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Analysis of the Diversity of Spontaneous Urban Flora – The Case of Temara City, Morocco

Hassan Boukita[1*], Rabea Ziri[1], Najiba Brhadda[1], Abdelazziz Chemchaoui[1], Souad Ghazi[1], Fathalah Elwahab[1], Boutaina Benchahid[1], Mohamed El Ammari[1]

[1] Plant and Animal Production and Agro-Industry Laboratory, Faculty of Science; Ibn Tofail University, B.P 133, Kenitra 14000, Morocco

* Corresponding author's e-mail: hassan.boukita@uit.ac.ma

ABSTRACT

Spontaneous flora offers many functions and potentialities in the urban ecosystem. However, few studies have been carried out on this subject in Morocco. The present study aimed to analyze the diversity of spontaneous flora in the urban area of Temara, to contribute to interpreting the structure and dynamics of Moroccan spontaneous flora. During the study, 90 floristic surveys were carried out along four transects, marked A, B, C, and D so that each transect started from the city center and went in one of the four directions of the study area. Transect A ran northwards from the city center, transect B westwards, transect C southwards, and transect D eastwards from the city center. To carry out the floristic surveys, several survey areas were chosen, given the heterogeneity of the urban environment. These areas ranged from a few cm^2 for rock fissure plants, through 10 to 25 m^2 for grasslands, to 25 to 100 m^2 for forest cuttings. The results revealed a total of 137 taxa grouped in 116 genera and belong to 33 floristic families. The Asteraceae family came out on top, with 30 species (21.90%) and 24 genera, and the Poaceae family was in second place with 21 species (15.33%) divided into 20 genera. Analysis of this floristic list indicates a predominance of the therophyte life form (48.90%), then hemicryptophytes (26.28%) followed by geophytes (10.22%) in terms of biological type, and a predominance of the Mediterranean element (31.19%) in terms of chorological type. Of the 137 taxa inventoried, 10 are very rare, 1 is rare, 1 has a doubtful presence, and 2 are endemics. This study showed that even in a disturbed and fragmented environment, such as the urban environment, certain spontaneous plant species adapt to the conditions prevailing in this habitat and show considerable diversity, thus contributing to a better interpretation of the composition and dynamics of the country's flora.

Keywords: floristic diversity, Morocco, urban ecosystem, spontaneous flora, Temara.

INTRODUCTION

The urban ecosystem is the result of accelerated urbanization, highly correlated with the loss and degradation of natural habitats, population growth, and intense human activities (Gross, 2019), leading to a loss of biodiversity in the urban environment (Malkinson et al., 2018). Furthermore, by creating new habitats with different characteristics, the urban environment contributes to promoting biodiversity (Qian et al., 2020). In the urban ecosystem, most of the flora is in the form of cultivated plants. However, there is also a significant proportion of flora that has not been cultivated by humans, known as spontaneous flora, which has managed, with its own resources, to tolerate the conditions of different urban habitats (Forman, 2014). In the urban ecosystem, spontaneous plants form new communities, thus creating new axes and opportunities for evaluating as well as studying the effect of anthropogenic activities on plant associations and related ecosystem services, as these studies will provide important aspects for better understanding the strategies with which plants respond to the conditions prevailing in urban environments and how these plants contribute to the characteristics of urban ecosystems (Hu

et al., 2021). Studies on spontaneous flora in the urban environment of Morocco are very limited. In order to contribute to the interpretation of the structure and dynamics of Moroccan spontaneous flora, this study proposes to inventory and analyze the diversity of spontaneous flora in the city of Temara.

MATERIAL AND METHODS

Study area

The Temara region (Figure 1), located southwest of Rabat and northwest of Morocco (33° 55' 13.177" N 6° 55' 38.629" W), is a coastal area along the Atlantic Ocean that forms part of the north-western coastal meseta (Chahid et al, 2012). Considering its north-western geographical location, the Temara area is part of the semi-arid and sub-humid bioclimate. The climate in this area is Mediterranean, with dry summers and mild, wet winters. The Atlantic Ocean has a buffering effect on nearby regions, including Temara, through the humidity it brings to the continent (Stoetzel and al., 2014). Annual precipitation averages 555 mm, and average temperatures are generally mild, with no recorded extremes (Taazzouzte et al., 2021).

