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FLORISTIC DIVERSITY OF THE GHARDAIA REGION

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ABSTRACT

Our work aims to inventory and analyze the vegetation in the Ghardaia region. To achieve this, we selected eight study sites. The inventory conducted allowed us to compile a floristic list of 86 species distributed across 29 families, with Asteraceae being the most represented (20 species). In terms of biological types, the species recorded across all stations show a balanced dominance between Chamaephytes and Therophytes. The flora includes 40 perennial plants and 42 annual plants. Among the families, three belong to Monocotyledons and 26 to Dicotyledons. The frequency of the inventoried species varies from one station to another, with a clear dominance of *Oudneya africana*, *Pergularia tomentosa*, and *Pituranthos chloranthus*, representing 4.05 % of the total, followed by *Echinops spinosus*, *Fagonia glutinosa*, and *Peganum harmala*, with a rate of 3.47 %. In third position, with a rate of 2.89 %, are *Artemisia herba-alba*, *Atractylis delicatula*, Cleome *amblycapra*, *Launaea glomerata*, and *Rhantherium adpressum*.

Keywords: Inventory, plant biodiversity, biological type, Ghardaia.

1-Introduction

The Sahara, covering nearly eight million km², is not only the largest desert but also one of the most emblematic due to its extreme aridity. Indeed, it is in this desert that drought conditions reach their peak. The vegetation cover is fragmented and highly irregular, with plants concentrating mainly in areas where water supply is slightly less unfavorable (OZENDA, 1983).

The vegetation of arid regions, particularly that of the Sahara, is very sparse, offering a generally bare and desolate landscape. Trees are rare and scattered, and grasses appear only during a very short period of the year when conditions become favorable. This Saharan flora is distinguished by its remarkable adaptation to a dry climate and saline soils (TRABUT and MARES, 1906, p.499).

Compared to the vastness of the area it occupies, this flora appears very poor, with only 1200 recorded species (OZENDA, 1983).

Our study aims to inventory and analyze plant biodiversity in several sampling stations selected in the Ghardaia region.

2-Presentation of the Study Site

The region of Ghardaia is located approximately 600 km south of the capital Algiers. The sampling stations are situated within the following geographical coordinates:

The northwestern limit of Ghardaia; Berriane: 32° 51′ 32″ North, 3° 45′ 46″ East.

The northeastern limit of Ghardaia; Guerrara: 32° 47′ 25″ North, 4° 29′ 32″ East.

The southern limit of Ghardaia; Sebseb: 32° 9′ 51″ North, 3° 35′ 20″ East.

The Wilaya of Ghardaia is bordered:

- To the north by the Wilaya of Laghouat (200 km);
- To the northeast by the Wilaya of Djelfa (300 km);
- To the east by the Wilaya of Ouargla (200 km);
- To the west by the Wilaya of El-Bayadh (350 km);
- To the southwest by the Wilaya of El-Goléa (275 km).

3-Selection of Study Stations

In order to understand the organization of the plant community in the study region, a floristic inventory was carried out using the linear transect method.

To conduct this work, we selected 8 stations based on the homogeneity of the vegetation cover, and within each of them, floristic surveys were carried out during the flowering period of the vegetation (March–May 2023). The selection of the stations is based on the homogeneity of the vegetation cover of the study site.

3.1 - Specific Richness (S)

It is the total number of species in the community or in a given survey. In our case, the total richness is the total number of plant species inventoried at our site.

3.2 - Average Richness (s)

It corresponds to the average number of species present in a sample of the biotope whose surface area has been arbitrarily fixed. The average richness makes it possible to calculate the homogeneity of the

population (Ramade, 2003). In our case, it represents the number of species inventoried in each station.

3.3 - Abundance-Dominance

The species present in each of the surveys are assigned two coefficients: the first expresses their abundance-dominance (an estimation of the number of individuals and their ground cover), and the second their sociability (the distribution pattern of individuals over the studied area).

- +: rare (or very rare) individuals and very low cover
- 1: fairly abundant individuals, but low cover <5%
- 2: very abundant individuals, cover at least 1/20 = 5%
- 3: any number of individuals, cover from 1/4 to 1/2 = 25–50%
- 4: any number of individuals, cover from 1/2 to 3/4 = 50–75%
- 5: any number of individuals, cover more than 3/4 >75%

Abundance-dominance scale (Braun-Blanquet et al., 1952)

4- Results

4.1- List of Inventoried Plants

A total of **86 plant species** was recorded, distributed across **29 different families** (Table 1). The **Asteraceae** family is the most represented with **20 species**, followed by the **Chenopodiaceae** with **8 species**, **Brassicaceae** with **7 species**, **Poaceae** with **6 species**, and **Fabaceae** with **5 species**. The families **Apiaceae**, **Euphorbiaceae**, **Liliaceae**, **Resedaceae**, and **Zygophyllaceae** each include **3 species**. Six other families — namely **Asclepiadaceae**, **Boraginaceae**, **Lamiaceae**, **Plantaginaceae**, **Solanaceae**, and **Tamaricaceae** are each represented by **2 species**. The remaining **11 families**, each mono-specific, make a modest contribution but nevertheless add to the floristic diversity and richness of this Saharan region see Appendix Table 6.

Table 1: Different Families of the Inventoried Species

Family	Frequency	Family	Frequency
Asteraceae	20	Tamaricaceae	2
Chenopodiaceae	8	Amaryllidaceae	1
Brassicaceae	7	Arecaceae	1
Poaceae	6	Campanulaceae	1
Fabaceae	5	Cistaceae	1
Apiaceae	3	Convolvulaceae	1
Euphorbiaceae	3	Cucurbitaceae	1
Liliaceae	3	Geraniaceae	1
Resedaceae	3	Polygonaceae	1

Zygophyliaceae	3	Rhamnaceae	1
Asclepiadaceae	2	Rosaceae	1
Boraginaceae	2	Rutaceae	1
Lamiaceae	2	Thymelaeceae	1
Plantaginaceae	2	Urticaceae	1
Solanaceae	2		

4.2 - Specific Richness

The total number of floristic species inventoried within the study region of Ghardaia is estimated at 86 species.

