Diversity of desert rangelands of Tunisia

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**ABSTRACT**

Plants are important components of any rangeland. However, the importance of desert rangeland plant diversity has often been underestimated. It has been argued that desert rangelands of Tunisia in good ecological condition provide more services than those in poor ecological condition. This is because rangelands in good condition support a more diverse mixture of vegetation with many benefits, such as forage for livestock and medicinal plants.

Nearly one-quarter of Tunisia, covering about 5.5 million hectares, are rangelands, of which 87% are located in the arid and desert areas (45% and 42%, respectively). Here, we provide a brief review of the floristic richness of desert rangelands of Tunisia. Approximately 135 species are specific to desert rangelands. The predominant families are Asteraceae, Poaceae, Brassicaceae, Chenopodiaceae, and Fabaceae. These represent approximately 50% of Tunisian desert flora.

1. Introduction

Rangelands cover about 40% of the world’s land area (White et al., 2000) and are as ecologically important as rain forests (Casper, 2009). Arid ecosystems comprise one-third of the global land surface, support 14% of the world’s inhabitants, and provide a significant share of the world’s agriculture (Nicholson, 2011). Arid environments may not be the most hospitable places on Earth, but the 30% or more of the global land surface that they cover does support an ever-growing human population and has fascinated explorers and scientists for centuries (Thomas, 2011).

Desert rangelands, like other arid rangelands, suffer from severe natural disturbances such as high rates of soil degradation and extremely low rainfall distribution, which, in part, may be caused by the climate due to their geographical location (Le Houërou, 2009). These problems are generally compounded by anthropogenic factors such as overgrazing and wood harvesting (Le Houërou, 2009). Taken together, these factors contribute to decreased biological diversity and rangeland productivity, as well as high rates of erosion, all of which are widespread problems in Tunisia (Gamoun, 2012; Tarhouni et al., 2014).

Tunisia is a small country, yet has highly diverse climatic and edaphic conditions (Floret and Pontanier, 1982). Rangelands constitute the largest use of land in Tunisia, where pastoralism remains vital. Furthermore, rangelands not only provide important goods and services but also represent a tremendous source of biodiversity. Nearly one quarter of Tunisia is rangeland, occupying about 5.5 million hectares, 87% of which are located in the arid and desert areas (45% and 42%, respectively). In Northern Africa, the term “desert” is most properly applied to zones that receive less than 100 mm of average annual rainfall, are little affected by human activity, and possess a very low production potential or likelihood of future evolution (Floret and Pontanier, 1982). The majority of the rangelands of south Tunisia exhibit moderate or severe desertification, and are being damaged and made less productive by mismanagement (Nefzaoui et al., 2011). Desertification includes deterioration of ecosystems and degradation of various forms of vegetation (Le Houërou, 1969).

The causes of desertification are myriad and often interconnected. They include overgrazing and overcutting for firewood and timber, inappropriate farming, poor irrigation, and poor management, which has led to salinity problems, mining, construction of highways and utility corridors, air pollution, recreational activities, particularly off-road vehicle recreation, and climate change (Bainbridge, 2007). The underlying causes of dryland degradation are commonly economic and cultural, rather than ecological (Hallsworth, 1987; Carney and Farrington, 1998; Chambers et al., 1991). The primary causes of current degradation in some arid areas have been identified as intensified and irrational human activities and climate variability (Ouled Belgacem and Louhaichi, 2019).

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Overgrazing is the main cause of rangeland degradation and desertification (Le Houérou, 1996; Ibáñez et al., 2007; Gamoun, 2014a, 2014b). It may be driven by economic pressure, greed, desperation, and sometimes ignorance (Bainbridge, 2007). For example, Africa as a whole contributes 36% of the world’s total land degraded by overgrazing and 49%–90% of the continent’s rangelands are believed to already be in the process of long-term degradation (Hudak, 1999).

The primary effects of overgrazing have been reported to be mainly of a biotic nature, resulting in a decrease in plant cover, and in particular, a loss of perennials, which constitutes one of the most significant indicators of desertification (Verstraete and Schwartz, 1991; Aronson et al., 1993). The main consequences of overloading rangelands are summarized as follows: (i) an increase in cultivated land decreases rangeland area; (ii) an increase in livestock number decreases rangeland area; (iii) rangeland is degraded, decreasing both forage yield and carrying capacity (Zhao et al., 1991).

