FLORISTIC DIVERSITY OF HAFIR FOREST (ALGERIA): IMPACTS OF DISTURBANCES ON SPECIES COMPOSITION

MOHAMMED LACHGUEUR[1]*, SABIHA BOUCHAOUR-DJABEUR[2]

1 University of Tlemcen, Faculty of SNV-STU, Department of Forest Resources, Laboratory No. 31: Conservation Management of Water, Soil, and Forests and Sustainable Development of Mountainous Areas in the Tlemcen Region, Algeria*

2 Lecturer-Researcher, University of Tlemcen, Faculty of SNV-STU, Department of Forest Resources, Laboratory No. 31: Conservation Management of Water, Soil, and Forests and Sustainable Development of Mountainous Areas in the Tlemcen Region, Algeria.

**Corresponding author:* MOHAMMED LACHGUEUR

Submitted: 01/05/2025 **Acceped:**01/07/2025 **Published :**01/08/2025

Abstract

The Hafir oak forest grove in Tlemcen (Algeria) extends over 10,157.55 hectares (ha). Vulnerable, it is constantly subjected to various degradation factors, such as fires, anthropogenic pressure and climate change. The objective of our study is to identify the floristic composition of this oak forest. To do this, we carried out 120 Sampling plots according to the Braun Blanquet method supplemented with itinerant surveys along transects during the years 2022 and 2023. These allowed us to inventory 387 taxa divided between 67 families and 264 genera. These taxa are mainly dominated by Therophytes (49%) and Hemicryptophytes (21%). The analysis of the flora identified reveals a predominance of the Mediterranean biogeographic type and the presence of 10 endemic species. The study of the Hafir Forest shows an ecosystem in a state of stress, as evidenced by the high disturbance index of 59.43%, reflecting an expressive therophytization in response to climatic and anthropogenic disturbances. This research highlights the ecological importance of the Hafir Forest and the need to adopt conservation measures to preserve its unique biodiversity in the face of current threats.

Keywords: Hafir, floristic inventory, disturbance, life formes, chorology, anthropo-zoogenic pressures, fires, adaptation.

Introduction

Cork oak forests, a Mediterranean forest ecosystem, play a crucial ecological and socio-economic role in the Mediterranean region. Dominated by the cork oak (*Quercus suber*), these forest formations according to Quézel & Médail, (2003) are not only reservoirs of biodiversity, but also essential spaces for soil protection, climate regulation and an important economic resource through the production of cork and other non-woody forest products. However, these ecosystems are currently facing multiple threats, in particular anthropogenic pressure: fires, overgrazing and climate change, which compromise their integrity and their sustainabiity (Khaldi, 1998; WWF, 2004).

The Hafir forest, located in the wilaya of Tlemcen (Algeria), is one of the rare natural formations of cork oak in the west of the country. With an area of 10,157.55 ha, this forest represents an ecological and cultural heritage of great value (Boudy, 1955). However, like many Mediterranean cork oak forests, it is exposed to increasing pressures that threaten its biodiversity and its structure. Overgrazing, recurrent fires, unsuitable forestry practices and climate change have caused a progressive degradation of this forest, by disturbing its floristic composition and its regenerative capacity (Benabdeli, 1996; Bouchaour-Djabeur, 2001; Bouhraoua, 2003; Bouchaour-Djabeur, 20216; Bouchaour-Djabeur et al., 2020, 2021, 2024).

In this context, in order to assess the state of health of the Hafir forest and to be able to propose adapted conservation measures, this study aims to examine the floristic composition by identifying and analyzing contemporary species, their distribution and their adaptation strategies to current environmental conditions. In addition, according to Zeraia (1981) and Dahmani (1984), the analysis of biological and biogeographic types will make it possible to better understand the ecological dynamics at work in this threatened ecosystem.

Through this study, our objective is to increase knowledge of the biodiversity of the Hafir forest and to provide scientific bases for the implementation of sustainable management strategies. The preservation of this forest is not only essential to maintain local biodiversity, but also to ensure the ecosystem services it provides to local populations and the environment as a whole (Chevallier, 2002; Nsibi et al., 2006).

2. Material and methods

2.1. Study area

Covering an area of 10,157 ha, the Hafir national Forest is located 20 km from the capital of the wilaya of Tlemcen. This forest radiates over a territory of five municipalities including Sabra, Sidi Medjahed, Beni Bahdel, Bouhlou and Ain Ghoraba (BNEDER., 1979b) (Fig. 1).

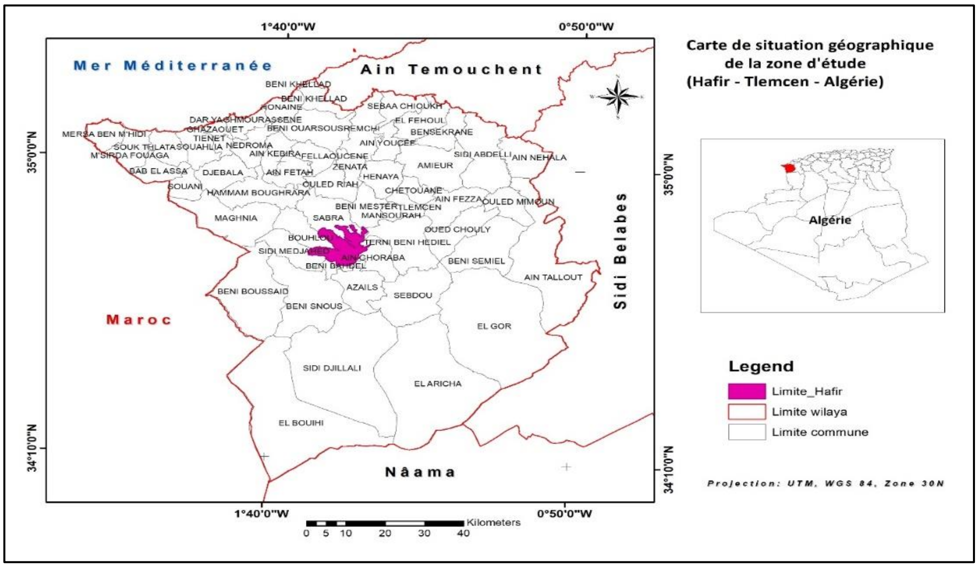

Figure 1: Situation map of the Hafir Forest (Tlemcen, Algeria)

Belonging to the Tlemcen mountains, the Hafir forest is characterized according to Doumergue (1910), Boudy (1948), Clair (1973), Benest (1985), Bouabdellah (1991) and Benest et al. (1999), by geological formations of upper Jurassic and lower Cretaceous age mainly formed of carbonates. Benest (1985), indicates that at the level of the Hafir forest, the Boumediene sandstones of upper Oxfordian-lower Kimmeridgian age are developing, characterized by the dominance of calcareous cement sandstones in the form of rather hard banks, with a thickness of up to 500 m.

The altitude of the Hafir forest varies from 700 m in the canton of Tebount to 1,418 m at the top of the canton of Djebel Koudiat Hafir near the forest house. An important hydrographic network composed of several wadis as well as a tangle of talwegs, some of which feed the Tafna wadi, characterizes the massif. Many streams and springs with low to medium flow depending on rainfall flow in full massif at the bottom of very deep depressions (Sauvagnac, 1956).

The Hafir bioclimate is characterized by a clear decrease in rainfall and an increase in temperatures, hence the existence of two dominant bioclimatic floors: the semi-arid and the sub-humid (Bouazza, 2020). These climatic conditions directly influence the dynamics of vegetation in a regressive direction (Bouazza and Benabadji, 2000).

The Hafir forest, is composed, in its natural state, essentially of deciduous trees, in particular three species of oak (*Quercus suber*, *Q. rotundifolia* and *Q. faginea* ssp. *tlemceniensis*), the wild olive tree (*Olea europea* ssp. *oleaster*) and a few feet of oxyphyllous ash trees (Fraxinus *oxyphylla*), but also softwoods such as Berber thuja (*Tetraclinis articulata*) and oxycedron juniper (*Juniperus oxycedrus*). In addition, Aleppo pine (*Pinus halepensis*), pine pine (*Pinus *pinea*), common cypress (*Cupressus sempervirens*) and eucalyptus (*Eucalyptus camaldulensis*) are found in some degraded cantons following reforestation carried out as part of soil defense and restoration on 575 ha between 1965 and 1969 (CFWT, 1995).

Bouhraoua, (2003), Letreuch, (2009), Bouchaour-Djabeur, 20216; Ghezlaoui et al., (2017); Bouchaour-Djabeur et al., 2020, 2021, 2024) describe that the undergrowth at the level of the Hafir forest is very rich in plants, either characteristic of high humidity, or symbol of degradation such as the presence of scrub. In the stations degraded by the fires, on the other hand, the scrub is very abundant.

Overgrazing

At the level of the Hafir forest, the progressive increase in the population practicing extensive sheep and cattle breeding generated a need that compromised the vegetation cover and significantly modified its floristic composition. This pressure has caused a degradation of the vegetation and has led to the constitution of ephemeral lawns where toxic and/or spiny non-palatable species dominate such as *Centaurea parviflora, Calycotome spinosa, Urginea maritima, Ulex boivinii, Asphodelus microcarpus, Echium vulgare* and *Atractylis humilis* (Bouazza et al., 2000; 2010).

