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Flora Diversity According to an Altitudinal Gradient in Kabylia Region

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Abstract
The study focuses on a floristic inventory according to an altitudinal gradient following a transect that includes five stations (Yakouren, Taddart, Tirsatine, Tizi Rached, Oued Aissi) located equidistant from the forest of Yakouren to the Sebaou Valley in Greater Kabyliarandom sampling was adopted during the spring season of 2015 by harvesting all the plant species encountered in a comprehensive manner, while focusing on their distribution taking into account environmental factors including climate, precipitation, rainfall, temperature, altitude and the nature of the substrate. The collected species are sorted, identified and counted. The recorded flora is divided into 5 classes (Magnoliopsida, Liliopsida, Pteridophyta, Monocotyledons and Equisetopsida), 25 orders divided into 27 families and 65 species. It shows the apparent impact of altitude and climate.

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1. INTRODUCTION

The flora of a geographical area is the most important biotic component (Ozenda, 1982), which expresses the ecological conditions (climatic, geological, historical, geomorphological and edaphic) that prevail there (Loisel, 1978). Thus, Myers (1990); Medailet Quezel (1999) point out that the Mediterranean region is one of the world's major centers of plant diversity whose current flora corresponds to various heterogeneous assemblages linked to the paleo-history of the region in Quezel (1978, 1985); Quezel *et al.* (1980).

Algeria, one of the biogeographic countries, which has an exceptional ecological entity by its extensive surface constituted by various ecosystems. Its vegetation cover is a very important ecological factor, especially in Kabylia, because of its topographical heterogeneity and the anthropic action that has created a very fragmented vegetation landscape that is presented in the form of rather complex mosaics.

Dahmani (1996) points out that the analysis of the floristic richness of the different groups, their biological and chronological characteristics, would make it possible to highlight their floristic originality, their state of conservation and, consequently, their heritage value. Knowledge of the biological and ecological peculiarities of the species as well as the identification of historical and current factors causing flora fluctuations are essential for any action to conserve biodiversity.

Preserving and conserving Kabylia's remarkable plant biodiversity is first and foremost achieved by conducting ecological inventories of the environment; this, in order to locate them and make an objective assessment of their heritage value and related issues, prior to any implementation of conservation actions.

It is in this perspective that we carried out an inventory of the Kabyle flora. This inventory is followed by an ecological study which made it possible to identify an important set of species whose distribution is related to the factors of the environment, in particular the climate (the precipitation and temperatures), altitude and nature of the substrate.

The taxonomic and nomenclatural reference chosen for the citation of the species is the African Plant Database (version 3.3.3), Conservatory and Botanical Garden of the City of Geneva and the South African National Biodiversity Institute, Pretoria, access March 2011, whose lead author for North Africa is A. Dobignard, as well as Angiosperms Phylogeny Group (APG) III (2009) and APG IV (2016).

2. MATERIAL AND METHODS

The study area is located in the north of Algeria, in the Tizi-Ouzou department (located at 100 km east of Algiers), in the great Kabylia and in the north side of Djurdjura massif, in 36 ° 42 'North latitude and 4 ° 13' East longitude. It extends, in its current boundaries over an area of 2958 Km^{2}where the Mediterranean climate prevails with a mild and rainy winter and a hot and humid summer considering the proximity of the dam Taksebt. The vegetation is classified in the thermo-mediterranean floor dominated by the olive tree (*Olea europaea*).

The study focuses on the effect of environmental factors (rainfall, temperature, altitude and substrate quality) on the distribution of the flora identified during therandom inventory carried out on an equidistant altitudinal transect between the different sampling stations (Yakouren, Taddart, Tirsatine, Tizi Rached, Oued Aissi, Tab.01) from a forest (Yakouren forest), high altitude, to the Oued Aissi area, in the valley of Sebaou. In addition to the inventory, the soil of the stations was randomly sampled at a depth of 20 cm and subjected to soil analysis.

Once the flora is harvested, it is sorted and identified using identification keys, as not as to mention the help of the research professors of our university. The results are subjected to statistical analyzes with Rand Statistica software (principal component analysis and factorial correspondence analysis) and ecological study (relative abundance, dominance de Berger-Parker, Shannon index and equitability).

Table 1: Geographic Coordinates of Study Stations

Stations	Latitude	Longitude	Altitude
Yakouren	36°44′05′′	4°26′19′′	765 m
Taddart	36°44′13′′	4°26′17,50′′	600 m
Tirsatine	36°44′21,57′′	4°19′16,80′′	151m
TiziRached	36°43′15′′	4°09′25′′	117 m
Oued Aissi	36°42′10,40′′	4°08′35,35′′	100 m

3. RESULTS

3.1. Analysis of the flora

The results show all the floristic groups inventoried in the different sampling stations (Yakouren, Taddart, Tirsatine, Tizi Rached and Oued Aissi) following an altitudinal gradient of the highest mountains of Yakouren towards the Sebaou Valley during the spring season of the year 2015(Table 2).

Table 2: Set of identified groups in the studied stations.

