The Vascular Flora of *Tetraclinis* Ecosystem in the Moroccan Central Plateau

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Abstract

The main objective of this study is to quantify the floral richness and diversity of *Tetraclinis* ecosystem in the Moroccan Central Plateau. The approach was based on over 300 floristic surveys covering the different parts of the Moroccan Central Plateau forests. It also entails the analysis and processing of data from studies in the region. The results indicate that there are 233 taxa belonging to 56 families.

Keywords: Floral richness, *Tetraclinis* ecosystem, Moroccan Central Plateau

Introduction

Due to its typical and geographical position between the Atlantic Ocean to the west and the Mediterranean Sea to the north, Morocco is characterized by high vascular plant diversity with approximately 4200 species and subspecies belonging to 135 families and 940 genera (Benabid, 2000). The endemic flora includes 951 species and subspecies, representing 21 % of the Moroccan vascular plants. The richest floristic regions for endemic species are located at the top of high mountains.

By its geographical position, its varied topography, geology, ecoregion and climate, the Central Plateau of Morocco includes a large area of forest ecosystems with an important floristic diversity. However, this flora richness is still not well known and botanical studies within the zone still remains limited.

Therefore, this study aims to quantify and characterize the floristic richness and diversity of *Tetraclinis* ecosystem in the Moroccan Central Plateau. This study was carried out for the purpose of better knowledge and to highlight the floristic potentialities of the region to support sustainable management biodiversity.

Study Area

Moroccan Meseta or Moroccan Central Plateau (Figure 1) is an old massive area located in the north-west of Morocco. It covers a wide range of highlands at altitudes between 500 and 1250 meters, extending from the Atlantic Ocean to the west until the Middle Atlas to the east and the Phosphate plateau to the south.

The area is geologically characterized by an immense diversity with the dominance of primary and quaternary structures. However, the schists, sandstone, and basalt from the quaternary are well represented (Combe *et al*., 1975). In terms of pedology, the Central Plateau region is marked by the soils diversity (rendzinas, brown forest soils, lithosols and regosols). However, due to the steep slopes, lithosols are by far, the most frequent type of soils (Beaudet, 1969).

The climate is Mediterranean with an average annual rainfall ranging from 350 to 1000 mm. Average low temperatures vary from 0.9 °C to 6 °C and average high temperatures vary from 29 °C to 35°C (Combe *et al*., 1975). Bioclimatic zoning shows the existence of four types of climate: humid, sub-humid, semi-arid, and arid (Combe *et al*., 1975).

The vegetation study of the area revealed a diversity in terms of species involved in the individualization of forest ecosystems. The major species encountered are *Tetraclinis articulata*, *Quercus rotundifolia*, and *Quercus suber*.

Furthermore, the Moroccan Central Plateau showcases an outstanding biological diversity through the presence of a large number of plant and animal species, and the existence of several Sites of Biological and Ecological Interest (SBEI) that reflect this magnitude.