We are therefore in the presence of a rural population who has no alternative but to pour themselves into agro-sylvo-pastoral activities, through the practice of a subsistence economy, which tends to exert an increasingly increased pressure on the forest. This forest represents a favorite terrain of the livestock route estimated at 2957 heads of sheep, 169 heads of cattle and 1130 heads of goats at the level of the localities of Hafir and Ain Ftouh (Municipality of Ain Ghoraba), Oued Zitoun, Jrada and Moul Dachra (Municipality of Sabra) and Tameksalet (municipality of Bouhlou) (DSA, 2023). Indeed, grazing in this region is carried out throughout the year. In the summer, the herds occupy the farmland after the harvest, and the rest of the year they graze in the forests.

Faced with this situation, uncontrolled overgrazing has become more and more dramatic, causing an imbalance in the floristic composition, a regression of the vegetation mat, a destruction of the surface horizons, soil erosion, an absence of natural regeneration of woody vegetation, and an occupation of natural environments by therophytes (Le Houerou, 1980; Babali, 2014).

The fires

Like the various forest formations, the cork oak forests are not spared from the phenomenon of fire. It represents the most dangerous and difficult aggression by its intensity, its brutality and its damage caused to the cork oak (Nsibi et al., 2006). These fires, whether caused by intentional human actions or by accidents, can lead to the total or partial destruction of vegetation and can modify the ecological conditions of the ecosystem by eliminating certain plant species and favoring the growth of other species better adapted to fire.

The Hafir forest experienced a significant number of fires that ravaged an area of the order of 3550.91 ha during the period from 1892 to 2020 (last recorded fire) (CFWT, 2024) as shown in the graph that follows (Fig. 2).

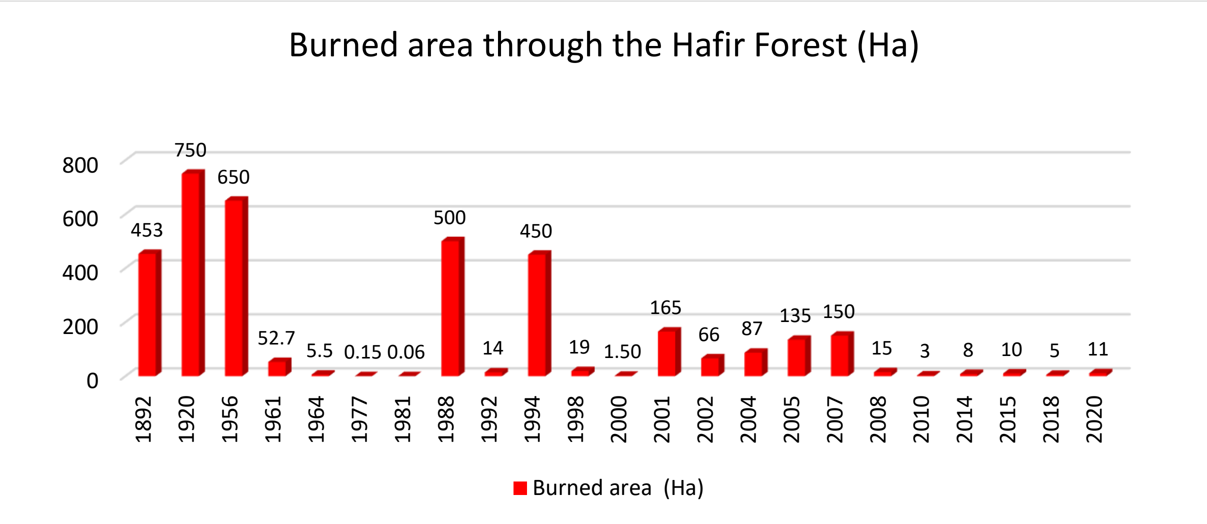

Figure 02: Evolution of fires through the Hafir forest during (1892-2020) (CFWT, 2024)

2.2. Methodology

The vegetation cover of the Hafir forest is characterized by a great heterogeneity, for this we opted for a stratified random sampling which takes into account the variability of the flora vegetation (Pardé and Bouchon, 1988). The vegetation inventory was carried out according to the Braun-Blanquet method (1951) and (Frontier, 1983).

Our inventory of the Hafir forest was conducted in 2022 and 2023, during the growing season (from February to October), in order to identify species from post-winter until autumn. Inside the forest, we have installed 120 plots representing average ecological conditions, making it possible to carry out the necessary surveys. The choice of the locations of the floristic surveys was guided by the homogeneity of the vegetation cover of the area in order to ensure the representativeness and reliability of the data collected. To complement the sampling and maximize the detection of rare or localized species, the floristic inventory was supplemented with itinerant surveys along transects of approximately 500 to 800 meters, crossing the main representative habitat types of the cork oak woodland. This approach increased spatial coverage and improved the chances of recording infrequent or habitat-specialist species. (Alexandre, 2010).

Gorenflot and Foucault (2005); Delpech, (2006), describe that the minimum area varies from 300 to 800 m^2 for forests, for this we opted for rectangular plots with a surface of 400 m^2 for each plot (20 m X 20 m) . At the end of the 120 plots carried out, we mentioned all the information on the characteristics of the plots, in particular the geographical coordinates and the altitude using GPS, the exposure using compass, the slope, etc. and established the list of all the (vascular) plant species present according to the Braun-Blanquet method of abundance-dominance coefficients.

Our study took into account several orographic parameters, in particular :

- The altitude :

Our inventory was conducted in the Hafir forest on several altitudes ranging from 700 m to 1399 m. The majority of the plots (86%, 103 plots) were carried out in the altitudinal ranges between 900 and 1299 m.

-The exposition :

The forest formations exposed to the West experienced the completion of 46 surveys followed by those exposed to the North with 39 surveys. The eastern and southern exposures are weakly represented in our study by 18 and 17 surveys respectively.

-The slope :

The vast majority (118) of the surveys were carried out on low to medium slopes. Only 2 surveys have been carried out on steep slopes due to the difficulty of access.

The identification of the inventoried plant species was made using the flora of Quézel & Santa (1962); Ozenda (1977) and Bonnier (1990). The determination of the biological types of plant species is based on the work of Ellenberg & Mueller-Dubois (1967).

We have noted for each species :

-the life form sensu Raunkiaer, (1934): Ph. (Phanerophyte), CH. (Chamephyte), HE. (Hemicryptophyte), GE (Geophyte), TH. (Therophyte).

-the chorological type: Endemic, Mediterranean, Nordic and Multiregional, (Quézel & Médail 2003)

In order to quantify the therophytization in our study area, we calculated the disturbance index defined by Hébrard (1995) by the following formula:

IP = (number of Chamephytes + number of Therophytes) / total number of species x 100

Data processing

The statistical processing of the floristic composition of our study area was carried out by the correspondence factor analysis (AFC) assisted by the "Past 4.06b" software To identify the factors that structure these plant communities (Legendre & Legendre, 2012) . To do this, a code consisting of four letters and a number is assigned to each of the taxa. The first letter indicates the genus, the other three letters that follow indicate the first letters of the species, the number represents the order of the taxa in the matrix, for example: *Aceras pyramidalis* is coded as follows: A-pyr 1.

The symbols of the abundance-dominance coefficients are not directly exploitable. Since the "+" is not a value, it has been replaced by the number "1".

We proceeded to the analysis of our results, organized in a matrix of 387 rows and 120 columns, considering only, the "presence (1) and the absence (0)" of the species, since the objective was the discrimination and the characterization of the species inventoried in the study area.

3. Results

3.1. Floristic composition

Like the forests around the Mediterranean, the Hafir Forest is characterized by a very rich floristic diversity. Our inventory allowed us to identify 12.33% of the Algerian flora and 21.74% of that of the Oran sector described by Quézel (2000), either 387 taxa of specific and sub-specific rank, divided between 264 genera and 67 families.

Eudicot angiosperms dominate with 50 families, 203 genera and 308 species. Monocots have 15 families, 56 genera, and 73 species. Gymnosperms are represented by only 2 families, 5 genera and 6 species (Fig. 3).

Of the 264 genera identified, 82 are multispecies while 182 are monospecific, giving a genera-to-species ratio of 68.22%. The genera with the most species are: *Cistus* with 5 species, closely followed by the genera *Silene, Euphorbia* and *Ranunculus*, each also with 5 species. in third place the genera *Plantago, Quercus, Linaria, Convolvulus* and *Galium*, each have 4 species (Fig. 4).

