

Article

# Saïda region plants diversity (West of Algeria): First typological study of its forest and pre-steppe habitats

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**Abstract :** In the present work we assessed the different facets of biodiversity in 10 habitats using the phytosociological method. The aim of this study was to characterize the most suitable habitats for biodiversity in Saida Mountains. The Matorral with *Tetraclinis articulata* (Vahl) Mast. and *Phillyrea* sp, the Matorral with *Tetraclinis articulata*, *Rosemarinus* sp, and *Quercus coccifera* L. scrub plant community appeared to be the most diversified in terms of biodiversity and Pre-steppe formation is poor (in terms of plant diversity). However, and generally speaking, biodiversity is maximal for the more or less open tree matorrals; which decreases in the case of degradation and ecosystem fragmentation. It should be stressed that all habitats present a particular flora that is very important for the conservation of the Saida Mountains.

**Keywords :** Saida Mountains; plants diversity; typology study; habitats; phytosociological method.

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## 1. Introduction

Quézel and Santa [1] have divided the Algerian territory into 20 biogeographic sectors and sub-sectors, the majority (15) of them are located in the north of Algeria. The endemism rate and rarity vary from one sector and/or sub-sector to another. The number of endemic taxa recorded is 464 while the number of rare taxa is estimated at 1818 [2].

According to [3] the Coastal Sahels sub-sector (O1) belonging to the Oran sector (O) is the richest in endemic species with 103 taxa and the Little Kabylie sub-sector (K2) belonging to the Kabyle and Numidian sector (K) is the richest in rare taxa with 487 species. This high rate of endemism and rarity in Numidia (K2) and the Coastal Sahel sub-sector (O1) is explained by the fact that these two areas make two hotspots of phytodiversity "Kabylies-Numidie-Kroumirie" for the first zone and "Betico-rifain complex" for the second one [2].

These two hotspots belong to the refuge areas of the Little Maghreb, which is considered a region with high phyto-diversity due to a large orographic and bioclimatic com-

plexity varying from the South to the North. At the dynamic level, phytodiversity in Algeria is in irreversible decline due to global changes, especially as a result of strong anthropogenic and climatic pressures [4-6].

The ecosystems of the Saida Mountains, as with all the other formations of Tellian Atlas (Tlemcen, Sidi Bel Abbès, Mascara, Tiaret...etc) have known a continuous shrinkage due to the fires, the anthropic actions, the inadequate management and a weak rainfall related to their geographical position. This critical situation is requiring urgent restoration and rehabilitation strategies [5, 7, 8, 9, 10, 11, 12, 13, 14, 15].

Fennane et al [16], Letreuch-Belarouci et al [17], and Aouadj et al., [9, 18] all agree on the importance of establishing a directory of natural habitats for the appropriate management of phytodiversity. Without this catalog, it will be difficult for managers to make decisions that are executable. The contribution of scientists will certainly help managers by providing them with a practical guide to a very nuanced and complex natural reality. Thus, the creation of "habitat catalogs" in the Mediterranean region is gaining more and more ground. Indeed, the Directorate General of Forests has just launched a call for tender for the inventory and mapping of habitats in Algeria. This first stage is devoted to collecting information on habitats (typology of stations). Another step has been envisaged for the identification of the most diversified endangered habitats that need immediate protective action. It is within this context that this present study aims to propose a method for assessing the biodiversity of habitats in an attempt to define the most sensitive types.

