Phytology

Characterization of the central and marginal ecological habitat of a rare medicinal species in Tunisia: Case of *Ruscus hypophyllum* L.

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Abstract

Ruscus hypophyllum is exploited as an ornamental species by local people and by visitors to the region during walks. The natural distribution of *Ruscus hypophyllum*, which has been steadily decreasing over the last few decades, is threatened by various anthropic pressures, which are increasingly reducing the natural regeneration capacity of the species. The study of the ecological habitat is essential to have a good knowledge of the autoecology of this species in order to determine the conditions in which it develops and to set up appropriate management rules. Indeed, *Ruscus hypophyllum* prefers clay soils, rich in nitrogen and with a C/N ratio higher than 10. The soils it prefers are acidic pH (3.3 - 7.3). According to the results obtained, this species is fairly resistant to summer drought (Tmax = 44°C). In the Kroumirie, the presence of *Ruscus hypophyllum* is rare above 650 m altitude, whereas it is regularly found in riparian situations, between 50 and 650 m, with a maximum around 450 m. The results obtained show that this species has an affinity for low slopes (0-10%).

Keywords: tunisia, *Ruscus hypophyllum*, central habitat, marginal habitat, environmental factors

Introduction

In the Mediterranean region, evolved a portion of forest area estimated at 2,145,000 ha. The latter has suffered in its life cycle of very difficult times; a forest in perfect balance toward a much-degraded forest; there is sometimes a materialization of this portion, such as the Tunisian forest. Because of its geographical position, Tunisia has a great diversity of biotopes occupied by important floristic richness.

Ruscus is a genus belonging and classified in the *Asparagaceae* family, subfamily *Nolinoidae*. However, the genus has fluctuated between different families and by turns located in *Liliaceae*, *Convallariaceae* and *Ruscaceae* (Veronese, 2015) [16]. This genus has hasapproximately 10 species with the most known being seven as follows: *R. aculeatus* (Butcher's Broom) originating from Mediterranean region is spread in western and southern Europe and Africa (Manole & Banciu, 2015) [13]; *R. colchicus*, common in Caucasus; *R. Hypoglossum* native to the Euro-Mediterranean, North Italy to Austria and Slovakia and east to Turkey and Crimea (Ivanova *et al*., 2013) [10]; *R. hypophyllum* widespread in the Iberian Peninsula and north-west Africa; *R. Streptophyllum* found in Madeira; and *R. hyrcanus*, endemic in the Talish Mountaine, Azarbaijan (Banciu & Aiftimie-Păunescu, 2012) [2]. *Ruscus hypoglossum* L. is an evergreen rhizomatous herbaceous perennial of the *Asparagaceae Juss* family (Ivanova *et al*., 2015) [11], the plants derived from the genus are generally used as medicinal and ornamental plants (Brezeanu & Banciu, 2010; Manole & Banciu 2015) [1, 13] as floral design, lanscape and indoor plants (Stamps, 2001) [15]. *Ruscus hypophyllum* is a very important ornamental grown commercially in north-west Tunisia. According to Palazón *et al*. (2006) [14] the knowledge of the biological and ecological characteristics of the species, just identification of as the historical and current factors at the origin of the fluctuations of the flora are essential to any action of the biodiversity conservation. The contemporary forests of Kroumirie are result from interaction of much diversified factors, in particular topography, geology, climatology and anthropogenic action.

The main objective of this work is to finalize the marginal and central ecological habitat of *Ruscus hypophyllum* in Tunisia.

Materials and Methods

Presentation of the study area

The Kroumirie area is located in the north-west of Tunisia and occupies mountainous areas. Indeed, due to its mountainous relief in contact with the Mediterranean, it offers a development of altitudinal levels at least as interesting, from the beaches and maritime rocks to the oak forest of medio-European character of the Djbel Gorra (1200m). The general altitude of the massif decreases from west to east. From a climatic point of view, our study area goes from a humid bioclimatic in Ain Draham which receives 1580 mm of rain per year, to 1030 mm/year in Tabarka on the coast. The distribution of rainfall is directly linked to the topography, and decreases progressively towards the west as well as the east. The region is subject to the prevailing north-west winds during the autumn and winter.