Sampling method

To inventory and examine as much of the spontaneous flora of the Temara urban area as possible, the authors opted for McDonnell's (1990) urban-rural transect method, in the form of 4 perpendicular transects, labeled A, B, C, and D, so that line A started from the city center towards the north of the city, line B from the city center towards the west, line C from the city center towards the south and line D from the city center towards the east of the city.

A series of field surveys were conducted during the period from May to June 2023, enabling to compile a list of species of spontaneous flora in the study area. To carry out the floristic surveys, the Braun-Blanquet method was adopted (Meddour, 2011), and a dominance-abundance index was obtained for each species studied. Considering the high level of disturbance in the urban environment, spontaneous vegetation is spatially more or less extensive. For this reason, the survey areas were adopted as proposed by (Gorenflot &

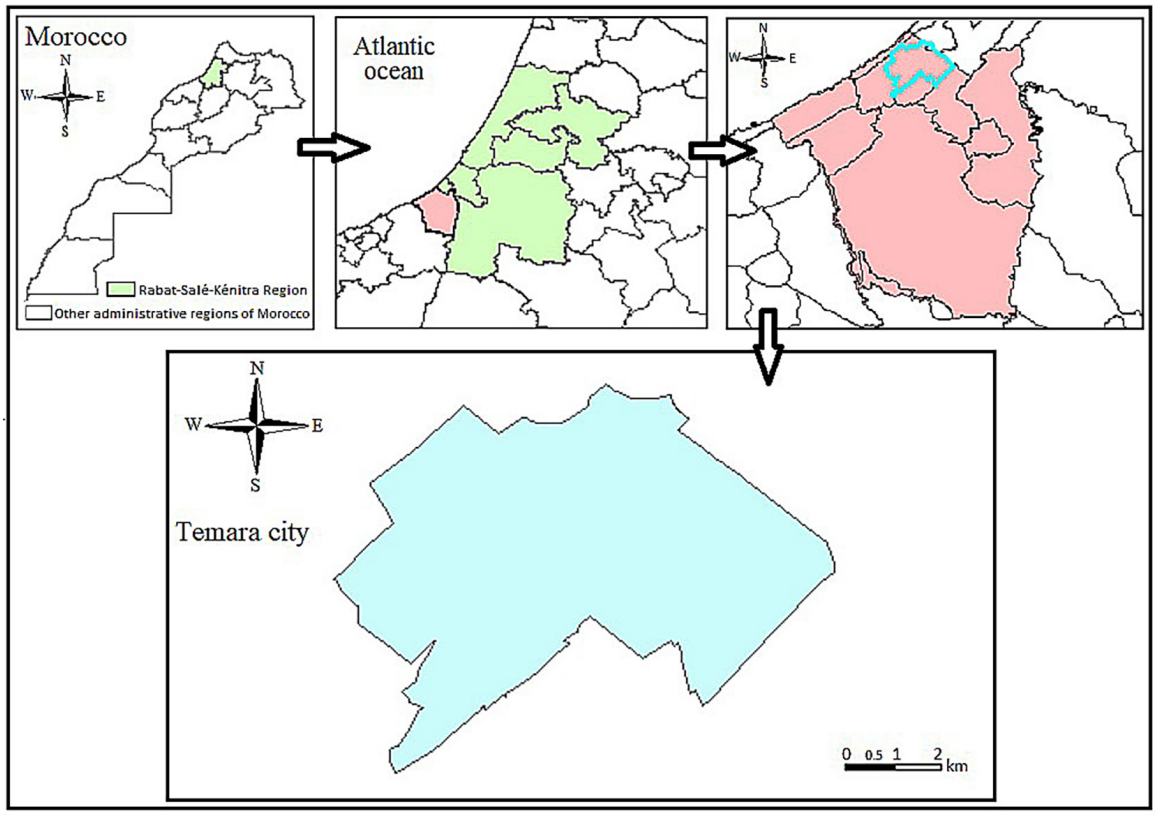

Fig. 1. Study area geographical location

De Foucault, 2005; Delpech, 2006), according to plot type: a few cm^2 for annual plants in rock fissures; 10 to 25 m^2 for grasslands and 25 to 100 m^2 for forest sections.