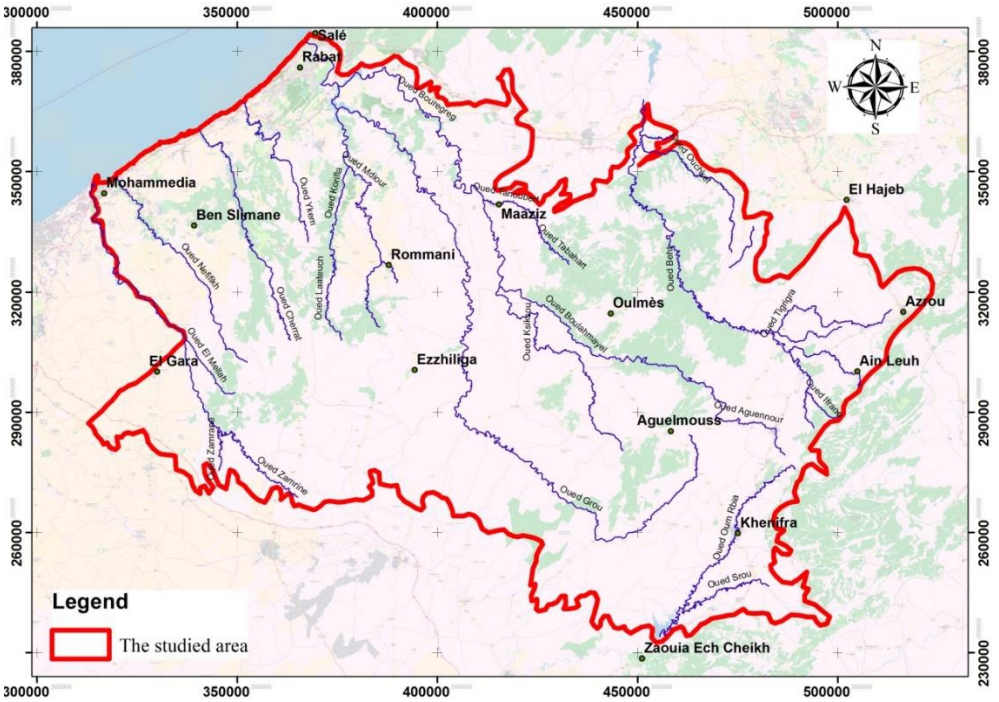

Figure 1. Location Map of the Studied Area

Methodology

The study was carried out from 2013 to 2016. The methodology used is based on the implementation of more than 300 floristic surveys, covering the diverse *Tetraclinis* stands of the Central Plateau, data collection and analysis from all studies related to the region including the forest management plans and papers on the Moroccan Central Plateau flora (Fennane, 1988; Fennane, 2003; Chkhichekh *et al.,* 2015; Dallahi *et al.*, 2016a; Dallahi *et al.*, 2016b).

-**The study of the biologic types,** according to Raunkiaer (1904), which are based on the place of the bud during seasons with adverse conditions are: Phanerophytes (Ph), Nanophanerophytes (Nph), Chamaephytes (Ch), Hemicryptophytes (He), Geophytes (G), and Therophytes (Th).

-Bioclimatic Zones: The different bioclimatic environments selected are those existing in the study area; meaning A: Aride; SA: Semi-aride; SH: Sub-humide, and H: Humide.

-Distribution within the Study Area: It describes the various biogeographic areas where the species in question is located. The studied biogeographic zones are: Moroccan Coastal Meseta (MCM) and Moroccan Central Plateau (MCP).

Result and Discussion

The data compilation and analysis of the floristic surveys conducted in the field has allowed us to identify 233 taxa.

Adoxaceae

Viburnum tinus L.; Nph; SH, H; MCP.

Amaranthaceae

Atriplex halimus L.; Nph; A, SA; MCP.
Chenopodium murale L.; Th; SA, SH; MCM.

Anacardiaceae

Pistacia lentiscus L.; Nph; SA, SH, H; MCM and MCP.
Pistacia atlantica Desf.; Ph; A, SA, SH; MCM and MCP.
Rhus pentaphylla (Jacq.) Desf.; Nph; A, SA; MCM and MCP.

Apiaceae

Ammi majus L.; Th; A, SA, SH, H; MCP.
Bupleurum semicompositum L.; Th; A, SA, SH; MCP.
Daucus carota L subsp. *Carota*; Th; A, SA, SH, H; MCM and MCP.
Eryngium tenue Lam.; Th; SA, SH; MCP.
Eryngium tricuspidatum L.; He; A, SA, SH, H; MCM and MCP.
Eryngium triquetrum Vahl.; He; A, SA, SH; MCP.
Smyrnium olusatrum L.; He; SA-H; MCM and MCP.

Apocynaceae

Caralluma europaea (Guss.) N.E. Br.; Ch; A, SA, SH; MCP.

Araceae

Arisarum vulgare Targ-Tozz.; G; A, SA, SH, H; MCM and MCP.