Desertification is largely a response to climatic trends and fluctuations in the availability of resources (Wang et al., 2005). Climate variability (high temperatures and low rainfall distribution) negatively affects rangeland productivity (Peters et al., 2013), and, where severe in dryland areas (Le Houérou, 1996; Darkoh, 1998; Harris, 2010; Reynolds, 2013). Sequences of dry years have been a major climatic force in the degradation of rangelands (Verner, 2013). The unreliable distribution of rainfall is an important component which contributes significantly towards the deterioration of rangeland productivity in the dry areas (Floret et al., 1978; Gamoun, 2013, 2014a, 2014b, 2014c, 2016a, 2016b). Evidence of this is provided through long-term annual rainfall figures in Tunisia, which reveal that desert rangelands are characterized by a dry climate, with hot dry summers and winters and very low levels of precipitation—about 75 mm—from 1997 to 2016 (Figs. 1 and 2).

The flora of desert areas has always attracted ecologists from around the world (Ward, 2016). As a result, the arid zones of Tunisia have been extensively studied over the past fifty years; indeed, the arid zone flora, climate, ecology, hydrogeology, and soils of Tunisia are among the best known in the world.

By any measure, the world’s arid rangelands qualify as modest repositories of biodiversity (Shachak et al., 2005). The biological diversity of many desert and semi-desert areas continues to be threatened by many different human activities, such as overharvesting of firewood and overgrazing (Bainbridge, 2007). In these areas, where overgrazing and wood collection drive changes in the structure and functioning of rangelands, any decrease in perennial plant cover and plant species diversity leads to changes in floristic composition, soil erosion, and modifications in nutrient, water, and energy flow (Floret et al., 1978; Jauffret and Lavorel, 2003).

In this paper, we provide a brief review of the floristic richness of part of a desert rangeland in Tunisia.

2. Rangeland diversity

Researchers in Tunisia have focused a lot of attention on rangelands as well as on plant diversity and community ecology (Ouled Belgacem et al., 2011; Tarhouni et al., 2015). Tunisia’s rangelands span a wide variety of environments from the arid steppe to desert rangelands of southern Tunisia. As in all Mediterranean countries, these steppe zones were previously used mainly for grazing and have been subjected to severe pressure from an increasing population, which has slowly stabilized (Floret and Hadjjej, 1977). In response to climatic conditions and grazing, the species composition, diversity and abundance, community structure, and plant life forms also changed (Ouled Belgacem et al., 2011; Tarhouni et al., 2015; Gamoun et al., 2016a, 2016b). Heavy grazing has left Tunisian ecosystems with a homogenized flora consisting only of species that are unpalatable and highly tolerant to herbivory and other forms of disturbance (Gondard et al., 2003; Jauffret and Lavorel, 2003). Sand deposits due to strong desert winds also further decrease vegetation growth by burying some plant parts, gradually decreasing the floristic variety (Bendali et al., 1999).

Sustainable rangeland management approaches have now been used to protect some sections of these desert rangelands in an effort to reduce the effects of degradation by increasing the vegetation composition, spatial distribution, and structure (Floret, 1981; Ouled Belgacem et al., 2008; Gamoun et al., 2010; Tarhouni et al., 2015). As a result, such sustainable practices have yielded diverse rangeland resources, with an abundant and rich diversity of plant species (Figs. 3 and 4 and Table 1).

Tunisia’s rangelands support 2162 species (Le Floc’h et al., 2010). In addition, rangelands in pre-Saharan Tunisia harbor a rich flora which includes about 836 species (Ferchichi, 2000). Approximately 135 of these species are specific to desert rangelands (Gamoun, 2012). Five predominant plant families, Asteraceae, Poaceae, Brassicaceae, Chenopodiaceae, and Fabaceae, represent approximately 50% of Tunisian desert flora (Fig. 5).

