | 2.80            | 3.03            | 2.52            |
| equitability                      | 0.57            | 0.84            | 0.58            | 0.76            | 0.82            | 0.68            |
| Simpson index                    | 0.66            | 0.80            | 0.65            | 0.79            | 0.82            | 0.70            |
The most abundant species in all phytocological groups are Dactyloctenium aegyptium (109 individuals), Phragmites communis (39 individuals) and Erigeron bonariensis (7 individuals). Dactyloctenium aegyptium is a very invasive annual species, associated with sandy soils and the use of animal fertilizers [39]. In addition, Dactyloctenium aegyptium is characterized by early emergence [40]. Phragmites communis adapt to humid and very salty environments [41]. Erigeron bonariensis is a particularly invasive species [42]. The seeds of this species are light, which facilitates the dispersal of seeds at low wind speed and therefore a fort invasion [43].

The principal characteristics of each group and their component surveys are as follows (Fig. 3, Fig. 4 and Fig. 5):

![FIGURE 3. Spectra of biological types.](image)

![FIGURE 4. Dispersion spectrum.](image)

![FIGURE 5. Phytogeographic spectrum.](image)

N: Raw; S: Real

Sub trop: Subtropical; Sah. Arab: Sahara-Arabian; Old wor: Old World; Cosmop: Cosmopolitan; Med: Mediterranean; Pantrop: Pantropical; Temp. Subtrop: Temperate Subtropical; Sah. Med: Sahara-Mediterranean; N. Amer: North American; Sah: Saharan; Amer: American; N Afr: North African; Med Sah. Arab: Mediterranean Saharo Arabian; Paleotemp: Paleotemperate; Med. As: Mediterranean-Asian; Sahelo. Sah: Sahelo-Saharan; Trop. Med: Tropical Mediterranean

Group 1 consists of 8 surveys in which 13 species were recorded. The most abundant species are Cyperus rotundus (48.48%) and Imperata cylindrica (30.30%). The most representative families are Amaranthaceae and Poaceae (30.77%) and Asteraceae (15.38%). In the raw spectrum of biological types, Therophyte shows a good representation with (53.85%) followed by Geophytes (30.77%). In the real spectrum, Geophytes show a fort presence (86.15%) followed by Therophytes (11.69%). For chorological types, the cosmopolitan element dominated the raw spectrum with (38.46%). In the real spectrum, the Subtropical element shows a fort presence (48.50%) followed by the cosmopolitan elements (41.12%). plant dispersal is dominated by Barochores species (90.47%) followed by Anemochores species (6.93%). In the raw spectrum, morphological types, annual species show a high representation (61.54%). Perennial species show a high representation (87.01%) in the real spectrum. The Shannon diversity index is 2.10 bits, the Pielou Equitability is 0.57 and the Simpson index is 0.66.

Group 2 consists of 5 surveys where 10 species were recorded. The most abundant species are Sonchus oleraceus (38.46%), Dactyloctenium aegyptium and Setaria viridis (12.82%). The most represented families are Poaceae (30%),
followed by Amaranthaceae, Asteraceae and Apocynaceae (20%). The raw and real biological spectrum shows a fort presence of Therophytes (70%; 82.05%) followed by Geophytes (20%, 10.26%) and Phanerophytes (10%; 7.69%). The flora of this group is dominated by cosmopolitan elements (40%; 53.85%) for the raw and real spectrum. The dispersion of plants is dominated by the Barochores type (40%; 64.11%) followed by the Zoocohores species (30%, 20.51%) and the Anemochores (30%; 15.38%) for the raw and real spectrum. For morphological types, Annual species shows a fort presence in the raw spectrum with (70%), and in the real spectrum (79.49%). The Shannon diversity index is 2.79 bits, the Pielou Equitability is 0.84 and the Simpson index is 0.80.

Group 3 consists of 13 surveys with 16 species. The most abundant species are Cynodon dactylon (54.08%), Dactyl俄tomentum aegyptium (21.94%). The Asteraceae with (25%) is the most represented family, followed by Amaranthaceae and Apocynaceae (12.5%) each. In the raw spectrum of biological types, Therophytes show good representation with (56.25%) followed by Geophytes (25%). In the real spectrum, Geophytes show a fort presence (63.27%) followed by Therophytes (31.63%). The two spectra of this group show that the flora of this group is dominated by cosmopolitan elements (31.25%; 62.76%). The raw and real spectrum shows that the flora of this group is dispersed by the Barochore type (37.5%; 86.23%) followed by the Anemochores species (37.5%, 9.18%) and the Zoocohores species (25%; 4.59%). In the real spectrum of morphological types, the Annuals show a good representation (56.25%). The Therophytes show a good representation (68.37%) in the real spectrum. The Shannon diversity index is 2.32 bits, the Pielou equitability is 0.58 and the Simpson index is 0.65.