## 2. Materials and Methods

### 2.1 Study area

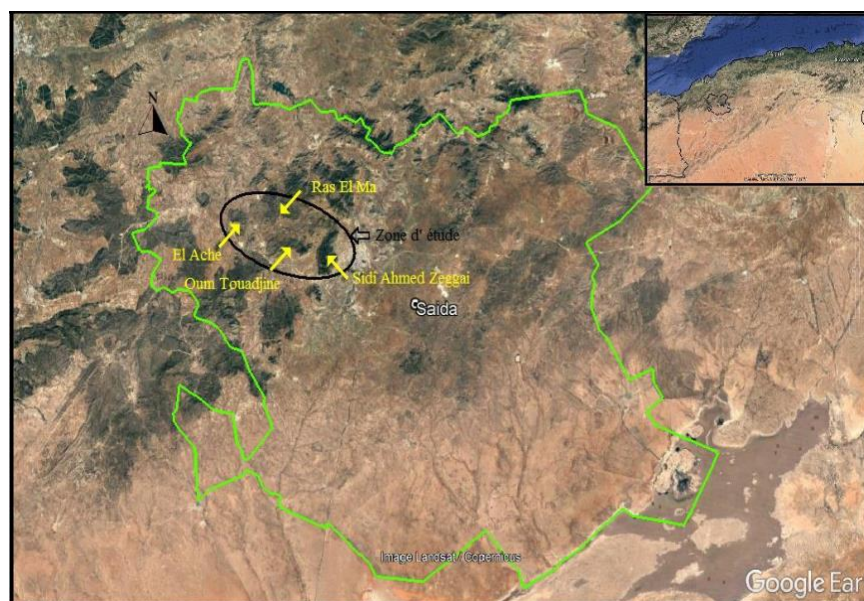
The area of Doui Thabet is located in the northwest of Algeria occupying mountainous areas of the massifs. It represents a small part of a whole forest complex of the Saida Mountains, where it occupies the mountainous hills, stretching for about twenty kilometers west of Saida town.

The study area is located according to the longitude/latitude-type projection (WGS84) between: (34.9674 degrees north), (34.8068 degrees South), (0.149499 degrees East) and (-0.1120236 West) (Fig.1). According to the DFM (Digital field Model), the study area has a heterogeneous relief, mainly rocky, with a total area of about 5624 hectares, an altitude between 580 and 1203 meters and an average altitude of 950 meters. The western sub-area is characterized by a low elevation between 580 meters and 900 meters (generally valley bottoms and foothills areas), while the high elevation distinguishes the eastern sub-area between 800 meters and 1203 meters. More than 40% of the area is dominated by low slopes (0% - 5%) which characterize the whole of the valley bottoms (lands located on the plains, Wadi "river" spreading areas) and low pedestriars. Twenty-five percent of the area has moderate slopes (5% - 15%) and characterizes the low pedestrian areas of hills (djebels and hilly areas). The remaining area (25%) has steep slopes (> 20%), particularly at the east, which causes erosion of the soils characterizing the high foothills and the summits of the mountain chains. In general, the studied area is exposed to all directions. The eastern and southern parts receive a significant amount of sunshine. While the north-facing part is exposed to a significant amount of humidity. These two factors are one of the parameters that can explain the type of vegetation and land-use in the area covered by the study. The main soil and lithological units characterizing soils in the Study Area are [19,20]:

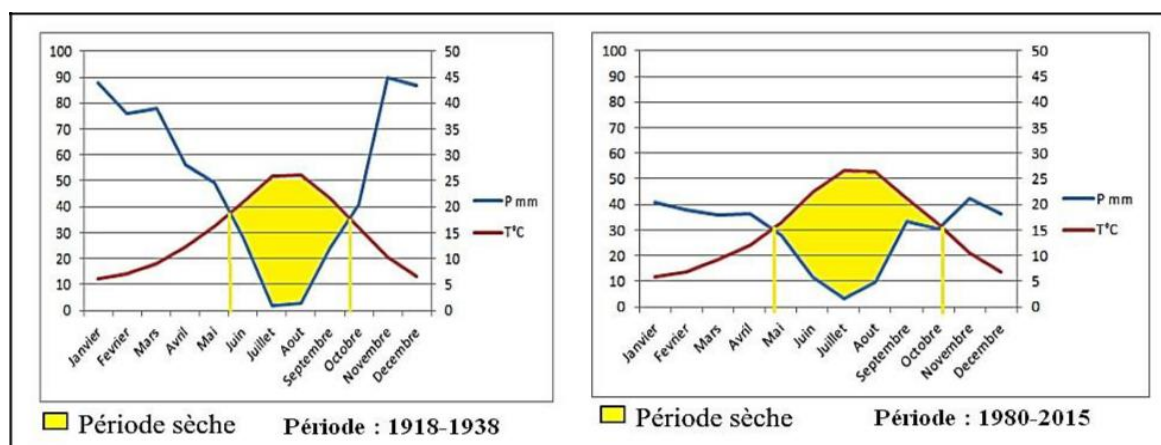
A. Lithosols: Are fairly extensive and are found on almost all denuded versants. They are shallow (generally less than 20 cm in thickness) and very fragmented.

