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FLORAL RICHNESS AND SEASONALITY OF PHYTODIVERSITY IN THE TESSALA MOUNTAINS, WESTERN ALGERIA

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Abstract

This work is devoted for the floral richness and seasonality evaluation of the plant communities of the Tessala Mountains in Western Algeria. The floristic inventory of the 30 surveys carried out on 10 selected stations has resulted in 152 species under 125 genera and 48 families. Seasonal floral richness is concentrated in both spring and summer seasons, while the monthly richness is significant between March to August. Vegetations formations are represented physiognomically by four strata, taken into consideration in descending order of importance: Herbaceous (68%), shrubby (12%), arbustive (11%), and arborescent (10%). The overall and seasonal distributions of biological types almost follow the diagrams: Therophytes (The) > Hemicryptophytes (Hem) > Phanerophytes (Pha) > Chamephytes (Cha) > Geophytes (Geo). During the two season: the winter and the spring, the annual herbaceous dominate the bio-morphological spectrum with perennial herbs. During the summer and autumn, perennial herbaceous plants dominate the bio-morphological spectrum. The families that are most existing overall and during the four seasons are Asteraceae, Poaceae, Lamiaceae and Fabaceae.

Introduction

The Mediterranean region has a very high heritage value floristy. They constitute meaningful reserves of genetic, specific, and functional diversity that should be best conserved to the sustainable management of this biological heritage and these potential resources (Quézel and Médail, 2003). Mediterranean landscapes offer a model for studying the evolution of flora and vegetation. The variability of these landscapes also their differences remain very remarkable (Quézel, 2000). Vegetation characterizes the state of an ecosystem and highlights its natural or induced changes in climate and soil (Rama, 2019; Ozenda, 1986). Therefore, the analysis of the floristic richness of the different groups, their biological and bio-morphological characteristics will make it possible to highlight their originality, state of conservation, and consequently their heritage **(**Benkelfat *et al*., 2020**).**

Algeria has one of the most diverse and original Flores of the Mediterranean basin. This flora includes 3,139 species in nearly 150 families, 653 of which are endemic, representing a rate of 12.6% endemism. Considering only the Oran sector, it retains about 1,780 plant species of the total Algerian flora or about 57% of the Algerian flora, but 95% of the Maghrebi Mediterranean flora (the latter having 1,865 species according to Quézel (2002).

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The Tessala Mountains present a great interest because of their geographical and ecological components. Its environmental and socio-economic role deserves to be noted and studied. This massif is home to plant diversity of particular interest, favorable to regeneration after fires, and overgrazing makes this area a natural forest (Saidi *et al*., 2016; Bouker *et al*., 2022).

Much work has been done on the Tessala Mountains based on the knowledge and degradation of phytodiversity (Ferka-Zazou, 2006; Chérifi *et al*., 2011; Bachir-Bouiadjra, 2011; Saidi *et al*., 2017).

Landscape dynamics could thus be highlighted and quantified by analyzing the composition and configuration of its elements form a morphological, functional and ecological complex (Bisane and Naik, 2019). Indeed, each ecological system is characterized by the interdependence of three key elements: its spatial structure, its composition, and its temporal functioning with the confrontation of environmental factors (Bogaert and Mahamane, 2005). The landscape will be directly linked to biodiversity, and it will illustrate the contest that exists between society and its environment (Burel and Baudry, 2003). The former generally reflect the seasonal rhythm of communities, in other words, their phenology, while the latter reflects the evolution of biocenosis and the ecosystem as a whole towards stages of increasing complexity (Lacoste and Salanon, 2001). Thus, the natural dynamics of plant groups generally range from simple structures to complex structures.

The main objectives assigned to our work is a continuation of several studies on vegetation dynamics in the Tessala mountains, since 2014 until now. previous research namely : The influence of fires on the phytodiversity of the Tessala Mountains (Saidi *et al*., 2014). The biological rise of post-disturbance (post-fire or post-overgrazing) plant communities in Mount Tessala, Western Algeria (Saidi *et al*., 2016). The impact of grazing on heterogeneity and plant diversity dynamics in the Tessala Mountains (Saidi *et al*., 2017).

Materials and Methods

Description of the study area

The Tessala mountains are located: in the west of Algeria, in the Wilaya of Sidi Bel Abbès. They are limited to the north by the Mleta plain and the Oran sebkha; to the east by the Beni-Chougrane mountains; to the west by the Sebaa Chioukh mountains, and the south by the Sidi Bel Abbès plain. It is a mountainous area with altitudes ranging from 600 to 1,000 m, culminating at 1,061 m in Tessala Djebel. The Tessala mountain range is formed by the Tessala and Bouhneche djebels; they are composed of badlands (Bneder, 1991;1993) and the forests of Tessala and Aïn-Trid. The climate of the Tessala region is a Mediterranean diet with two seasons of equivalent duration (Ferka-zazou, 2006).

This set of mountains belongs to the semi-climatic bioclimatic stage-upper arid to temperate winters characterized by marine influences and precipitation of about 400 mm per year. Minimum temperatures range from 6 to 10°C, and maximum temperatures range from 20 to 30°C. The risk of frost is high in the region, is a limiting factor for vegetation. The dry period extends over six months, except in areas higher up where the cooler northern exposure mitigates the effects of drought (Ferka-zazou, 2006).

Sampling

`For the characterization of phytodiversity, the Zuricho Montpeliéraine stigmatist method developed by Braun-Blanquet (1951) which were used.

Between 2013 and 2017, conducted space-time monitoring for three years. It is based on geographic coordinates, altitude, exposure, slope, substrate, cover rate, and vegetation physiognomy (Dagnelie, 1970; Table 1). Thirty surveys spread over 10 stations were carried out using a phytoecological approach. Floristic surveys with a surface area of 100 m² are carried out and monitored for a period of 4 years (beginning 2013, 2014, 2015, 2016, end 2017).