Group 4 consists of 10 surveys with 13 species. The most abundant species are Calotropis procera (37.31%), Phragmites communis (23.88%). The most represented family is the family Poaceae (23.1%), followed by Asteraceae, Solanaceae and Apocynaceae (15.38%). In the raw spectrum of biological types, Therophytes show good representation with (69.24%). Phanerophytes (37.31%) dominated the real spectrum. The raw chorological spectrum of this group is dominated by the cosmopolitan element (23.1%), the Sahelo-Saharan element (37.32%) followed by the cosmopolitan element (31.35%) dominated the real spectrum. Zoocohores species are dominated by the raw dispersal spectrum with (38.46%), the Anemochores dominate the real spectrum (65.68%). In the raw spectrum of morphological types, annuals show a good representation (69.23%). In the real spectrum, perennial shows a good representation (71.64%). The Shannon diversity index is 2.80 bits, the Pielou equitability is 0.76 and the Simpson index is 0.79.

Group 5 consists of 11 surveys with 13 species. The most abundant species are Zygophyllum album (34.85%) and Salsola vermiculata (12.12%). The most represented families are: the family Zygophyllaceae, Poaceae, Amaranthaceae and Asteraceae (15.38%). In the raw spectrum of biological types, Therophyte shows good representation with (69.24%) followed by Chamephyte (15.38%). in the real spectrum, Chamephyte shows a fort presence with (46.97%) followed by Therophyte (40.91%). For chorological types, the cosmopolitan element dominated the raw spectrum with (23.1%). In the real spectrum, the Saharo-Arabian element shows a good presence (34.85%) followed by the cosmopolitan elements (22.73%). Plant dispersal is dominated by the Barochore type (38.46%; 45.45%) in two spectra. The raw spectrum of morphological types shows a good presence of annuals (61.54%). In the real spectrum, the Perennials show a good presence (69.7%). The Shannon diversity index is 3.03 bits, the Pielou equitability is 0.82 and the Simpson index is 0.82.

Group 6 consists of 10 surveys with 13 species. The most abundant species are Dactyl俄tomentum aegyptium (48.18%), Amaranthus retroflexus (17.27%). The most represented families are: the family Asteraceae (38.48%), Poaceae (15.38%). In the raw and real spectrum, the biological spectrum shows an excellent presence of Therophytes (76.93%, 82.73%). For chorological types, the cosmopolitan element dominated the raw spectrum with (38.48%). In the real spectrum, the Pantropical element shows a fort presence (48.19%) followed by the cosmopolitan elements (14.54%). The dispersion of plants is dominated by the Barochore type (46.16%; 57.27%) in two spectra. In the raw and real spectrum of morphological types, the annual shows a fort presence (76.92%; 82.73%). The Shannon diversity index is 3.03 bits, the Pielou equitability is 0.82 and the Simpson index is 0.82.

According to the life forms classification of Raunkiaer (1934), the G2 and G6 were dominated by Therophytes. The dominance of Therophytes is explained by their adaptation to agrarian ecosystems and the availability of water [44]. The G1 and G3 are dominated by the Geophytes; this dominance is probably related to their adaptation to superficial plowing practices [45, 34]. The pressure of working of soil favors the abundance of geophytes [31]. Vegetative propagation is their only mode of survival, as sexual reproduction is very infrequent for most of these species [46]. Phanerophytes dominated G4, indicating that they are found especially in green spaces without maintenance [30]. In general, Phanerophytes are rare in the Sahara and hot deserts [47, 48, 49]. The fort presence of Chamephytes in the G5 shows the good adaptation of Chamaephytes to the ecological conditions of hot arid and hyper-arid environments through the development of specific strategies [49].