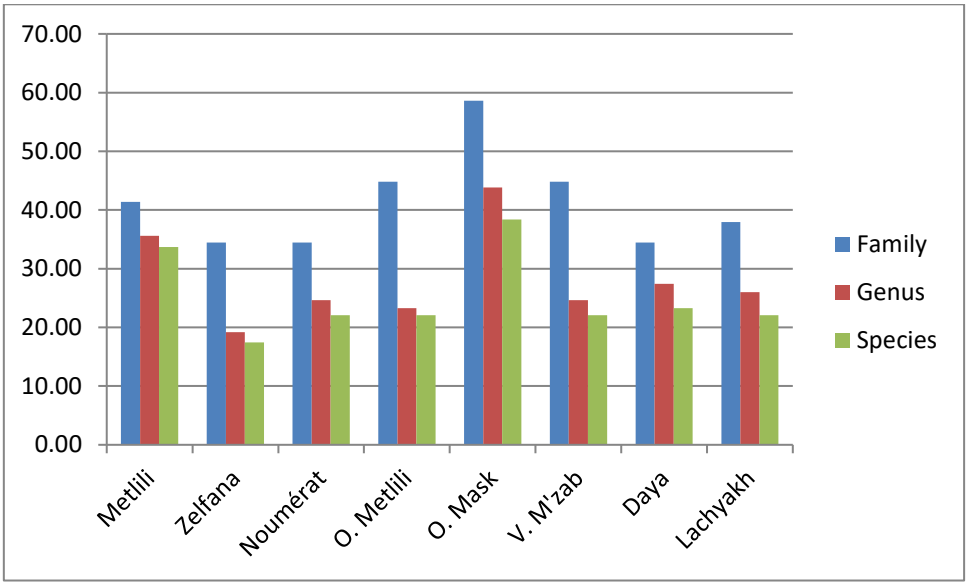

Figure 1. Distribution of Families, Genera, and Species – Ghardaia 2023

Figure 1 illustrates the distribution of families, genera, and species across different localities in the Ghardaia region.

Diversity at the Family Level:

- Only the station **"O. Mask"** shows the highest family diversity, with a percentage of approximately **60%**. This station therefore appears to have the greatest diversity of plant families.
- Other stations such as **"Metlili"**, **"O. Metlili"**, and **"V. M'zab"** also show a good representation of families, with values ranging between **40% and 50%**.

Diversity at the Genus Level:

- Genus-level diversity is relatively balanced across the stations, although **"O. Mask"** and **"Metlili"** show a higher representation of genera compared to the other stations.
- Stations like **"Noumérat"** and **"Zelfana"** have lower genus diversity, around **20%**.

Diversity at the Species Level:

- The distribution of species is relatively balanced in most stations, with representation ranging between **20% and 40%**.
- **"V. M'zab"** appears to have a relatively higher proportion of species.

It can be concluded that O. Mask stands out with greater diversity at the family level, suggesting marked floristic richness in this station. Metlili shows good diversity across all categories (families, genera, species), which could indicate a station with a balanced and diverse ecosystem. Finally, Zelfana and Noumérat appear to be the stations with the lowest diversity, both in terms of families, genera, and species.

4.3 - Average Richness

According to the results obtained (Table 2), the first station is rich with 33 species, while the last station is rich with 15 species see Table 7 detailed in the appendix.

Table 2. Station-Based Floristic Richness

	Specific Richness
O. Mask	33
Metlili	29
Daya	20
Noumérat	19
O. Metlili	19
V. M'zab	19
Lachyakh	19
Zelfana	15
Richesse Totale	173
Average Richness (%)	21,625

O. Mask stands out for its particularly high biodiversity, which may indicate ecological conditions favorable to a wide variety of species.
Metlili also shows rich biodiversity, followed by other stations such as Daya and Noumérat, which are around the average.
Zelfana presents lower specific richness, which could be linked to more restrictive environmental conditions or greater disturbance.
These data can be used to guide conservation efforts by focusing on areas with high biodiversity while seeking to understand and improve conditions in areas with low specific richness.

4.4 - Botanical Classes of the Ghardaia Region

Dicotyledon	Monocotyledon
76	10

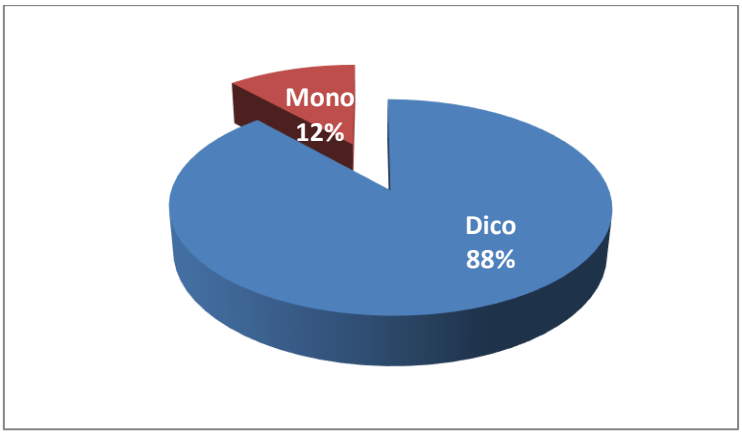

Figure 2. Botanical Classes of the Ghardaia Region – 2023.

According to the following figure (Figure 2), the class of dicotyledons is dominant, representing 88.37% of the specific richness, while monocotyledons are less represented, accounting for 11.63% in the Ghardaia region (Table 3).