Table 1. Geographic characterization of each station in the study area.

Station	Geographic coordinate		Elevation (m)	Slope %	Exposure
S1	X:0°46'229" O	Y: 35°15'975" N	762	25	South –East
S2	X: 0°46'278" O	Y: 35°16'047" N	771	25	South - West
S3	X: 0°46'238" O	Y: 35°16'134" N	800	5	South
S4	X: 0°46'767" O	Y: 35°16'374" N	1006	5	Nord-West
S5	X: 0°46'774" O	Y: 35°15'514" N	935	50	Nord-West
S6	X: 0°46'375" O	Y: 35°16'226" N	833	15	South - West
S7	X: 0°46'521" O	Y: 35°16'289" N	859	30	South
S8	X: 0°46'567" O	Y: 35°16'097" N	846	10	South - West
S9	X: 0°45'826" O	Y: 35°16'073" N	710	25	South - West
S10	X: 0°45'917" O	Y: 35°15'969" N	680	60	East-South

During the follow-up, floristic lists are established and taking into account all species present in each survey, the first expressing their abundance-dominance and sociability scale (Braun-Blanquet *et al*., 1952), stratification scale by Benabdeli (1996) for the woody vegetation of Oranie, the floristic richness, and biological and bio-morphological spectrum.

The determination of plant species not recognized on the spot, samples were taken and then identified from the descriptions of some works, we used the new flora of Algeria of Quézel, and Santa and North Africa of Meyer supplemented if necessary by the guide of the Mediterranean flora, and the various Algerian Flores.

Identify of floristic heritage of the Tessala mountains was: All the Mediterranean nature (Sterry, 2014), guide to Mediterranean flora (Bayer *et al*., 2009), larousse: the herbarium of wild plants (Thierry, 2011), the great colorful flora of (Gaston and Robert, 1990), North Africa of Maire (1952, 1987), Sahara flora (Ozenda, 1977), new flora of Algeria and the southern desert regions Quézel and Santa (1962, 1963) and also the tela botanica forum: North African flora project.

Results and Discussion

Assessment of plant biodiversity

A total of 152 species under 125 genera and 48 families are shown in Table 2. This list is the subject of several treatments such as; specific richness, biological spectra, morphological and bio-morphological types, species listed, and the different families to which these species belong in each season.

Seasonal floristic richness

The floristic richness is concentrated in the two seasons: spring (140 species) and summer (86 species). The flora of these two seasons can be described as rich one. However, in the winter season (59 species), very rich one. On the other hand, the autumn season (22 species) medium flora (Fig. 1).

Table 2. List of species and their flowering phenology (type and biological cycle).

Species	Family	Flowering	Biological type	Biological cycle
Acacia nilotica (L.) Willd. *ex* Delile	Fabaceae	January-April	Phanerophytes	Tree
Adonis aestivalis L.	Ranunculaceae	April-June	Therophytes	Annual herbaceous
Aegilops triuncialis L.	Poaceae	May-July	Therophytes	Annual herbaceous
A. ventricosa Tausch.	Poaceae	May-August	Therophytes	Annual herbaceous
Ajuga iva (L.) Scherb.	Lamiaceae	March-November	Chamephyte	Perennial herbaceous
Ammi visnaga Gaertn.	Apiaceae	May-October	Therophytes	Annual herbaceous, biennial herbaceous
Ampelodesma mauritanica (Poir.) Dir.	Poaceae	May-June	Geophytes	Perennial herbaceous
Anacyclus clavatus (Desf.) Pers.	Asteraceae	May-July	Therophytes	Annual herbaceous
A. arvensis L.	Primulaceae	February-July	Therophytes	Annual herbaceous
Anagallis monelli L.	Primulaceae	February-July	Therophytes	Perennial herbaceous
Anchusa azurea Mill.	Boraginaceae	March-July	Hemicryptophytes	Perennial herbaceous
Arbutus unedo L.	Ericaceae	November - February	Phanerophytes	Shurb
Aristolochia baetica L.	Aristolochiaceae	January-June	Phanerophytes	Perennial herbaceous
Artemisia vulgaris L.	Asteraceae	June-September	Hemicryptophytes	Perennial herbaceous
Asparagus acutifolius L.	Asparagaceae	July-September	Geophytes	Perennial herbaceous
Asperula hirsuta Desf.	Rubiaceae	March-June	Hemicryptophytes	Annual herbaceous
Asphodelus microcarpus Salzm *et* Viv	Xanthorrhoeaceae	May-July	Geophytes	perennial herbaceous
Asteriscus maritimus (L.) Less.	Asteraceae	April-July	Hemicryptophytes	Perennial herbaceous
Astragalus hamosus L.	Fabaceae	March-may	Therophytes	Annual herbaceous
Atractylis caespitosa Desf.	Asteraceae	June-August	Therophytes	Perennial herbaceous
A. cancellata L.	Asteraceae	April-June	Therophytes	Annual herbaceous
Atractylis gummifera L.	Asteraceae	August-November	Hemicryptophytes	Perennial herbaceous
Avena sterilis L.	Poaceae	May-July	Therophytes	Annual herbaceous
Avenula pratensis L.	Poaceae	March-September	Hemicryptophytes	Perennial herbaceous
Ballota hirsuta Benth.	Lamiaceae	April-September	NanoPhanerophytes	Perennial herbaceous
Bartsia trixago L.	Orobanchaceae	April-July	Therophytes	Annual herbaceous
Bellis annua L.	Asteraceae	February-June	Therophytes	Annual herbaceous
Brassica nigra (L.) Koch.	Brassicaceae	March-July	Therophytes	Annual herbaceous
Briza maxima L.	Poaceae	May-June	Therophytes	Annual herbaceous
Bromus rubens L.	Poaceae	April-July	Therophytes	Annual herbaceous
B. sterilis L.	Poaceae	May-August	Therophytes	Annual herbaceous
B. tectorum L.	Poaceae	May-August	Therophytes	Annual herbaceous
Bryonia cretica subsp. *Dioica* (Jacq.)	Cucurbitaceae	May-August	Geophytes	Perennial herbaceous
Calendula arvensis L.	Asteraceae	April-September	Therophytes	Annual herbaceous
Calicotome spinosa L.	Fabaceae	April-June	NanoPhanerophytes	Shrub and Sub-shrub
Cardaria draba (L.) Desv.	Brassicaceae	March-June	Hemicryptophytes	Perennial herbaceous
Carduus pycnocephalus L.	Asteraceae	March-June	Therophytes	Annual herbaceous
Carthamus caeruleus L.	Asteraceae	March-June	Hemicryptophytes	Perennial herbaceous
Centaurea calcitrapa L	Asteraceae	April-August	Hemicryptophytes	Biennial herbaceous
C. eriophora L.	Asteraceae	April-July	Therophytes	Annual herbaceous
C. parviflora Desf.	Asteraceae	April-July	Hemicryptophytes	Annual herbaceous Biennial herbaceous