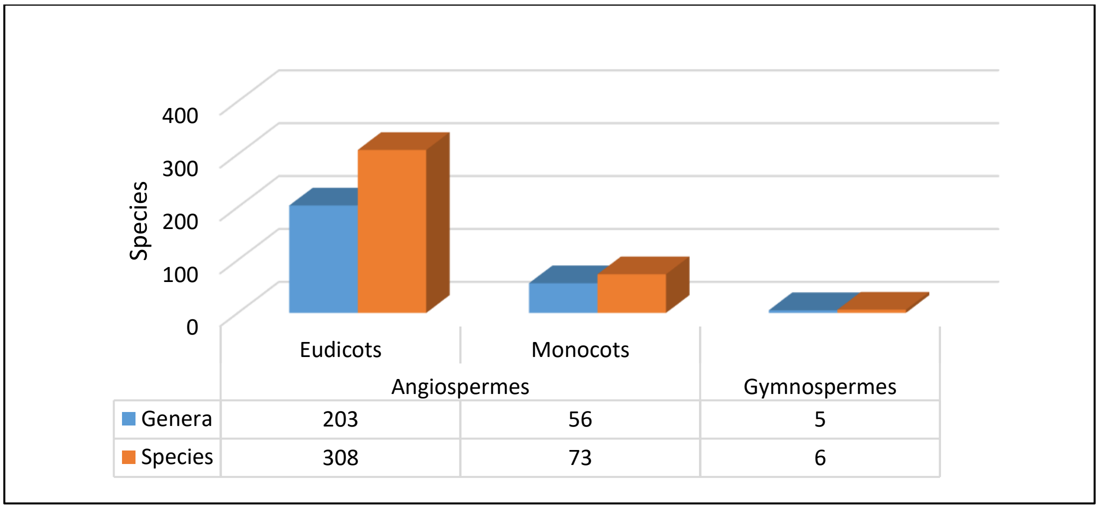

Figure 3: Distribution of the flora in systematic groups

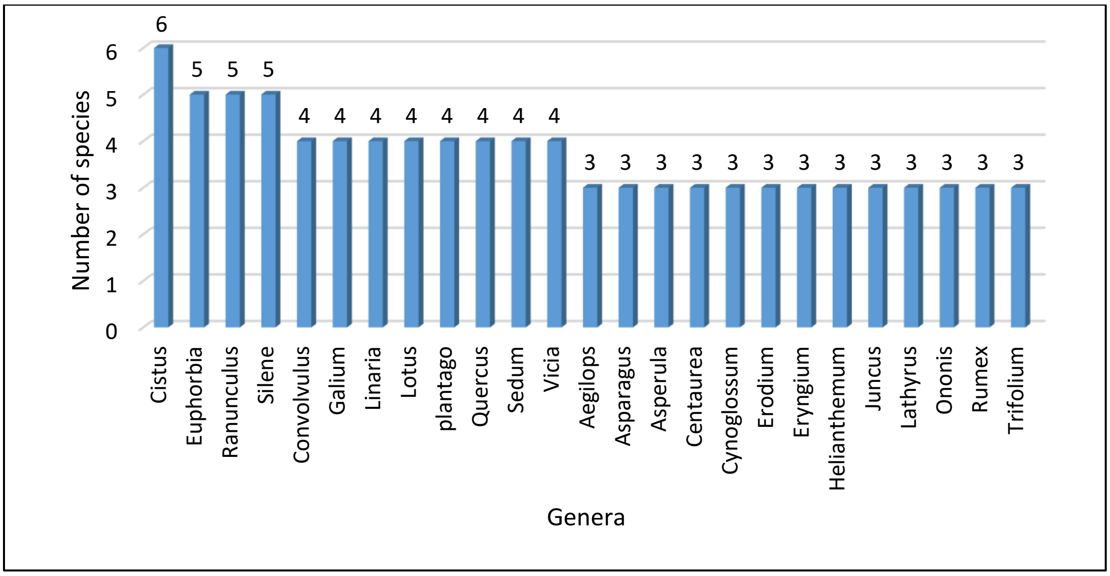

Figure 4: The most represented genera

With a family/number of species ratio of 17.31%, the taxa are categorized into 67 families (36 pluri-generic families and 31 mono-generics). Only 11 families represent more than 60% of the total inventoried species, these are classified in descending order as follows: *Asteraceae* (55 species, 44 genera), *Fabaceae* (44 species, 26 genera), *Poaceae* (30 species, 24 genera), *Apiaceae* (17 species, 14 genera), *Brassicaceae* (16 species, 14 genera), *Orchidaceae* and *Caryophyllaceae* (respectively 14 and 13 species, 10 and 08 genera), the *Lamiaceae* and the *Rubiaceae* (respectively 12 species, 9 and 6 genera), the *Plantaginaceae* (11 species, 5 genera) and finally the *Cistaceae* (10 species, 3 genera). The rest of the families have a low representation. (Fig. 5).

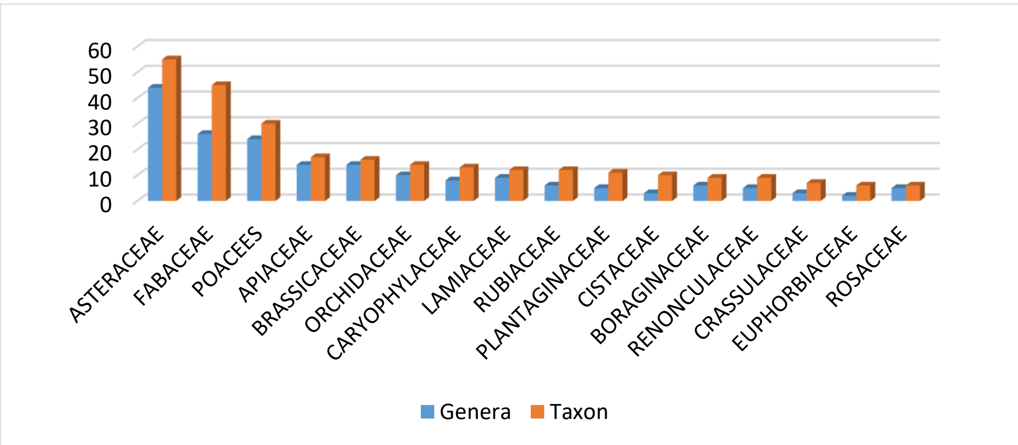

Figure 5 : The most represented families

The inventoried flora is classified in several biological forms. Annual herbaceous plants are represented with 52%, perennial herbaceous plants with 35% and finally perennial woody plants with 13% (Fig. 6).

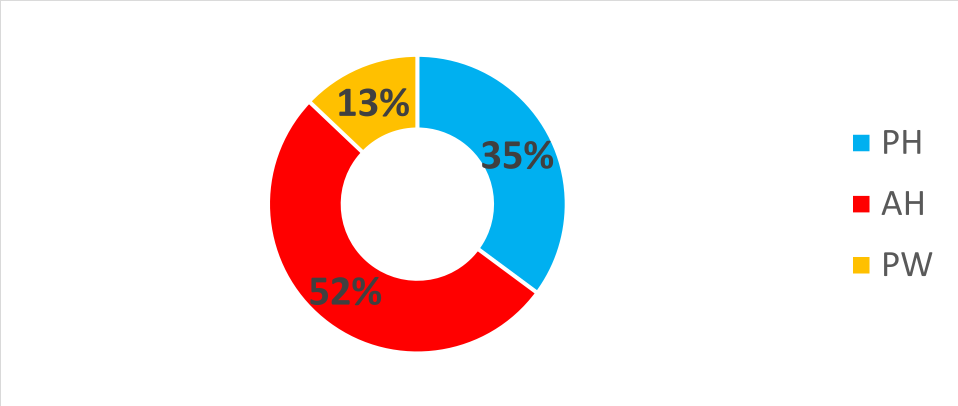

Figure 6 : Distribution of flora by life span

Legend: PH (perennial herbaceous), AH (annual herbaceous), PW (perennial woody).

3.2. Life forme

The results obtained highlight the dominance of Therophytes with a considerable rate of 49%, followed by Hemicryptophytes with 21%. Geophytes, Chamephytes and Phanerophytes appear respectively with 13%, 11% and 6%. (Fig. 7). The classification of the biological types by importance demonstrates that the vegetation studied has a biological spectrum of type : TH > HE > GE > CH > PH. The calculated disturbance index is equal to 59.43%.

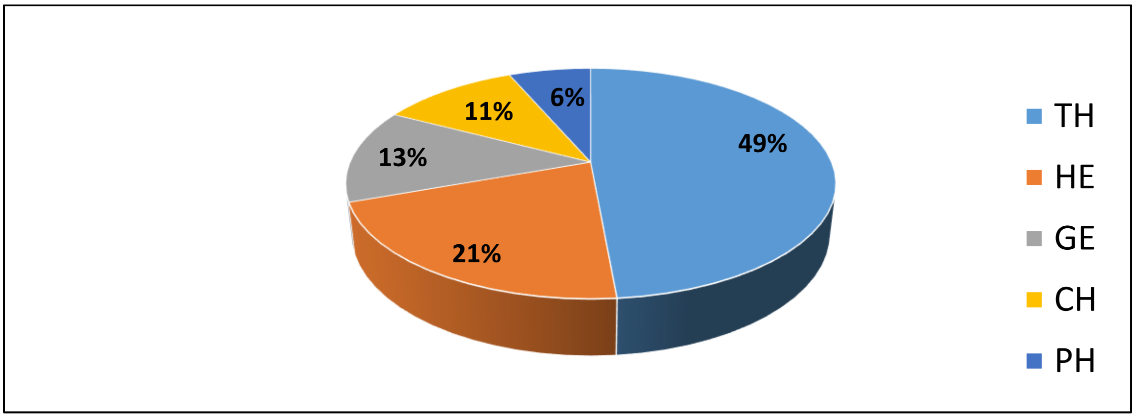

Figure 7: Distribution of flora by life form

PH (Phanerophytes), HE (Hemicryptophytes), GE (Geophytes), CH (Chamephytes), TH (Therophytes).