B. Brown-red soils: Among these soils, we can distinguish brown-red soils with a humus horizon and Mediterranean brown-red soils with a slight texture. These soil types occupy the hillsides. They are formed on calcareous or dolomitic materials. They are fersialitic (rich in iron and silica) that have evolved under a caducifoliated forest in fresher and moister conditions. Their rubefaction corresponds to a warmer phase with sclerophyllous vegetation and results in red fersialitic soils or "Terra rossa". The Ombro-Thermal Diagram (OTD) of the Saida climate station between 1980 and 2015 (Fig. 2) shows that

the climate is of the Mediterranean type with a long period of drought. A drought lasts 6 to 8 months, from the beginning of May to the end of October (the current dry period is one and a half months longer than the former one). The thermal regime of the region is characterized by very high temperatures in summer and low temperatures in winter. The highest temperatures are recorded during the months of July and August, with a maximum of between 34°C and 36°C on average for the ancient and new periods respectively. As a consequence, this corresponds to high evaporation. Low temperatures occur in February with an average temperature of 9°C for the new period and 8°C for the ancient one. The minimum average temperature recorded is between 2.5°C and 2.8°C for the ancient and new periods respectively. The Emberger rainfall index classifies the Doui Thabet State Forest as upper semi-arid ( $Q_2 = 39$ ) with a fresh variety [21;22].



**Figure 1.** Geographic map of the Saida Mountains.



**Figure 2.** Ombro-thermic diagram of the study area of the ancient [23] and the new Period [24].

## 2.2. Methodology

Fieldwork for the plant inventories was held during the autumn and spring of the 2017 until 2019 (some plants are autumnal flowering, others spring flowering: early and late).

Floristic statements were performed in the different species of plants covering the entire area of study. The number of readings in each homogeneous zone depends on the diversity of ecological descriptors and the extent of each vegetation formation. At the level of each record, we mentioned the geographic location, pedological characteristics, orographic, substrate, structure, and covering rate of each stratum, as well as the abundance-domination coefficient (ADC) and the sociability of each species (Fig. 3).

### 2.2.1. Technique

In this study, we evaluated the phytodiversity of the habitats of the Saida Mountains using some indices developed by different authors. During these analyses, it is easier to use the number rather than the name of the association and the habitat. The correspondence between group numbers and the names of associations and habitats is defined in the following outline.

### 2.2.2. Biodiversity Indices

On the basis of the hierarchy proposed by Whittaker [25] and Vanpeen [26], the analysis of specific richness was carried out on four levels: specific richness by record or landscape, local richness, global richness, and original richness:

*One-off richness*: is the number of species found in a habitat. This wealth is instantly calculated habitat by habitat.

*Local richness*: is the average number of species per record of the same category according to one of the selected agglomerations (in this case, the type of habitat is taken into account). It reflects, for a given sample category, the average of the one-off richness per record and thus allows taking into account the heterogeneity of the records.

*Global richness*: is the sum of the species present in the studied category. It can be estimated for each type of habitat. Comparison of the different lists of related categories provides an indication of the heterogeneity and the degree of distinction between categories. The species common base is a list of the species present in all habitats. It, therefore, represents the number of species found throughout the spatial aggregation categories. It also reflects the homogeneity of vegetation and the species most commonly prevalent or having no particular ecological requirement.

*Original richness*: represents species that are present in one habitat. This diversity reflects the heterogeneity of the environments and their significance in the floristic heritage. A habitat will definitely contribute to the global richness of the area according to the originality of its species. In this study, we have used the punctual richness of each record in order to define: 1) the profiles of the punctual richness, 2) the average of this richness for every association or habitat (local richness), and finally, 3) the total number of species inventoried in all habitats (global richness).

To the previous analyses we included the following indices:

*Specific diversity*: Many authors have argued that the frequencies of categories should be considered when measuring biodiversity. Shannon-Weaver [27], proposed an index correcting wealth "richness" by the relative frequencies of the categories. If this index is very small (porch of 0); the number of species is low and only one or a few species dominate. On the other hand, if the index is higher, then the number of species is important and they will be equitably distributed.