Classes	*Magnoliopsida*	*Liliopsida*	*Pteridophyta*	*Monocotylédones*	*Equisetopsida*
Orders	18	3	1	1	2
Families	20	3	1	1	2
Species	53	7	1	2	2

A total of 65 species belonging to 5 classes (Magnoliopsida, Liliopsida, Pteridophyta, Monocotyledonous and Equisetopsida) were distributed over 25 orders and 27 families were identified in each of the five stations during the sampling period (Table2).

Table 3: Total plant species identified in the different study stations.

Classes	Orders	Families	Species	Y.	Tad.	Tir.	T.R	O.A
Magnoliopsida	Rosales	Rosaceae	*Rubus ulmifolius*	1	0	0	1	0
			Potentilla sp.	1	0	0	0	0
			Craetegus monogyna	1	0	0	0	0
			Rosa sempervirens	1	0	0	0	0
	Ranunculales	Ranunculaceae	*Ficaria verna*	1	0	0	0	0
			Clematis flamula	0	0	1	0	0
	Violales	Tamaricaceae	*Tamarix Africana*	0	0	0	0	1
	Ericales	Ericaceae	*Erica arborea*	1	0	0	0	0
	Fabales	Fabaceae	*Cytisus triflorus*	1	0	0	0	0
			Calycotome spinosa	0	1	0	0	0
			Lotus ornithopodioides	0	1	1	0	1
			Melilotus officinalis	0	0	1	0	0
			Trifolium stellatum	0	0	1	0	0
			Trifolium arvensis	0	0	1	0	0
			Trifolium sp.	0	0	0	0	1
			Tetragonolobus biflorus	0	0	0	0	1
			Medicago polymorpha	0	0	0	0	1
	Fagales	Fagaceae	*Quercus canariensis*	1	0	0	0	0
			Quercus suber	0	1	0	0	0
	Lamiales	Lamiaceae	*Echium austral*	0	0	1	0	1
			Menthapulegium	0	0	0	1	0
	Asterales	Asteraceae	*Galactites tomentosa*	0	1	1	0	1
			Chrysanthemum myconis	0	1	1	0	0
			Bellis anua	0	1	0	0	0
			Sanchus sp.	0	1	0	1	0
			Inula vicosa	0	1	0	1	1
			Reichardia picroides	0	1	0	1	0
			Eryngium campestre	0	1	0	0	0
			Eryngium tricuspidatum	0	1	0	0	0
			Asteriscus maritima	0	0	1	0	0
			Urospermum dalechampri	0	0	1	0	0
			Andryala integrifolia	0	0	1	0	1
			Cichorium intybus	0	0	0	1	0
			Crepis versicaria	0	0	0	0	1
			Anacyclus trixago	0	0	0	0	1
			Tolpis sp	0	0	0	0	1
	Malvales	Malvaceae	*Malva sylvestris*	0	1	0	1	1

			Lavatera sp.	0	0	1	0	0
	Papaverales	Fumariaceae	*Fumarias p.*	0	1	0	0	0
	Primulales	Primulaceae	*Anagalis arvensis*	0	1	0	0	0
	Caryophylales	Caryophylaceae	*Silene fuscata*	0	1	0	0	1
			Silene gallica	0	0	0	0	1
	Plantaginales	Plantagionaceae	*Plantago lanceolata*	0	1	1	1	0
	Violales	Cistaceae	*Citus montspeliensis*	0	1	0	0	0
	Geraniales	Oxalidaceae	*Oxalis pes-caprae*	0	1	0	0	0
	Scrophylariales	Scrophylariacées	*Verbascum sineatum*	0	0	1	0	1
			Bellardia trixago	0	0	1	0	0
		Oleaceae	*Fraxinus augustifolia*	0	0	0	1	0
	Solanales	Convolvolaceae	*Convolvulus althaeoides*	0	0	1	1	1
	Polygonales	Polygonaceae	*Rumex bucephalophorus*	0	0	0	0	1
			Rumex sp.	0	0	0	1	0
	Brassicales	Brassicaceae	*Sinapis arvensis*	0	0	0	1	1
Liliopsida	Orchidales	Orchidaceae	*Orchis sp.*	1	0	0	0	0
	Liliales	Liliaceae	*Asphodelus microcarpus*	0	1	0	0	0
			Alium sp.	0	1	0	0	0
	Poales	Poaceae	*Bromus sp.*	0	0	1	1	0
			Phalaris sp.	0	0	0	1	0
			Hordeum vulgare	0	0	0	1	0
			Arundo donax	0	0	0	1	0
Pteridophyta	Polypodiales	Aspleniaceae	*Asplernium sp.*	1	0	0	0	0
Monocotylédones	Poales	Poaceae	*Avena sterilis*	0	0	1	1	0
Equisetopsida	Fabales	Fabaceae	*Scorpiurus miricatus*	0	1	0	0	0
	Aspiales	Aspiaceae	*Daucus carota*	0	0	0	0	1

1 : presence0 : absence

The results show that the class of Magnoliopsida is best represented and the order of Asterals ranks first with 15 species.