Data analysis

Species identification was made concerning the following floras: The catalog of Moroccan plants (Jahandiez & Maire, 1931-1932-1934, Emberger & Maire, 1941), consulted at the scientific institute in Rabat, Morocco, and The synonymic index of the flora of North Africa (Dobignard & Chatelain, 2010 and 2011). It was completed by nomenclature checks on the databases of the Tela-Botanica website (tela-botanica.org). It should be mentioned that a preliminary identification of species was carried out in the field, using the "Pl@ntNet" mobile application (Version 3.11.2) developed by Tela-Botanica, and subsequently verified by consulting the Floras cited above. The rarity and endemism statuses of the taxa are determined based on those adopted by (Fennane & Ibn Tattou, 1998). Taxon threat categories are defined concerning Elements for a Red Book of the vascular flora of Morocco (Fennane, 2017 & 2018). The phytogeographical distribution of the species identified in this study was established based on The New Flora of Algeria and southern desert regions (Quézel & Santa, 1962, 1963).

RESULTS AND DISCUSSION

Systematic aspect

The floristic surveys carried out as part of this study revealed the existence of 137 species spread over 116 genera and belonging to 33 botanical families (Table 1). According to the analysis of these results, the most species-rich family is the Asteraceae, with 30 species (21.90%). This family is also considered the richest in Morocco, with 550 species (Fennane, 2012), followed by the Poaceae family with 21 species (15.33%). The Scrophulariaceae, Portulacaceae, Araceae, Convolvulaceae, Nitrariaceae, Frankeniaceae, Tamaricaceae, Cyperaceae, Fagaceae, Arecaceae, Primulaceae, Geraniaceae, Nyctaginaceae and Rubiaceae families are the least represented in this study area, with just one species (0.73%) each. The high representativeness of Asteraceae and Poaceae can be explained by the great capacity of their taxa to regrow (Diallo et al., 2015), given their presence in the majority of the surveys carried out, despite the differences that may exist between the habitats inventoried in terms of the nature of the substrate, exposition to trampling, the pressure of management and maintenance of urban spaces, etc. Thus, most Asteraceae and Poaceae are characterized by the production of

Table 1. Richness and specific contribution of inventoried families

Families	Number of species	Contribution (%)	Families	Number of species	Contribution (%)
Asteraceae	30	21.90	*Plantaginaceae*	02	01.46
Poaceae	21	15.33	*Oxalidaceae*	02	01.46
Amaranthaceae	11	08.03	*Scrophulariaceae*	01	0.73
Solanaceae	09	06.57	*Portulacaceae*	01	0.73
Brassicaceae	08	05.84	*Araceae*	01	0.73
Fabaceae	07	05.11	*Convolvulaceae*	01	0.73
Caryophyllaceae	06	04.38	*Nitrariaceae*	01	0.73
Papaveraceae	04	02.92	*Frankeniaceae*	01	0.73
Apiaceae	03	02.19	*Tamaricaceae*	01	0.73
Euphorbiaceae	03	02.19	*Cyperaceae*	01	0.73
Polygonaceae	03	02.19	*Fagaceae*	01	0.73
Asparagaceae	03	02.19	*Arecaceae*	01	0.73
Lamiaceae	03	02.19	*Primulaceae*	01	0.73
Boraginaceae	02	01.46	*Geraniaceae*	01	0.73
Urticaceae	02	01.46	*Nyctaginaceae*	01	0.73
Plumbaginaceae	02	01.46	*Rubiaceae*	01	0.73
Malvaceae	02	01.46			

large numbers of small seeds, which increases their chances of being disseminated more easily, especially by wind, and colonizing more environments after seasonal rainfall.

In terms of generic richness (Figure 2), almost half of the families (17 families) are known by just 1 genus. However, the Asteraceae family ranks first, with 24 genera, or 20.69% of the total. The Poaceae family, with 20 genera or 17.24% is in the second place. Four genera are the most represented in the study site, with 3 species each: *Crepis*, *Chenopodium*, *Amaranthus,* and *Solanum*. In turn, 13 genera are known from two species each: *Erigeron*, *Carduus*, *Centaurea*, *Sonchus*, *Elytrigia*, *Sinapis*, *Sisymbrium*, *Lotus*, *Papaver*, *Salvia*, *Malva*, *Plantago* and *Oxalis*. Note that the genus *Silene* is represented by only one species (*Silene gallica* L.), despite being considered the richest genus of vascular species in Morocco with 67 species and 16 subspecies, followed by the genus *Ononis* with 58 species and 24 subspecies (Fennane, 2012), but, in this study, the genus *Ononis* recorded only one species as well (*Ononis natrix* L.).