The soil of the Kroumirie, formed from a permeable bedrock (Numidian sandstone) and lacking in limestone. In the shelter of the *Quercus Suber* and *Quercus faginea* forests in the low mountains, the soil has the characteristics of a leached mull soil.

The plant formation is composed essentially by the presence of the kermes oak forest in the dunes of Tabarka and Mekna. This forest is made up of pure stands of *Quercus suber* and *Quercus faginea* on more than half of its surface area and of mixed *Quercus suber* and *Quercus faginea* on the remaining parts. The shrub layer is essentially formed by *Phillyera media*,

Rahmnus alaternus, *Smilax aspera*, *Pistacea lentiscus*, *Olea aleaster*, *Myrtus communis*, *Erica arborea*, *Calycotome villosa*, *Arbutus unedo*, *Viburnum tinus*, *Lavandula stoechas*, *Cytissus triflorus*.

Botanical and morphological description of the species

Fragan (*Ruscus hypophyllem* L.) belongs to the genus Ruscus and the family Asparagaceae (APG III classification, 2009) or Liliaceae (Gronquist classification, 1981). Bare-leaf Fragan is a sub-shrub with a bushy, spreading habit and evergreen leaves. These leaves are replaced by flattened stems resembling alternate, reduced leaves (cladodes). This species is dioecious. The flowers appear in spring. It consists of yellow flowers. The berries are round and bright red (Figure 1).

Fig 1: Specie and fruit of *Ruscus hypophyllum* (photo: Jdaidi Nouri 05/06/2020 Ain Saida)

Sampling

The first step in a self-ecological study is to know the distribution of the species. *Ruscus hypophyllum* is not collected in the forest inventory. Therefore, we selected the stations for sampling in a subjective way based on information provided by the forest population, as well as that collected during previous work, Debazac in 1959. We selected 8 stations (Table 1) for the analysis of the ecological habitat of this species in Kroumirie. We marked out 80 circular plots of 500 m² in all the stations studied. For the characterization of the ecological habitat of this species, all species of *Ruscus hypophyllum* were also inventoried, positioned and monitored, thus, all topographic and edaphic parameters were determined on all plots.

Table 1: The main characteristics of the stations studied

Device	Altitude (m)	Orientation	Latitude	Longitude
Kroufa	390	S-E	N36°55’56’’	E008°56’47’’
Hamdia	530	S-W	N36’52’10’’	E008°46’33’’
Malloula	210	S-W	N36°56’13’’	E008°46’33’’
Ain Saida	50	N-E	N36’52’25’’	E008°41’47’’
Tbeinia	780	N-E	N36’46’13’’	E008°46’36’’
Souiniet	510	S-W	N36°47’15’’	E008°48’15’’
Ain Jemel	355	S-E	N36°52’20’’	E008°41’44’’
Ain Bacouch	150	S-E	N36°56’17’’	E008°46’37’’

Determination of the ecological habitat of *Ruscus hypophyllum*

The topographic habitat of *Ruscus hypophyllum* was described according to the following parameters: altitude (in m), slope (in %) and orientation (in degrees). To study the edaphic habitat of *Ruscus hypophyllum* in Tunisia, we opted for the same methodology of Jdaidi and Hasnaoui (2018) [12], one soil profile was dug per station. In total 10 profiles were dug, which led to the collection of 40 soil samples. The soil analysis covers 10 parameters: total pH H2O2, total fine silt (LF), total coarse silt (LG), total fine sand (SF), total coarse sand (SG), total clay (A), total organic matter (OM), total nitrogen (N), total C/N ratio and total carbon (C). With regard to climatic parameters (total annual precipitation (PT avg), autumn precipitation (PA), winter precipitation (PH), spring precipitation (PP), mean annual temperatures (TA avg), annual mean temperatures of absolute maxima (TA max) and annual mean temperatures of absolute minima (TA min)), we used the data of the meteorological stations of Tabarka and Ain Draham, while proceeding to the adjustments imposed by the altitude (Emberger, 1955; Hasnaoui, 1992) [7, 9] and which are as follows an increase in precipitation of 0.7 mm/m of altitude, a decrease in temperature of 0.5°C/100 m of altitude.