Table 3. Contribution of Botanical Classes by Station

	Dicotyledon		Monocotyledon	
Metlili	24	**82,76**	5	**17,24**
Zelfana	15	**100,00**	0	**0,00**
Noumérat	19	**100,00**	0	**0,00**
O. Metlili	18	**94,74**	1	**5,26**
O. Mask	31	**93,94**	2	**6,06**
M'zab	17	**89,47**	2	**10,53**
Daya	19	**95,00**	1	**5,00**
Lachyakh	19	**100,00**	0	**0,00**
W. Ghardaia	86	**88,37**	11	**11,63**

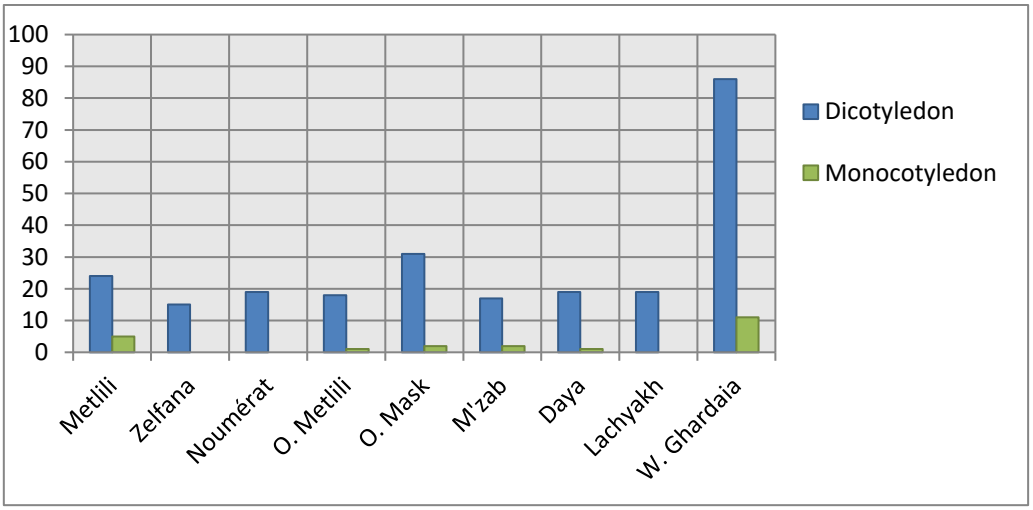

Figure 3: Specific Richness of Monocotyledons and Dicotyledons Inventoried in Each Station.

Figure 3 shows the distribution of plant species according to their classification into dicotyledons and monocotyledons across different stations in the Ghardaia region.

A- Dominance of Dicotyledons:

- Figure 3 shows that **dicotyledons** are significantly more represented than monocotyledons in all stations.
- **"O. Mask"** and **"Metlili"** show a notable representation of dicotyledons, around **30%**.

B- Low Representation of Monocotyledons:

- ✓ Figure 3 illustrates that **monocotyledons** are weakly represented across all stations.
- ✓ The proportion of monocotyledons is particularly low, generally **below 10%** in all stations.
- ✓ Localities such as **"Zelfana"**, **"Noumérat"**, and **"O. Metlili"** show the lowest diversity in monocotyledons.
- ✓ There is a clear dominance of dicotyledons in the flora of the studied stations, which may indicate ecological conditions favoring this group of plants.
- ✓ This distribution could reflect the ecological adaptations of dicotyledonous plants to the arid region of Ghardaia, where they appear to be better adapted than monocotyledons.

4.5 - Biological Types

A. Biological Types of the Ghardaia Region

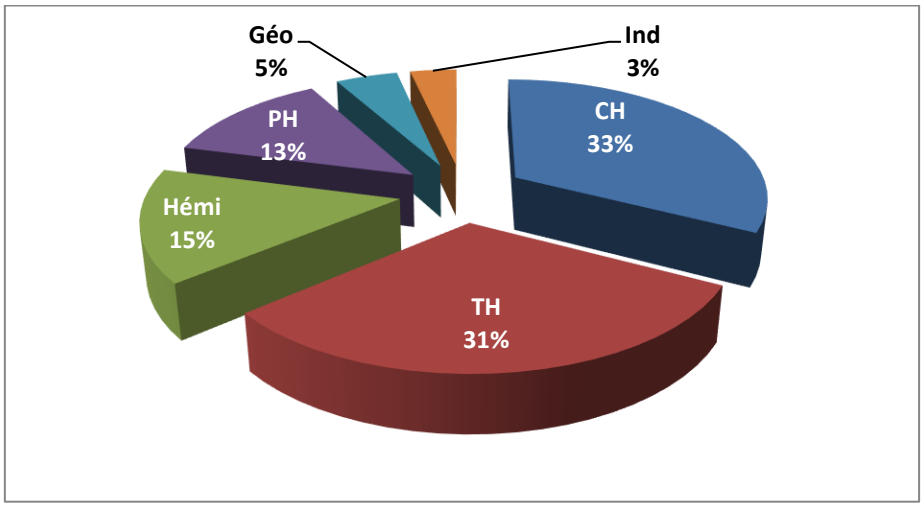

Figure 4. Biological Types of the Ghardaia Region – 2023

Figure 4 shows the distribution of the biological types of plant species observed in the Ghardaia region, based on their survival strategies and ecological adaptations.

❖ **Dominance of Chamaephytes (CH) and Therophytes (TH)**

- ✓ Chamaephytes (CH) represent 33% of the flora, indicating that these plants, which survive partly in the form of low woody stems, are the best adapted to the arid environment of the region.

- ✓ Therophytes (TH), representing 31%, are the second most abundant. These annual plants, which complete their life cycle rapidly during the favorable season, are well adapted to extreme conditions.

❖ **Notable Presence of Hemicryptophytes (Hémi) and Phanerophytes (PH)**

- ✓ Hemicryptophytes (Hémi) make up 15% of the species. This group includes perennial plants that survive with buds located at ground level—an effective strategy in arid environments.
- ✓ Phanerophytes (PH), which are plants with buds located well above the ground (such as trees and shrubs), represent 13% of the flora.