Biological aspect

Biological types

In terms of life forms (Figure 3**)**, according to Raunkiaer's (1934) classification of plant adaptation strategies to the environment, therophytes dominate the study area with a contribution of 48.90%. Next in descending order are hemicryptophytes (26.28%), geophytes (10.22%), and

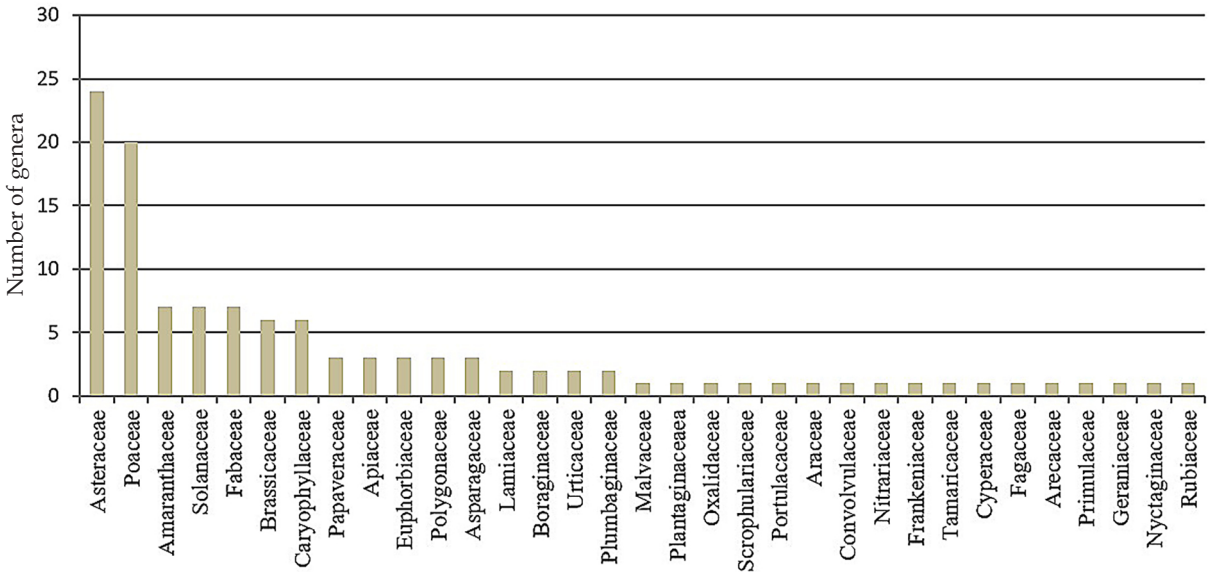

Fig. 2. Generic richness by botanical family

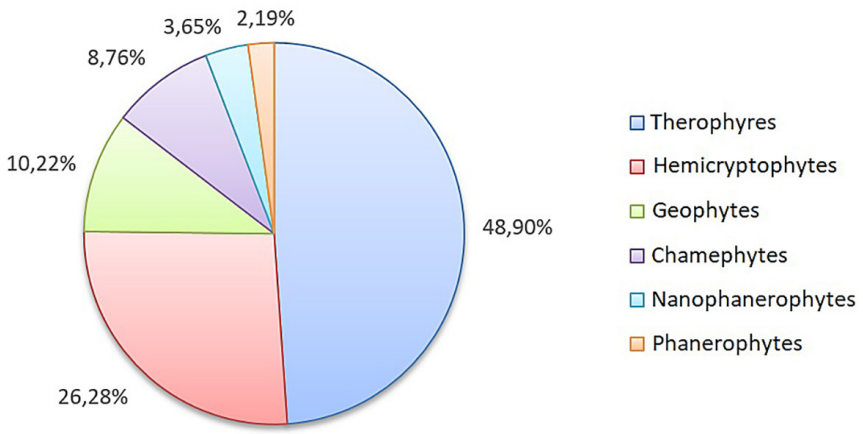

Fig. 3. The global biological spectrum of the study area

chamephytes (8.76%); this order of importance is in agreement with that found by (Rimani et al., 2019) in spontaneous weeds associated with saffron crops (*Crocus sativus* L.). Next come nanophanerophytes (3.65%) and finally phanerophytes (2.19%). Chafik et al. (2010) also showed the dominance of therophytes among weeds in the green spaces of the city of Berkane, noting that the two most common weeds in the city's green spaces are *Cyperus rotundus* L. and *Cynodon dactylon* (L.) Pers. These two species were also found in the Temara urban area according to this study, but in a lower abundance. The high rate of therophytes is mainly linked to the harsh climate and anthropogenic activities, which contribute to the degradation of conditions favorable to the establishment of new species (Hachemi, 2015). Thus, therophytes crowd out other life forms when environmental conditions become harsh (Yerou, 2022) as in the case of the urban environment.

