# Biodiversity Assessment and Conservation of Threatened Plant Species Belonging to the Unique Steppe with Trees in Tunisian Drylands

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# Biodiversity assessment and conservation of threatened plant species belonging to the unique steppe with trees in Tunisian drylands.

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**Key words:** Conservation, functional traits, national park, rare species, dryland.

## Abstract
Biodiversity conservation from heavy grazing impacts, through the creation of national parks, is usually considered to sustain higher ecosystem resilience and to protect the natural plant cover as well as the threatened species. The study was carried out in Bou Hedma national park, a biosphere reserve containing the unique *Acacia tortilis* (Forssk.) Hayne subsp. *raddiana* (Savi) Brenan steppe with trees in Tunisia. Several functional traits of seven (7) rare and threatened plant species are used to highlight their adaptive strategies in order to understand the evolution of plant communities and the overall ecosystems functioning inside the park. Such results may provide many environmental benefits and maintain the flora biodiversity under harsh dryland conditions.

## Introduction
Increased temperature, variability in rainfall and prolonged droughts are the main climatic conditions influencing the dryland ecosystems productivity (Maestre et al. 2012). These ecosystems are threatened both by climate variations and human factors. Ouled Belgacem and Louhaichi (2013) showed that climate variability and strong human activities are the main causes of degradation in arid and semi-arid regions. Tunisia, like other north African countries, is currently facing degradation and desertification of its most fragile ecosystems, such as the arid rangelands. The natural vegetal cover is suffering from the rarefaction or the disappearance of the most palatable plant species and the spread of the unpalatable ones (Tarhouni et al. 2010; Ouled Belgacem and Louhaichi 2013; Louhaichi et al. 2019). To conserve biodiversity and maintain the auto-regeneration process of the natural ecosystems, Tunisia was created a set of national parks in different bioclimatic zones. According to Ferchichi (2013), these parks represent the majority (237.000 ha) of the protected areas in the country (250.000 ha). Bou Hedma national park, which contains the unique *Acacia tortilis* (Forssk.) Hayne subsp. *raddiana* (Savi) Brenan steppe with trees in Tunisia, was created in 1980 to preserve arid plant communities and fauna. Under protection, the plant species developed some adaptive strategies to survive. These strategies are supposed to be different from those under heavy disturbances. The assessment of several plant-functional traits can highlights their adaptations face to different stresses and disturbances. The main traits are associated with resource acquisition, such as SLA (specific leaf area), LDMC (leaf dry matter content) and LA (leaf area). Our overall aims are to study some functional traits of seven (7) threatened plant species inside the park.

## Methods and Study Site
Our investigations were carried out in Bou Hedma national park (34.476102 N, 9.649239 E; Figure 1), created in 1980 with an area of 16,488 ha. This park contains the unique *A. tortilis* steppe with trees in Tunisia and plays a key role in the biodiversity conservation of flora and fauna (Tarhouni, 2003). The park is characterized by an arid bioclimate with an average annual rainfall of 300 mm and an average temperature of 32 to 36°C in summer and 4 to 7°C in winter. Seven (7) plant species, classified as rare and threatened of extinction according the Tunisian regulation (JORT, 2006), are founded inside the park from a total of 54 species in whole country (Table 1).

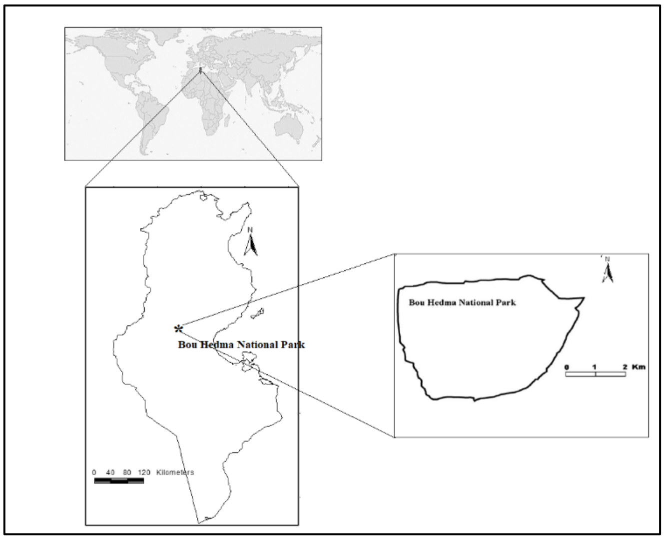


**Figure 1:** Geographical location of Bou Hedma national park.

**Table 1:** Conservation status of the studied species according to the IUCN and the Tunisian regulations. VU: Vulnerable, NE: Not Evaluated, LC: Least Concern, NT: Near Threatened, R: Rare.