Species	Family	Flowering	Biological type	Biological cycle
Centaurea pullata L.	Asteraceae	May-June	Hemicryptophytes	Biennial herbaceous
Centaurium erythraea Rafn.	Gentianaceae	April-June	Therophytes	Perennial herbaceous
Ceratonia siliqua L.	Fabaceae	August-November	Phanerophytes	Tree
Chamaerops humilis L.	Arecaceae	April-June	Chamephytes	Perennial herbaceous
Cistus salviifolius L.	Cistaceae	April-June	Chamephytes	Shrub and Sub-shrub
Convolvulus althaeoides L.	Convolvulaceae	March-June	Hemicryptophytes	Perennial herbaceous
Crataegus oxyacantha L.	Rosaceae	April-June	Phanerophytes	Shrub and Sub-shrub
Cupressus sempervirens L.	Cupressaceae	April-may	Phanerophytes	Tree
Cynara cardunculus L.Var.	Asteraceae	March-August	Hemicryptophytes	Perennial herbaceous
Cynodon dactylon (L.) Pers.	Poaceae	August-September	Geophytes	Perennial herbaceous
Dactylis glomerata L.	Poaceae	April-September	Hemicryptophytes	Perennial herbaceous
Daphne gnidium L.	Thymelaeaceae	March-October	NanoPhanerophytes	Shrub and Sub-shrub
Daucus carota L.	Apiaceae	March-October	Hemicryptophytes	Biennial herbaceous
Dittrichia viscosa L. Greuter.	Asteraceae	October-November	Chamephytes	Perennial herbaceous
Echinops spinosus L.	Asteraceae	June-August	Hemicryptophytes	Perennial herbaceous
E. strigosus L.	Asteraceae	December-March	Hemicryptophytes	Perennial herbaceous
Echium angustifolium Mill.	Boraginaceae	March-July	Chamephytes	Perennial herbaceous
Eruca vesicaria (L.) Car.	Brassicaceae	February-May	Therophytes	Annual herbaceous
Eryngium triquetrum Vahl.	Apiaceae	March-July	Hemicryptophytes	Perennial herbaceous
Eucalyptus globulus Labill.	Myrtaceae	June-September	Phanerophytes	Tree
Ficus carica L.	Moraceae	May-August	Phanerophytes	Shurb
Filago pyramidata L.	Asteraceae	April-July	Therophytes	Annual herbaceous
Foeniculum vulgare (Mill.) Gaertn.	Apiaceae	May-October	Hemicryptophytes	Perennial herbaceous
Fraxinus excelsior L.	Oleaceae	April-may	Phanerophytes	Tree
Fumana thymifolia (L). Spach *ex* Webb.	Cistaceae	March-June	Therophytes	Annual herbaceous
Fumaria officinalis L.	Fumariaceae	March-September	Therophytes	Annual herbaceous
F. parviflora Lam.	Fumariaceae	March-July	Therophytes	Annual herbaceous
Glebionis coronaria L.	Asteraceae	May-September	Therophytes	Annual herbaceous
Globularia alypum L.	Plantaginaceae	November-May	Chamephytes	Shrub and Sub-shrub
Hedera helix L.	Araliaceae	September-November	Phanerophytes	Shrub and Sub-shrub
Hedypnois rhagadioloides (L.) F.W.	Asteraceae	March-June	Therophytes	Annual herbaceous
Helianthemum apenninum L.	Cistaceae	May-August	Chamephytes	Perennial herbaceous
H. polyanthum Desf.	Cistaceae	May-August	Therophytes	Perennial herbaceous
Hordeum maritimum With.	Poaceae	April-August	Therophytes	Annual herbaceous
H. vulgare L.	Poaceae	May-July	Therophytes	Annual herbaceous
Hypochaeris radicata L.	Asteraceae	April-September	Hemicryptophytes	Perennial herbaceous
Iris sisyrinchium L.	Iridaceae	March-May	Geophytes	Perennial herbaceous
Juniperus communis L.	Cupressaceae	April-may	NanoPhanerophytes	Shrub and Sub-shrub
Linaria triphylla (L.) Mill.	Plantaginaceae	March-June	Therophytes	Annual herbaceous
Lobularia maritima (L.) Desv.	Brassicaceae	April-September	Chamephytes	Perennial herbaceous
Malva sylvestris L.	Malvaceae	February-May	Hemicryptophytes	Biennial herbaceous
Marrubium vulgare L.	Lamiaceae	May-September	Chamephytes	Perennial herbaceous
Medicago polymorpha L.	Fabaceae	March-May	Therophytes	Annual herbaceous