3.2. Effect of altitude

The diversity of the vegetation comes from the variety of climatic conditions because of the differences in the altitude between the study stations (Figure 1)

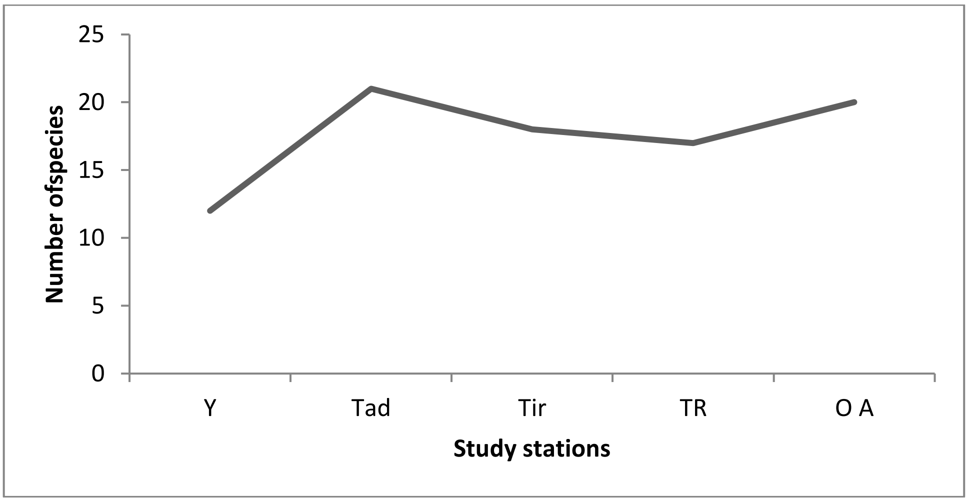


Figure 1: Evolution of the number of plant species inventoried according to altitude.

The results inform that the plant species are unequally distributed according to the difference in altitude. They are more abundant in medium altitudes following the favourable climatic conditions notably a rainfall of 336.4mm/year and an average annual temperature of the order of 15.4°C. In the same way, the loam-clay texture of the soil retains a certain humidity of the substrate and a good richness in organic matter.

3.3. Distribution of floristic groups in the different stations

The distribution of flora in the different study stations (Figure 2).

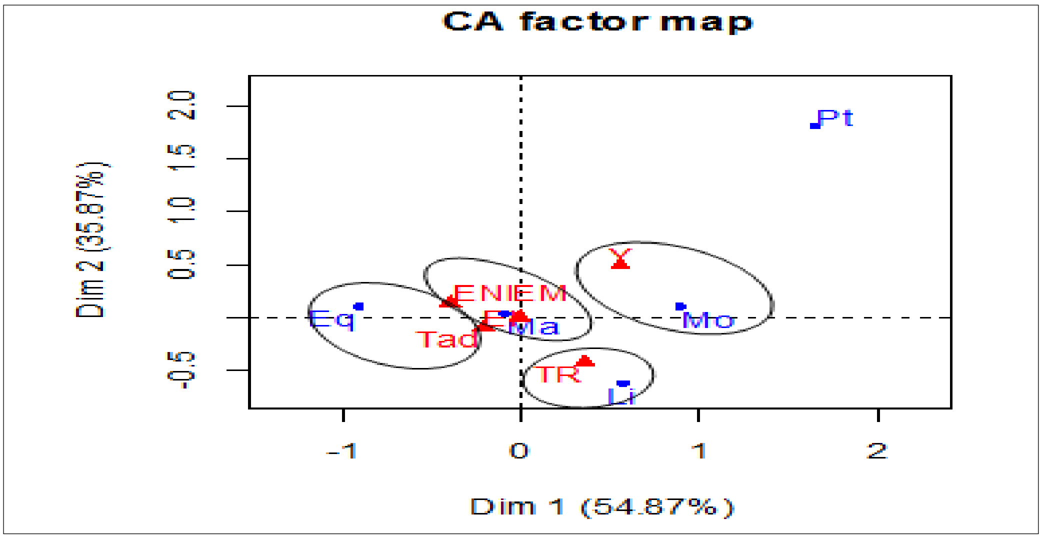


Figure 2: Distribution and nuclei affinity of the floristic groups and studied stations in the F1 × F2 factorial plane.

In the AFC of Figure 2, 4 homogeneous groups are required:

Group 1, connects the Monocotyledon class to the Yakouren station,

Group 2, shows the relation of the Equisetopsida class and the Taddart station,

Group 3, connects the Tizi Rached station and the Liliopsida class,

Group 4, connects the EI (Tirsatine) stations and ENIEM (Oued Aissi) with Magnoliopsida class.

This analysis of the previous figure is well explained by the results of Figures 3 and 4 which express the relation of the edaphic factors and climatic characters with the spatial distribution of the inventoried plant species.