The distribution of life form by families showed a plasticity of 27 families which group 4 to 2 biological types in a single family. Each of the following families, in this case *Fabaceae*, *Poaceae, Ranunculaceae* and *Crassulaceae*, are present under four biological types, while *Asteraceae, Lamiaceae, Rosaceae, Apiaceae, Plantaginaceae* and *Convulvulaceae* are present under three biological types. The rest, either 17 families, group two biological types, in particular the *Orchidaceae, Brassicaceae, Caprifoliaceae, Caryophylaceae, Cistaceae, Convulvulaceae, Cyperaceae, Dipsacaceae, Ericaceae,* etc. (Fig. 8).

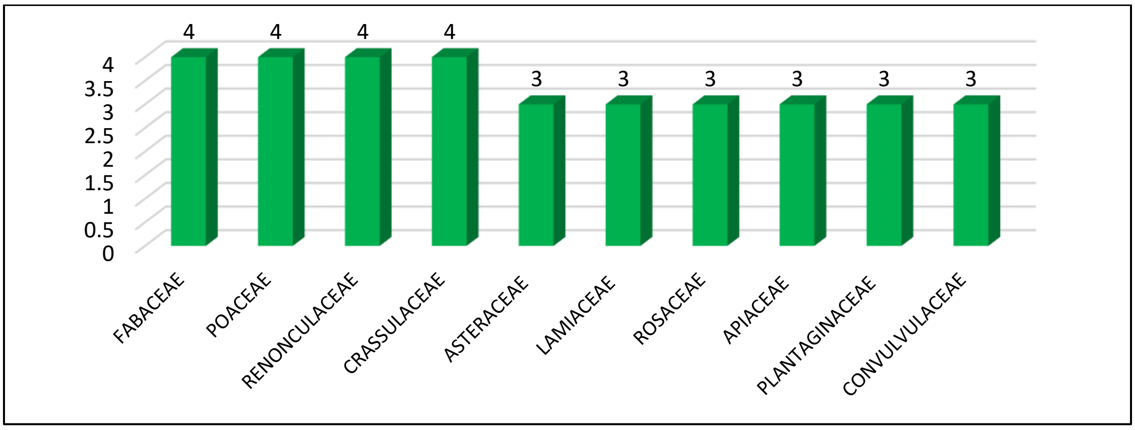

Figure 8: Distribution of life form by families

3.3. Chorological types

The analysis of the biogeographic spectrum of the studied vegetation shows the dominance of the Mediterranean chorological type with a rate of 74% (*Allium roseum, Asperula arvensis Asparagus acutifolius*). The pluriregional types in this case those of Eurasia, Paleo temperate, Cosmopolitan, Paleo subtropical, etc., occupy the second position with a rate of 22% of the total flora inventoried (*Melandrium album, Sedum acre, Campanula erinus*). The endemic types with a rate of 3% are represented by the North African, Algerian-Moroccan endemic and Algerian-Moroccan-Libyan endemic species (*Glossopappus macrotus, Jasonia rupestris, Ophrys fusca subsp maghribeca, Genista atlantica, AtractyIis macrophylla, Galium tricornutum*). The Nordic type including the circumboreal, Euro-Siberian and south-western European species (*Cardamine hirsula subsp. hirsuta, Phleum phleoides, Ranunculus gramineus*) is represented by only 1% of the total flora studied (Fig. 9).

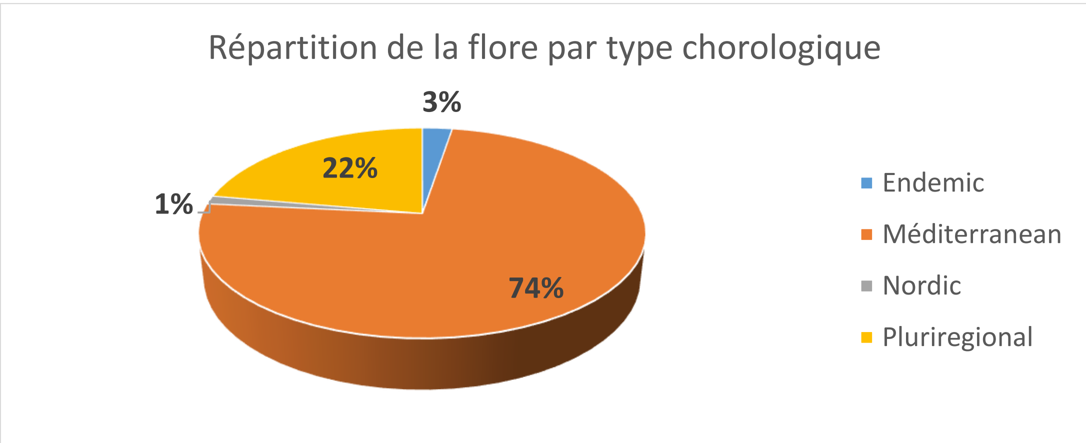

Figure 9 : Distribution of flora by chorological type

4. Discussion

With a sampling effort of 120 plots and transect , our floristic inventory was not very exhaustive for the entire Hafir forest. Some areas that had a high homogeneity and some grasslands were not taken into consideration. Despite this, we were able to highlight a significant floristic richness of the order of 387 species divided between 264 genera and 67 families.

Furthermore, studies were carried out in the same region of Tlemcen, particulary that of Babali, (2018), describes, through 400 plots, 645 taxa divided between 85 families and 387 genera in the Moutas hunting reserve. Those of Medjahdi et al. (2018), in the cork oak forests of Hafir and Zariffet, highlighted 239 taxa divided between 174 genera and 61 families. In the same region and across the Tlemcen Mountains, Ghezlaoui et al. (2017) described 195 species belonging to 143 genera and 48 families.

Regarding central Algeria, the work carried out through the Chréa cork oak forest by Mekidech et al. (2018), highlighted 213 species belonging to 50 families. At the Western Tellian Atlas of Tiaret, the results obtained by Miara et al. (2017) based on 278 plots, highlighted 566 species belonging to 76 families. Zemmar and al. (2020), described 151 species divided into 125 genera and 54 families in the forest of Bissa Chlef. In the cork forest of Jebel Saadia, Hedidi, (2019) identified 127 species divided between 103 genera and 39 families.

In the east of the country, Bouchibane, (2021), recorded 377 taxa, 65 families and 246 genera in the mountain ranges of Kabylie Babors, and in the cork forests of eastern Numidia, Bennadja and al (2013), recorded 292 species.

In Morocco, Soukayna and al. (2024), identified 407 species divided between 257 genera and 67 families in the Zerhoun cork oak forest.

The dominance of the families *Asteraceae, Fabaceae* and *Poaceae* in our results has been pointed out by the authors already mentioned above. These families are known for their great diversity and their ability to adapt to different environments, which reflects their presence in several biological types. Kazi (2010) reported that these families clearly dominate the Oran weed flora with 166 species, either 39% of the total population. In our case, the *Asteraceae, Fabaceae* and *Poaceae* families alone capitalize on 33.51% of the total flora recorded. *Brassicaceae, Caryophyllaceae, Apiaceae, Orchidaceae* and *Boraginaceae* are among the other families that are well-represented in our inventory. They are arranged in much the same order of importance as Algerian flora (Kazi, 2010).

The Hemicryptophytes, Geophytes, Chamephytes, and Phanerophytes are greatly outnumbered by Therophytes, which account for 49% of the flora studied. In climates characterized by distinct seasons or frequent disturbances, the dominance of Therophytes and Hemicryptophytes suggests an environment where annual or biannual survival strategies are advantageous. The prevalence of therophytes in the Mediterranean region is often around 50%, as reported by Daget (1980), Olivier et al. (1995), and Madon & Medial (1996).

The biological spectrum of the Hafir forest (TH > HE > GE> CH > PH) is typical of the semi-arid Mediterranean bioclimatic atmosphere according to the authors cited above. This therophytization announced in the Tlemcen region, defined by the high proportion of therophytes (Barbero et al., 1995), is due according to Babali (2014), to frequent overgrazing and especially to riparian crops, adding to this the recurrence of fires (Zemmar, 2020).

The unfavourable climatic conditions prevailing in the Hafir forest make the environment favourable to the proliferation of Therophyte species. This observation is in agreement with Negre, (1960); Daget, (1980) and Barbero et al, (1990) who point out that the therophytization of the environment, which represents a strategy of avoiding unfavourable periods (cold and drought), is linked either to the winter cold or summer drought of the region, or to disturbances of the environment (grazing). During the period from 1892 to 2020, more than 3550 ha of vegetation cover were ravaged by fires across the Hafir forest, which caused a loss of biodiversity and the creation of openings in forest formations allowing the opportunity for annual species to colonize the forest. The excessive overgrazing of the Hafir forest, which mainly affects the composition and diversity of the herbaceous stratum (Mekidech et al, 2018), has strongly contributed to this therophytization, knowing that this forest is under pressure from a herd estimated at more than 2957 head of sheep, 169 head of cattle and 1130 head of goats in the localities closest to the forest, not counting the livestock of the communes of in this case Sabra, Bouhlou and Sidi Medjahed.