Chorological types

The biogeographical distribution (Figure 4) reveals the predominance of Mediterranean species (Med) (31.19%), followed by Eurasian (Euras), (9.63%), Macaronesian (Macar), (8.71%), American (Amer), (7.80%), Cosmopolitan (Cosm), (5.96%), African (Afr), (5.04%), Asian (Asi), (4.59%), West Mediterranean (W. Med), (4.13%), European (Eur), (3.67%) and Canarian (Canar), (3.21%) species. The other types are less represented in the study area, with a proportion of less than 3% each, but they remain important for the richness and diversity of the chorological potential in this zone. The high rate of the Mediterranean element is similar to the findings of other studies carried out on Moroccan flora, both spontaneous and adventitious (Zidane et al., 2010; Rimani et al., 2019; Irifi, 2021).

Endemism, rarity, and threat status

The rarity rate in the list of species recorded (Table 2) is 8.76%. Of the 137 species, 10 are considered very rare (RR); (*Andryala integrifolia* L. subsp *ampelusia* Maire, *Avena fatua* L., *Camphorosma monspeliaca* L., *Crepis bursifolia* L., *Eragrostis curvula* (Schrad.) Nees, *Lagurus ovatus* L. subsp. nanus (Guss) Messeri, *Raphanus raphanistrum* L. subsp. *landra* (DC.) Bonnier & Layens, *Scleranthus perennis* L., *Urtica dioica* L. and *Verbesina encelioides* (Cav.)), 1 rare (R); (*Limonium tuberculatum*) and 1 species of doubtful presence (??); (*Tamarix gallica* L.). As regards threat status, the taxa inventoried are divided into seven categories: 106 are mentioned as common (LC), 23 are not applicable, which means not subject to evaluation, 2 are insufficiently documented (DD), 2 are vulnerable (VU), 2 are endangered (EN), 2 are near threatened (NT), and 1 is a critically endangered taxon (CR); (*Camphorosma monspeliaca* L.). It should be noted that Morocco has not yet drawn up an official red list by the criteria proposed by The International Union for Conservation of Nature (IUCN). The elaboration of this list has become a necessity to better preserve the rare and threatened taxa of the country's flora. The degree of endemism found in all the taxa listed in this work is considered very low, and only 2 taxa have been mentioned: *Andryala integrifolia* L. subsp *ampelusia* Maire, endemic to Morocco (E), and *Limonium tuberculatum,* endemic to Morocco, Mauritania, and the