Species	Family	Flowering	Biological type	Biological cycle
M. rigidula (L.) All.	Fabaceae	March-June	Therophytes	Annual herbaceous ouBiennial herbaceous
Mentha rotundifolia L.	Lamiaceae	May-October	Hemicryptophytes	Perennial herbaceous
Misopates orontium (L.) Raff.	Plantaginaceae	June-September	Therophytes	Annual herbaceous
Muscari comosum L.	Asparagaceae	March-June	Geophytes	Perennial herbaceous
Narcissus serotinus L.	Amaryllidaceae	September-October	Geophytes	Perennial herbaceous
Nerium oleander L.	Apocynaceae	April-September	Phanerophytes	Shrub and Sub-shrub
Olea europaea var. *oleaster* L	Oleaceae	March-June	Phanerophytes	Tree
O. europaea var. *sativa* L.	Oleaceae	March-June	Phanerophytes	Shurb
Onopordum macracanthum Schousb.	Asteraceae	July-September	Hemicryptophytes	Perennial herbaceous
Ornithogalum umbellatum L.	Asparagaceae	April-June	Geophytes	Perennial herbaceous
Pallenis spinosa (L.) Cass	Asteraceae	April-June	Hemicryptophytes	Biennial herbaceous
Papaver rhoeas L.	Papaveraceae	May-July	Therophytes	Annual herbaceous
Paronychia argentea (Pourr) Lam.	Caryophyllaceae	May-June	Hemicryptophytes	Perennial herbaceous
Phagnalon saxatile (L.) Cass	Asteraceae	March-July	Hemicryptophytes	Perennial herbaceous
Phillyrea angustifolia L.	Oleaceae	March-May	Phanerophytes	Shrub and Sub-shrub
Phlomis crinita Cav.	Lamiaceae	March-June	Hemicryptophytes	Annual herbaceous
Picris echioides L.	Asteraceae	April-August	Therophytes	Biennial herbaceous
Pinus halepensis Mill.	Pinaceae	January-December	Phanerophytes	Shurb
Pistacia atlantica Desf.	Anacardiaceae	January-April	Phanerophytes	Shurb
Pistacia lentiscus L.	Anacardiaceae	March-May	NanoPhanerophytes	Shrub and Sub-shrub
P. terebinthus L.	Anacardiaceae	April-July	Phanerophytes	Shurb
Plantago albicans L.	Plantaginaceae	April-June	Hemicryptophytes	Perennial herbaceous
P. lagopus L.	Plantaginaceae	March-June	Therophytes	Annual herbaceous
Prunus dulcis (Mill.) D.A.Webb.	Rosaceae	January-April	Phanerophytes	Tree
Quercus coccifera L.	Fagaceae	April-may	NanoPhanerophytes	Shurb
Q. ilex L.	Fagaceae	April-may	Phanerophytes	Tree
Ranunculus arvensis L.	Ranunculaceae	April-June	Therophytes	Annual herbaceous
Raphanus raphanistrum L.	Brassicaceae	March-July	Therophytes	Annual herbaceous Biennial herbaceous
Reseda alba L.	Resedaceae	May-October	Therophytes	Annual herbaceous ouBiennial herbaceous
Rhagadiolus stellatus (L.) Gaertner.	Asteraceae	March-June	Therophytes	Annual herbaceous
Rhamnus alaternus L.	Rhamnaceae	February-April	Phanerophytes	Shrub and Sub-shrub
Rhaponticum acaule (L.) DC	Asteraceae	April-September	Hemicryptophytes	Perennial herbaceous
Rosa canina L.	Rosaceae	May-July	nanoPhanerophytes	Shrub and Sub-shrub
R. sempervirens L.	Rosaceae	April-June	NanoPhanerophytes	Shrub and Sub-shrub
Rosmarinus officinalis L.	Lamiaceae	January-December	Nanophanérophyte	Shrub and Sub-shrub
Rubia peregrina L.	Rubiaceae	April-June	Phanerophytes	Perennial herbaceous
Rubus ulmifolius Schott.	Rosaceae	June-August	NanoPhanerophytes	Shurb
Rumex bucephalophorus L.	Polygonaceae	April-October	Therophytes	Annual herbaceous
Ruta chalepensis L.	Rutaceae	March-June	Nanophanérophyte	Perennial herbaceous
R. montana L.	Rutaceae	March-August	Hemicryptophytes	Perennial herbaceous