In the Tunisian desert rangelands the abundance of plant life forms includes 75 species of Therophyte (49%), 38 species of Chamaephyte (25%), 20 species of Hemicryptophyte (13%), 11 species of Nanophanerophyte (7%), 7 species of Geophytes (5%) and 2 species of Phanerophyte (1%). Anthropogenic disturbances in dry habitats have been shown to generate an increase in micro-scale species richness (Holzapfel et al., 1992). As for Therophytes, their...
presence may be explained in particular by the large number of micro-habitats available to annual plants that have rapid germination and growth, thus increasing their abundance (Gamoun et al., 2011, 2012). Chamaephytes are over-represented in arid rangelands because they are highly adapted to arid conditions (Raunkiaer, 1934; Orshan et al., 1984; Floret et al., 1990; Jauffret and Visser, 2003; Gamoun et al., 2012). The low abundance of Hemicryptophytes reduces competition for soil moisture to the benefit of Chamaephytes (Gamoun et al., 2011) (Fig. 6). On the other hand, the low presence of Geophytes mainly reflects the long period of drought in these arid rangelands (Gamoun et al., 2011, 2012).

Grazing is not the only driver in arid ecosystems. Variable and unpredictable precipitation regimes, as well as limited soil nutrient concentrations are also major factors that determine arid ecosystem features (Noy-Meir, 1985; Walker, 1987). Gamoun et al. (2012) reported changes in the plant community composition in response to grazing and soil texture. In arid rangelands, edaphic factor availability strongly determines vegetation, and soil type has been found to limit arid plant dynamics within rangelands by affecting grazing regimes practices (Gamoun, 2012). Each soil type is characterized by specific vegetation. Range production, cover, and species richness are low and highly irregular in arid zones, and
always spatially limited to sandy and gravelly soils (Gamoun, 2012). The introduction of herbivores is generally believed to reduce plant diversity. Selective grazing by livestock has been shown to negatively affect plant diversity and species composition in arid ecosystems. Heavy grazing of natural rangelands leads to loss of several highly palatable species (Louhaichi et al., 2009). However, the soil type influences the response to grazing. For example, vegetation response on sandy and gravelly soils is more diversified and more productive than on limestone and loamy soil, whereas the latter is more adapted to grazing pressure (Gamoun et al., 2011). On the whole, grazing causes a spatial homogenization of the plant community in areas dominated by Chamaephytes. Under grazed conditions, the vegetation is dominated by perennial species which are generally present in the ungrazed rangelands. These perennial species may benefit from an adaptation caused by drought and grazing (Fensham et al., 2010). The absence of perennial species such as Echiochilon fruticosum Desf., Stipa lagascae Roem. & Schult., and Stipagrostis ciliata (Desf.) de Winter is due to their high

Fig. 4. Some plant species of desert rangelands of Tunisia (photos by Mouldi Gamoun): (a) Rhanterium suaveolens Desf., (b) Echiochilon fruticosum Desf., (c) Plantago albicans L., (d) Stipa tenacissima L., (e) Artemisia herba-alba Asso., (f) Periplaca angustifolia Labill., (g) Gymnocarpus decander Forssk., (h) Anthyllis heroniana Batt., (i) Stipagrostis ciliata (Desf.) de Winter (j) Ziziphus lotus (L.), (k) Helianthemum kabiricum Delile, (l) Retama rorum (Forssk.) Webb & Berthel., (m) Haloxylon scoparium Pomel., (n) Haloxylon schmittianum Pomel., (o) Stipagrostis pungens (Desf.) de Winter, (p) Stipa lagascae Roem. & Schult.
palatability. Alternatively, perennial species may have decreased because of intensive grazing and possibly from a trampling effect from livestock in the sandy and gravelly soils of such rangelands (Gamoun et al., 2011). Otherwise, on ideal grazing land, there is a greater variety of plant species available for selective grazing and grazing animals are highly selective when given the opportunity. Thus, positive manipulation of the soil-forage plant-grazing animal complex should play a central role in any grazing management strategy for arid rangelands (Vallentine, 2001).