Statistical analysis

Based on the method of Carballeira *et al*. (2005); Jdaidi and Hasnaoui (2018) [12], we determined the ecological characteristics of the habitat of *Ruscus hypophyllum* (topographic, climatic and edaphic). With all the calculated parameters, we elaborated a database informing us about the ecological habitat of this species in Kroumirie. This was analyzed in a univariate form (Walpole *et al*., 1999; Diaz-Maroto *et al*., 2005) [17, 6], which allowed us to calculate a series of characteristic values (Gandullo *et al*., 1991) [8]: Lower Limit (LL) (minimum value of the parameter in all the sampling points), Lower Threshold (LT), Mean Value (MV), Upper Threshold (UT) and Upper Limit (UL) (maximum value of the parameter in all the sampling points), through which it is possible to delimit the ecological habitat of *Ruscus hypophyllum*, in accordance with the following criteria (Diaz-Maroto, 1997; Diaz-Maroto *et al*., 2005; Jdaidi & Hasnaoui, 2018) [5, 6, 12]:

- The interval defined by the upper and lower thresholds, formed by 80% of the plots studied, is qualified as central or optimum habitat, with respect to a parameter.

- Consider as marginal habitat, with respect to a parameter, the intervals between the lower limit and the lower threshold and between the upper limit and the upper threshold, formed by 20% of the plots surveyed.

In principle, the central habitat defines the most suitable topographic, climatic and edaphic conditions for *Ruscus hypophyllum* in Tunisia, while in the marginal habitat; the non-optimal condition of some parameters makes the suitability of the season for cherry more doubtful (Gandullo *et al*.,1991) [8]. The ecological habitat analysis of *Ruscus hypophyllum* was determined using descriptive statistics with the XLSTAT program.

Results and Discussions

Climatic habitat of *Ruscus hypophyllum*

The central habitat of the *Ruscus hypopllum* populations in Kroumirie (Table 2 and Figure 2) is characterized by an average total precipitation that varies between 890 and 1350 mm. In our study area, there is a longer summer drought in Tabarka (5 months) than in Ain Draham (3 months). According to the same figure, the central habitat of *Ruscus hypophyllum* is characterized by an average annual temperature that varies between 10.5 and 18.5°C, while the maximum annual temperature is between 24 and 37°C. Like the rainfall factor, temperature has an important influence on the natural spatial distribution and growth of this species. The marginal climatic habitat of this species highlights the existence of stations with low summer precipitation (25 mm), a minimum annual temperature of 5°C and a maximum above 44°C. Our species is very tolerant of summer drought and very sensitive to the minimum temperature of the cold season. The results obtained in this work show that climatic factors do indeed influence the ecological habitat of *Ruscus hypophyllum*.

Table 2: Descriptive statistics of the climatic parameters

	Lower limit	Lower threshold	Value Average	Upper threshold	Upper limit	Standard deviation	CV (%)
PT avg (mm)	760	890	987	1350	1550	295,7	26,7
P H (mm)	450	545	620	655	694	86,688	14,62
P E (mm)	25	38	55	75	130	36,751	56,89
P A (mm)	312	338	357	398	425	40,708	11,12
P P (mm)	204	258	310	348	377	62,146	20,73
TA avg (°C)	8,5	10,5	13	18,50	21,5	4,882	33,90
TA min (°C)	5	7,5	11	12,3	13,5	3,152	31,96
TA max (°C)	19	24	30	35	44	8,685	28,56

PT average (Annual total precipitation) ; PE (Summer precipitation) ; PA (Autumnal precipitation) ; PH (Winter precipitation) ; PP (Spring precipitation) ; TA average (Average annual temperatures) ; TA max (Annual average temperatures of the absolute maxima) ; TA min (Annual average temperatures of minimum absolved) ; CV (Coefficient of variance).