Species	Family	Flowering	Biological type	Biological cycle
Salvia argentea L.	Lamiaceae	June-August	Hemicryptophytes	Perennial herbaceous
S. officinalis L.	Lamiaceae	May-July	Chamephytes	Shrub and Sub-shrub
Scolymus hispanicus L.	Asteraceae	April-August	Therophytes	Biennial herbaceous
S. maculatus L.	Asteraceae	June-August	Therophytes	Annual herbaceous
Sedum sediforme (Jacq.) Pau.	Crassulaceae	June-August	Chamephytes	Perennial herbaceous
Sideritis incana L.	Lamiaceae	March-June	Therophytes	Annual herbaceous
Silene colorata Poiret.	Caryophyllaceae	March-May	Therophytes	Annual herbaceous
Silybum marianum L. Gaertn.	Asteraceae	April-July	Hemicryptophytes	Biennial herbaceous
Sinapis arvensis L.	Brassicaceae	January-May	Therophytes	Annual herbaceous
Sisymbrium officinale L.	Brassicaceae	May- September	Hemicryptophytes	Annual herbaceous
Sonchus oleraceus L.	Asteraceae	June-October	Therophytes	Annual herbaceous
Stipa tenacissima L.	Poaceae	March-may	Hemicryptophytes	Perennial herbaceous
Tamarix gallica L.	Tamaricaceae	April-June	Phanerophytes	Shrub and Sub-shrub
Teucrium polium L.	Lamiaceae	April-August	Chamephytes	Perennial herbaceous
Thymelaea hirsuta (L.) Endl.	Thymelaeaceae	October-May	Chamephytes	Shrub and Sub-shrub
Thymus ciliatus Desf.	Lamiaceae	March-May	Chamephytes	Perennial herbaceous
T. ciliatus ssp. *coloratus L.*	Lamiaceae	April-July	Chamephytes	Perennial herbaceous
Torilis nodosa L.	Apiaceae	April-July	Therophytes	Annual herbaceous
Trifolium angustifolium L.	Fabaceae	April-June	Therophytes	Annual herbaceous
T. cherleri L.	Fabaceae	May-July	Therophytes	Annual herbaceous
T. stellatum L.	Fabaceae	March-July	Therophytes	Annual herbaceous
Turgenia latifolia (L.) Hoffm.	Apiaceae	May-August	Therophytes	Annual herbaceous
Urginea maritima L.	Hyacinthaceae	August-October	Geophytes	Perennial herbaceous
U. pancration Phil.	Hyacinthaceae	August-October	Geophytes	Perennial herbaceous
Urtica membranacea L.	Urticaceae	March–September	Therophytes	Annual herbaceous
Verbascum sinuatum L.	Scrophulariaceae	May-August	Hemicryptophytes	Biennial herbaceous
Viburnum tinus L.	Adoxaceae	February-may	Phanerophytes	Shrub and Sub-shrub
Ziziphus lotus (L.) Lam.	Rhamnaceae	May-June	Phanerophytes	Shrub and Sub-shrub

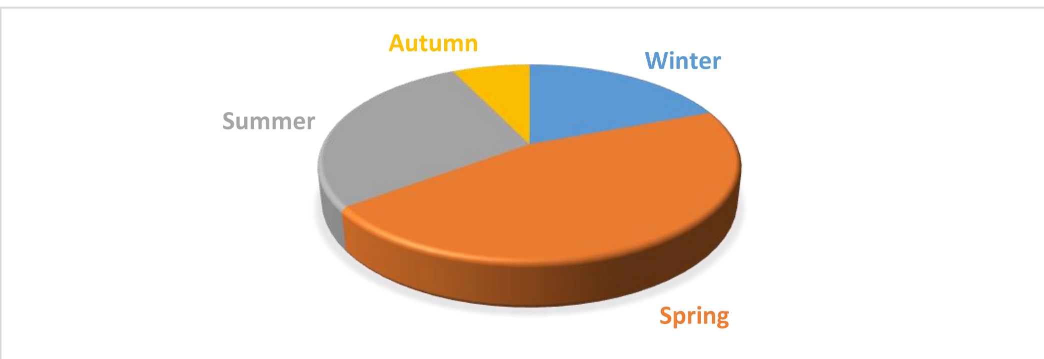

Fig. 1. Floristic richness by season for all sampled stations.

Floristic richness, which at least partially reflects the structure and functioning of plant communities, is heavily influenced by rainfall patterns and varies highly from season to season. It is used for the qualitative characterization of the ecosystem since the increase in floristic richness during spring and winter can be the cause of a process of self-restoration of a degraded ecosystem (Bonet, 2004; Zhang *et al.*, 2005) because anthropozogenic action is very influential (Chérifi *et al*., 2011) not forgetting that 32% of our flora sampled is annual and spend the summer as seeds. The variation in composition and floristic richness between the four seasons seems to be more influenced by geographical location. During the dry season, intense grazing is responsible for changing the structure and composition of the vegetation. In the long term (Allam *et al*., 2019), it can cause a reduction in revegetation speed after the first rains following a drought (Kinloch and Friedel, 2005; Metzger, 2005). Seasonal drought seems to affect floristic wealth more than animal activity. Therefore, it also appears that the unfavorable season is the first cause of the changes in composition and the decrease in floristic wealth.The monthly floristic richness in the Tessala Mountains varies from 6 to 126 species (Fig. 2), which confirms that the agreeable season favors the increase of the floristic procession, the ideal time is May.

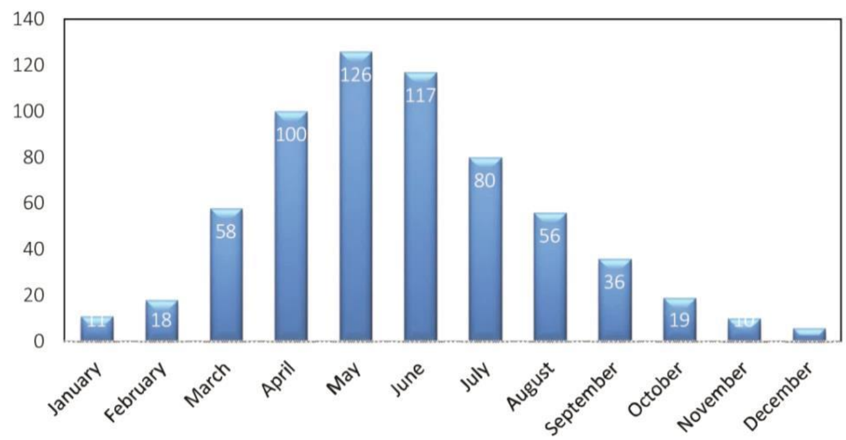

Fig. 2. Floristic richness by month for all sampled stations.