❖ **Low Representation of Geophytes (Géo) and Undetermined (Ind)**

- ✓ Geophytes (Géo) account for 5%. This group, which survives through underground organs (bulbs, rhizomes), is less common in this environment.
- ✓ Undetermined species (Ind) represent 3%, corresponding to plants for which the biological type has not been identified.

The vegetation of the studied region is dominated by Chamaephytes and Therophytes, reflecting significant adaptation to arid conditions. These plants possess survival strategies that allow them to withstand long periods of drought and extreme temperatures.

The diversity of biological types indicates a varied yet specialized adaptation of plant species to the desert environment, with a clear preference for small perennial plants or annuals.

B- Contribution of Biological Types by Station

Table 4. Contribution of Biological Types by Station

	Ind	CH	TH	Hémi	PH	Géo	Disturbance Index
Metlili	10,34	27,59	41,38	10,34	0,00	10,34	**68,97**
Zelfana	0,00	46,67	26,67	6,67	20,00	0,00	**73,33**
Noumérat	0,00	42,11	31,58	21,05	0,00	5,26	**73,68**
O. Metlili	0,00	10,53	26,32	15,79	42,11	5,26	**36,84**
O. Mask	0,00	54,55	15,15	18,18	9,09	3,03	**69,70**
V. M'zab	0,00	52,63	21,05	15,79	10,53	0,00	**73,68**
Daya	0,00	25,00	45,00	15,00	10,00	5,00	**70,00**
Lachyakh	0,00	52,63	36,84	10,53	0,00	0,00	**89,47**
Ghardaia	**5,70**	**53,2**	**51,3**	**24,7**	**20,9**	**7,6**	**63,95**

According to Table 4, the distribution of plant biological types across different stations is presented in percentages. These percentages show the dominance of the various biological types (Chamaephytes, Therophytes, etc.) in each station.

1. Metlili

- Therophytes (TH) dominate with 41.38%, indicating a strong presence of annual plants that complete their life cycle during the wet season.

- Chamaephytes (CH) represent 27.59%, showing a notable presence of small perennial plants.
- Geophytes (Géo) and Undetermined (Ind) types are equally represented at 10.34%, suggesting a diversity of adaptation strategies to the arid environment.

2. Zelfana

- Chamaephytes (CH) are largely dominant with 46.67%, highlighting the prevalence of perennial plants adapted to aridity.
- Therophytes (TH) follow with 26.67%, showing a good representation of annual plants.
- Phanerophytes (PH) account for 20%, indicating the presence of shrubs or trees.

3. Noumérat

- Chamaephytes (CH) dominate with 42.11%.
- Therophytes (TH) follow with 31.58%.
- Hemicryptophytes (Hémi) are well represented at 21.05%, indicating the presence of perennial plants that survive with buds at ground level.

4. O. Metlili

- Phanerophytes (PH) are dominant with 42.11%, indicating a strong presence of trees and shrubs.
- Therophytes (TH) follow with 26.32%.
- Hemicryptophytes (Hémi) represent 15.79%.

5. O. Mask

- Chamaephytes (CH) are dominant with 54.55%, highlighting their adaptation to this environment.
- Therophytes (TH) are present at 15.15%.
- Hemicryptophytes (Hémi) represent 18.18%.

6. V. M'zab

- Chamaephytes (CH) dominate with 52.63%.
- Therophytes (TH) follow with 21.05%.
- Hemicryptophytes (Hémi) are represented at 15.79%.

7. Daya

- Therophytes (TH) dominate with 45.00%, highlighting the dominance of annual plants.

- Chamaephytes (CH) account for 25.00%.
- Hemicryptophytes (Hémi) represent 15.00%.

8. Lachyakh

- Chamaephytes (CH) dominate with 52.63%.
- Therophytes (TH) follow with 36.84%, showing strong representation of annual plants.
- Hemicryptophytes (Hémi) are at 10.53%.

In conclusion, Chamaephytes (CH) are often dominant, particularly in O. Mask, Lachyakh, V. M'zab, and Zelfana. This reflects a strong adaptation of small perennial plants to these arid environments.

Therophytes (TH), which complete their life cycle within a single season, are also well represented, especially in Metlili and Daya.

Phanerophytes (PH) are particularly dominant in O. Metlili, suggesting a locality with a strong presence of trees and shrubs.

The low presence of Hemicryptophytes (Hémi) and Geophytes (Géo) may be due to inadequate soil conditions; soils that are too sandy, too clayey, or very poor in nutrients may not provide the necessary conditions for their survival. Geophytes, in particular, often depend on soil that allows them to effectively store nutrients and water in underground organs. A soil that is too compacted or poorly drained can limit their development.

Each station presents a unique combination of biological types, highlighting the specific adaptation of plant species to local conditions in the Saharan region.

C - Disturbance Index

The disturbance index is an ecological tool used to assess the degree of disturbance or change within an ecosystem or habitat. It reflects the extent to which an area has been affected by external factors such as human activities, natural disasters, or other disturbances.

✓ **High Disturbance:**

Lachyakh is the most disturbed area, followed by **Noumérat**, **V. M'zab**, **Zelfana**, **Daya**, **O. Mask**, and **Metlili**, all of which show high levels of disturbance, with respective values of:

89.47; 73.68; 73.68; 73.33; 68.97; 70.00; 69.70.

✓ **Low Disturbance:**

O. Metlili has the lowest disturbance index (**36.84**), suggesting relatively low disturbance in this area.

These indices may reflect various disturbance factors such as the impact of human activities, environmental changes, or natural disturbances.

Understanding these indices helps assess the ecological status of the sites and to plan appropriate management and conservation actions.

At the regional level, the Ghardaia region shows a moderate level of disturbance compared to other sites.