Arecaceae

Chamaerops humilis L.; Ch; A, SA, SH; MCM and MCP.

Aristolochiaceae

Aristolochia longa L.; G; SA, SH, H; MCM.
Aristolochia baetica L.; Nph; SA, H; MCP.

Asparagaceae

Ornithogalum umbellatum L.; Ch; SA, SH; MCM.
Asparagus acutifolius L.; G; A, SA, SH; MCM and MCP.
Asparagus albus L.; Nph; A, SA, SH; MCM and MCP.
Asparagus altissimus Munby; Nph; S, A, SA; MCM and MCP.

Asteraceae

Atractylis cancellata L.; Th; A, SA, SH, H; MCP.
Calendula algeriensis Boiss. & Reut.; Th; SA; MCM.
Carduus marianus L.; He; MCP.
Carlina corymbosa L.; He; SA, SH, H; MCM.
Carlina involucrata Poir.; Th; A, SA, SH, H; MCP.
Carlina racemosa L.; He; A, SA, SH; MCP.
Cichorium intybus L. subsp *pumilum* (Jacq.) Ball.; He; SA; MCM.

Cirsium acarna (L.) Moench.; Th; MCP.
Crepis vesicaria L.; He; SA, SH; MCM.
Cynara humilis L.; G; A, SA, SH; MCM.
Cynara hystrix Ball.; G; MCP.
Echinops spinosus L.; He; A, SA, SH, H; MCP.
Evax pygmea (L.) Brot.; Th; A, SA, SH; MCM and MCP.
Filago gallica L.; Th; SA, SH, H; MCM and MCP.
Filago germanica L.; Th; A, SA, SH, H; MCP.
Galactites tomentosa Moench; Th; SA, SH, H; MCM.
Hyoseris radiata L.; G; SA, SH; MCP.
Leontodon hispidulus (Del.) Boiss.; Th; A, SA, SH; MCM and MCP.
Leontodon saxatilis Lamk.; He; A, SA, SH; MCP.
Leontodon tuberosis L.; He; A, SA, SH; MCP.
Matricaria recutita (L.) Rauchert; Th; MCP.
Ormenis mixta (L.) Dumort.; Th; SA, SH; MCM and MCP.
Phagnalon saxatile (L.) Cass.; Ch; A, SA, SH, H; MCM and MCP.
Picris aculeata Vahl.; Ch; SA, SH; MCP.
Pulicaria odora (L.) Reichenb. var. *typica* Fiori.; He; SA, SH, H; MCM and MCP.
Scolymus hispanicus L.; He; A, SA, SH, H; MCM and MCP.
Senecio vulgaris L.; Th; SA, SH; MCP.
Silybum marianum L. Gaertn.; Th; SA, SH; MCP.
Sonchus asper (L.); Th; SA, SH, H; MCM and MCP.
Sonchus oleraceus L.; He; A, SA, SH, H; MCP.
Taraxacum officinale Weber.; He; MCP.
Tolpis barbata (L) Graetn.; Th; A, SA, SH, H; MCM and MCP.

Boraginaceae

Anchusa azurea Mill.; He; A, SA, SH, H; MCM.
Echium plantaginum L.; Th; A, SA, SH, H; MCM and MCP.

Brassicaceae

Biscutella didyma L. f. *parviscutata* Maire & Weiller; Th; A, SA, SH; MCM and MCP.
Cardamine hirsuta L.; Th; SA, SH, H; MCM.
Diplotaxis catholica (L.) DC.; Th; A, SA, SH, H; MCM and MCP.
Trachystoma aphanoneurum (Maire & Weiller); Th; SA; MCP.

Campanulaceae

Campanula dichotoma L.; Th; SA, SH; MCP.
Campanula lusitanica L.; Th; SA, SH, H; MCP.

Caprifoliaceae

Knautia arvensis (L.) Coult.; He; MCP.
Lonicera arborea Boiss.; Ph; SH, H; MCP.
Lonicera implexa Aiton.; Nph; SA, SH, H; MCP.