Few studies have evaluated the effects of controlled grazing on plant diversity in arid areas. Gamoun (2014) reported that vegetation diversity was higher in protected areas than in heavily grazed areas in the desert rangeland of southern Tunisia. In contrast, moderate grazing did not significantly affect species richness, diversity index, or species composition. In another study in the same area, Gamoun and Hanchi (2014) found that plant diversity increased as grazing intensity decreased. Ward et al. (2000) and Jauffret and Lavorel (2003), among others, have shown that palatability may play an important role in determining the effects of grazing on arid ecosystems. For these studies, however, the differences in plant diversity between the ungrazed and lightly grazed areas were small. The largest difference between the ungrazed and heavily-grazed sites was the disappearance of very palatable species under a heavy grazing treatment, including Anabasis.
Table 1

| Species | Family | Life form | Acceptability index |
|---------|--------|-----------|---------------------|
| Anthyllis hennonianibatt. | Fabaceae | Chamaephyte | 4 |
| Ayuga iva (L.) Schreb. | Lamiaceae | Therophyte | 3 |
| Allium roseum L. | Alliaceae | Geophyte | 2 |
| Anabasis orypedorum Maire. | Chenopodiaceae | Chamaephyte | 5 |
| Anacyclus clavatus (Desf.) Pers. | Asteraeae | Therophyte | 4 |
| Anacyclus monanthos ssp cyrtolepidioides (Pomel) | Asteraeae | Therophyte | 4 |
| Anarthrinum fruticosum Desf. subsp. Brevifolium | Scrophulariaceae | Chamaephyte | 1 |
| Argyroknium uniflorum (Deerne.) Jaub. & Spach. | Fabaceae | Chamaephyte | 5 |
| Artemisia decumbens (Vent.) Coss. & Krallik | Boraginaceae | Therophyte | 2 |
| Artemisia campestris L. | Asteraeae | Chamaephyte | 2 |
| Artemisia herba-alba Asso | Asteraeae | Chamaephyte | 2 |
| Asphodelus refractus Boiss. | Asphodelaceae | Therophyte | 1 |
| Asphodelus temulofolus Cav. | Asphodelaceae | Therophyte | 0 |
| Astragalus armatus Willd. | Fabaceae | Chamaephyte | 2 |
| Astragalus asterias Steven. | Fabaceae | Therophyte | 2 |
| Astragalus corrugatus Bertol. | Fabaceae | Therophyte | 2 |
| Astragalus cancellata L. | Asteraeae | Therophyte | 1 |
| Astragalus carduus (Forssk.) C. Chr. | Asteraeae | Chamaephyte | 0 |
| Astragalus puberula Boiss. | Asteraeae | Therophyte | 1 |
| Astragalus serratuloides Sieber ex Cass. | Asteraeae | Hemichamperophyte | 2 |
| Arthroxylum halimus L. | Chenopodiaceae | Nanophanerophyte | 3 |
| Bassia maricata (L.) Asoc. | Chenopodiaceae | Therophyte | 2 |
| Brassica tournefortii Gouan. | Brassicaceae | Therophyte | 1 |
| Caculdeus tripterocarpus Rap. | Asteraeae | Therophyte | 3 |
| Cacalote mesilosa (Poir.) Link. | Asteraeae | Therophyte | 1 |
| Calliconon azele Maire | Polygonaceae | Nanophanerophyte | 3 |
| Calliconon polygonoides L. | Polygonaceae | Nanophanerophyte | 4 |
| Carthamus ericetophalus (Boiss.) greater | Asteraeae | Therophyte | 1 |
| Centaurea furredae Coss. & Desv. | Asteraeae | Therophyte | 3 |
| Citrus crassicoccus (L.) Schrad. | Cucurbitaceae | Hemichamperophyte | 0 |
| Cleome amblyocarpa Baratte & Murb. | Cleomeae | Hemichamperophyte | 0 |
| Convoleus supinus Coss. & Krallik. | Convoleuceae | Therophyte | 2 |
| Cuscuta epithymum (L.) L. | Cuscutaceae | Therophyte | 0 |
| Cotula dichotoma (Forsk.) Batt. & Trab. | Poaceae | Therophyte | 4 |
| Cynara cardunculus L. subsp. Cardunculus | Asteraeae | Hemichamperophyte | 0 |