The similarity index: Similarity indices allow a comparison between two sites. They assess the similarity between two groups of readings by relating the common species to both readings to the species-specific to each reading. Commonly used indices include:

- The Dice or Czekanowski index of Guinocet [28]: This index is between 0 (no species common to both habitats) and 1 (identical habitats).

$$S = 2nt / (ax + bx + cx + \dots + nx)$$

Where

a = number of species common to record 1 and record n

b - Number of species present only in record 1

c - Number of species present only in record n

### 3. Results and Discussions

The forest groups of the Saida Mountains belong to a series of 4 species, namely: *Pinus halepensis* Mill, *Tetraclinis articulata*, *Juniperus oxycedrus* L., and *Quercus coccifera*. The syntaxonomic study conducted by some authors [29, 30] identified 10 habitats corresponding to 10 plants associations (Tab. 1).

**Table 1.** Matching group numbers and names of associations and habitats.

| No | Habitat                                              | Association                                                                       | Place                           |
|----|------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------|
| 1  | Matorral of Aleppo pine                              | <i>Pinutium halepensis</i>                                                        | Sidi Ahmed Zeggai               |
| 2  | Aleppo Pine Reforestation                            | <i>Aleppo Pine Reforestation</i>                                                  | Ras El Ma                       |
| 3  | Matorral to Thuya and Filary                         | <i>Tetraclino articulatae-Phillyreum latifoliae</i>                               | El Ache and Lardjeme            |
| 4  | Matorral in Thuya and Rosemary                       | <i>Rosemary tournefortii-Tetraclinetum articulatae</i>                            | El Ache and Oum Touadjine       |
| 5  | Frustrated with Lentisques                           | <i>Clear low matorrals at Pistacia lentiscus</i>                                  | Sidi Ahmed Zeggai and Ras El Ma |
| 6  | Matorral to Thuya, calicotome and lavender stoechas  | <i>Calycotomo intermediae-Tetraclinetum articulatae lavandulotosum stoechadis</i> | El Ache                         |
| 7  | Matorral to Thuya calicotome, and Aleppo pine        | <i>Calycotomo intermediae-Tetraclinetum articulatae pinetosum halepensis</i>      | El Ache and Sidi Ahmed Zeggai   |
| 8  | Matorral in Thuya and calicotome and wild olive tree | <i>Calycotomo intermediae-Tetraclinetum articulatae oleetosum</i>                 | El Ache and Sidi Ahmed Zeggai   |
| 9  | Kermes oak scrub                                     | <i>Quercetum shardsae</i>                                                         | El Ache and Sidi Ahmed Zeggai   |
| 10 | Pre-steppe                                           | <i>Stippa tenacissima</i>                                                         | El Ache                         |

#### *The floristic richness*

The overall richness of the different forest habitats varies from 78 for Group 3 to 20 for Group 6. This discrepancy is partly responsible for the differences in overall wealth observed. This variation in the number of inventories is due to the size of the areas occupied by each habitat. Groups 3, 4, and 9 are by far the groups that occupy the largest areas, while groups 5, 10, and 11 remain much localized. Some groups, such as Group 4, have almost half the overall richness of Group 3 with the same number of records.

#### *Local richness*

Groups 3, 4, and 9 have the highest local richness (62, 81 species/100 m<sup>2</sup> respectively) followed by groups 2, 6, and 8. The lowest values recorded are 28 and 24 in groups 1 and 7 respectively. Local richness is lower in closed environments and more important in open environments.

#### *Original richness*

Among the combinations of habitats studied, only 5 species constitute the common fund of these areas. These species are: *Pinus halepensis* Mill, *Tetraclinis articulata*, *Cistus* sp, *Lavandula* sp and *Pistacia lentiscus* L. These species also have very high sums of abundance coefficients. 344 species are present only once in the combinations. Only 3 habitats have a significant native richness (group 3: 78 species, group 4: 41 species, and group 9: 39 species). Four additional habitats have a medium original richness (between 09 and 25 species). The rest of the habitats have very low rates of native richness.

### Floristic diversity

Graphic representations of percentages of species expressed by biological type give an idea of the structure of forest habitats in the region. Therophytes are best represented in most groups, with the exception of group 8 where Nanophanerophytes dominate. This biological type is well represented in more or less dense forest groupings including Phanerophytes. The Chamephytes seem to be related to forest groups and matorrals rich in Cisto-Rosmarinitea traits. Geophytes do not exhibit any particular tendency. The highest rates are observed at the level of groups 4 and 3 (Table 2), both very close to the coast.