The G1 dominated by the Subtropical element is explained by the effect of climate change in Mediterranean Africa since the Miocene, which will probably favor the installation of subtropical species, or the replacement of the range of native species [50, 51]. The G2 and G3 dominated by the cosmopolitan species can be explained by the fact that, the cultural biotope is a very open environment, regularly disturbed; accommodating many species introduced accidentally during the introductions of new crops or improved varieties [52]. In terms of the geographic distribution of species, the dominance of Sahelo-Saharan species in the G4 is probably due to systems of resistance to disturbances in this locality. This dominance can be explained by the fact that these species are more adapted to the bioclimatic conditions of the environment than other exotic species [53]. The Saharo-Arabian element is well represented in the G5, this may be because the region is considered a
The vegetation studied is characterized by the dominance of Geophytes and Therophytes, and the specific richness of these green spaces is composed of 32 species represented mainly by perennial species. This floristic richness is due to the microclimate of the green spaces, the diversity of the trees planted, the use of organic fertilizer. The vegetation studied is characterized by the dominance of Geophytes and Therophytes, this situation favors the installation of plants of barochore and anemochore dispersal strategies. Phytogeographically, the most abundant of cosmopolitan plants reflect the adaptation of plants to anthropogenic activities. Finally, urban green spaces constitute a reservoir of plant biodiversity and a protected area for spontaneous species.

**REFERENCES**

[1] Bekkouch, Kouddane N.E, Daroui E.A, Boukroute A & Berrichi A (2011). Inventaire des arbres d’alignement de la ville d’Oujda. Nature & Technology, 5, 87-91.

[2] R. Radji, Kokou K (2013). Classification et valeurs thérapeutiques des plantes ornementales du Togo. Vertigo, 13.3. DOI: https://doi.org/10.4000/vertigo.14519.

[3] P. Clergeau, Une écologie du paysage urbain (Editions Apogée, Rennes, 2007).

[4] Y.J.C. Kouadio, Vroh B.T.A, Bi Z.B.G, Yao C.Y.A, N’guessan K.E (2016). Évaluation de la diversité et estimation de la biomasse des arbres d’alignement des communes du Plateau et de Cocody (Abidjan - Côte d'Ivoire). Journal of Applied Biosciences, 97,9141-9151.

[5] D. Zhang, Zheng H, He X, Ren Z.B, Zhai C, Yu X, Mao Z, Wang P (2016). Effects of forest type and urbanization on species composition and diversity of urban forest in Changchun, Northeast China. Urban Ecosystems, 19, 1, 455-473.

[6] H. Lv, Yang Y, Zhang D, Du H, Zhang J, Wang W, He X (2019). Perimeter-area ratio effects of urbanization intensification forest characteristics, landscape patterns and their associations in Harbin City, Northeast China. Urban Ecosystems, 22, 4, 631-642.

[7] G.J.R. Nomel, Kouassi R.H, Ambe A.S.A, Kouadio Y.J.C, Doumbia M, N’guessan K.E (2019). Diversité et stock de carbone des arbres d’alignement : Cas d’Assabou et Dioulakro de la ville de Yamoussoukro (Centre de la Côte d’Ivoire). Journal of Environmental Science, Toxicology and Food Technology, 13, 4, 84-89.

[8] Millennium Ecosystem Assessment Assessment, Ecosystems and Human Well-being (Island Press, United States of America, 2005).

[9] J. Dombrow, Rodriguez M, Sirmans C.F (2000). The market value of mature trees in single-family housing markets. Appraisal Journal, 68, 1, 39-43.

[10] D.J. Nowak, Crane, D.E, Stevens, J.C (2006). Air pollution removal by urban trees and shrubs in the United States. Urban forestry & urban greening, 4, 3-4, 115-123.

[11] A.A. Osseni, Gbesso G.H.F, Nansi K.M, Tente A.B.H (2020). Phytodiversity and services écosystémiques associés aux plantations d’alignement des rues aménagées de la ville de Grand-Popo au Bénin. Bois et Forêts des Tropiques, 345, 85-97.

[12] J.N. Consales (2003). Les jardins familiaux de Marseille, Gênes et Barcelone. Entre enjeux potentiels et fonctions réelles de l’agriculture urbaine. Rives méditerranéennes, 15, 1-12.

[13] A.S. Fall, Fall S.T, Cités horticoles en survie? L’agriculture urbaine dans les grandes Niayes au Sénégal (Centre de recherches pour le développement international. Ottawa, Ontario, 2001).

[14] R. Radji, Kokou K, Akpagana K (2010). Etude diagnostique de la flore ornementale togolaise. International Journal of Biological and Chemical Sciences, 4, 2, 491-508.