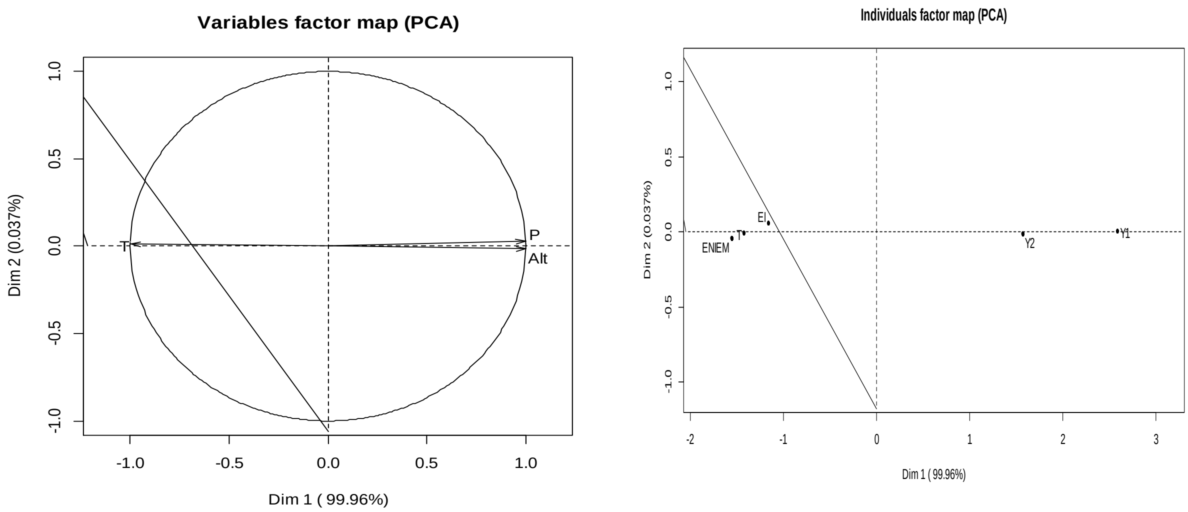


Figure 3: Representative ACP of the distribution of climatic characters and altitude in the studied stations.

According to Figure 3, the Yakouren and Taddart stations, at high and medium altitude, are correlated with precipitation and the stations Tirsatine (EI), Tizi Rached and Oued Aissi (ENIEM), at low altitude, are correlated with temperatures which creates the floristic mosaic of this region.

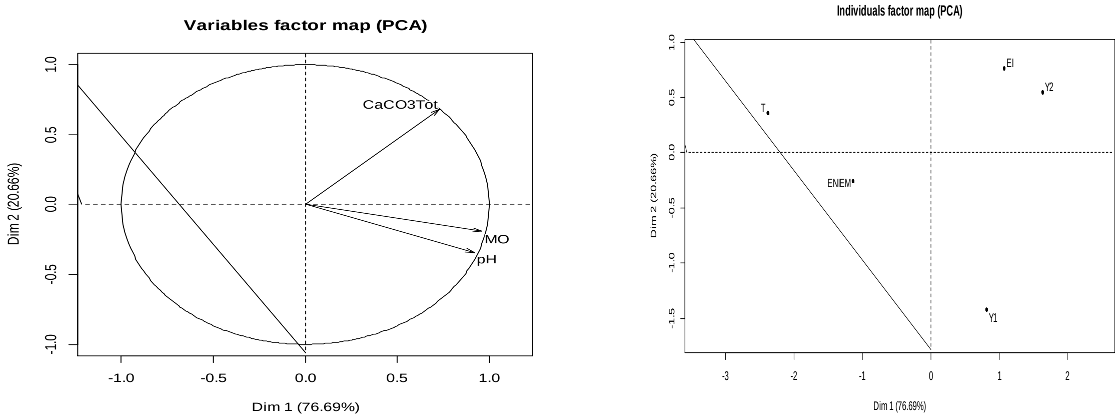
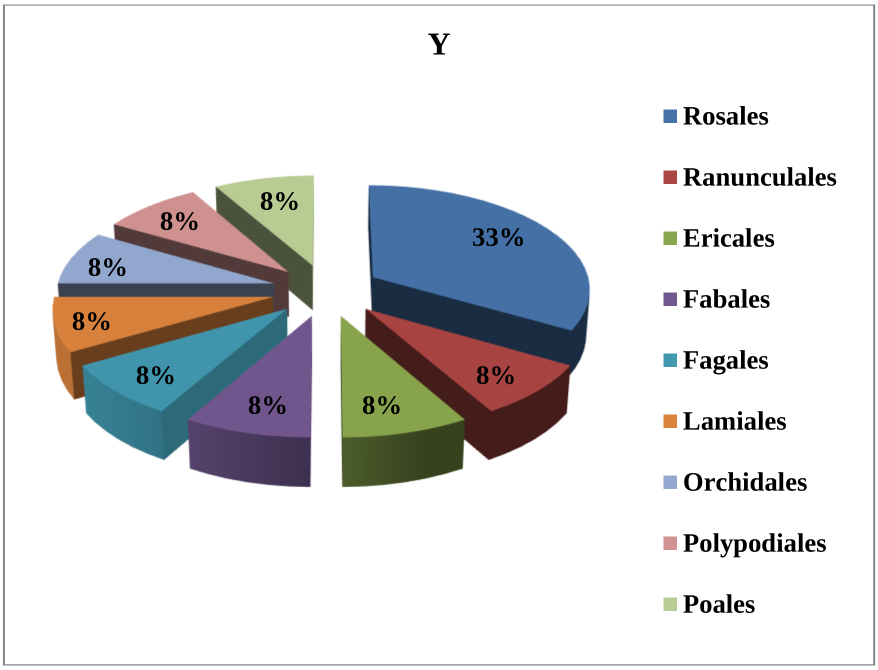