The disturbance index calculated in our study area is equal to 59.43%. Those evaluated by Hedidi, (2019), Larbi, (2021), Zemmar, (2020), Meddah, (2020), Benkhettou, (2015), Merioua et al, (2013) are respectively in the order of 59.45%, 27%, 42%, 53.5%, 63.6% and 68%.

According to Blondel et al., (2010), Mediterranean ecosystems are characterized by high environmental heterogeneity, resulting in marked ecological gradients. To identify the factors that structure these plant communities, multivariate analyses are necessary (Legendre & Legendre, 2012), but few studies simultaneously integrate biological traits and ecological strategies (sensu Díaz et al., 2016).

The factorial correspondence analysis (CFA) of the inventoried species, of which only those with a relative frequency of 10% or more (144 species) were retained, highlighted 4 key dimensions structuring the distribution of these species by confirming clear and hierarchical ecological patterns (Tab. 3).

Table N° 3: contribution of species in the 3 axes of the AFC.

Species	Code	Life form.	Cluster	Factor1	Factor2	Factor3
Phillyrea latifolia L.	*P-lat 288*	PH	1	0.0042	- 0.6705	- 0.0248
Erica multiflora	*E-mul 138*	CH	1	0.0194	- 0.6905	- 0.0181
Reseda alba subsp. alba L.	*R-alb 312*	TH	1	- 0.0019	- 0.8054	- 0.0023
Lomelosia stellata (L.) Raf.	*L-ste 225*	TH	1	- 0.0043	- 0.8108	- 0.0021
Lupinus hirsutus L.	*L-hir 231*	TH	1	- 0.0008	- 0.7962	0.0495
Convolvulus arvensis	*C-arv 106*	GE	1	0.0174	- 0.7672	- 0.0601
Juncus effusus L.	*J-eff 195*	GE	1	0.0191	- 0.7645	- 0.0580
Trigonella gladiata	*T-gla 365*	TH	1	0.0022	- 0.8313	- 0.0078
Aceras pyramidalis (L.) Reichenb	*A-pyr 1*	GE	1	0.0359	- 0.5385	0.0852
Hippocrepis biflora	*H-bif 180*	TH	1	0.0113	- 0.8481	0.0452
Rosa canina	*R-can 316*	CH	1	0.0191	- 0.8211	- 0.0353
Marrubium vulgare	*M-vul 239*	HE	1	0.0287	- 0.7854	0.0630
Ajuga chamaepitys (L.) Schreber	*A-cha 8*	TH	1	0.0057	- 0.8302	- 0.0196
Medicago orbicularis	*M-orb 241*	TH	1	- 0.0113	- 0.6644	0.5156
Lithospermum officinale	*L-off 222*	TH	1	0.0018	- 0.9204	- 0.0240
Lobularia maritima	*L-mar 223*	TH	1	0.0019	- 0.9139	- 0.0246
Mantisalca salmantica	*M-sal 238*	HE	1	0.0029	- 0.9072	- 0.0351
Verbascum blattaria L.	*V-bla 375*	TH	1	0.0030	- 0.9070	- 0.0335
Lonicera implexa L.	*L-imp 226*	PH	1	0.0376	- 0.7066	- 0.0142
Lotus conimbricensis	*L-con 228*	TH	1	0.0217	- 0.8622	- 0.0135
Veronica beccabunga	*V-bec 377*	TH	1	0.0189	- 0.7698	0.0047
Viburnum lantana	*V-lan 379*	TH	1	0.0304	- 0.7821	0.1365
Helianthemum virgatum	*H-vir 177*	TH	1	0.0129	- 0.9143	0.0183
Rubia peregrina subsp. peregrina	*R-per 320*	HE	1	0.0101	- 0.8057	- 0.0269
Senecio glaucus subsp. mauritanicus	*S-gla 332*	HE	1	0.0351	- 0.8134	0.1281
Trisetaria flavescens	*T-fla 366*	HE	1	0.0040	- 0.9557	- 0.0318
Valerianella coronata	*V-cor 374*	HE	1	0.0036	- 0.9521	- 0.0353
Cotyledon umbilicus veneris subsp. pendulina	*C-umb 110*	GE	1	0.0250	- 0.7233	- 0.0626
Glossopappus macrotus	*G-mac 170*	TH	1	0.0273	- 0.9308	- 0.0135
Callipeltis cucullaris	*C-cuc 72*	TH	1	0.0087	- 0.9318	0.0781
Thapsia garganica	*T-gar 355*	TH	1	0.0340	- 0.6490	0.5605
Andryala integrifolia	*A-int 18*	TH	1	0.0165	- 0.8736	- 0.0129
Muscari neglectum Guss.	*M-neg 254*	GE	1	0.0173	- 0.8538	- 0.0301
Calycotome spinosa	*C-spi 70*	CH	1	0.0246	- 0.9176	- 0.0083
Centaurium erythraea Raf.	*C-ery 86*	HE	1	0.0115	- 0.8456	- 0.0422
Narcissus serotinus L.	*N-ser 257*	GE	1	0.0255	- 0.8959	- 0.0163
Quercus faginea subsp. tlemcenensis (DC.) Maire et Weille	*Q-fag 303*	PH	1	0.0369	- 0.7347	0.0259
Verbena officinalis L.	*V-off 376*	HE	1	0.0216	- 0.8826	- 0.0203

Ampelodesmos mauritanicus (Poiret)	*A-mau 14*	CH	1	0.0058	- 0.8575	0.4389
Ballota hirsuta	*B-hir 51*	HE	1	0.0159	- 0.8024	0.3904
Linaria triphylla (L.) Miller	*L-tri 218*	TH	1	0.3192	- 0.7225	0.2866
Veronica hederifolia	*V-hed 378*	TH	1	0.0303	- 0.6795	0.4250
Bellis annua subsp. minuta	*B-ann 53*	TH	2	0.2773	- 0.2243	- 0.0167
Vitis vinifera	*V-vin 385*	TH	2	0.1930	- 0.2037	0.0489
Ononis biflora Desf.	*O-bif 265*	TH	2	0.3738	- 0.6158	0.0274
Createagus azarolus var. azarolus	*C-aza 112*	PH	2	0.5293	- 0.4471	- 0.0500
Specularia falcata (s.l.)	*S-fal 346*	TH	2	0.4126	- 0.6801	- 0.0124
Erica arborea L.	*E-arb 137*	CH	2	0.7289	- 0.3571	- 0.0273
Cistus triflorus	*C-tri 102*	CH	2	0.7766	- 0.3443	- 0.0301
Rosa sempervirens	*R-sim 317*	CH	2	0.4688	- 0.6264	0.0159
Helianthemum helianthemoides	*H-hel 175*	TH	2	0.5116	- 0.6957	0.0096
Quercus suber L. subsp. suber	*Q-sub 305*	PH	2	0.8509	- 0.3381	- 0.0132
Cytisus villosus Pourret	*C-vil 127*	CH	2	0.7946	- 0.3911	- 0.0330
Cistus salvifolius	*C-sal 101*	CH	2	0.6549	- 0.5842	- 0.0336
Trachelium caeruleum L.	*T-cae 360*	TH	2	0.5929	- 0.6103	0.0228
Stachys ocymastrum	*S-ocy 347*	TH	2	0.5468	- 0.4702	0.4239
Orchis italica Poiret	*O-ita 273*	GE	2	0.7404	- 0.5814	- 0.0230
Ranunculus macrophyllus	*R-mac 308*	HE	2	0.6918	- 0.5071	- 0.0080
Quercus coccifera L. subsp. coccifera	*Q-coc 302*	PH	2	0.6637	- 0.6551	- 0.0041
Asperula hursuta	*A-hur 43*	HE	2	0.6555	- 0.6454	0.0060
Asperula cynanchica	*A-cyn 42*	HE	2	0.6937	- 0.6268	- 0.0090
Cardamine hirsula subsp. hirsuta Syme	*C-hir 75*	TH	3	0.0261	- 0.0265	0.7605
Cynosurus echinatus	*C-ech 123*	TH	3	0.0609	- 0.0426	0.0985
Erodium moschatum	*E-mos 141*	TH	3	0.2393	- 0.1233	0.1852
Euphorbia falcata	*E-fal 147*	TH	3	- 0.0069	- 0.0281	0.9299
Ulex boivinii	*U-boi 369*	PH	3	- 0.0056	- 0.0300	0.9271
Ulex parviflorus	*U-par 370*	PH	3	- 0.0056	- 0.0300	0.9271
Lamarckia aurea	*L-aur 202*	TH	3	0.0673	- 0.2463	0.2070
Sedum album L. subsp. gypsicolum (Boiss. et Reut., Maire)	*S-alb 329*	HE	3	0.0024	- 0.0302	0.9213
Argyrolobium zanonii (L.) Link	*A-zan 31*	HE	3	0.0453	- 0.0484	0.1217
Campanula erinus	*C-eri 74*	TH	3	0.0189	- 0.0299	0.8586
Rumex pulcher	*R-pul 323*	HE	3	0.0464	- 0.0475	0.1187
Stipa parviflora	*S-par 349*	TH	3	0.0285	- 0.0337	0.8850
Urospermum picroides	*U-pic 372*	GE	3	0.0755	- 0.0698	0.1941
Hedera algeriensis	*H-alg 172*	CH	3	0.0385	- 0.0590	0.0561
Briza maxima	*B-max 63*	TH	3	0.0139	- 0.0323	0.8943
Medicago minima	*M-min 240*	TH	3	0.0607	- 0.0458	0.8113
Orchis anthropophora (L.) All.	*O-ant 272*	GE	3	0.0384	- 0.0560	0.0005
Pistacia lentiscus L.	*P-len 295*	PH	3	0.0594	- 0.0587	0.1276