| Cynodon dactylon (L.) Pers. | Poaceae | Geophyte | 5 |
| Cynorhodon coccineum L | Cynorhodaceae | Geophyte | 0 |
| Daucus sahariensis Murb. | Apiaceae | Therophyte | 3 |
| Deverra denadata (Viv.) R. Pfeister & Podlech. | Apiaceae | Therophyte | 3 |
| Deverra tortuosa (Desf.) DC. | Apiaceae | Chamaephyte | 2 |
| Dipcadi serotinum (L.) Medik. | Hyacinthaceae | Geophyte | 0 |
| Diploctis horro (Forssk.) Boiss. | Brassicaceae | Therophyte | 2 |
| Diploctis simplex Spreng. | Brassicaceae | Therophyte | 3 |
| Echingia spinosa L. | Asteraeae | Therophyte | 0 |
| Echioclonfruticosum Desf. | Boraginaceae | Chamaephyte | 5 |
| Enarthroxylum clavulatus Godr. | Brassicaceae | Therophyte | 2 |
| Ephelea altissima Desf. | Ephedraceae | Nanophanerophyte | 2 |
| Erodium crassijolium L’Hér. | Geraniaceae | Therophyte | 3 |
| Erodium glaucophyllum (L.) L’Hér. | Geraniaceae | Therophyte | 0 |
| Erucaria pinnata (Viv.) Tackh. & Boulos | Brassicaceae | Therophyte | 3 |
| Eryngium illicifolium Lam. | Apiceae | Therophyte | 0 |
| Euphorbia retusa Forssk. | Euphorbiaceae | Therophyte | 0 |
| Euphorbia terracina L. | Euphorbiaceae | Therophyte | 0 |
| Fagonia cretica L. | Zygophylaceae | Therophyte | 0 |
| Fagonia glutinos Delile. | Zygophylaceae | Therophyte | 0 |
| Farsetia aegypti Turra. | Brassicaceae | Chamaephyte | 3 |
| Flago germanica L | Asteraeae | Therophyte | 1 |
| Gagea fibrosa (Desf.) Schultz. & Schult. f. | Lilaeae | Geophyte | 0 |
| Gymnarrhena micrantha Desf. | Asteraeae | Therophyte | 2 |
| Gymnocypris deccander Forssk. | Caryaephyllaceae | Chamaephyte | 5 |
| Haloenenium strobilaceum (Pall.) M. Bieb. | Plumbaginaceae | Hemichamperophyte | 2 |
| Haloxylon schmittianum Pomel. | Chenopodiaceae | Chamaephyte | 1 |
| Haloxylon scoparium Pomel. | Chenopodiaceae | Chamaephyte | 1 |
| Haplodipterygium tuberculatum (Forssk.) Juss. | Rutaceae | Chamaephyte | 0 |
| Helianthemum kahiricum Delile. | Cistaceae | Chamaephyte | 4 |
| Helianthemum sessilisform (Desf.) | Cistaceae | Chamaephyte | 5 |
| Herrnia filipes (Forssk.) Gay. | Caryophylaceae | Chamaephyte | 3 |
| Hypocrepis areolata Desf. | Fabaceae | Therophyte | 4 |
| Ifoga spicata (Forssk.) Sch. Bip. | Asteraceae | Therophyte | 1 |
| Kickxia aegyptiaca (L.) Nabelek. | Scrophulariaceae | Chamaephyte | 2 |
| Koelpinia linearis Pall. | Asteraceae | Therophyte | 4 |
| Launaea angustifolia (Forss.) Mischl. | Asteraceae | Therophyte | 4 |
| Launaea capitata (Spreng.) Dandy | Asteraceae | Therophyte | 3 |
oropediourum (Maire), Cutandia dichotoma (Forssk.), Batt. & Trab., E. fruticosum (Desf.), Helianthemum kahircum (Delile), Helianthemum sessiliflorum (Desf.), Hippocrepis areolata Desv., Launaea nudicaulis (Linn.) Hook. f., Launaea angustifolia (Desf.) Muschl., Koelpinia linearis Pall., Polygonum equisetiforme S. & Sm., Scorzonera undulata Vahl. and S. lagascae Roem. & Schult., (Gamoun, 2014a, 2014b). Jauffret and Lavorel (2003) note that long-spine species such as Astragalus armatus Willd., and unpalatable, highly fibrous species such as Thymelaea hirsuta (L.) Endl., are dominant in arid Tunisian rangelands, and suggest this is a consequence of long grazing history. Similarly, unpalatable shrubs such as Haloxylon scoparium Pomel., T. hirsuta (L.) Endl., and Anabasis articulata (Forssk.) Moq., are often dominant in heavily grazed arid regions of the Middle East (Ward, 2004).