4.6 - Life Form Categories of the Flora of Ghardaia

Table 5. Contribution of Life Form Categories of the Flora of Ghardaia

	Perennial		Ephemeral		Undetermined	
Metlili	10	**34,48**	15	**51,72**	4	**13,79**
Zelfana	9	**60,00**	6	**40,00**	0	**0,00**
Noumérat	7	**36,84**	12	**63,16**	0	**0,00**
O. Metlili	12	**63,16**	7	**36,84**	0	**0,00**
O. Mask	17	**51,52**	16	**48,48**	0	**0,00**
V. M'zab	10	**52,63**	9	**47,37**	0	**0,00**
Daya	11	**55,00**	9	**45,00**	0	**0,00**
Lachyakh	6	**31,58**	13	**68,42**	0	**0,00**
W. Ghardaia	40	**46,51**	42	**48,84**	4	**4,65**

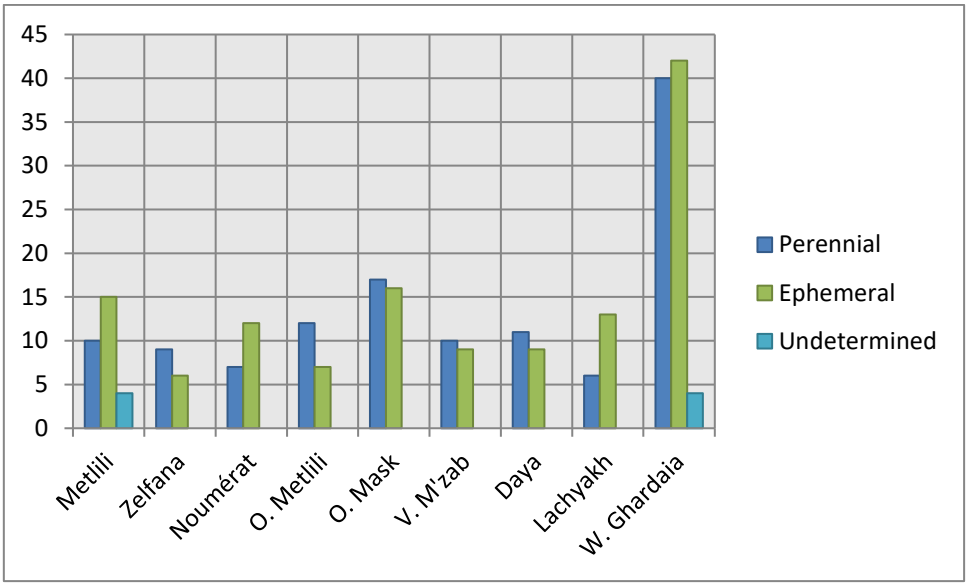

Figure 5. Contribution of Life Form Categories in the Ghardaia Region.

According to Table 5 and Figure 5, the distribution of plant types (perennials, ephemerals) is represented across various stations (Metlili, Zelfana, Noumérat, O. Metlili, O. Mask, V. M'zab, Daya, Lachyakh, and the overall Ghardaia region).

1. **Perennial Plants**

✓ Perennial plants are present in all stations, but their proportion varies. For example, O. Mask has the highest proportion of perennials, followed by O. Metlili, Daya, and Metlili, which have a moderate number of perennial species.

2. **Ephemeral Plants**

✓ Ephemeral plants are also present in all stations, but their abundance is relatively high in O. Mask, Metlili, Lachyakh, and Noumérat.

In conclusion, the varied distribution of plant types in these stations appears to make the region a diversity hotspot, with a strong presence of both plant types. The distribution may be influenced by the specific ecological conditions of each locality, such as soil, climate, or level of disturbance.

5- Discussion

To discuss the full set of results we have explored, we must address various aspects related to the plant biodiversity of the Ghardaïa region. This discussion encompasses botanical families, biological types, species abundance-dominance, and their distribution across the different localities of the study:

5.1 - Distribution of Botanical Families

- **Family Diversity:** The Ghardaïa region presents significant diversity with 86 species distributed across 29 families. The Asteraceae family is the most represented with 20 species, followed by Chenopodiaceae (8 species) and Brassicaceae (7 species). This reflects the successful adaptation of these families to desert conditions, where species have developed survival mechanisms to withstand aridity.
- **Less Represented Families:** Some families, although sparsely represented (e.g., Tamaricaceae with 2 species or Amaryllidaceae with only 1 species), still contribute to the overall floristic richness. These mono-specific families indicate ecological specialization, where certain species occupy very specific niches.

5.2 - Analysis of Biological Types

- **Dominance of Chamaephytes (CH) and Therophytes (TH):** Chamaephytes (CH) and Therophytes (TH) dominate the studied stations, representing **33%** and **31%** of the inventoried flora, respectively. This distribution indicates that the vegetation is primarily composed of species capable of withstanding harsh climatic conditions. Chamaephytes, in particular, are adapted to aridity by keeping their buds close to the ground, thereby minimizing evapotranspiration, while therophytes survive by completing their life cycle rapidly before the dry season.
- **Stational Variability:** The different study sites show variations in the distribution of biological types. For example, **O. Metlili** shows a dominance of **Phanerophytes (PH)** at **42.11%**, which could suggest an area with more favorable microclimates or the presence of underground water sources. This contrasts with other stations such as **O. Mask** and **Lachyakh**, where **Chamaephytes** are overwhelmingly dominant.

5.3 - Species Abundance-Dominance

- **Dominant Species:** The most frequent species in the region include *Oudneya africana*, *Pergularia tomentosa*, and *Pituranthos chloranthus*, which show strong dominance with a **cover rate of 4.05%**. These species are well adapted to desert conditions, occupying key ecological niches.
- **Secondary Species:** Other species such as *Echinops spinosus*, *Fagonia glutinosa*, and *Peganum harmala*, with a **cover rate of 3.47%**, play an important role in the ecosystem despite their lower

dominance. These species may be crucial for ecosystem stability by providing habitats for wildlife and contributing to overall plant diversity see Table 7 in the appendix.