Biological types

Global biological spectrum : The therophytes remain the predominant and the best-represented type (37%), hemicryptophytes (23%), phanerophytes (16%), chamephytes (10%) and geophytes (7%); the global distribution of biological types follow the following schemes: Th > He > Ph > Ch > Geo (Table 3), this is consistent with the order of biological types in the Tessala Mountains (Bouterfas *et al*., 2013; Fertout, 2014). This general distribution of the biological types also corresponds approximately to that described in north western Algeria by Kadi-Hanifi (2003) and Benabadji *et al*., 2009 and Chérifi *et al*., 2011. These variations in biological spectra are mainly related to local variations in bioclimatic parameters and multiple pressures exerted by humans and animals. They reflect the relationship between the dominant biological types of a spectrum, the degree of environmental degradation, and the constraints associated with each singular medium (Verlaque *et al*., 2001; Latreche and Mehdadi, 2006; Bouker *et al*., 2022).

Seasonal biological spectrum: At the four-season level, the distribution of biological types follows the following patterns: Spring > Summer > Winter > Autumn, except for phanerophytes have a tolerance for winter than summer. Spring remains the predominant season and is best represented by biological types (Th, He, Ph, Ch, and Geo respectively 33, 33, 08, 12 and 55), followed by Th, He, Ph, Ch, and Geo respectively 11, 22, 06, 07 and 40), winter (Th, He, Ph, Ch, and Geo respectively 16, 12, 04, 04 and 23) and autumn (Th, He, Ph, Ch, and Geo respectively 06, 03, 03 and 07). In general, the Tessala Mountains have different distributions of biological spectra in space and time. Therophytes occupy a great place at least in all seasons, then come sometimes the hemicryptophytes (Spring and Summer), and sometimes the phanerophytes (Winter and Autumn), followed by the chamephytes and geophytes.

Spring: Th He Ph Ch Ge **Summer:** Th He Ph Ch Ge

Winter: Th Ph He Ch Ge **Autumn:** Th Ph He Ch Ge

Table 3. Biological types of species surveyed by season.

Biological Type	Global	Spring	Summer	Winter	Autumn
Phanerophytes	35	33	**11**	**16**	06
Hemicryptophytes	35	33	22	12	03
Geophytes	11	08	06	04	03
Chamephytes	15	12	07	04	03
Therophytes	56	55	40	23	07

Therophytes are the most dominant in all seasons at least regarding number. Their presence in our semi-arid environment is linked to their adaptation strategy. Therophtisation is a strategy for drought adaptation that the presence of sand even in reduced layers in Saharan habitats leads to the development of psammophytes, especially annual ones. That therophytes do not exhibit specific morphological adaptations to aridity. They escape extreme conditions in the seed state. It appears that the presence of therophytes is generally related to precipitation.

The phanerophytes and hemicryptophytes occupy the second position in all the seasons. The phanerophytes are the most suitable since they have a root system that allows searching for water in the soils during the severe seasons. In addition, hemicryptophytes are very common in favorable water conditions and ambient temperatures.In general, chamephytes are adapted to the conditions of arid environments (low temperatures and aridity). Geophytes are less represented throughout the year. They are considered as arid-passive perennial plants to resist extreme conditions (drought, low temperature) by limiting their growth or temporarily suppressing it.

Bio-morphological type

Overall morphological spectrum: In the Tessala mountains, the plant formations are represented physiognomically by four strata: arborescent, shrubby, bushy, and herbaceous. The proportion analysis of various categories of morphological types detected is variable. In our case, four categories are considered in descending order of importance: herbaceous (68%), bushy (12%), shrubby (11%), and tree-like (10%).

In this regard, these types of plant formations are the result of several factors like a human intervention with some forest management overgrazing exerts some influence on the distribution of the different morphological types (Le Floch, 2001). Climate change thus promotes the development of herbaceous and bushy stratum species (Aboura, 2006). Structurally, the morphological spectrum of the Tessala mountains with a massive dominance of the tree, shrub, and shrub layers and under stretched shrubs. The forest dynamics of the site have a strong capacity for regeneration (Saidi *et al*., 2016). Even if part of the study area is degraded, there are still areas with an adequate intact structure that give this forest a significant biological interest.

Global bio-morphological type: The perennial herbaceous plants dominate the bio-spectrum overall morphological with annual herbaceous which occupies the second place with rates of respectively 35.53% and 32.24%. The shrubs and under-shrubs occupy the third place with 12.5% and are followed by biennial herbaceous with 9.21%. As for the trees and shrubs, they remain the least present at a rate of 5.26% (Table 4). It is well established that environmental conditions influence in one way or another the development and distribution of species and, in this respect, the bio-spectrum morphological would be wholly indicative of the local climate that shapes the structure of the vegetation.

Table 4. Bio-morphological types of species surveyed by season.

Season/ Bio-m	Tree	Shrub	Shrub and Sub-shrub	Perennial herbaceous	Annual herbaceous	Biennial herbaceous
Global	5.26%	5.26%	12.50%	35.53%	32.24%	9.21%
Winter	5.08%	8.47%	13.56%	30.51%	35.59%	6.78%
Spring	5%	5%	12.86%	32.86%	34.29%	10%
Summer	2.33%	3.49%	6.98%	41.86%	11.63%	33.72%
Autumn	4.55%	9.09%	22.73%	40.91%	9.09%	13.64%

Seasonal bio-morphological type: Table 5 show that analysis of vegetation in its seasonal bio-morphological spectrum reveals the following findings:

Winter: Ha > Hv > As > At > Hb > A **Spring:** Ha > Hv > As > Hb > At > A

Summer: Hv > Hb > Ha > As > At > A **Autumn:** Hv > As > Hb > Ha > At > A

The proportion of the bio-morphological types is as follows, during winter and spring. The annual herbaceous ones dominate the bio-spectrum morphological with rates of 35.59% and 34.29% followed by Perennial herbaceous 30.51% and 32.86%. Shrubs and sub-shrubs 13.56% and 12.86%, biennial herbaceous 6.78% and 10%, during the summer and autumn seasons: perennial herbaceous plants dominate the bio-morphological spectrum with 41.86% and 40.91 %, followed by Biennial herbaceous plants occupy the second place for the summer season with a rate of 33.72%, shrubs and sub-shrubs occupy the second place for the autumn season with 22.73%. Then come the annual herbaceous plants in the fourth place with 11.63% and 9.09%.