Caryophyllaceae
Cerastium dichotomum L.;Th; MCP.
Cerastium glaucum Gren.; Th; SA, SH, H; MCP.
Cerastium glomeratum Thuill.; Th; SA, SH; MCP.
Herniaria glabra L.; He; SA, SH, H; MCM.
Paronychia argentea Lamk.; He; A, SA, SH, H; MCM and MCP.
Polycarpon tetraphyllum L.; He; A, SA, SH, H; MCP.
Silene gallica L.; Th; SA, SH; MCM.
Spergula arvensis L.; Th; MCP.
Cistaceae
Cistus albidus L.; Nph; SA, SH, H; MCM and MCP.
Cistus ladaniferus L.; Ch; SH, H; MCM and MCP.
Cistus monspeliensis L.; Nph; SA, SH; MCM.
Cistus salviifolius L.; Ch; SA, SH, H; MCM and MCP.
Cistus villosus L.; Ch; SA, SH, H; MCM and MCP.
Helianthemum guttatum (L.) Mill.; Th; SA, SH, H; MCM and MCP.
Helianthemum ledifolium (L.) Miller; Th; A, SA, SH, H; MCM.
Convolvulaceae
Convolvulus althaeoides L.; G; A, SA, SH, H; MCM.
Convolvulus siculus L.; Th; SA; MCP.
Crassulaceae
Sedum hirsutum All.; Ch; MCP.
Sedum sediforme (Jacq.) Pau.; He; MCP.
Umbilicus horizontalis (Guss.) DC.; G; A, SA, SH; MCP.
Umbilicus rupestris (Salisbury) Dandy.; He; MCP.
Cucurbitaceae
Bryonia dioica Jacq.; G; A, SA, SH, H; MCP.
Cupressaceae
Tetraclinis articulata (Vahl.) Masters.; Ph; SA, SH; MCM and MCP.
Dioscoreaceae
Tamus communis L.; G; SA, SH, H; MCM and MCP.
Dipsacaceae
Dipsacus sativus (L.) Honck.; He; MCP.
Ephedraceae
Ephedra fragilis Desf.; Nph; SA, SH; MCM and MCP.
Ericaceae
Arbutus unedo L.; Nph; SA, SH, H; MCP.
Euphorbiaceae
Euphorbia peplus L.; Th; A, SA, SH, H; MCM.
Mercurialis annua L.; Th; A, SA, SH, H; MCM and MCP.
Fabaceae
Anthyllis tetraphylla L.; Th; SA, SH, H; MCP.

Astragalus lusitanicus L.; G; SA, SH; MCM and MCP.
Calycotome villosa (Poiret) Link; Ch; SH, H; MCM.
Ceratonia siliqua L.; Ph; SA, SH; MCP.
Coronilla scorpioides (L.) Koch.; Th; SA, SH, H; MCP.
Coronilla viminalis Salisb.; Th; A, SA, SH; MCP.
Cytisus arboreus (Desf.) DC.; Nph; SA, SH, H; MCP.
Cytisus triflorus L'Hérit.; Ch; SH, H; MCP.
Genista linifolia L.; Nph; SA, SH; MCM.
Lotus arenarius Brot.; Th; MCP.
Lotus corniculatus L.; He; MCP.
Lotus creticus L.; He; MCP.
Medicago hispida Gaertn.; Th; SA, SH; MCM and MCP.
Medicago murex Willd.; Th; SA; MCP.
Medicago polymorpha L.; Th; A, SA, SH, H; MCM.
Medicago truncatula Gaertn.; Th; SA; MCM.
Ononis natrix L.; He; MCP.
Ononis pendula Desf.; Th; SA; MCP.
Ornithopus compressus L.; Ch; A, SA, SH; MCM and MCP.
Sarothamnus arboreus (Desf.) DC.; Nph; SA, SH, H; MCP.
Scorpiurus muricatus L.; Th; A, SA, SH; MCP.
Trifolium angustifolium L.; Th; A, SA, SH, H; MCM and MCP.
Trifolium arvense L.; Th; SA, SH, H; MCP.
Trifolium campestre Schreb.; Th; MCM.
Trifolium ochroleucon Huds.; He; MCP.
Trifolium stellatum L.; Th; SA, SH, H; MCM and MCP.
Vicia sativa L.; Th; SA, SH, H; MCP.
Vicia tenuifolia Roth.; Th; MCP.
Vicia tetrasperma (L.) Schreber.; Th; A, SA, SH, H; MCM and MCP.