5.4 - Comparison Between Stations

5.4.1 - Variability in Specific Richness

The diagrams show a variation in specific richness in terms of families, genera, and species across the different stations. For example, O. Mask presents the highest diversity in terms of families, which could indicate a more heterogeneous environment offering a greater variety of ecological niches.

The specific richness data indicate the total number of species per station:

- O. Mask: 33 species *(highest)*
- Metlili: 29 species
- Daya: 20 species
- Noumérat, O. Metlili, V. M'zab, Lachyakh: 19 species
- Zelfana: 15 species *(lowest)*

The total richness across all stations combined is 173 species, with an average richness of approximately 21.625 species per station.

- O. Mask and Metlili show high specific richness, which may indicate diverse ecosystems and potentially lower levels of disturbance.
- Zelfana displays the lowest specific richness, which could be linked to harsher arid conditions, greater ecological disturbance, or reduced availability of ecological niches.

The results highlight significant ecological complexity among the different stations studied. The relationship between specific richness, disturbance indices, and the distribution of plant types underscores the influence of both environmental and anthropogenic factors on these ecosystems.

- Stations with high specific richness and moderate disturbance indices, such as O. Mask and Metlili, seem to offer a balance between biodiversity and ecological resilience. These areas could serve as priority targets for conservation in order to preserve their biological diversity.
- Stations with high disturbance indices (e.g., Lachyakh) show significant environmental stress, which may require ecological restoration efforts to improve ecosystem stability and biodiversity.
- The variable presence of perennials and ephemerals indicates that some stations are more stable (with more perennials), while others are more prone to disturbances or marked seasonal cycles (with more ephemerals).

5.4.2 - Distribution of Monocotyledons and Dicotyledons

Dicotyledons are overwhelmingly dominant across all stations. This is consistent with expectations in desert environments, where dicotyledons have evolved to maximize survival under harsh conditions—often through morphological adaptations such as thick leaves and deep root systems.

5.4.3 - Interpretation of Biological Types

- **Local Adaptations:** The tables show how biological types vary between stations. For example, Metlili and Daya exhibit a high proportion of therophytes, which may indicate areas where environmental conditions favor rapid life cycles. In contrast, phanerophytes are particularly significant at O. Metlili, suggesting a zone where moisture or other resources are sufficient to support larger woody plants.
- **Dominance of Chamaephytes:** Their notable presence in many stations shows that they are well adapted to extreme desert conditions, a common trait in Saharan regions. This dominance also suggests severe environmental pressure, where only the most resilient plants are able to survive.

5.4.4 - Disturbance Indices

Disturbance indices were observed for the different stations as follows:

- **Lachyakh**: **89.47** *(Very high)*
- **Noumérat**, **V. M'zab**: **73.68** *(High)*
- **Zelfana**: **73.33** *(High)*
- **Daya**: **70.00** *(High)*
- **O. Mask**: **69.70** *(High)*
- **Metlili**: **68.97** *(High)*
- **W. Ghardaia**: **63.95** *(Moderate)*
- **O. Metlili**: **36.84** *(Low)*
- **Lachyakh** presents the **highest disturbance index**, suggesting that this station is heavily impacted by ecological disturbances (such as human activities, fires, etc.).
- **O. Metlili** has the **lowest disturbance index**, indicating that this area is relatively **well preserved**.
- The other stations show **high to moderate indices**, which may reflect varying degrees of **environmental stress** affecting vegetation and biodiversity.

5.4.5 - Distribution of Plant Types

The graph illustrated the distribution of plant types (perennials, ephemerals, undetermined) across different stations:

- Zelfana and Lachyakh show a dominance of ephemerals, which may indicate disturbed conditions or marked seasonal cycles.
- O. Mask presents a notable presence of perennials, reflecting a certain degree of ecological stability.
- The distribution of plants between perennials and ephemerals can indicate the resilience or vulnerability of ecosystems. For instance, a high proportion of ephemerals may suggest disturbed

or highly seasonal environments, while the dominance of perennials could point to greater ecosystem stability.

6 - CONCLUSION

- **Adaptation to Aridity:** The analysis of the results highlights vegetation that is highly adapted to the extreme aridity of the Sahara. The most dominant species are those with specific adaptations to reduce water loss and survive in an environment with low and irregular precipitation.
- **Ecological Heterogeneity:** The differences between localities emphasize the **ecological heterogeneity** within the Ghardaïa region, even in an overall uniform environment like the Sahara. This local diversity allows a variety of species to coexist, contributing to the region's overall biodiversity richness.
- **Implications for Conservation:** Understanding the distribution of biological types and species dominance is crucial for conserving biodiversity in the Sahara. Dominant species such as **chamaephytes** and **therophytes** are essential for ecosystem stability, and any disturbance to their habitats could have negative impacts on the entire ecosystem.

These findings can serve as a foundation for future studies on plant adaptation in desert environments and for developing conservation strategies tailored to the Saharan region.

In conclusion, these results provide an overview of the ecological dynamics of the different stations and highlight the complex interactions between biodiversity, disturbance, and ecosystem resilience. This information may be essential for guiding management and conservation strategies in these regions.