Anthemis pedunculata subsp. eu-pedunculata M.	*A-ped 20*	HE	3	0.0416	- 0.0577	0.0026
Anthericum liliago L. subsp. algeriense	*A-lil 21*	GE	3	- 0.0006	- 0.0351	0.6483
Neslia paniculata	*N-pan 261*	TH	3	0.0138	- 0.0302	0.8900
Coronilla scorpioides	*C-sco 109*	TH	3	0.0091	- 0.0350	0.6751
Plantago lanceolata	*P-lan 300*	HE	3	0.0154	- 0.0421	0.7391
Ruscus aculeatus L.	*R-acu 325*	GE	3	0.0454	- 0.0614	0.0216
Globularia alypum subsp. alypum L.	*G-aly 169*	CH	3	0.0052	- 0.0442	0.6616
Ornithopus compressus	*O-com 274*	TH	3	0.3243	- 0.0154	0.6837
Tetraclinis articulata (Vahl)	*T-art 352*	PH	3	0.0173	- 0.0416	0.7071
Quercus ilex subsp. ballota (Desf.)	*Q-ile 304*	PH	3	0.0749	- 0.0757	0.1362
Lithospermum apulum	*L-apu 221*	TH	3	0.4575	- 0.0596	0.5823
Lotus ornithopodioides L.	*L-orn 230*	TH	3	0.4578	- 0.0307	0.6086
Papaver rhoeas	*P-rho 281*	TH	4	0.5410	- 0.0083	0.0670
Phlomis lychnitis	*P-lyc 291*	TH	4	0.5770	- 0.0038	0.0076
Reichardia picroides	*R-pic 311*	TH	4	0.6498	- 0.0040	0.0335
Paronychia echinata Lamk.	*P-ech 284*	TH	4	0.4871	- 0.0224	0.0466
Erodium chium	*E-chi 139*	TH	4	0.7282	0.0168	0.0070
Fumaria parviflora	*F-par 157*	TH	4	0.7468	0.0258	- 0.0225
Euphorbia paralias	*E-par 149*	TH	4	0.7313	0.0136	0.0213
Linum usitatissimum subsp. angustifolium (Huds.) Fiori	*L-usi 220*	TH	4	0.5142	- 0.0849	0.1574
Euphorbia platyphyllos	*E-pla 150*	TH	4	0.7301	0.0050	0.0319
Lotus creticus	*L-cre 227*	HE	4	0.5921	- 0.0289	0.1089
Chrysanthemum coronarium	*C-cor 94*	TH	4	0.7080	0.0063	0.1076
Koeleria phleoides	*K-phl 199*	TH	4	0.8032	0.0150	- 0.0034
Helianthemum hirtum	*H-hir 176*	TH	4	0.8145	0.0122	0.0009
Phalaris canariensis	*P-can 287*	TH	4	0.6106	- 0.0136	0.1124
Reseda luteola L.	*R-lut 313*	TH	4	0.5445	- 0.0218	- 0.0079
Calendula suffruticosa Vahl	*C-suf 69*	TH	4	0.7922	0.0100	0.0490
Cistus arboreus subsp. baetica	*C-arb 97*	TH	4	0.8178	0.0088	0.0081
Geranium lucidum	*G-luc 165*	TH	4	0.7406	0.0091	0.0368
Juncus bufonius	*J-buf 194*	TH	4	0.8247	0.0074	0.0330
Iberis odorata	*I-odo 187*	TH	4	0.8323	0.0110	- 0.0142
Phagnalon saxatile	*P-sax 285*	CH	4	0.6161	- 0.0142	0.0029
Bifora testiculata	*B-tes 56*	TH	4	0.7684	0.0137	0.0651
Cuscuta epithymnm L.	*C-epi 118*	TH	4	0.6725	- 0.0017	0.0109
Cistus monspeliensis	*C-mon 100*	CH	4	0.8504	0.0095	- 0.0186
Echium italicum subsp. pyrenaicum	*E-ita 135*	TH	4	0.6151	0.0064	0.5055
Cistus ladaniferus subsp. mauritianus Pau & Sennen	*C-lad 99*	CH	4	0.5820	- 0.0151	0.4824
Gagea lacaitae	*G-lac 159*	GE	4	0.8421	0.0064	0.0075

Chamaerops humilis subsp. argentea André.	*C-hum 90*	CH	4	0.6768	- 0.0081	0.4330
Carlina lanata	*C-lan 78*	TH	4	0.6693	- 0.0020	0.4315
Cistus villosus L.	*C-vil 98*	CH	4	0.8848	0.0086	0.0039
Crepis vesicaria	*C-ves 114*	HE	4	0.9244	0.0130	- 0.0038
Ranunculus spicatus	*R-spi 310*	HE	4	0.9404	0.0108	- 0.0055
Xeranthemum inapertum	*X-ina 387*	TH	4	0.9227	0.0074	0.0034
Asperula arvensis	*A-arv 41*	TH	4	0.7547	- 0.0041	0.0964
Colutea arborea	*C-arb 104*	PH	4	0.9124	0.0084	- 0.0110
Lavatera olbia	*L-olb 208*	HE	4	0.9442	0.0116	- 0.0031
Galium mollugo subsp. corrudaefolium (Vill.) Briquet	*G-mol 161*	HE	4	0.9341	0.0108	- 0.0054
Daphne gnidium L. var. mauritanica L.	*D-gni 129*	CH	4	0.8793	- 0.0057	0.0084
Pallenis maritima	*P-mar 277*	CH	4	0.8124	- 0.0071	0.0152
Melandrium album	*M-alb 242*	HE	4	0.9395	0.0085	- 0.0065
Aira Cupaniana Guss.	*A-cup 7*	GE	4	0.9441	0.0070	0.0150
Mentha pulegium	*M-pul 246*	HE	4	0.8812	0.0002	0.0707
Agrostis Reuteri	*A-reu 6*	GE	4	0.9623	0.0082	- 0.0048
Merendera filifolia	*M-fil 249*	GE	4	0.8164	- 0.0147	0.0336
Viburnum tinus subsp. tinus L.	*V-tin 380*	TH	4	0.7761	- 0.0377	0.0359
Stellaria media subsp. typica	*S-med 348*	CH	4	0.7520	- 0.0330	0.0374
Valeriana tuberosa L.	*V-tub 373*	TH	4	0.8019	- 0.0299	0.0645
Narcissus cantabricus DC.	*N-can 256*	GE	4	0.8455	- 0.0173	0.0236
Plantago albicans	*P-alb 297*	HE	4	0.9000	- 0.0118	0.0873
Antirrhinum majus subsp. eu-majus P.F	*A-maj 24*	HE	4	0.8715	- 0.0154	0.0675
Asphodelus microcarpus	*A-mic 44*	GE	4	0.7845	- 0.0154	0.3641
Teucrium polium	*T-pol 354*	CH	4	0.7232	- 0.0218	0.4197
Ophrys speculum L.	*O-spe 270*	GE	4	0.8120	- 0.0277	0.0524

Legend: TH (Therophytes,), HE (Hemicryptophytes), GE (Geophytes), CH (Chamephytes) and PH (Phanerophytes).

Factor	**1**	**2**	**3**
Eigenvalue	45.551	29.446	14.603
% variance	31.63	20.45	10.14

Since the graphical representation of the scatter plots shows a condensation that makes it impossible to distinguish between species, we resorted to the use of the hierarchical K-means classification to segregate the different clusters (Fig. 13).