**Table 2.** Results of biological indices for each habitat.

| Habitat | (S) | (H') |
|---------|-----|------|
| 1       | 24  | 0.97 |
| 2       | 22  | 0.90 |
| 3       | 78  | 2.10 |
| 4       | 41  | 1.80 |
| 5       | 22  | 0.90 |
| 6       | 20  | 0.85 |
| 7       | 34  | 1.10 |
| 8       | 30  | 1.00 |
| 9       | 39  | 1.40 |
| 10      | 18  | 0.87 |

### 4. Conclusions

The different facets of phytodiversity were assessed for each habitat. The main highlights can be stated as follows: Groups 3, 4, and 9 show a very important global, original and local richness. Remarkable flora is also rich in these groups. However, the Shannon Weaver index is very high in groups 3, 4, and 9 while it is average for the other group. In general, it can be said that all the habitats of the Saida Mountains present an important flora requiring the conservation and restoration of this area. Numerous rare and endemic species are specially assigned to certain types of habitats. We can also make one more important observation that the floristic richness of the habitats is maximal for the more or less open tree matorrals, and it decreases in the case of degradation and the closure of the environment as well. Despite the importance of the original and remarkable flora at Saida mount, the constancy and abundance of certain species should not be neglected. The latter form the backbone of the plant formations of the Saida Mountains. The presence of these species is often related to the importance of certain disturbances.

### References

1. Quézel, P., Santa, S. Nouvelle flore de l'Algérie et des régions désertiques méridionales. 1962.
2. Benabdeli, K. Aspects physionomico-structuraux et dynamique des écosystèmes forestiers face à la pression anthropogène dans les monts de Tlemcen et les Monts de Dhaya. Algérie occidentale. Thèse de doctorat ès Sciences. Université de Marseille III, 1996, 356p.
3. Nasrallah, Y. Caractérisation de la variabilité morphologique des 21 provenances algériennes de Chenet vert (*Quercus totendifolia* Lam.), évaluation de leur adaptation écologique dans la région semi-aride de Saida. These Doctorat en sciences agronomique. Ecole nationale supérieure d'agronomie El Harache. 2014, 213P.