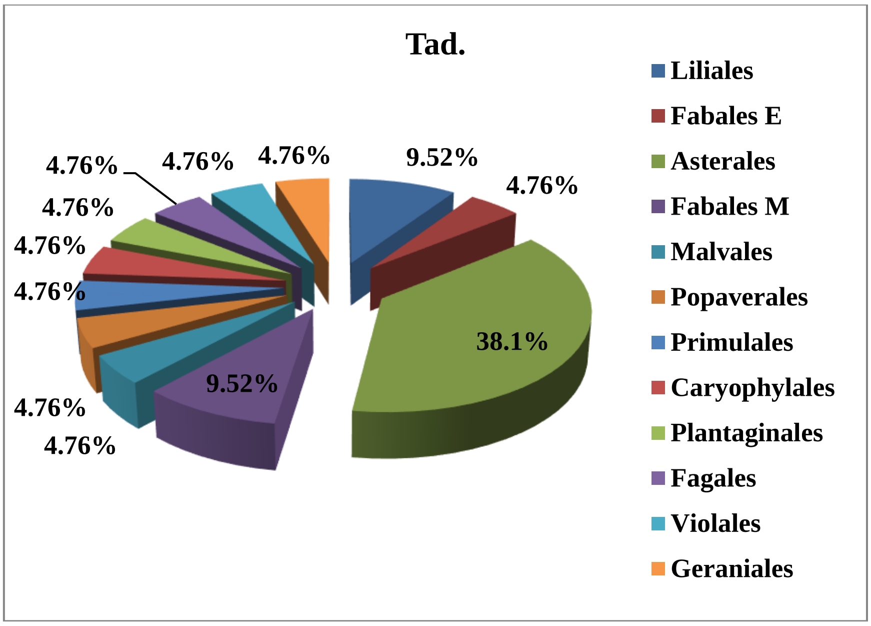
Figure 4: Representative of the distribution of edaphic characters in the studied stations.

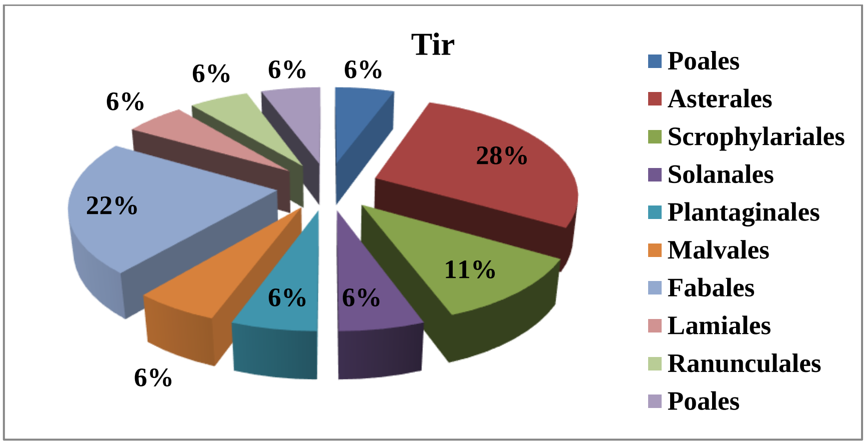
According to Figure 4, Oued Aissi and Tizi Rached stations are that contain the lowest amounts of MO. and neutral pH. Station Y_2 (Taddart) is the richest in $CaCO_3$.