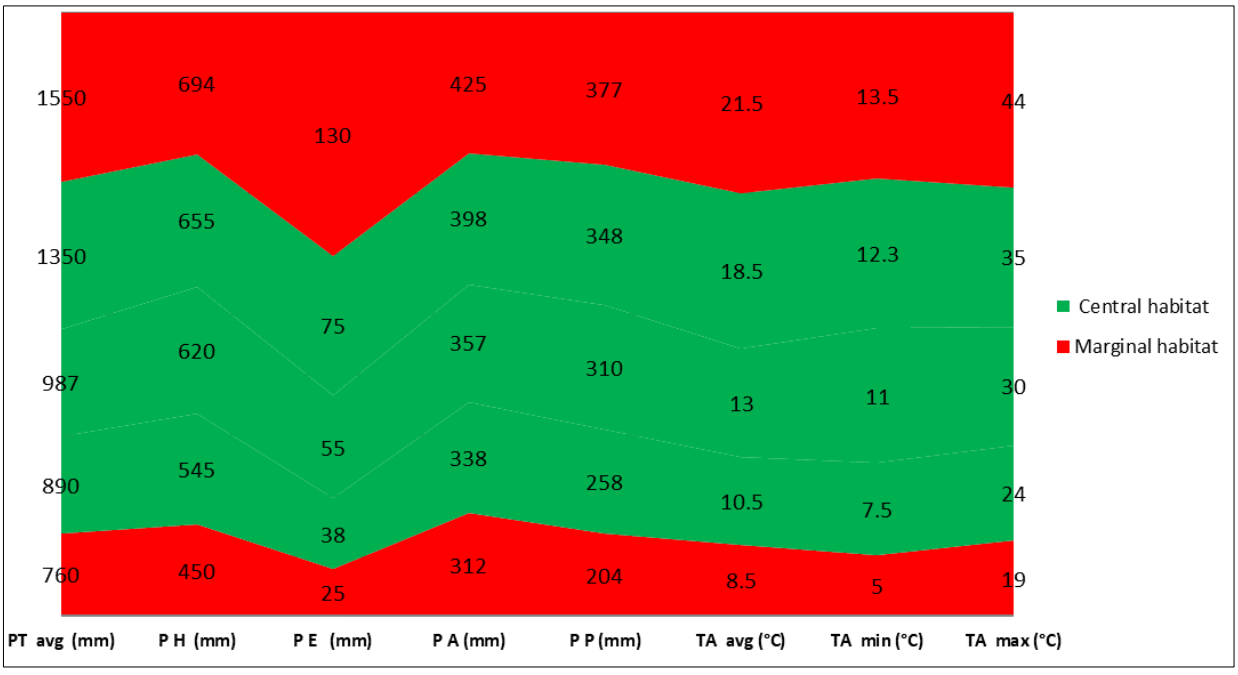

Fig 2: Central and marginal climatic habitat of *Ruscus hypophyllum* in Tunisia

Topographical habitat of *Ruscus hypophyllum*

As far as the core habitat is concerned, the optimum of *Ruscus hypophyllum* is observed on stations at medium altitude (100-500 m) (Table 3 and Figure 3). The highest densities are observed on low and medium slopes (0-10%). According to the same table, this species settles on southern and south-eastern slopes, preferring light and warmth. Regarding the marginal habitat, it is important to point out the existence of populations of *Ruscus hypophyllum* in alticolous stations (650 m), on slopes (25%) and on southern slopes (tab.3 and fig.3). The clay soils on which *Ruscus hypophyllum* has established populations cover the middle altitudes (200-450 m). This species develops preferentially on plateaus (0-10% slope) with southern and south-eastern exposure.