As for trees and shrubs, they remain the least present during the four seasons their rates are between 2.33% and 5.08% and 3.49% to 9.09%, the annual and perennial herbaceous species are largely dominated by the winter and spring seasons is a valuable adaptation to the high variability of rainfall. Thus, climatic rigors favor the development of short-cycle annual and perennial herbaceous species at the expense of generally more demanding perennial woody species, as regards water and trophic requirements (Aboura, 2006). During the wet seasons, an explosion of germination of annuals is noticed in all the arid zones of north Africa (Djebbouri and Terras, 2019), while the woody well adapted to the aridity are slowly but quite irremediably influenced by the disturbance (Bouker *et al.*, 2022 ; Bonet, 2004; Ni-J, 2003).

Floristic analysis of families: The percentages of the different families surveyed 48 families and 125 genders were identified (summarised in Table 5).

The families best represented are those of Asteraceae with a rate of 21.05%. It has the best diversity: 25 gender and 32 species. Poaceae occupy the second place with a rate equivalent to 9.21% and a significant floristic richness with 10 gender and 14 species. The Lamiaceae family is in the third position with 7.89%, or 10 gender and 12 species. The Fabaceae family is in the fourth position with 5.92% that is 06 gender and 09 species.

The families best represented on the generic and specific planes alone account for 64.47% of the flora of the Tessala Mountains. The same families dominate in the Flores of Southern Oran, Algiers, and Constantine (Bouzenoune, 1984; Boughani, 1987, 1995). According to data from the

Table 5. Floristic analyses of seasonal families.

Family	Species	Generic	Winter	Spring	Summer	Autumn
Adoxaceae	01	01	01	01		
Amaryllidaceae	01	01			01	01
Anacardiaceae	03	01	03	03		
Apiaceae	06	06	02	06	05	01
Apocynaceae	01	01		01	01	
Araliaceae	01	01			01	01
Arecaceae	01	01				
Aristolochiaceae	01	01	01	01		
Asparagaceae	03	03	01	02	01	
Asteraceae	32	25	12	29	23	04
Boraginaceae	02	02	02	01	01	01
Brassicaceae	07	07	04	07	05	
Caryophyllaceae	02	02	01	02		
Cistaceae	04	03		04	03	01
Convolvulaceae	01	01		01		
Crassulaceae	01	01		01	01	
Cucurbitaceae	01	01		01	01	
Cupressaceae	02	02		02		
Ericaceae	01	01	01			01
Fabaceae	09	6	05	08	03	01
Fagaceae	02	01		02		
Fumariaceae	02	01	02	02	01	
Gentianaceae	01	01		01		
Hyacinthaceae	02	01	01	01	01	02
Iridaceae	01	01	01	01		
Lamiaceae	12	10	04	12	09	02
Malvaceae	01	01	01	01		
Moraceae	01	01		01	01	
Myrtaceae	01	01		01	01	
Oleaceae	04	03	03	04		
Orobanchaceae	01	01		01	01	
Papaveraceae	01	01		01	01	
Pinaceae	01	01	01	01	01	01
Plantaginaceae	05	04	02	05	01	01
Poaceae	14	10	02	14	10	
Polygonaceae	01	01		01	01	01
Primulaceae	02	01		02	02	01
Ranunculaceae	02	02		01	01	01
Resedaceae	01	01		01	01	01
Rhamnaceae	02	02	01	02		
Rosaceae	05	04	01	05	02	
Rubiaceae	02	02	01	02	01	
Rutaceae	02	01	02	02	01	
Scrophulariaceae	01	01		01	01	
Tamaricaceae	01	01		01		
Thymelaeaceae	02	02	02	02	01	01
Urticaceae	01	01	01	01	01	
Xanthorrhoeaceae	01	01		01	01	
Total 48	152	125	59/26	140/44	86/33	22/17
The report NF/NE	31.58 %		44.07%	31.43%	38.37%	77.27%
The generic coefficient			82.24 %			

literature (Ozenda, 1991; Quézel, 1965), the Asteraceae, Fabaceae, and Poaceae dominate in the sub-sector of the Saharan Atlas Auresio-Constantinos of the Maghrebi steppic domain. On the other hand, the Sahara-Mediterranean district is characterized by the predominance of Saharan elements dominated by the Boraginaceae and Apiaceae. According to Ozenda (1991), Asteraceae, Poaceae, and Fabaceae account for 35-40% of the flora of each Saharan area.

The ratio of the number of families to the number of species is 31.58%. It is 14% for South of Constantine and 18% for South Algiers. The generic coefficient, that is to say, the ratio of the number of genera to the number of species, reaches here 82.24%, while it is equal to 57% in the zone bordering South of Constantine (Boughani, 1995).

The number of families per season varies from 17 in summer to 44 in spring, while the ratio between the number of families and species varies from 77.27% in summer to 31.43% in spring.

That explains the impoverishment of families during the unfavorable seasons. A large number of families depend more or less on the favorable conditions favored by the spring. The more heat and humidity there is, the more abundant families are. Among the most important factors determining the adaptations of families in wealth and floristic composition are temperature, precipitation, solar radiation, and winds. These elements act together through a complex system of factors that influence vegetation (Billings and Bliss, 1959; Galen and Stanton, 1995). Climate is considered to be the primary factor, on a global scale, influencing the distribution and composition of species (Mccarty *et al.*, 2001; Pearson and Dawson, 2003). It is recognized that climatic conditions control the distribution of species, as well as the composition of biomes (Prentice *et al*., 1992; Pearsonand Dawson, 2003).