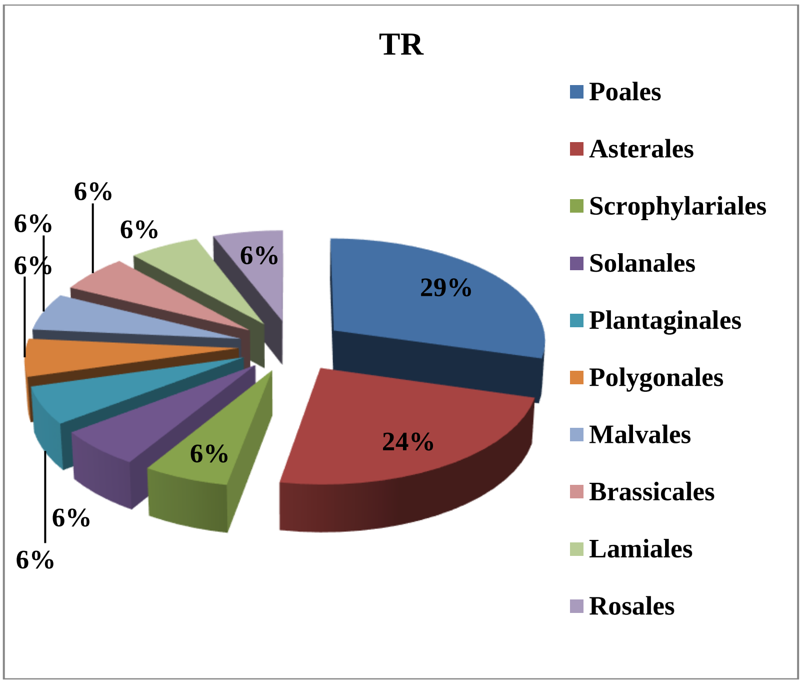
3.4. Relative abundance

During the flora sampling at the studied stations (Yakouren, Taddart, Trsatine, TiziRached and Oued Aissi), a total of 65 species are collected (Figure 5).




Tad.
Liliales
Fabales E
Asterales
Fabales M
Malvales
Popaverales
Primulales
Caryophylales
Plantaginales
Fagales
Violales
Geraniales
9.52%
4.76%
38.1%
9.52%
4.76%
4.76%
4.76%
4.76%
4.76%
4.76%
4.76%
4.76%
4.76%


Tir
Poales
Asterales
Scrophylariales
Solanales
Plantaginales
Malvales
Fabales
Lamiales
Ranunculales
Poales
6%
28%
11%
6%
6%
6%
22%
6%
6%
6%


TR
Poales
Asterales
Scrophylariales
Solanales
Plantaginales
Polygonales
Malvales
Brassicales
Lamiales
Rosales
29%
24%
6%
6%
6%
6%
6%
6%
6%
6%

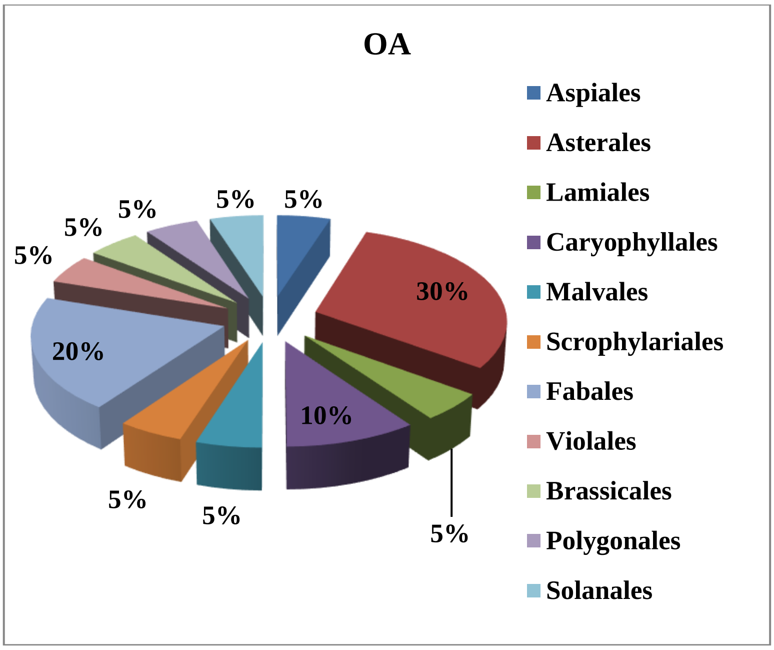


Figure 5: Relative abundance of floral orders in the studied stations.

3.5. Dominance of Berger-Parker

The class of Magnoliopsida predominates by the order of the Asterals in the study stations except of the reference station Yakouren where the Rosales order predominates and the Tizi Rached station where the order of the Poales predominates. The dominance of Berger-Parker (BP) expressed in the different study stations shows in the Table 4.

Table 4: Berger-Parker's dominance of the flora of the study stations

Stations	**Y.**	**Tad.**	**Tir.**	**T R.**	**OA.**
Dominance BP.	0.33	0.38	0.28	0.29	0.30

3.4.3. Shannon Index (H')

The results ofShannon diversity index which reflects the diversity of the study stations are shown in Figure 6.

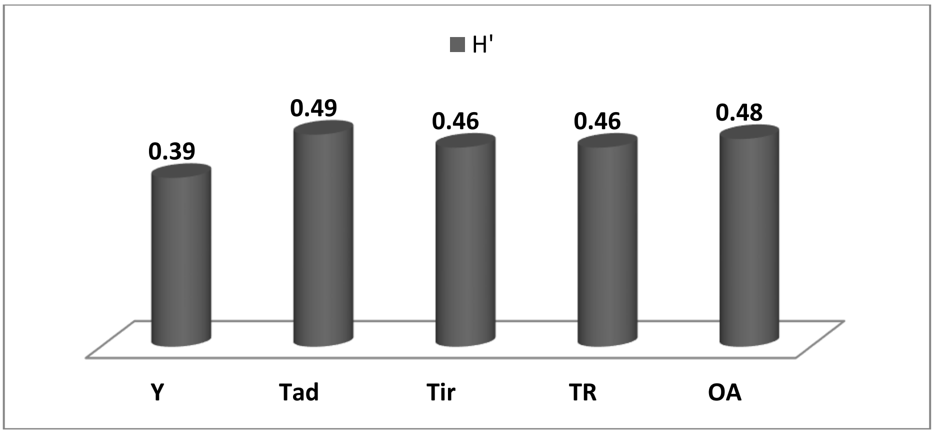


Figure 6: Shannon index of the flora of the studied stations.