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Appendix

Table 6. Botanical families represented in Ghardaia

N°	Species	Family
1	*Pancratium saharae* Goss. ex Batt. & Trab.	Amaryllidaceae

2	*Ammodaucus leucotricus* Coss	Apiaceae
3	*Ferula vesceritensis* Coss. &Dur.	Apiaceae
4	*Pituranthos chloranthus* (Coss. et Dur) Benth. et Hook.	Apiaceae
5	*Phoenix dactylifera* L.	Arecaceae
6	*Nerium oleander* L.	Asclepiadaceae
7	*Pergularia tomentosa* L.	Asclepiadaceae
8	*Anvillea radiata* L. Coss. et DR.	Asteraceae
9	*Artemisia herba alba* Asso	Asteraceae
10	*Atractylis delicatula* Batt. & Chevallier	Asteraceae
11	*Bubonium graveolens* Forssk.	Asteraceae
12	*Carduncellus eriocephalus* Boiss.	Asteraceae
13	*Carlina brachylepis* Batt.	Asteraceae
14	*Centaurea dimorpha* Viv	Asteraceae
15	*Centaurea Sp1*	Asteraceae
16	*Centaurea Sp2*	Asteraceae
17	*Chrysanthemum macrocarpum* Coss	Asteraceae
18	*Cotula cinerae* Del	Asteraceae
19	*Echinops spinosus* Bove.&.Dc	Asteraceae
20	*Ifloga spicata* (Forssk)	Asteraceae
21	*Launaea glomerata*	Asteraceae
22	*Launaea resedifolia*	Asteraceae
23	*Launea mucronata* (Forssk.) Muschler.	Asteraceae
24	*Perraldirea coronopifolia* Coss	Asteraceae
25	*Pulicaria crispa* Forssk.	Asteraceae
26	*Rhantherium adapressum* Coss	Asteraceae
27	*Spitzelia coronopifolia* Sch	Asteraceae
28	*Echium humile Desf.*	Boraginaceae
29	*Megastoma pusillum* Coss	Boraginaceae
30	*Cleome amblyocarpa* Barr. & Murb.	Brassicaceae
31	*Cleome arabica L.*	Brassicaceae
32	*Diplotaxis harra* Forrsk.Boiss.	Brassicaceae
33	*Moricandia arvensis*	Brassicaceae
34	*Moricandia suffruticosa* (Desf.) Coss. & Dur.	Brassicaceae
35	*Oudneya africana* R. Br.	Brassicaceae
36	*Zilla macroptera* Coss.	Brassicaceae
37	*Campanula bordesiana* Maire	Campanulaceae
38	*Anabasis articulata* Forrsk. Moq.	Chenopodiaceae
39	*Cornulaca monacantha* Del.	Chenopodiaceae
40	*Haloxylon scoparium* (Pomel).	Chenopodiaceae

41	*Salsola baryosma* (Schult.).	Chenopodiaceae
42	*Suaeda fructicosa*	Chenopodiaceae
43	*Traganum nudatum* Del.	Chenopodiaceae
44	*Arthrophytum scoparium* Pomel	Chénopodiaceae
45	*Periploca angustifilolia*	Chénopodiaceae
46	*Helianthemum lippii* (L.).	Cistaceae
47	*Convolvulus supinus* Coss. & Kral	Convolvulaceae
48	*Colocynthis vulgaris* (L.) Schrad	Cucurbitaceae
49	*Euphorbia guyoniana* Boiss. & Reut.	Euphorbiaceae
50	*Euphorbia retusa* Forssk.	Euphorbiaceae
51	*Ricinus communis* L.	Euphorbiaceae
52	*Astragalus armatus* Willd	Fabaceae
53	*Astragalus gombo* bunge.	Fabaceae
54	*Astragalus Sp*	Fabaceae
55	*Genista saharae* Coss. & Dur.	Fabaceae
56	*Retama retam* Webb.	Fabaceae
57	*Monsonia helohopioide*	Geraniaceae
58	*Teucrium polium*	Lamiaceae
59	*Salvia pumila = Salvia aegyptiaca* L.	Lamiaceae=Labiatae
60	*Androcymbium punctatum* (Schlecht.)	Liliaceae
61	*Asphodelus tenuifolius* Cav.	Liliaceae
62	*Dipcadi serotinum* (L.).	Liliaceae
63	*Acanthorrhinum ramosissimum* Cosson & Durieu.	Plantaginaceae
64	*Plantago ciliata* Desf	Plantaginaceae
65	*Cymbopogon schoenanthus*	Poaceae
66	*Cynodon dactylon (L.).*	Poaceae
67	*Phragmites communis*	Poaceae
68	*Stipagrostis obtusa* (Del.)	Poaceae
69	*Stipagrostis plumosa* (L.).	Poaceae
70	*Stipagrostis pungens* (Desf.) de Winter	Poaceae
71	*Calligonum comosum* L'Hérit	Polygonaceae
72	*Randonia africana* Coss.	Resedaceae
73	*Reseda Arabica* Boiss.	Resedaceae
74	*Reseda villosa* Coss.	Resedaceae
75	*Zizyphus lotus*	Rhamnaceae
76	*Neurada procumbens* L.	Rosaceae
77	*Ruta tuberculata*	Rutaceae
78	*Datura stramonium* L.	Solanaceae
79	*Solanum nigrum*	Solanaceae

80	*Tamarix articulata* Vahl.	Tamaricaceae
81	*Tamarix gallica*	Tamaricaceae
82	*Thymelaea microphylla*	Thymelaeceae
83	*Forsskaolea tenacissima* L.	Urticaceae
84	*Zygophyllum album* L.	Zygophyliaceae
85	*Fagonia glutinosa* Del	Zygophyllaceae
86	*Peganum harmala* L.	Zygophyllaceae

Table 7. Distribution of flora inventoried in each station.