Deserts are biologically stressful environments and plants have acquired two principal strategies to cope with the harsh arid conditions and herbivory: avoidance and tolerance (Laity, 2008). These strategies allow plants to cope with heat and drought to ensure that

| Species                        | Family      | Life form       | Acceptability index |
|--------------------------------|-------------|-----------------|---------------------|
| Launaea fragilis (Asso) Pau.   | Asteraceae  | Therophyte      | 2                   |
| Launaea nudicaulis (Linn.) Hook. f. | Asteraceae  | Therophyte      | 4                   |
| Lavandula multifida L.         | Lamiaceae   | Chamaephyte     | 0                   |
| Limoniastrium guyonianum Boiss. | Plumbaginaceae | Hemicryptophyte | 3                   |
| Limoniastrium monopetaleum (L.) Boiss. | Plumbaginaceae | Hemicryptophyte | 3                   |
| Limonium pruniflorum (L.) Chaz. | Plumbaginaceae | Hemicryptophyte | 3                   |
| Linaria lasiora Desf.          | Scrophulariaceae | Therophyte     | 1                   |
| Lobularia libyca (Viv.) Meissn. | Brassicaceae | Therophyte      | 3                   |
| Lotus halophilus Boiss. & Spruner | Asteraceae  | Therophyte      | 3                   |
| Lycium shawii Roem. & Schult.  | Solanaceae   | Nanophanerophyte| 2                   |
| Lygeum spartum Loell. ex L.    | Poaceae      | Hemicryptophyte | 2                   |
| Matthiola longipetala (Vent.) DC. | Brassicaceae | Therophyte      | 2                   |
| Medicago minima (L.) L.        | Fabaceae     | Therophyte      | 3                   |
| Moricandia arvensis (L.) DC.   | Brassicaceae | Chamaephyte     | 2                   |
| Murania prostrata (Desf.) Desv. | Brassicaceae | Therophyte      | 3                   |
| Nitraria retusa (Forssk.) Asch. | Nitrariaceae | Therophyte      | 2                   |
| Nolletia chrysocomoides (Desf.) Cass. ex Less. | Asteraceae | Chamaephyte     | 2                   |
| Nonea calycina (Roem. & Schult.) Selvi | Boraginaceae | Therophyte      | 2                   |
| Pallenis hierochuntica (Michon) Greuter. | Asteraceae | Therophyte      | 2                   |
| Paronychia arabica (L.) DC.     | Caryophyllaceae | Therophyte   | 1                   |
| Peganum harmala L.             | Zygophyllaceae | Chamaephyte  | 0                   |
| Pennisetum divisum (Forssk. ex J.F. Gmel.) Henrard | Poaceae | Hemicryptophyte | 3                   |
| Periploca angustifolia subsp. angustifolia (Labil.) | Asclepiadaceae | Nanophanerophyte| 3                   |
| Plantago alicans L.            | Plantaginaceae | Therophyte     | 3                   |
| Plantago ovata Forssk.         | Plantaginaceae | Therophyte     | 3                   |
| Polygonum equisetiforme Sibth. et Sm. | Polygonaceae | Hemicryptophyte| 4                   |
| Reaumuria vermiculata L.       | Tamaricaceae | Therophyte      | 0                   |
| Reichardia tingitana (L.) Roth  | Asteraceae   | Therophyte      | 2                   |
| Reseda alba L. subsp. Alba     | Resedaceae   | Therophyte      | 1                   |
| Retama rostram (Forssk.) Webb & Berthel. | Fabaceae | Nanophanerophyte| 3                   |
| Rhanterium suaveolens Desf.    | Asteraceae   | Chamaephyte     | 2                   |
| Rhus tripartita (Ucria) Grande  | Anacardiaceae | Nanophanerophyte| 2                   |
| Salvia tetratona Delile         | Chenopodaceae | Phanerophyte    | 2                   |