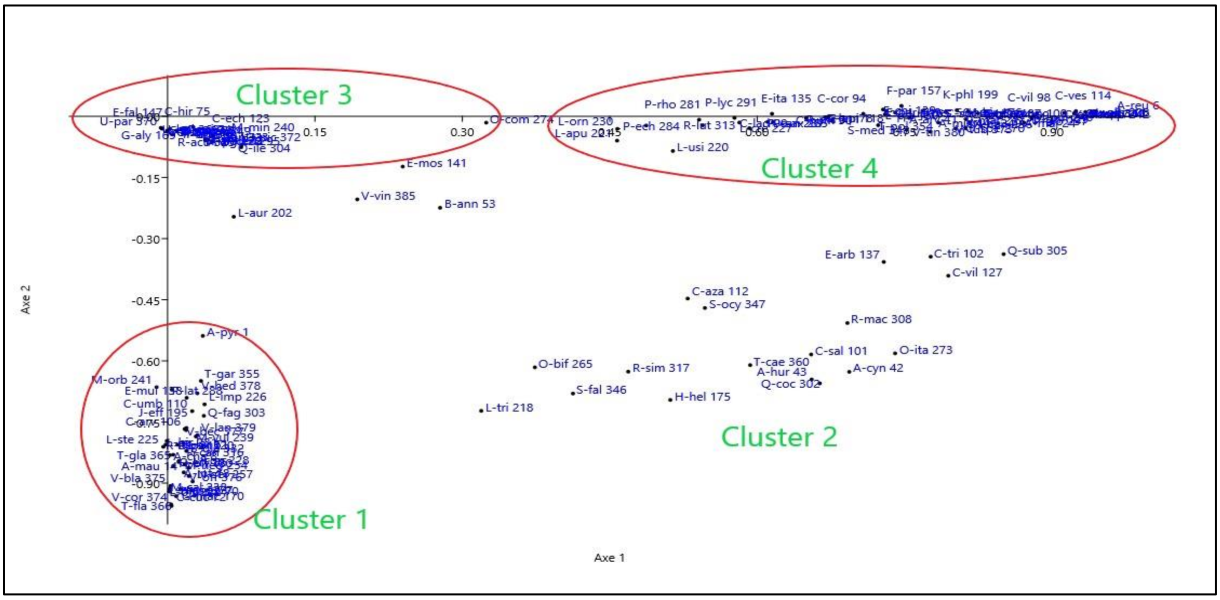

Figure 13: Species Factorial Design (Axis 1 and Axis 2)

Axis 1 (Factor 1), which represents 31.63% of the cumulative variance, marks a wide gradient contrasting the pioneer species of disturbed and open environments (*Lavatera olbia* and *Crepis vesicaria*, scores >0.9, cluster 4) with those of stable and less disturbed species (*Quercus ilex*, cluster 3). This axis mainly reflects the effect of human activities and natural disturbances on the distribution of species (Vilà et al., 1999), which is a phenomenon well documented in studies of Mediterranean ecosystems (Mouldi et al., 2010).

Axis 2 (Factor 2), representing 20.4% of the variance, is a gradient of edaphic aridity, with taxa such as *Trisetaria flavescens* (score -0.956) and *Globularia alypum* (score -0.570) being characteristic of the dry and poor soils of Mediterranean scrubland, (Mouldi et al., 2010).

Analysis of the contribution of individual species reveals that five species alone account for more than a quarter (28%) of the total variance: *Ranunculus spicatus* (6.1%), *Cistus monspeliensis* (5.8%), *Lavatera olbia* (5.5%), *Crepis vesicaria* (5.3%) and *Trisetaria flavescens* (5.3%). These hyper-contributing species are very good bioindicators of the large ecological gradients detected, as indicated in studies on species of the genus *Ranunculus* that are recognized for their sensitivity to environmental conditions and their role in photosynthesis under different light and temperature gradients (Carillo et al., 2019). The same goes for *Cistus monspeliensis*, which has bioactive properties and plays an ecological role in Mediterranean soils (Abou El Anouar et al., 2024).

As for *Lavatera olbia*, this species thrives in nutrient-rich soils and contributes to the structuring of plant communities (Mainetti and al., 2023). Finally, *Crepis vesicaria* is considered a bioindicator for assessing ecological gradients related to soils and sustainable agricultural practices (Wikipedia contributors, 2024).

The ecological typology that results confirms the coherence of the first groupings : Cluster 1 mainly includes species specialized in stable habitats (median factor 2 = -0.81), whereas generalists of disturbed habitats are found in Cluster 4 (median factor 1 = +0.73). It is discovered that the three species : *Veronica hederifolia, Echium italicum*, and *Linaria triphylla* have atypical factor profiles with high values on many axes at once, indicating unique ecological strategies.

Statistical validation tests (bootstrap analysis, Mantel test) corroborate the robustness of these findings. Excellent spatial coherence ($r=0.82$, $p=0.002$) and stable axis (95% CI [22.3-25.9%] for Factor1) are also present.

This rigorous multivariate analysis, validated by resampling methods, thus provides a solid basis for the interpretation of the distribution of plant species along the main recognized ecological gradients. The findings highlight a number of areas of potential practical utility in the management and preservation of the Hafir forest by using established bio-indicator species to track anthropogenic disturbances or climatic change. High Factor 1 species (*Crepis, Lavatera*) are necessary for the ecological repair of our ecosystem and the preservation of degraded soils. These species are perfect for colonizing degraded areas, while very negative factor 2 species (*Trisetaria, Glossopappus*) are suggestive of poor soils.

5. Conclusion

As previously stated, our inventory was not exhaustive for the entire Hafir forest; however, it was able to provide an overview of the floristic composition of the area studied. After this investigation, it was clear that 21.74% of the Oran sector's flora and 12.33% of Algeria's were identified. With a significant incidence of 49% for Therophytes and a preponderance of *Asteraceae*, *Fabaceae*, and *Poaceae*, this reported flora attests to the Hafir forest's susceptibility to anthropogenic and climatic disturbances, particularly overgrazing and frequent fires. Our research establishes a basis for future studies aimed at fully understanding floristic diversity to maintain, preserve, and enhance natural resources. It also supports botanists' efforts throughout the Tlemcen Mountains. A catalog of the medicinal plants in the region could also be added to this effort in the future.

6. Bibliographical references

1- Abou el Anouar et al., 2024 : Abou el Anouar, S., Bergui, M., Louafi, B., Ahidar, N., Salhi, A., & Benjelloun, M. (2024). Ethnobotanical investigation of Cistus monspeliensis (L.) in Northern Morocco: Traditional uses and future prospects. Ethnobotany Research and Applications. DOI : 10.32859/era.29.61.1-17.

2- Babali B., 2014-Contribution à une étude phytoécologique des monts de Moutas (Tlemcen- Algérie occidentale) : Aspects syntaxonomique, biogéographique et dynamique. Thèse. Doct. Univ. Abou Bakr Belkaid-Tlemcen. 198 p.
3- Babali B. ; Bouazza M. ; Merzouk A., 2018- La diversité végétale de la forêt de Moutas – Tlemcen, édit . Revue Ecologie-Environnement, 5 P.
4- Barbero M., Bonin G., Loisel R. et Quezel P., 1990 - Changes and distrubances of forest ecosystems caused by human activities in the western part of Mediterranean bassin.Vegetatio (87),p:151-173.
5- Barbero M., Loisel R. et Quezel P., 1995 - Les essences arborées des îles méditerranéennes. Leur rôles écologiques et paysages. Ecologia mediterranea. XXI (1/2) p:55– 69.
6- Benabdeli, R. ,1996- Étude écologique et sylvicole des formations forestières de la région de Tlemcen. Thèse de doctorat , Université de Mostaganem, Algérie.
7- Benest M., 1985 - Evolution de la plate forme de l'ouest algérien et du nord-est marocain au cours du Jurassique supérieur et au début du Crétacé : Stratigraphie, milieux de dépôt et dynamique sédimentaire. Thèse Doc. Es Sci., fasc. 1 et 2, Univ. Lyon, 585 p.
8- Benest M., Bensalah M., Bouabdellah H. et Ouardas T., 1999 - La couverture mésozoïque et cénozoïque du domaine Tlemcénien (Avant pays Tellien d'Algérie occidentale): Stratigraphie, paléoenvironnement, dynamique sédimentaire et tecto-genèse alpine, bulletin du service géologique de l'Algérie, Vol.10, No2.
9- Benkhettou, A., Azouzi, B., Djili, K., Benkhettou, M., Zedek, M. & Saadi, R.,2015- Diversité floristique du massif du Nador en zone steppique (Tiaret, Algérie). Europ. Sci. J. 11(21): 401- 4191.
10- Bennadja S, De Belair G & Ait Kaki Y., 2013 - La subéraie de la Numidie orientale: une source de biodiversité. Quaderni di Botanica ambientale e applicata 24: 49- 53.
11- B.N.E.D.E.R., 1979b - Etude d'inventaire des terres et forêts de l'Algérie du Nord : Wilaya de Tlemcen. Min. Agri. Rev. Agr., Alger, 156 p.
12- Bonnier, G. 1990. La grande flore de France en couleur. Ed. Belin.
13- Bouabdellah H., 1991-Dégradation du couvert végétal steppique de la zone Sud-Ouest Oranaise (le cas d'El Aricha). Thèse. Magist. I.G.A.T. Univ. Oran. 268p + annexes.
14- Bouazza M. et Benabadji N., 2000 - Contribution à une étude bioclimatique de la steppe à Artemisia herba-alba Asso. Dans l'Oranie (Algérie occidentale). Revue sécheresse. 11 (2) p : 117 – 123.