Table 3: Descriptive statistics of topographic parameters

	Lower limit	Lower threshold	Value Average	Upper threshold	Upper limit	Standard deviation	CV (%)
ALT(m)	50	200	450	550	650	222,710	58,60
P (%)	0	5	10	15	25	7,917	71,97
ORI (°)	0	45	135	180	315	110,227	81,57

ALT (Altitude); P (Slope); ORI (Orientation); CV (Coefficient of Variance).

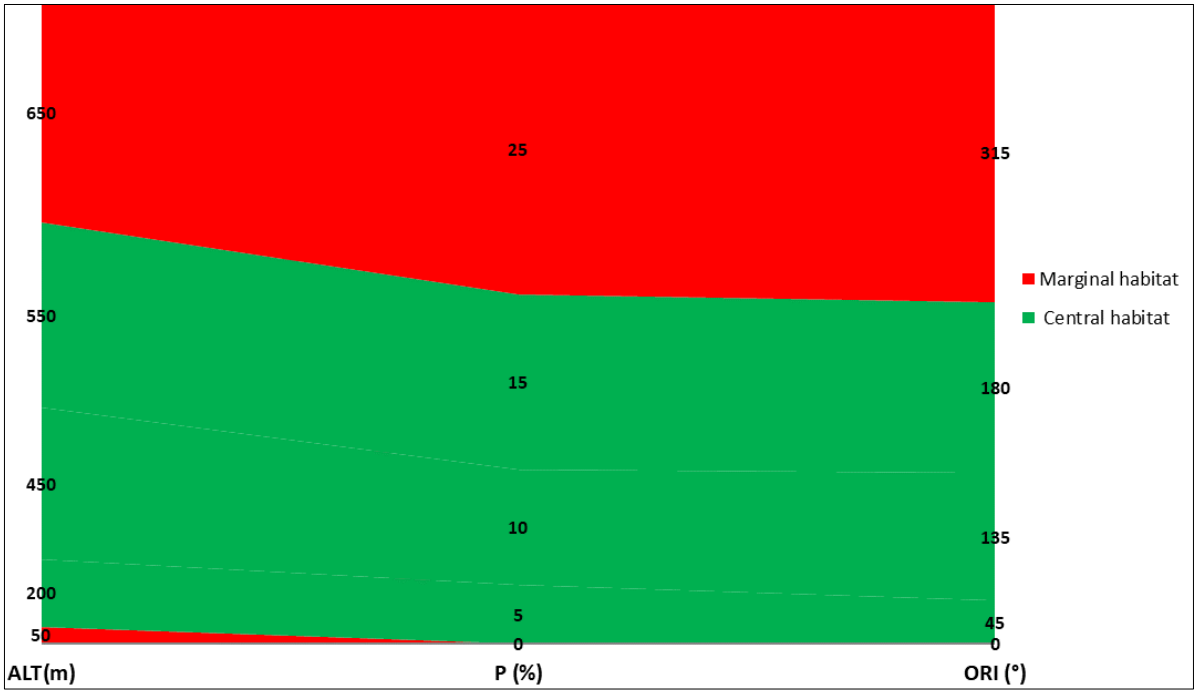

Fig 3: Central and marginal topographic habitat of *Ruscus hypophyllum* in Tunisia