Fagaceae

Quercus faginea Lamk.; Ph; SH, H; MCP.
Quercus rotundifolia Lam.; Ph; SA, SH, H; MCM and MCP.
Quercus suber L; Ph; SA, SH, H; MCM and MCP.

Gentianaceae

Centaurium erythraea Rafn.; Th; A, SA, SH; MCP.
Centaurium maritimum (L.) Fritsch.; Th; SA, SH, H; MCP.

Geraniaceae

Erodium bipinnatum (Cav.) Willd.; Th; SA, SH; MCM and MCP.
Erodium chium (L) Willd.; Th; A, SA; MCM.
Geranium molle L.; Th; A, SA, SH, H.; MCM and MCP.
Geranium purpureum Vill.; Th; MCM.

Lamiaceae

Lavandula multifida L.; Ch; A, SA, SH; MCM and MCP.

Lavandula stoechas L.; Ch; SA, SH, H; MCM and MCP.
Ajuga iva (L) Schreb; He; A, SA, SH, H; MCP.
Ballota hirsuta Bentham; Nph; A, SA, SH, H; MCP.
Cleonia lusitanica (L.) L.; Th; A, SA, H; MCP.
Lamium flexuosum Ten.; He; H; MCP.
Prasium majus L.; Nph; A, SA, SH, H; MCM and MCP.
Teucrium decipiens Cosson & Balansa.; Th; SA; MCP.
Teucrium fruticans L.; Nph; SA, SH, H; MCM and MCP.

Liliaceae

Allium pallens L.; G; SA, SH, H; MCP.
Linum strictum L.; Th; SA, SH, H; MCM and MCP.
Smilax aspera L.; Ph; SA, SH, H; MCM and MCP.
Urginea maritima (L.)Baker; G; A, SA, SH, H; MCM and MCP.

Malvaceae

Malva sylvestris L.; He; A, SA, SH, H; MCP.
Lavatera trimestris L.; Th; MCM and MCP.

Myrtaceae

Myrtus communis L.; Nph; SA, SH, H; MCP.

Oleaceae

Jasminum fruticans L.; Nph; A, SA, H; MCM and MCP.
Olea europaea L. var *oleaster*; Ph; A, SA, SH, H; MCM and MCP.
Phillyrea angustifolia L.; Ph; SA, SH, H; MCP.
Phillyrea latifolia L.; Ph; SA, SH, H; MCM and MCP.
Phillyrea media L.; Ph; SA, SH, H; MCM and MCP.

Osmundaceae

Osmunda regalis L.; He; MCP.

Papaveraceae

Fumaria macrosepala Boiss.; Th; MCP.
Papaver rhoeas L.; Th; A, SA, SH, H; MCP.

Plantaginaceae

Anarrhinum pedatum Desf.; He; A, SA, SH, H; MCM and MCP.
Globularia alypum L.; Ch; SA, SH; MCP.
Plantago coronopus L.; Th; A, SA, SH; MCM.
Plantago lagopus L.; Th; SA; MCM and MCP.
Plantago lanceolata L.; He; MCP.
Plantago mauritanicum Boiss. & Reut.; Th; SA, SH, H; MCM.
Plantago ovata Forsk.; Th; A, SA, SH; MCP.
Plantago psyllium L.; Th; SA; MCM and MCP.