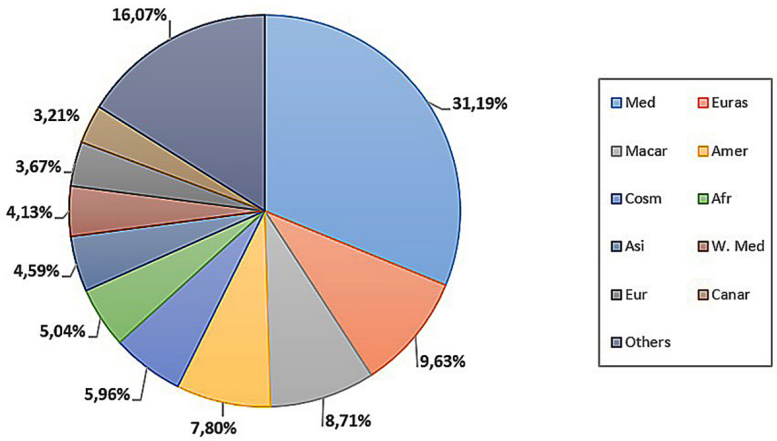

Fig. 4. Biogeographical types of inventoried taxa

Table 2. Degrees of rarity, endemism, and threat categories of recorded taxa

Species	Rarity			Threat categories						Endemism	
	RR	R	??	CR	EN	VU	NT	DD	LC	E	MC
Anagallis foemina Mill.								+			
Andryala integrifolia L. subsp *ampelusia* Maire	+								+	+	
Avena fatua L.	+						+				
Camphorosma monspeliaca L.	+			+							
Crepis bursifolia L.	+										
Crepis foetida L.							+				
Elytrigia juncea (L.) Nevski								+			
Eragrostis curvula (Schrad.) Nees	+										
Lagurus ovatus L. subsp. nanus (Guss) Messeri	+								+		
Limonium tuberculatum (Boiss.) Kuntze		+				+					+
Raphanus raphanistrum L. subsp. *landra* (DC.) Bonnier & Layens	+								+		
Scleranthus perennis L.	+				+						
Sinapis pubescens L.						+					
Tamarix gallica L.			+						+		
Urtica dioica L.	+										
Verbesina encelioides (Cav.) Benth & Hooke.f. ex A.Gray	+										

Macaronesian islands (MC). Nationally, the Moroccan flora includes 640 species and 280 subspecies, representing 920 taxa endemic to Morocco and 4 species endemic to Morocco, Mauritania, and the Macaronesian islands (Fennane, 2012).

CONCLUSIONS

This work has shown the spontaneous floristic composition of the Temara urban area, with a fairly high specific richness for certain botanical families (Asteraceae and Poaceae) and limited richness for others. The predominance of therophytes in the study area (48.9%) was noted, as this biological type is the most adaptable to highly fragmented environments such as the urban environment. A clear predominance of the Mediterranean element compared with other biogeographical types was also observed. The conducted study recorded a low level of endemic taxa (two taxa out of 137), but the number of very rare taxa was quite high (10 taxa). These species and subspecies contribute to maintaining the phytodiversity of both the area surveyed and the country in general, making their preservation a priority for various stakeholders. This study is limited to vascular plants, but bryophytes and lichens also represent a considerable proportion of the vegetation in the urban ecosystem, which can be the subject of similar studies and analyses.

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REFERENCES

1. Chafik Z., Bekkouch I., Kouddane N., Berrichi 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.
2. Chahid D., Boudad L., El Hmaidi A., Lenoble A. 2012. Apport du SIG et du MNT dans l'étude des cordons littoraux de la région de Témara (Maroc). In Taza GIS-days : international conference of GIS users, 546-548.
3. Delpech R. 2006. La phytosociologie. http://www.tela-botanica.org/page:menu_407
4. Diallo M., Saleh M., Bassene C., Wood S., Diop A., Guisse A. 2015. Influence de la litière foliaire de cinq

espèces végétales tropicales sur la diversité floristique des herbacées dans la zone du Ferlo (Senegal). International Journal of Biological and Chemical Sciences, 9(2), 803. https://doi.org/10.4314/ijbcs.v9i2.20