| Species | Families | IUCN status | Status in Tunisia |
|---|---|---|---|
| *Acacia tortilis* (Forssk.) Hayne subsp. *raddiana* (Savi) Brenan. | Fabaceae | VU | R |
| *Cenchrus ciliaris* L. | Poaceae | NE | R |
| *Digitaria nodosa* Parl. | Poaceae | NE | R |
| *Juniperus phoenicea* L. | Cupressaceae | LC | R |
| *Pistacia atlantica* Desf.. | Anacardiaceae | NT | R |
| *Tetrapogon villosus* Desf. | Poaceae | NE | R |
| *Thymelaea sempervirens* Murb. | Thymelaeaceae | NE | R |

Six individuals from each species were randomly selected to measure their functional and biometric traits during the spring 2017. Six leaves were collected from each individual to measure the leaf traits. The collected leaves were placed in moistened paper, and put in a refrigerator to prevent dehydration. In the laboratory, the leaves were weighed (to obtain their fresh matter (FM)), flattened, fixed and photographed. The photos were then analysed using 'Image J' software to calculate the leaf area (LA). The sampled leaves were than oven dried for 48 hours at 60°C to obtain their dry matter content (DM). The leaf water content (LWC), as a percentage of FM, was calculated as LWC = ((FM - DM)/FM) × 100. The leaf dry matter content (LDMC), in mg. $g^{-1}$ FM, was obtained as: DM / FM (Garnier et al., 2001). Specific leaf area (SLA), in $cm^2$ $g^{-1}$ DM, was calculated as: LA / DM. The bio-volume (in $m^3$) was calculated as $BV = ((4 / 3) \times \pi \times r^3) / 2$, where r is the average radius of the plant and it is obtained as $r = ((D / 2) + (d / 2) + h) / 3$, with : D is the largest diameter, d is the smallest diameter and h is the height of species. The canopy cover (CC in $m^2$) is the area covered by the aerial organs of each species and it is calculated as $CC = \pi \times r^2$.

## Results

### *Biometric traits*

The BV and the CC of the studied species are shown in Table 2. BV and CC varied widely between the species. *A. tortilis* showed a high value of BV and CC (132.62 $m^3$ and 32.46 $m^2$ respectively). The smallest ones were around 0.032 $m^3$ and 0.19 $m^2$ in *T. villosus*. The analysis of variance indicates a highly significant difference of BV ($p=0.002$) and CC ($p<0.01$) between the seven species.

**Table 2:** Bio-volume (BV) and the canopy cover (CC) of the studied species inside Bou Hedma national park during the spring 2017.

| | *D. nodosa* | *T. villosus* | *C. ciliaris* | *P. atlantica* | *A. tortilis* | *J. phoenicea* | *T. sempervirens* |
|---|---|---|---|---|---|---|---|
| **BV ($m^3$)** | 0.54 | 0.032 | 0.33 | 40.12 | 132.62 | 5.83 | 0.56 |
| **CC ($m^2$)** | 1.25 | 0.19 | 0.89 | 20.08 | 32.46 | 5.3 | 0.57 |

***Leaf traits***

Figure 2 shows a high value of leaf area and specific leaf area in poaceae family. Leaf area reaches 6.2, 5.1 and 3 $cm^2$ respectively for *T. villosus*, *D. nodosa* and *C. ciliaris.* However, it was around 0.3 $cm^2$ in *A. tortilis*, a key plant species of the park. For *P. atlantica* the LA is around 3.9 $cm^2$ followed by *J. phoenicea* (0.2 $cm^2$) and *T. sempervirens* (0.1 $cm^2$). Concerning *SLA,* the maximum value was recorded for *T. villosus* (447,52 $cm^2g^{-1}$) and the minimum for *T. sempervirens* (32,47 $cm^2g^{-1}$).