At the study stations, the Shannon index (H ') is variable with a maximum of 0.49 bits at the Taddart station and a minimum of 0.39 bits for the Yakouren station. This means that the plant community in the studied stations are contrasted as a result of a very varied quantitative representation of the species in the sample.

The rich soil of Oued Aissi in MO, which is the first source of nutrients (trace elements) for vegetation, gives it a certain floristic diversity.

3.6. Equitability

The equitability or relative diversity index is calculated for the studied stations and the results are shown in Figure 7. In general, the equitability increases with the number of species, that is to say a low index is the consequence of a small number of taxa and / or the dominance of a few species.

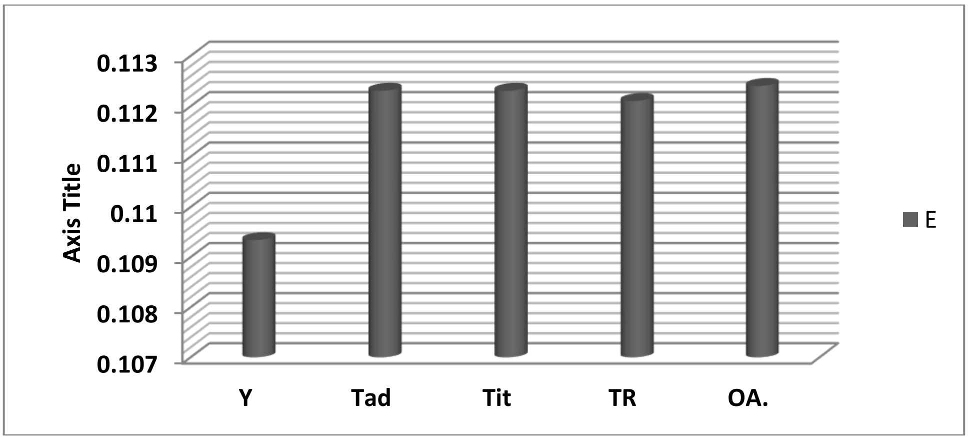


Figure 7: Equitability of the flora of the study stations.

According to Figure 7, the equitability is close to zero in all the studied stations. Taddart station has the maximum value is recorded (E = 0.112307) while the minimum value is recorded at the Yakouren station (E = 0.10933). This means that almost all the numbers are concentrated on a present species.

4. DISCUSSION

The protection of the biodiversity and the environment is one of the major concerns of humanity; it has even become a leitmotif in recent years taking into account the global warming. This can only be done with the assessment of the biodiversity, generally based on the structure and composition of communities, as the biodiversity, is a multidimensional concept (Purvis and Hector, 2000) which reflects the biological complexity of communities (Hedde *et al.*, 2013).

The inventory and the floristic analysis of the natural vascular vegetation of an environment are essential to know the overall composition of the existing taxa, the biogeography of the species listed and the ecology of the study environment (Hammada *et al.,* 2004).

Measuring biodiversity, as it was originally defined by Wilsson (1988), means "counting the whole species present in a given place". Vegetation is therefore used as a reliable reflection of stationary conditions; it is the synthetic expression according to Beguin *et al.* (1979) and Rameau (1987).

Dahmani (1996) indicates that the analysis of the floristic richness of the different groupings, which are characterized by their biological and chronological features, would make it possible to highlight their floristic originality, their state of conservation and, consequently, their heritage value.

The Algerian floristic diversity is represented from the biogeographical sub-division of Quezel et Santa (1962 -1963), and from the international map of the vegetation cover of Barrey *et al.* (1974). At the biocenotic level, the records arranged, following a decreasing altitudinal gradient, illustrate the biological and structural aspects of the mosaic of plant communities present in the stations and their dynamic links. These surveys show 65 species belonging to 5 classes *(Magnoliopsida, Liliopsida, Pteridophyta, Monocotyledons and Equisetopsida)* which are distributed over 25 orders and 27 families. The class of *Magnoliopsida* is the best represented with the order of the *Asterales* which ranks first with 15 species. These results confirm those obtained by Quezel (1978, 1985) who worked on the flora of the Mediterranean region, Daget *et al.* (1977) and Daget (1980) who treated the therophytic status of Mediterranean lawns in Languedoc, as well as Pignati (1978) who studied the evolutionary trends of Mediterranean flora and vegetation.