Factor Analysis of Correspondence (AFC): The AFC performed, whose matrix of crossing all the selected climatic and biological variables of the ten sampled stations, makes it possible to identify four groups of plant formations (Fig. 3). On the factorial plant, the F1 axis provides the most information in the AFC (57.31% inertia) compared to the F2 axis (37.50% inertia). The discrimination of the four groups was chosen in conjunction with the parallel upward Ascending hierarchical classification (AHC).

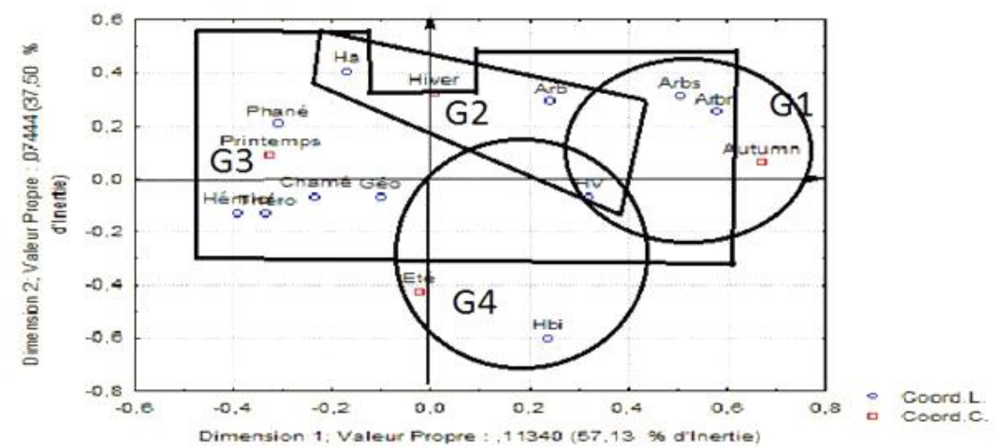

Fig. 3. Graphical representation of factor analysis of correspondence (AFC)

Hiv :Winter ; Prin: Spring ; Eté : Summer ; Aut : Autumn ; Arb: Tree ; Arbs: Shrub; Abri Shrub and Sub-shrub; Ha : annual herbaceous; Hv : perennial herbaceous ; Hb : biennial herbaceous; Phané : Phanerophytes ; Chamé : Chamephytes ; Géo : Geophytes ; Hémi : Hemicryptophytes ; Théro : Therophytes.G1: Autumn ; G2 : Winter ; G3 : Spring ; G4 : Summer.

Based on contributions made by individuals and variables: Group G1 is represented by the plant diversity associated with the autumn season, where shrubs bushes and under growths, and perennial herbaceous plants dominate.

The G2 group is characterized by the winter season-related flora, dominated by trees, annual herbaceous plants, and perennial herbaceous plants.

Group G3 is represented by spring flora where all biological, and bio-morphological forms dominate.

The G4 group is represented by the summer flora, where perennial and biennial herbaceous plants dominate.

Based on the results obtained, we confirm that these variations in biological and bio-morphological spectra are mainly related to local seasonal variations and edaphic parameters altitude and slope factors in addition to anthropogenic action. This same observation is confirmed by the studies of Sauvage (1961). It reflects the link between floristic composition and climate change due to seasonal variations. These results are confirmed by several authors, such as Daget and Poissonet (1997, 1991, 1980), and (Floret *et al*., 1990). Who reported the relationships between the distribution of biological and bio-morphological types on the one hand and environmental factors, in particular the climate (precipitationand temperature) as well as altitude, slope, and substrate type, and have a stable forest model (Xuan Minh, 2022; Bouker *et al*., 2022).

Conclusion

Seasonal monitoring of the phytodiversity of the Tessala Mountains has led to the following main conclusions:

The floristic inventory resulted this flora can be described as aparticularly rich. The variation of the analytical elements of phytodiversity (floristic richness, biological type, morphological and bio-morphological type, and distribution of families) reflects, at least partially, the structure and functioning of plant communities; during the spring is heavily influenced by the rainfall regime and varies highly from one season to the next. It is used for the qualitative characterization of the ecosystem since any increase can be the origin of a process of self-reestating and revegetation of our degraded ecosystem.

The different floristic, biological, and bio-taxonomic analyses confirm the richness, and the great diversity of the sector studied. The statistical treatments highlight the high diversity of natural elements in place.

By these findings brought by our study, the punctual study of disturbances is more than necessary either in its intensity, frequencies, and duration or by its effects over time that are sought specifically to understand the plant dynamics in spaces highly affected by multiple threats.

The floristic follow-ups have allowed us to confirm the periods when vegetation develops the most; in this case; spring validates the tradition related to sampling during this season.

On the other hand, the temporal monitoring of phytodiversity is part of the recent methods for the knowledge of the implementation, regression, or positive evolution of the different taxa. We have confirmed that the best period is from March to July-August.

The conservation actions that must be implemented practically in concrete cases such as the Tessala mountains must integrate all these factors; linked to the diversity of plant groups, their respective plant diversity at quantitative and qualitative levels. Biological conservation methods can only be relevant and effective if they take into consideration the current dynamics of the local biodiversity of these mountains.

The different approaches taken in our work as well as the results obtained shed light on the current state of the vegetation formations of the Tessala mountains, of their current evolutions under the effect of the various disturbances and thereby give concrete form to a scientific basis based on a pragmatic biological and ecological conservation.

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