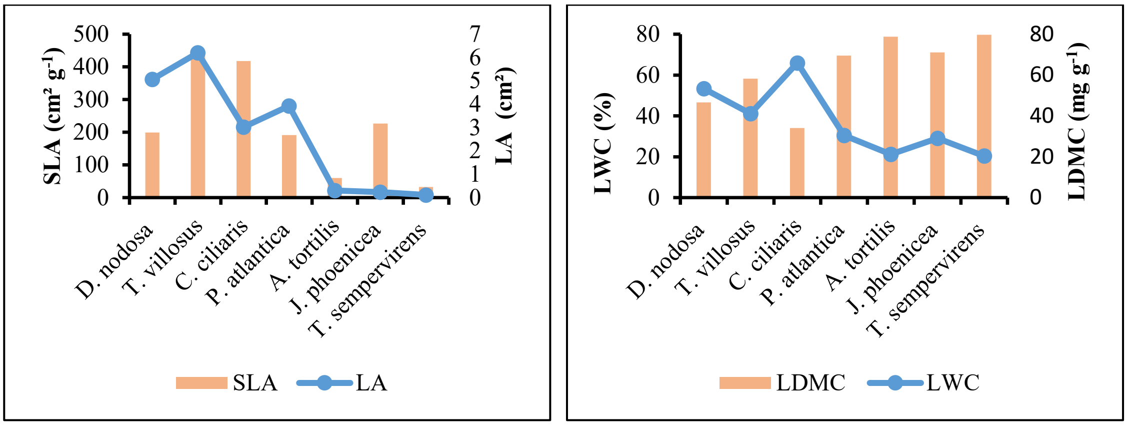


**Figure 2:** Leaf area (LA), Specific leaf area (SLA), leaf dry matter content (LDMC) and leaf water content (LWC) of the studied species inside Bou Hedma national park during the spring 2017 (n = 6).

The LWC and LDMC are important factors and indicate the plant water status. The results show that the poaceae recorded a high value of LWC that reaches 65% in *C. ciliaris*, 53% in *D. nodosa* and 42% in *T. villosus.* However, contrasting results are noted for the dry matter content (LDMC). ANOVA shows highly significant differences in these parameter between species ($p < 0.01$).

**Discussion and conclusion**

Plant functional traits are any attributes that have significant effects on plant fitness and reflect plant adaptation to their local environment (Ackerly, 2004). *A. tortilis*, the keystone species of the park, shows the highest value of BV and CC. It plays a key role in ecosystem functioning and stability. This tree was known by its positive effects on neighbouring species, under highly stressful conditions. It could facilitate the growth of other species by improving ecological conditions under its wide canopy (Noumi et al. 2011). The species, qualified as highly drought tolerant, was expected to enhance soil nutrient content and to improve the soil structure by adding organic matter (Gedda 2003; Abdallah et al. 2008). Moreover, the tree reduces the water evaporation from soil (Munzbergova and Ward 2002).

It is probable that LA plays a fundamental role in competition for light (Schneider and Huyghe 2015). It is linked to strategies for the acquisition and use of resources by the plant. Our result showed that the acquisition of resources is easier for Poaceae family since they have high values of LA. This concurs with the studies of Schneider and Huyghe (2015) showing that grasses have advantages for resource acquisition. In the same way, Sun and Dickson (1996) argued that grasses and shrubs have been found to be competent with trees for resources. The LWC is an important parameter and indicates the plant water status. *C. ciliaris* recorded the highest water content. These results can be explained, in part, by the competitive capacity of this species. This concurs with the studies of Noumi et al. (2015) showing that *C. ciliaris*, nurse species, competed with *Acacia*, target species, for water resource.

Wilson et al. (1999) noted, "*LDMC is a compromise between rapid assimilation and growth leading to an extreme and effective conservation of resources in the well-protected tissues*". A high content of leaf dry matter (LDMC) with a low specific leaf area (SLA) tells us about the strong capacity of the studied species to retain nutrients for a long time under harsh conditions. In this case, the studied species can be considered as conservative species. Likely, the resistance to drought can be associated with the establishment of adaptive strategies to survive. Thanks to functional traits, the resistance of spontaneous plants to various constraints in arid zones, can be easily highlighted and known.

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