Plumbaginaceae

Limonium lobatum (L. fil.) Chaz.; Th; A, SA; MCM.
Limonium sinuatum (L.) Miller; Th; A, SA, SH; MCM and MCP.

Poaceae
Aegilops ovata subsp *triaristata* (Wild) Roy; Th; SH; MCP.
Anthoxanthum odoratum L.; Th; SA, SH, H; MCP.
Aristida caerulescens Desf.; He; A, SA; MCP.
Arrhenatherum elatius (L.) Presl.; He; SA, SH, H; MCM.
Arundo donax L.; He; A, SA, SH, H; MCP.
Avena sterilis L.; Th; A, SA, SH; MCM and MCP.
Bellis sylvestris Cyr.; Th; A, SA, SH, H; MCM.
Brachypodium phoenicoïdes (L.) Roem . & Schultes.; Th; SA, SH; MCM.
Briza maxima L.; Th; SA, SH, H; MCM and MCP.
Briza minor L.; Th; SA, SH, H; MCP.
Bromus hordeaceus L.; Th; A, SA, SH, H; MCP.
Bromus mollis L.; Th; A, SA, SH, H; MCM and MCP.
Bromus rigidus Roth.; Th; A, SA, SH, H; MCM.
Bromus rubens L.; Th; A, SA, SH, H; MCM and MCP.
Cynodon dactylon (L.) Pers.; G; A, SA, SH, H; MCP.
Cynosurus elegans Desf.; Th; MCP.
Dactylis glomerata L.; He; A, SA, SH, H; MCM and MCP.
Festuca caerulescens Desf; He; A, SA, SH, H; MCM and MCP.
Hordeum murinum L.; Th; SA, SH; MCM.
Hyparrhenia hirta (L.) Stapf; He; SA, SH; MCM and MCP.
Koeleria pubescens (Lamk.) P. Beauv.; Th; SA, SH, H; MCM.
Lamarckia aurea (L) Moenc; Th; A, SA, SH; MCM and MCP.
Lolium multiflorum Lam.; Th; SA, SH; MCP.
Lolium rigidum Gaud; Th; A, SA, SH; MCM and MCP.
Melica ciliata L.; He; MCM and MCP.
Melica minuta L.; Th; MCP.
Oryzopsis miliacea (L.) Asch. & Schweinf.; He; SA, SH, H; MCM.
Poa annua L.; Th; SA, SH, H; MCM.
Poa bulbosa L.; Th; SA, SH, H; MCP.
Stipa capensis Thumb.; Th; A, SA; MCP.
Stipa lagascae Roem. & Schult.; Th; A, SA; MCM.
Trachynia distachya (L.) Link; Th; MCP.
Vulpia alopecuros (Schousb.) (Link.); Th; A, SA, SH; MCP.
Vulpia geniculata (L) Link Hort.; Th; A, SA, SH; MCM.
Vulpia myuros (L.) Gmel.; Th; A, SA, SH; MCM.
Polygonaceae
Rumex bucephalophorus L.; Th; A, SA, SH, H; MCP.
Polypodiaceae
Notholaena vellea (Aiton) Desv.; He; MCP.
Primulaceae
Anagallis arvensis L.; Th; A, SA, SH, H; MCP.

Asterolinum linum-stellatum (L.) Duby.; Th; A, SA, SH, H; MCM.

Ranunculaceae

Anemone palmata L.; G; SA, SH, H; MCP.
Clematis cirrhosa L.; Ph; SA, SH, H; MCM and MCP.
Ranunculus bulbosus L.; He; A, SA, SH, H; MCM.
Ranunculus paludosus Poiret.; He; SA, SH, H; MCP.

Resedaceae

Reseda alba L.; MCM and MCP.

Rhamnaceae

Rhamnus lycioïdes L. subsp. *oleoïdes* (L.) Jah. Et Maire; Nph; SA, SH; MCM and MCP.
Rhamnus lycioides L. subsp. *atlantica*; Nph; SA, SH; MCM and MCP.
Ziziphus lotus (L) Lam.; Nph; S, A, SA, SH; MCP.