[15] B.F. Nero, Kwaponk N.A, Jatta R, Fatunbi O (2018). Tree species diversity and socioeconomic perspectives of the urban (food) forest of Accra, Ghana. Sustainability, 10, 10, 3417.

[16] F. Fousséni, Wouyo A, Madjouma K, Djibril K, Kissao G, Kperkouma W, Koffi A (2019). Floristic composition and biodiversity between the phytocological groups are attributed to the micro-environmental conditions characterizing the associated surveys of each group, in particular soil properties, microclimate and irrigation [20].

**CONCLUSION**

This work has highlighted the importance of studying plant communities associated with urban green spaces in southwestern Algeria. The specific richness of these green spaces is composed of 32 species represented mainly by perennial species. This floristic richness is due to the microclimate of the green spaces, the diversity of the trees planted, the use of organic fertilizer. The vegetation studied is characterized by the dominance of Geophytes and Therophytes, this situation favors the installation of plants of barochore and anemochore dispersal strategies. Phytogeographically, the most abundant of cosmopolitan plants reflect the adaptation of plants to anthropogenic activities. Finally, urban green spaces constitute a reservoir of plant biodiversity and a protected area for spontaneous species.
[22] K. Fandjinou, Zhang K, Folega F, Yang X (2018). Sustainable land management and ecological service assessment in Northwest of China: Case study of Yanchi, Peoples Republic of China. African Journal of Agricultural Research, 13, 31, 1551-1563.

[23] P. Quézel, Santa S, Nouvelle flore de l’Algérie et des régions désertiques méridionales (Centre national de la recherche scientifique, Paris, 1962-1963).

[24] C. Raunkier, The life forms of plants and statistical plant of geography (Oxford: Clarendon Press, London, 1934).

[25] L. Van Der Pijl, Principles of dispersal in higher plants (Springer, Berlin, Heidelberg, 1982).

[26] Macheroun, Kadik L, Neffar S, Chenchouni H (2021). Environmental drivers of taxonomic and phylogenetic diversity patterns of plant communities in semi-arid steppe rangelands of North Africa. Ecological Indicators, 132, 108279.

[27] C.E. Shannon, Weaver W, A Mathematical Model of Communication (Urbana, IL: University of Illinois Press, Chicago, 1949).

[28] E.C. Pielou (1966). Species diversity and pattern diversity in the study of ecological succession. Journal of theoretical biology, 10, 2, 370-383.

[29] R. Schlaepfer, Büttler, R (2002). Critères et indicateurs de la gestion des ressources forestières: prise en compte de la complexité et de l'approche écosystématisée.

[30] Z. Chafik, Bekkouch I, Kouddane N, Berriachi A, Taleb A (2010). Diversité et importance des mauvaises herbes des espaces verts de la ville de Berkane. Revue Marocaine de Protection des Plantes, 1, 25-32.

[31] Z. Chafic, Berriachi A, Bouali A, Taleb A (2013). Systematic, phytoecological and agronomic survey of citrus fruits weed flora in the Northeastern Morocco. Journal of biology, 10, 20-29.

[32] Marco, Barthelemy C, Dutoit T, Bertaudière-Montes V (2010). Bridging human and natural sciences for a better understanding of urban floral patterns: The role of planting practices in Mediterranean gardens. Ecology and Society, 15, 2, 2.

[33] J.V. Marc, Martouzet D (2012). Les jardins créoles et ornementaux comme indicateurs sociospatiaux : Analyse du cas de Fort-de-France, Vertigo, (Hors-série 14).

[34] E. Štefanic, Kovacevic V, Antunovic S, Japundzic-Palenkic B, Zima D, Turalija A, Nistorovic N (2019). Floristic biodiversity of weed communities in arable lands of Istria peninsula (from 2005 to 2017). Ekologija Bratislava, 38, 2, 166-177.

[35] L.G. Holm, Plucknett D.L, Pancho J.V, Herberger J.P, The World’s Worst Weeds: Distribution and biology (Univ. Press of Hawaii, Honolulu, 1977).

[36] L.G. Holm, Pancho J.V, Berriachi A, Berriachi A, Plucknett D. L, A geographical atlas of world weeds (John Wiley & Sons, New York, 1991).

[37] S.A. Al-Robai, Mohamed H.A, Howladar S.M, Ahmed A.A (2017). Vegetation structure and species diversity of Wadi Turbah Zahran, Albaha area, southwestern Saudi Arabia. Annals of Agricultural Sciences, 62, 1, 61-69.