4. Aouadj, S.A. Impact des techniques de restauration écologique sur la dynamique des écosystèmes dégradés des monts de Saida : Cas des forêts de Doui Thabet – (Ouest Algérie). Thèse de doctorat, Université Aboubakr Belkaïd – Tlemcen. 2021, 148P.
5. Boulghobra, N., Saifi, M., Benmalek, A. Evaluation et cartographie des feux de forêts généralisés d'août 2021 à Bejaia et Tizi Ouzou: Approche géomatique. *Journal Algérien des Régions Arides* 14.2 (2022) : 60-67.
6. Nasrallah, Y., Aouadj, S.A. Khatir, H. Impact of the exploitation of medicinal plants on biodiversity conservation in the region of Saida and El Bayadh, Algeria". *Biodiversity, research and conservation*. 2020, 60 : 11-22.
7. Bouazza, K., Ghemmez, A., Berdali, N., Naggar, O., Labdelli, A. Etude éco-dendrométrique de *Pinus halepensis* Mill. dans la forêt communale de Tiaret (Djebel Guezoul). *Journal Algérien des Régions Arides*. 2017 ; 14, 34-40
8. Allam, A., Borsali, A. H., Kefifa, A., Zouidi, M., & Gros, R. Effect of fires on certain properties of forest soils in Western Algeria. *Acta Technologica Agriculturae*, 2020, 23(3), 111-117.
9. Aouadj, S.A., Nasrallah, Y., Hasnaoui, O. Ecological characterization and evaluation of the floristic potential of the forest of Doui Thabet (Saida Western Algeria) in the context of the restoration. *Eco. Env. & Cons.* 2020, 26 (1). 266-278.
10. Djebaili, S. Recherche phytosociologique et phytoécologique sur la végétation des hautes plaines steppiques de l'Atlas saharien algérien. Thèse de doctorat. Univ. Sci. Lanquedoc, Montpellier. 1978.
11. Hasnaoui, O. Contribution à l'étude des Chamaeropaies dans la région de Tlemcen, Aspects botanique et cartographiques. Thèse de doctorat. Univ. Aboubekr Belkaïd Tlemcen. 2008, 210p.
12. Hasnaoui, O., Bouazza M. Indicateurs de dégradation des bio-ressources naturelles de l'Algérie occidentale : cas de la steppe de la wilaya de Saida. *Algerian Journal of Arid Environment*. 2015, 5 (1) ; 63-75.
13. Aouadj, S.A., Nasrallah, Y., Hasnaoui, O. Regional phytogeographic analysis of the flora of the Mounts of Saida (western Algeria): evaluation-restoration report. *Biodiversity Journal*. 2020, 11 (1). 25–34.
14. Aouadj, S.A., Nasrallah, Y., Hasnaoui, O., Khatir H. Impacts of anthropogenic pressure on the degradation of the forest of Doui Thabet (Saida, Western Algeria) in the context of the restoration. *Acta scientifica naturalis*. 2020, 7 (2): 68-78.
15. Allam, A., Borsali, A. H., Kefifa, A., Zouidi, M., Da Silva, A. M. F., RéBufa, C. (2021). Impact of water erosion on the properties of forest soils. *Notulae Scientia Biologicae*, 2021, 13(2), 10921-10921.
16. Fennane, M., Ibn Tattou, M., Mathez, J., Ouyahya, A. El Oualidi J. Flore Pratique Du Maroc ; Manuel De Détermination Des Plantes Vasculaires, Vol. 1. Trav. Inst. Sci., Rabat, Sér. Botanique. 1999, 36 : 558 p.
17. Letreuch-Belarouci, A., Medjahdi, B., Letreuch Belarouci, N., Benabdeli, K. Diversité Floristique Des Subéraies Du Parc National De Tlemcen (Algérie). *Acta Botanica Malacitana, Màlaga*. 2009, 34 : 77- 80
18. Aouadj, S.A., Hasnaoui, O., Nasrallah, Y. Ethnobotanical Approach and Floristic Inventory of Medicinal Plants in the Doui Thabet Region (Saida-Western Algeria). *Phytochemistry & Bioactive Substances*. 2020, 14 (1): 92-104.
19. Aouadj, S.A., Nasrallah Y., Hasnaoui O., Khatir H. Impact of ecological restoration techniques on the dynamics of degraded ecosystems of the mounts of Saida: Case of the forests of Doui Thabet (West Algeria). *Acta scientifica naturalis*, 2020, 7 (2): 68-77.
20. Zouidi, M., Borsali, A. H., Allam, A., Gros, R. Quality estimation of the western Algeria forest soils. *Malaysian Journal of Soil Science*, 2019, 23: 87-98.
21. Aouadj, S.A., Nasrallah Y., Hasnaoui O. Note on the orchids of mounts of Saida (Saida Western Algeria) in the context of the restoration. *Ecology, Environment. & Conservation* . 2020, 26 (2): 37-45.
22. Zouidi, M., Borsali, H, B., Allam, A., Gros, R. Microbial activities and physicochemical properties of coniferous forest soils in two forest areas (arid and semi-arid) of western Algeria. *Bosque*, 2019, 40(2): 163-171.
23. Seltzer, P. Le climat de l'Algérie. Inst. Météor. et de Phys. du Globe. Alger. 1946, 219 p.
24. ONM. Rapport des données annuelles de l'office national de météorologie, station de Saida. 2015.
25. Whittaker, R.H. Evolution and measurements of species diversity. *Taxon*, 1972, 21: 213-251.

26. Vanpeene, B, S. Transformation des paysages et dynamiques de la biodiversité végétale. Les écotones, un concept clé pour l'étude des végétations post-culturelles. Thèse de Doctorat. ENGREF, Grenoble. 1998, 312 p.
27. Shannon, C. E, Weaver, W. The mathematical theory of communication, university of Illinois Press Urbana 1963, pp117
28. Guinochet, M. Logique et dynamique du peuplement végétal : phytogéographie, phytosociologie biosystématique, applications agronomiques. No. 7. Masson, 1955.
29. Aouadj, S.A., Nasrallah, Y., Hasnaoui, O., Khatir, H. Rare, endemic and threatned flora of the mounts of Saida (western Algeria). *Agrobiologia*. 2020, 11 (2): 45–57.
30. Djebbouri, M., Zouidi, M., Terras, M., Merghadi, A. Predicting suitable habitats of the major forest trees in the Saïda region (Algeria): A reliable reforestation tool. *Ekológia (Bratislava)*, 2022, 41(3): 236 –246.