5. Dobignard A., Chatelain C. 2010-2011. Index synonymique de la Flore d'Afrique du Nord. Edit. Conservatoire et Jardin botanique de la ville de Genève. Publ. hors série, n°11. Vol. 1 (2010), Vol. 2 & 3 (2011).
6. Emberger L. and Maire R. 1941. Catalogue des plantes du Maroc (Spermatocytes et Ptéridophytes). Tome IV, supplément aux volumes I, II, et III. - Alger, Minerva, et Mém. h.s. Soc. Nat. Maroc, LIX-LXXV, 915-1181.
7. Fennane M. and Ibn Tattou M. 1998. Catalogue des plantes vasculaires rares, menacées ou endémiques du Maroc. Bocconea, 8, 243.
8. Fennane M. 2012. Statistiques et commentaires sur l'inventaire actuel de la flore vasculaire du Maroc. Bulletin de l'Institut Scientifique, 31(1), 1-9.
9. Fennane M. 2017-2018. Eléments pour un Livre rouge de la flore vasculaire du Maroc. Fasc. 2, 3 et 4 (2017), Fasc. 5, 6, 7, 8, 9 et 10 (2018). Edit. Tela-Botanica.
10. Forman R.T.T. 2014. Urban ecology : Science of cities. New York : Cambridge University Press.
11. Gorenflot R., and De Foucault B. 2005. Initiation à la phytosociologie. Complément au chapitre 23. In : Biologie végétale, les Cormophytes. Dunod (Ed.), 1-27.
12. Gross M. 2019. The future is urbanized. Current Biology 29, 947–949. https://doi.org/10.1016/j.cub.2019.09.043.
13. Hachemi N. 2015. Contribution à l'étude de la Thérophytisation des matorrals des Monts de Tlemcen: Aspects Ecologiques et Cartographie (Tlemcen-Algérie occidentale). Thèse de Doctorat Université de Tlemcen, Algeria, 142.
14. Hu L., Qin D., Lu H., Li W., Shang K., Lin D., Zhao L., Yang Y., Qian S. 2021. Urban growth drives trait composition of urban spontaneous plant communities in a mountainous city in China. Journal of Environmental Management, 293, 112869. https://doi.org/10.1016/j.jenvman.2021.112869
15. Irifi H. 2021. Diversité floristique et paysagère du cours d'eau de la basse vallée de l'oued Tamri (Haute atlas atlantique, Maroc). Geomaghreb, (17).
16. Jahandiez E. and Maire R. 1931. Catalogue des plantes du Maroc (Spermatocytes et Ptéridophytes). Tome premier: Ptéridophytes, Gymnospermes, et Monocotylédones. -Alger, Minerva, XL, pp. 150.
17. Jahandiez E. and Maire R. 1932. Catalogue des plantes du Maroc. Tome deuxième: Dicotylédones Archichlamydées. -Alger, Minerva, 161 et 558.
18. Jahandiez E. and Maire R. 1934. Catalogue des plantes du Maroc. Tome troisième: Dicotylédones Gamopétales et supplément aux volumes I, II. - Alger, Minerva, LI-LVIII, 559-913.
19. Malkinson D., Kopel D., Wittenberg L. 2018. From rural-urban gradients to patch – matrix frameworks: plant diversity patterns in urban landscapes. Landscape and Urban Planning 169, 260–268. https://doi.org/10.1016/j.landurbplan.2017.09.021.
20. McDonnell M. J., and Pickett S. T. A. 1990. Ecosystem Structure and Function along Urban-Rural Gradients: An Unexploited Opportunity for Ecology. Ecology, 71(4), 1232–1237. https://doi.org/10.2307/1938259
21. Meddour R. 2011. La Méthode phytosociologie stigmatiste de Braun-Blanquet. Université Mouloud Mammeri de Tizi Ouzou, Faculté des Sciences Biologiques et Agronomiques, Algérie.
22. Qian S., Qin D., Wu X., Hu S., Hu L., Lin D., Zhao L., Shang K., Song K., Yang Y. 2020. Urban growth and topographical factors shape patterns of spontaneous plant community diversity in a mountainous city in southwest China. Urban Forestry & Urban Greening 55, 126814. https://doi.org/10.1016/j.ufug.2020.126814.
23. Quézel P., and Santa S. 1962-1963. Nouvelle flore de l'Algérie et des régions désertiques méridionales. Editions C.N.R.S. Paris, Tomes I et II, pp. 1165.
24. Raunkiaer C. 1934. The life forms of plants and statistical plant geography. Clarendon Press. Oxford, pp. 623.
25. Rimani M., Mzabri I., Chafik Z., Berrichi A. 2019. Weeds flora associated with Saffron (Crocus sativus L.) in Morocco. Materials Today: Proceedings, 13, 1108-1114. https://doi.org/10.1016/j.matpr.2019.04.078
26. Stoetzel F., Campmas E., Michel P., Bougariane B., Ouchaou B., Amani F., El Hajraoui M.A., Nespoulet R. 2014. Context of modern human occupations in North Africa: Contribution of the Témara caves data. Quatern. Int. 320, 143-161.
27. Taazzouzte M., Haidara I., Ghafiri A., Lamacha H., El Moutaki S. 2023. Geochemistry of the Groundwater of the Temara Aquifer (North-West Morocco). Ecological Engineering & Environmental Technology (EEET), 24(6).
28. Yerou H., Belgharbi B., Homrani A., Miloudi A., Homrani A. 2022. Impact de la restauration par mis en defens sur les potentialites pastorales d'un parcours steppique à dominance d'artemisia herba alba dans l'algerie occidentale. Livest. Res. Rural Dev, 34.
29. Zidane L., Salhi S., Fadli M., Antri M.E., Taleb A., Douira A. 2010. Etude des groupements d'adventices dans le Maroc occidental. Biotechnol. Agron. Soc. Environ. 14(1), 153-166.