Rosaceae

Crataegus monogyna Jacq.; Nph; SA, SH, H; MCP.
Rosa canina L.; Nph; MCP.
Sanguisorba minor Scop.; He; SA, SH; MCM.

Rubiaceae

Crucianella angustifolia L.; Th; SA, SH, H; MCP.
Galium mollugo L.; He; MCP.
Galium parisiense L.; Th; SA, SH, H; MCP.
Rubia peregrina L.; Ch; A, SA, SH, H; MCP.
Sherardia arvensis L.; Th; MCM.

Rutaceae

Ruta chalepensis L.; Ch; MCM and MCP.

Santalaceae

Osyris lanceolata Hochst. & Steude; Nph; SA, SH, H; MCP.

Selaginellaceae

Selaginella denticulata (L.) Spring; He; MCM and MCP.

Solanaceae

Nicotiana glauca Graham; Nph; MCM
Withania frutescens (L.) Pauquy; Nph; SA; MCM and MCP.

Tamaricaceae

Tamarix africana Poir.; Nph; MCP.
Tamarix gallica L.; Nph; MCP.

Urticaceae

Parietaria mauritanica DR.; Th; A, SA, SH; MCP.
Urtica dioica L.; He; SA, SH; MCP.

Valerianaceae

Fedia pallescens Maire; Th; SH; MCP.

Verbenaceae

Vitex agnus-castus L.; Nph; A, SA, SH, H; MCP.

Vitaceae
Vitis vinefera L.; Nph; SA, SH, H; MCP.
Xanthorrhoeaceae
Asphodelus microcarpus Salzm. & Viv.; G; SA, SH; MCM and MCP.

The flora of *Tetraclinis* ecosystem in the Moroccan Central Plateau contains about 56 families. However, six important families contain almost 51% of the flora. However, these families are in order of importance: Poaceae (15%), Asteraceae (14%), Fabaceae (12%), Lamiaceae (4%), Caryophyllaceae (4%), and Plantaginaceae (4%).

Biological type analysis shows a dominance of Therophytes. This predominance is attributed to various factors such as the climate aridity of the region, associated with anthropogenic activities like grazing and deforestation. Indeed, the biological spectrum is typical of the semi-arid climate with a distribution percentage of 46% for Therophytes, 21% for Hemicryptophytes, 13% for Nanophanerophytes, 7% for Chamaephytes, 7% for Geophytes, and 6% for Phanerophytes.

Phytosociologically, these taxa are essentially integrated into the associations:

- *Lonicero implexae-Tetraclinetum articulatae* (Fennane, 1982),
- *Phillyreo latifoliae-Oleetum sylvestris* (Barbéro, Quézel & Rivas-Martínez, 1981),
- *Coronillo viminalis-Tetraclinetum articulatae* (Barbéro, Quézel & Rivas-Martínez, 1981),
- *Phillyro mediae- Tetraclinetum articulatae* (Fennane, 1982).

The phytosociological classification shows that these associations belong to the class of *Quercetea ilicis* Br.-Bl. 1947, the order of *Pistacio-Rhamnetalia alaterni* (Rivas-Martínez, 1975) and the alliances of *Tetraclini articulatae-Pistacion atlanticae* (Rivas-Martínez *et al.*, 1984) and *Asparago-Rhamnion oleoidis* (Rivas-Martínez, 1975).

Conclusion

The floristic analysis of the *Tetraclinis* ecosystem in the Moroccan Central Plateau shows that species richness represents 5% of the Moroccan vascular flora. The Moroccan Central Plateau is a home to an exceptionally rich floristic biodiversity, which is the result of its geographical position, orographic and edaphic characteristics, geological history, and its past and current climatic conditions. The protection of these taxa is needed more than ever, particularly those associated with *Tetraclinis* stands of the Central Plateau. However, it must be able to afford rigorous protection. Indeed, overgrazing and human pressure on the forest resources are likely to affect prejudicially this natural heritage.

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