Magnoliopsida are most often referred to as dicotyledons. They are very important green plants in botany of which all these species are flowering plants, some are herbaceous but some woody plants exist, such as magnolias (Moore *et al*., 2007).

The identified plants species are more abundant at medium altitudes following favourable climatic conditions with a rainfall of 336.4mm per year and an average annual temperature of around 15.4°C as well as the soil texture, silty-clay, which keeps some humidity of the substrate and a good richness in organic matter (Lembrouk, 2019).This confirms that climate plays an essential role in determining the distribution of plants, which are distributed uneuanlly according to the difference in altitude. This role is particularly emphasized by Emberger (1930, 1971) concerning the Mediterranean vegetation.

Barbero *et al.* (1982) have bioclimatically characterized the forest vegetation on the Mediterranean rim. They approach the concept of vegetation stage by taking into account the major climatic factors and in particular the average annual temperature which allows it a possible translation these variations the overall altitudinal and latitudinal successions of the vegetation. As a result, rain and temperature is the hinge of the climate Bary *et al.* (1979) which defines the Mediterranean bioclimate of which Kabylia is part (Quezelet Medail, 2003).

Djebaïli (1978) defines rainfall as being the primary factor that allows to determinate the type of climate. Indeed, this one condition the maintenance and distribution of the plant cover on the one hand, and the degradation of the natural environment by the phenomenon of erosion on the other hand; especially in early spring. For Belgat (2001), the intensity and frequency of the rains play a major role in:

The stability or instability of soils, combined with the physical factors of the soil, can promote or disadvantage the structural stability of the soil.

They act on the solubility and migration of nutrients in the soil. Consequently, they participate in the spatial distribution of species. They hasten or block the evolution of organic and mineral materials, and they are involved in the formation of soils.

The temperature is the second constituent factor of the climate, influencing the development of the vegetation because of the aridity (Greco, 1966) where the thermal amplitude has a certain influence and a direct action on the biological cycle of the plant cover. Its value is ecologically important to know since it presents the extreme thermal limit to which plants must resist each year (Djebaili, 1984).

Summer land winds, characterized by great violence and strong drying power, such as sirocco in the Maghreb, hot current, always dry which occurs from 15 to 22 days approximately mainly in summer with a maximum frequency in July according to Djebaili (1984), reduce atmospheric humidity to less than 30% and help spread fires by accelerating evapotranspiration which increases the ability of plants to ignite (Quezelet Medail, 2003). As a result, Godron (1971) confirms that the "summer drought" is the first discriminating characteristic of the Mediterranean.

Above 600-700m, snow appears almost regularly every winter where it melts very quickly. It is only on peaks above 1000 m that the snow cover can last (Hadjadj-Aoul, 1995), this is the case in our study region in greater Kabylia.

A combination of rainfall and temperature data is very interesting to characterize the influence of the climate of the region. Based on Lionello *et al.* studies in 2006, on global changes, the Mediterranean region could be subject to complex climatic variations. According to Velez (1999), climatic conditions were particularly unfavourable during the 1980s, characterized by extremely serious droughts, which strongly affected all the countries of the Mediterranean basin, in particular Morocco, Algeria, Portugal, Spain and France.

Benabadji and Bouazza (2000), emphasize that the effects of the summer xerothera are attenuated by relative humidity, especially when forest or preforest cover exists. The increase in anthropogenic processes (pastoralism and agriculture) together, with climatic variations constitute the factors of soil and vegetation degradation in the region studied. Le Houerou (1971) underlines on this subject that the consequences of the climate are at the origin of one of the essential mechanisms of the degradation of Mediterranean vegetation in general.

According to Loisel (1978), vegetation is the result of the integration of floristic, climatic, geological, historical, geomorphological and edaphic factors. From a purely biogeographical point of view, the current Mediterranean flora corresponds to various heterogeneous sets linked to the paleo-history of the region, declare Quezel (1978 and 1985), Quezel *et al.* (1980).

Biodiversity at the level of a landscape is therefore the result of the processes of disturbance, succession and the spatial organization of environmental gradients that results from it (Froise, 1999). Faced with these harsh climatic conditions, nature is obliged to adapt so as to vary its environments in order to resist. Adding to this; it is including the effect of forest fires (almost every summer) that must be managed well in order to safeguard this flora richness by integrating the population and participating rural people in the work undertaken by the administration (plantations, opening of roads, brush clearing and opening of firewalls for fire prevention, firefighting teams, etc.). This can only be ensured with a good execution of the environmental legislation which protects the natural heritage and the intensification of surveys and sociological studies applied with adequate technologies and means, especially the adoption of soils emergency protection measures.

Finally, it should be remembered that the project to manage at least part of the Akfadou forest, of which Yakouren is a part, in the National Park dates back to 1921 and that, today more than ever, it is necessary to relaunch and to materialize thus restart the forest school project in Yakouren, which is already subsidized by the European Union in 2008 as part of the Euromed program.

The current landscapes are the result of a common natural and human history that spans several thousands of years. The state of the ecosystem will ultimately depend on human action. One of the greatest threats to biodiversity is the degradation of ecosystems.

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