15- Bouazza M. et Benabadji N., 2010 - Changements climatiques et menaces sur la végétation en Algérie occidentale. Changements climatiques et biodiversité. Vuibert – APAS. Paris. p:101 – 110.
16- Bouazza N., Kcherifi K., Babali B. et Bouazza M., 2020- Bibliographical note on the syntaxonomy of the vegetation of Tlemcen, Hafir, Moutas and its reserve (North-Western Algeria), édit. Bangladesh J. Plant Taxon , 14 P.
17- Bouchibane M., Zemouri M. & Toumi R., 2021- Contribution à l'étude de la végétation de certains massifs montagneux de la Kabylie des Babors (Nord-Est algérien), édit. Bull. de la Société Royale des Sciences de Liège, Vol. : 91, articles, 2021, p. 317 – 360.
18- Boudy, 1948 - Economie forestière nord-africaine. Tome 1 : Milieu physique et milieu humain. Larose, Paris, 686 p.
19- Boudy, P. ,1955- Les forêts du Nord-Ouest algérien. Annales de Géographie , 64(347), 357-374.
20- Bouhraoua, M. ,2003- Dynamique spatio-temporelle des écosystèmes forestiers méditerranéens en Algérie. Thèse de doctorat , Université d'Oran, Algérie.
21- Braun-Blanquet, J. ,1951 - Pflanzensoziologie Grundzuge der vegetetions Kunde (2eme Ed) Springer, Vienne. Ed. 2, Autriche, 631.
22- Carillo et al., 2019 : Carillo, P., Cirillo, C., De Micco, V., Arena, C., De Pascale, S., & Rouphael, Y. (2019). Photosynthesis in Ranunculus asiaticus L.: The Influence of Vernalization on Photosynthetic Processes. Frontiers in Plant Science. DOI : 10.3389/fpls.2019.00241.
23-
24- CFWT, 1995 - Fascicule de gestion de la forêt domaniale de Hafir,Canton Oued Fernane, 4 p
25- CFWT, 2024- bilan des incendies de l'année 2024 à travers la wilaya e Tlemcen, 6 P.
26- Chevallier, P., 2002- La gestion durable des écosystèmes forestiers méditerranéens. Editions Quae , Versailles, France.
27- Clair A., 1973 – notice explicative de la carte lithologique de la région de Tlemcen au 1/100000.
28- Daget, P. ,1980- Sur les types biologiques botaniques en tant que stratégies adaptatives (cas des Thérophytes). Actes du Colloque D'Ecologie théoriques, E.N.S, Paris: 89-114.
29- Dahmani, A. ,1984- Contribution à l'étude écologique et phytosociologique des chênaies-lièges de l'Algérois. Thèse de doctorat , Université d'Alger, Algérie.
30- Delpech R., 2006- La phytosociologie. http://www.tela-botanica.org/ page:menu_407

31- Doumergue G., 1910 - Carte géologique détaillée de l'Algérie au 1/50.000. Feuille de Terni n°300.

32- DSA, 2023 - campagne nationale du recensement du cheptel ovin, bovin, caprin et équin à travers la wilaya de Tlemcen, 4 P.

33- Ellenberg, I. & Mueller-Doubois, D. ,1967 - A key to Raunkier plant life forms with revised subdivisions. Ver. Geobot. Int. Bois 378: 56-73.

34- Frontier, S. ,1983- Stratégie d'échantillonnage en écologie. Edit. Masson et Cie. Coll. d'Ecol. Press, University De Laval, Québéc.

35- Ghezlaoui1 S.B. et Benabadji N., 2017- La végétation des monts de Tlemcen (Algérie).Aspect phytoécologique. Botanica Complutensis Bot. complut. 42, 2018: 101-124, pp :102-123.

36- Gorenflot R. & De Foucault B., 2005- Initiation à la phytosociologie. Complément au chapitre 23. In : Biologie végétale, les Cormophytes. Dunod, éd., 1-27.

37- Hedidi D., Saidi D., Belhacini F. and Boughalia M., 2019- Floristic diversity of saadia mountain (Algerian North-West), édit. Plant Archives Vol. 19, 5 P.

38- Kazi Tani, C., Lebourgeois T. & Munoz, F. ,2010 - Aspects floristiques de la flore des champs du domaine phytogéographique oranais (Nord-Ouest algérien) et persistance d'espèces rares et endé-miques. Fl. Medit., 20, 5-22.

39- Khaldi, M. ,1998- Protection et aménagement des écosystèmes forestiers en Algérie. Revue Forestière Française , 50(4), 321-330.

40- Larbi R., Sahar Meddour O., Bouxin G. & Meddour R. ,2021- Diversité floristique et phytogéographie de la cédraie du massif forestier d'Ait Ouabane (versant nord-oriental du parc national du Djurdjura, Algérie). Lejeunia, NS 204, 15 pp1.

41- Legendre, P. & Legendre, L. (2012) Numerical Ecology. Elsevier.

42- Le Houerou H.N., 1980 - L'impact de l'homme et de ses animaux sur la forêt méditerranéenne. For. médit. 2(1) : 31-44.

43- Letreuch-Belarouci, A., 2009- Caracterisation structurale des subéraies du parc national de Tlemcen, régénération naturelle et gestion durable. – Thèse de Doctorat, Université de Tlemcen.

44- Madon, O. & Medail, F. ,1996- The ecological significance of annuals on a Mediterranean grassland (Mt Ventoux, France). – Pl. Ecol. 129: 189-1991.

45- Meddour R., 2011-La méthodologie phytosociologique Braun-blanquetotüxenienne. Université Mouloud Mammeri.Tizi Ouzou, 15-40 p.

46- Medjahdi B. & Letreuch-Belarouci, A., 2017- Typologie phytosociologique des formations forestières et préforestièrs des monts des Trara (Ouest-Algérien). Documents Phytosociologiques, série 3, 6 : 132–171.
47- Medjahdi, B., Letreuch-Belarouci, A., Maazouz, S. & Taibi, K., 2018 - Diversité floristique des subéraies des monts de Tlemcen (Nord-Ouest algérien). Fl. Medit. 28: 67-771.
48- Mekidech S., Brakchi-Ouakour L., Kadik L. , 2018- Impact des perturbations anthropiques sur la diversité végétale de la subéraie de Chréa, au nord de l'Algérie, édit. Bois et Forêts des Tropiques, p. 53-66.
49- Merioua, S. M., Seladji, A. & Benabadji, N. , 2013- Anthropozoic impact on the floristic biodiversity in the area of Beni Saf (Algeria). The Open Ecol. J., 3: 254-2641.
50- Miara M. & al. , 2017- Diversité floristique des milieux forestiers et préforestiers de l'Atlas tellien occidental de Tiaret (N-O Algérie), édit. Evaxiana, p. 1-25.
51- Mouldi G. ; Mohamed C. ; Azaiez O.,(2010). *Ecologia Mediterranea*, Vol. 36 (2)
52- Negre, R. ,1966- Les thérophytes. Mém. Soc. Bot. France, 92-108.
53- Nsibi, M., Amrane, A., & Saadoun, M. ,2006- Importance écologique et économique des écosystèmes forestiers méditerranéens en Algérie. Revue des Sciences de l'Eau , 19(2), 193-206.
54- Nsibi, R., Souayah, N., Khouja, L.M., Khaldi, A., & Bouzid, S. ,2006- Impacts des facteurs biotiques et abiotiques sur la dégradation de subéraie tunisienne. Geo-Eco-Trop, 30(1), 25–34.
55- Olivier, L., Muracciole, M. & Reduron, J-P. ,1995- Premiers bilans sur la flore des îles de la Méditerranée. État des connaissances et conservation. – Ecol. Medit. 21: 355-72.
56- Parde, J. & Bouchon J., 1988- Dendrométrie. 2nd Edition, Ecole National du Génie Rural, des Eaux et Forets, Nancy, 327.
57- Quézel, P., & Médail, F. ,2003- Biodiversité végétale et biogéographie des régions méditerranéennes. Ed. Elsevier , Paris, France.
58- Quézel, P., & Médail, F. (2003). Écologie et biogéographie des forêts du bassin méditerranéen (Collection Écologie et gestion de l'espace naturel). Paris : Elsevier.
59- Quézel P. et Santa S., 1962 ;1963 - Nouvelle flore de l'Algérie et des régions désertiques méridionales. Tome I et Tome II. CNRS, Paris, 1087 p.... Ozenda P. 1977. Flore du Sahara. 2ème édition, C.N.R.S., Paris, 622 p.
60- Quézel P. et Santa S., 1962 - Nouvelle flore de l'Algérie et des régions désertiques méridionales. Tome 1. CNRS, Paris, 565 p.

61- Quézel P., 2000 - Réflexion sur l'évolution de la flore et de la végétation au Maghreb Méditerranéen. Ibis. Press. Edit. Paris. 117P.
62- Raunkiaer C. 1934 - Biological types with reference to the adaptation of plants to survive the unfavourable season. in Raunkiaer. pp 1-2.
63- Sauvagnac G., 1956 - Les forêts domaniales d'Hafir et de Zarieffet. Bull. Amis Soc vieux Tlemcen, Oran : 47-53.
64- Soukayna B.& al, 2024- Study of the Floristic Diversity of the Moulay Driss Zerhoun Region in the Prerif Range, Morocco.
65- Vilà et al. (1999) – Plant community responses to disturbance (Journal of Vegetation Science) → Clusters liés aux perturbations.
66- WWF ,2004 - Conservation des écosystèmes forestiers méditerranéens : enjeux et erspectives. Rapport WWF Méditerranée.
67- Zemmar, N., M'hammedi Bouzina, M., Ababou, A. & Hedidi, D. ,2020- Analysis of the floristic diversity in a southern Mediterranean ecosystem. Case of Bissa forest,
68- Wikipedia contributors, 2024 : Crepis vesicaria - Wikipedia. Consulté en août 2024 pour des informations générales sur la taxonomie et l'écologie de Crepis vesicaria https://en.wikipedia.org/wiki/Crepis_vesicaria