[38] N.H. Gomaa (2012). Composition and diversity of weed communities in Al-Jouf province, northern, Saudi Arabia. Saudi journal of biological sciences, 19, 3, 369-376.

[39] Tanji, Benicha M, Mamdouh M (2015). Contribution à l’étude des adventices associés aux cultures dans les sols sableux du périmètre irrigué du Loukkos : cas du fraisier et de l’arachide. Revue Marocaine de Protection des Plantes, 7, 67-80.

[40] K. Noba (2002). La flore des paysages de la province du Bassin arachidier (Sénégal) : structure dynamique et impact sur la production du mil et de l’arachide. Thèse de Doctorat d’Etat de Biologie Végétale. FST, UCAD, Dakar, 128p.

[41] R. Nègre, Petite flore des régions arides du Maroc occidental (Centre National de la Recherche Scientifique, Paris, 1962).

[42] H. Wu, Walker S, Rollin M. J, Tan D.K.Y, Robinson G, Werth J (2007). Germination, persistence, and emergence of flaxleaf fleabane (Conyza bonariensis [L.] Cronquist). Weed biology and Management, 7, 3, 192-199.

[43] M.C. Andersen (1992). An analysis of variability in seed settling velocities of several wind-dispersed Asteraceae. American Journal of Botany, 79, 10, 1087-1091.

[44] R.S. Sarr, Mbaye M.S, Ba A.T (2007). La flore adventice des cultures d'ignon dans la zone péri-urbaine de Dakar (Niayes) Sénégal. Webbia, 62, 2, 205-216.

[45] M.C. Loudiy (1986). Etude botanique et écologique de la végétation spontanée du plateau de Meknès (Maroc). Thèse de 3ème cycles, USTL, Montpellier, 147p.

[46] L. Zidane, Saïhi S, Fadli M, El Antri M, Taleb A, Daoui A (2010). Étude des groupements d’aventices dans le Maroc occidental. Biotechnologie, Agronomie, Société et Environnement, 14, 1, 153-166.

[47] M. Bouallala (2013). Etude floristique et nutritive spatio-temporelle des parcours camelins du Sahara occidental Algérien : cas des régions de Béchar et Tindouf. Thèse de Doctorat. Université d’Ouargla, Algérie.

[48] M. Gamoun, Belacem A.O, Louhaichi M (2018). Diversity of desert rangelands of Tunisia. Plant diversity, 40, 5, 217-225.

[49] M. Azizi, Chenchouni H, Belarouci M.E.H, Bradai L, Bouallala M (2021). Diversity of psammophyte communities on sand dunes and sandy soils of the northern Sahara Desert. Journal of King Saud University-Science, 33, 8, 101656.

[50] P. Quézel, La végétation du Sahara du Tchad a la Mauritanie (Fisher G. Université de Cornell, Stuttgart, 1965).

[51] C. Lévêque, Tabacchi É, Menozzi M.J (2012). Les espèces exotiques envahissantes, pour une remise en cause des paradigmes écologiques. Sciences Eaux Territoires, 6, 1, 2-9.

[52] H.G. Baker (1986). Patterns of plant invasion in North America. In: Mooney H.A., Drake J.A. (eds) Ecology of Biological Invasions of North America and Hawaii. Ecological Studies (Analysis and Synthesis), Springer, New York, NY, Ecological studies, 58: 44-57.

[53] K. Noba, Bâ A.T, Caussanel J-P, Mbaye Ms, Barralis G (2004). Flore adventice des cultures vivrières dans le sud du Bassin arachidier (Sénégal). Webbia, 59, 2, 293-308.

[54] M.A. El-Sheikh, Thomas J, Arif I.A, El-Sheikh H.M (2021). Ecology of inland sand dunes “nafuds” as a hyper-arid habitat, Saudi Arabia: Floristic and plant associations diversity. Saudi Journal of Biological Sciences, 28, 3, 1503-1513.

[55] L.C. Sehoun, Osseni A.A, Orouladjii M, Lougbegnon T.O, Codjia J.C.T (2021). Diversité floristique des formations végétales urbaines au Sud du Bénin (Afrique de l’Ouest). Revue Marocaine des Sciences Agronomiques et Vétérinaires, 9, 2, 266-273.

[56] L. Bradai, Bouallala M, Bouziane N.F, Zaoui S, Neffar S, Chenchouni H (2015). An appraisal of eremophyte diversity and plant traits in a rocky desert of the Sahara. Flora Geobotanica, 50, 3, 239-252.