| Salvia tetranda Forssk.        | Chenopodaceae | Phanerophyte    | 2                   |
| Salvia vermiculata L.          | Chenopodaceae | Chamaephyte    | 3                   |
| Salvia aegyptica L.            | Lamiaceae    | Chamaephyte     | 3                   |
| Salvia verbenaca L.            | Lamiaceae    | Chamaephyte     | 3                   |
| Saviynya parviflora (Delile) Webb. | Brassicaceae | Therophyte      | 3                   |
| Scabiosa arenaria Forssk.       | Dipsacaceae  | Therophyte      | 2                   |
| Schismus barbatus (L.) Thell.   | Poaceae      | Therophyte      | 4                   |
| Scorzonera undulata Vahl.      | Asteraceae   | Geophyte        | 4                   |
| Senecio gallicus L.            | Asteraceae   | Therophyte      | 1                   |
| Stipa capensis Thunb.           | Poaceae      | Therophyte      | 2                   |
| Stipa lagascae Roem. & Schult.  | Poaceae      | Hemicryptophyte | 4                   |
| Stipa parviflora Desf.         | Poaceae      | Hemicryptophyte | 4                   |
| Stipa tenacissima L.           | Poaceae      | Hemicryptophyte | 3                   |
| Stipagrostis ciliata (Desf.) de Winter. | Poaceae | Hemicryptophyte | 4                   |
| Stipagrostis obtusa (Delile) Nees. | Poaceae | Hemicryptophyte | 4                   |
| Stipagrostis plumosa (L.) Munro. | Poaceae | Hemicryptophyte | 3                   |
| Stipagrostis pungens (Desf.) de Winter. | Poaceae | Hemicryptophyte | 3                   |
| Suaeda vermiculata Forssk. ex J.F. Gmel. | Chenopodaceae | Chamaephyte    | 3                   |
| Tamarix gallica L.             | Tamaricaceae | Nanophanerophyte| 2                   |
| Teucrium alopecurus De Noé      | Primulaceae  | Chamaephyte     | 1                   |
| Teucrium polium L.              | Lamiaceae    | Chamaephyte     | 2                   |
| Thecimum humile Vahl. Symb.     | Santalaceae  | Therophyte      | 1                   |
| Thymelaea hirsuta (L.) Endl.    | Thymelaceae  | Chamaephyte     | 0                   |
| Thymelaea microphylla Coess. & Durieu. | Thymelaceae | Chamaephyte     | 2                   |
| Tragacum nudatum Delile.        | Chenopodaceae | Chamaephyte     | 3                   |
| Tribulus terrestris L.          | Zygophyllaceae | Therophyte   | 1                   |
| Zeaephus lotus (L.) Lam.         | Bhamanaceae  | Nanophanerophyte| 2                   |
| Zygophyllum album L. f.         | Zygophyllaceae | Chamaephyte | 0                   |
neither internal temperatures nor tissue dehydration reach deadly levels. The majority of the flora in deserts are evaders, surviving stressful periods by living permanently or temporarily in cooler and/or moister microhabitats (Laity, 2008).

3. Conclusion

Many plants live in deserts, but it is only xerophytes that can withstand and live under long-term dry conditions. Asteraceae, Poaceae, Brassicaceae, Chenopodiaceae, and Fabaceae represent approximately 50% of Tunisian desert flora. This diversity provides many benefits that can meet the demands of both the local people for medicinal plants and fruits, as well as livestock requirements through providing forage. Mismanagement and climate change have gradually destroyed previously productive ecosystems. To reverse the degradation and desertification of these natural resources, restoration and improved management is essential.

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Appendix A. Supplementary data

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