Species	Met	Zel	Nou	O. Mt	O. Ms	V. M	Day	Lach
Oudneya africana R. Br.	1	0	1	1	1	1	1	1
Pergularia tomentosa L.	0	1	1	1	1	1	1	1
Pituranthos chloranthus (Coss. et Dur) Benth. et Hook.	0	1	1	1	1	1	1	1
Echinops spinosus Bove.&.Dc	0	0	1	1	1	1	1	1
Fagonia glutinosa Del	1	1	1	0	1	0	1	1
Peganum harmala L.	0	0	1	1	1	1	1	1
Artemisia herba alba Asso	0	0	1	1	1	0	1	1
Atractylis delicatula Batt. & Chevallier	1	1	1	0	0	0	1	1
Cleome amblyocarpa Barr. & Murb.	0	0	1	1	1	0	1	1
Launaea glomerata	1	0	1	0	0	1	1	1
Rhantherium adapressum Coss	1	1	0	1	1	1	0	0
Colocynthis vulgaris (L.) Schrad	0	0	1	0	1	0	1	1
Zilla macroptera Coss.	0	0	1	0	0	1	1	1
Anvillea radiata L. Coss. et DR.	0	1	0	0	0	1	1	0
Astragalus armatus Willd	0	0	1	0	0	0	1	1
Bubonium graveolens Forssk.	0	0	1	0	1	0	0	1
Campanula bordesiana Maire	0	0	1	0	0	0	1	1
Centaurea dimorpha Viv	1	0	1	0	0	0	0	1
Helianthemum lippii (L.).	1	0	0	0	1	1	0	0
Moricandia arvensis	0	1	0	0	0	0	1	1
Zizyphus lotus	0	1	0	0	1	1	0	0
Cynodon dactylon (L.).	1	0	0	0	1	0	0	0
Euphorbia guyoniana Boiss. & Reut.	0	0	0	1	1	0	0	0
Genista saharae Coss. & Dur.	0	0	0	1	1	0	0	0
Monsonia helohopioide	1	1	0	0	0	0	0	0
Pulicaria crispa Forssk.	0	1	0	0	1	0	0	0
Reseda villosa Coss.	0	0	1	0	0	0	0	1
Retama retam Webb.	0	1	0	0	1	0	0	0
Salvia pumila = Salvia aegyptiaca L.	0	0	1	0	0	0	0	1
Spitzelia coronopifolia Sch	1	0	0	0	0	0	1	0
Stipagrostis pungens (Desf.) de Winter	0	0	0	1	1	0	0	0
Thymelaea microphylla	0	0	0	0	1	1	0	0
Zygophyllum album L.	1	0	0	0	1	0	0	0
Acanthorrhinum ramosissimum Cosson & Durieu.	0	0	0	0	1	0	0	0
Ammodaucus leucotricus Coss	1	0	0	0	0	0	0	0

Anabasis articulata Forrsk. Moq.	0	0	0	0	1	0	0	0
Androcymbium punctatum (Schlecht.)	1	0	0	0	0	0	0	0
Arthrophytum scoparium Pomel	0	1	0	0	0	0	0	0
Asphodelus tenuifolius Cav.	1	0	0	0	0	0	0	0
Astragalus gombo bunge.	0	0	0	0	1	0	0	0
Astragalus Sp	1	0	0	0	0	0	0	0
Calligonum comosum L'Hérit	0	0	0	1	0	0	0	0
Carduncellus eriocephalus Boiss.	0	0	0	0	1	0	0	0
Carlina brachylepis Batt.	0	0	0	0	1	0	0	0
Centaurea Sp 1	1	0	0	0	0	0	0	0
Centaurea Sp 2	1	0	0	0	0	0	0	0
Chrysanthemum macrocarpum Coss	1	0	0	0	0	0	0	0
Cleome arabica L.	0	1	0	0	0	0	0	0
Convolvulus supinus Coss. & Kral	0	0	0	0	1	0	0	0
Cornulaca monacantha Del.	0	0	0	0	1	0	0	0
Cotula cinerae Del	1	0	0	0	0	0	0	0
Cymbopogon schoenanthus	0	0	0	0	0	1	0	0
Datura stramonium L.	0	0	0	1	0	0	0	0
Dipcadi serotinum (L.).	1	0	0	0	0	0	0	0
Diplotaxis harra Forrsk.Boiss.	0	0	0	0	1	0	0	0
Echium humile Desf.	1	0	0	0	0	0	0	0
Euphorbia retusa Forssk.	0	0	0	0	1	0	0	0
Ferula vesceritensis Coss. &Dur.	0	0	0	0	1	0	0	0
Forsskaolea tenacissima L.	0	0	0	1	0	0	0	0
Haloxylon scoparium (Pomel).	1	0	0	0	0	0	0	0
Ifloga spicata (Forssk)	1	0	0	0	0	0	0	0
Launaea resedifolia	0	0	0	0	0	1	0	0
Launea mucronata (Forssk.) Muschler.	0	0	0	1	0	0	0	0
Megastoma pusillum Coss	0	0	0	0	0	0	1	0
Moricandia suffruticosa (Desf.) Coss. & Dur.	0	0	1	0	0	0	0	0
Nerium oleander L.	0	0	0	1	0	0	0	0
Neurada procumbens L.	1	0	0	0	0	0	0	0
Pancratium saharae Goss. ex Batt. & Trab.	0	0	0	0	0	0	1	0
Periploca angustifilolia	0	1	0	0	0	0	0	0
Perraldirea coronopifolia Coss	0	0	0	0	0	0	1	0
Phoenix dactylifera L.	0	0	0	1	0	0	0	0
Phragmites communis	0	0	0	0	0	1	0	0
Plantago ciliata Desf	1	0	0	0	0	0	0	0
Randonia africana Coss.	0	1	0	0	0	0	0	0
Reseda Arabica Boiss.	0	0	0	0	1	0	0	0
Ricinus communis L.	0	0	0	1	0	0	0	0
Ruta tuberculata	0	0	0	0	0	1	0	0
Salsola baryosma (Schult.).	1	0	0	0	0	0	0	0
Solanum nigrum	0	0	0	0	0	1	0	0
Stipagrostis obtusa (Del.)	1	0	0	0	0	0	0	0
Stipagrostis plumosa (L.).	1	0	0	0	0	0	0	0
Suaeda fructicosa	0	0	0	0	0	1	0	0
Tamarix articulata Vahl.	0	0	0	1	0	0	0	0
Tamarix gallica	0	0	0	0	0	1	0	0

Teucrium polium	0	0	0	0	1	0	0	0
Traganum nudatum Del.	1	0	0	0	0	0	0	0
TOTAL	**29**	**15**	**19**	**19**	**33**	**19**	**20**	**19**