Edaphic habitat of *Ruscus hypophyllum*

The core edaphic habitat of this species is observed on soils with clay textures (39-43%), silty-clay textures and low acidity (4.8 - 5.5). *Ruscus hypophyllum* fears very poorly structured clay soils or soils with low porosity. This species is observed on soils with a low organic matter content (1.06 and 7.45 %), with a C/N ratio varying from 12.77 to 32.40 (Table 4, Figure 4). At this scale this carbon-nitrogen ratio indicates a low mineralization of organic matter which is characterized by a high carbon releasing humus. The highest densities of this species are observed on nitrogen-poor soils (0.09 - 0.33%) (Table 4, Figure 4). The analysis of the ecological habitat of *Ruscus hypophyllum according to* the physico-chemical variables of the soil allowed us to establish relationships between some of these variables and the density of this species. The densest sites are the richest in clay, low in nitrogen and organic matter, with a high C/N ratio (above 10). These results suggest that, in addition to light, certain soil parameters (such as texture, nitrogen content, organic matter and C/N ratio) may also condition the natural distribution of *Ruscus hypophyllum*. This species seems to prefer a soil rich in clay and carbon.

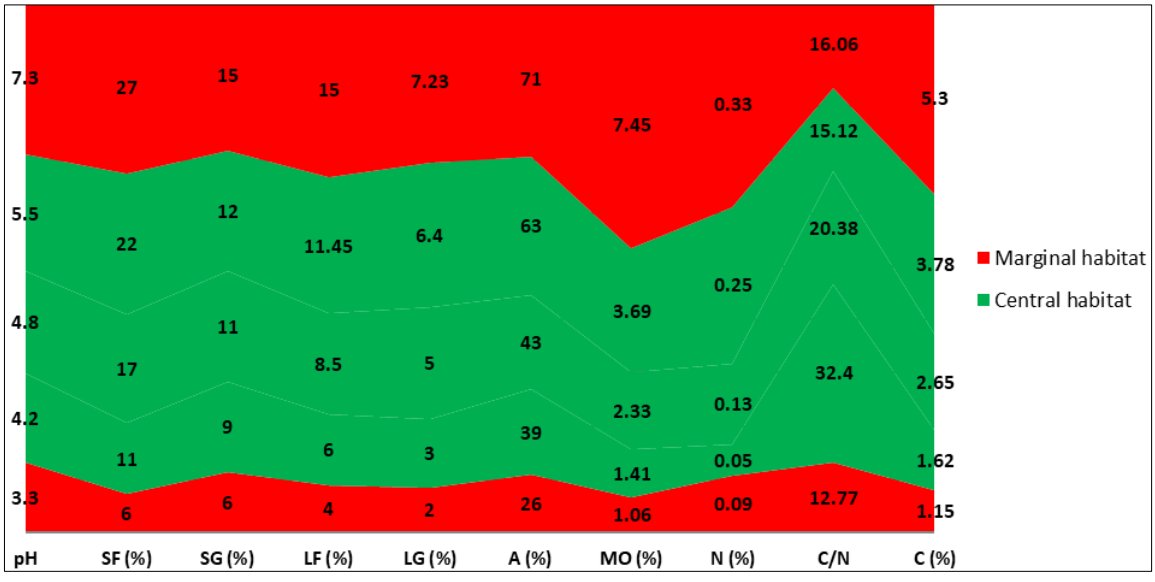

Fig 4: Central and marginal edaphic habitat of *Ruscus hypophyllum* in Tunisia

Table 4: Descriptive statistics of the parameters soil factors

	Lower limit	Lower threshold	Value Average	Upper threshold	Upper limit	Standard deviation	CV (%)
pH	3,3	4,2	4,8	5,5	7,3	1,34	26,69
SF (%)	6	11	17	22	27	7,499	45,17
SG (%)	6	9	11	12	15	3,006	28,35
LF (%)	4	6	8,5	11,45	15	3,905	43,43
LG (%)	2	3	5	6,4	7,23	1,977	41,83
A (%)	26	39	43	63	71	13,390	27,66
MO (%)	1,06	1,41	2,33	3,69	7,45	2,317	72,67
N (%)	0,09	0,05	0,13	0,25	0,33	0,104	61,17
C/N	12,77	32,4	20,38	15,12	16,06	6,976	36,05
C (%)	1,15	1,62	2,65	3,78	5,30	1,500	51,72

LF (Total fine silt) ; Total pH H2O2 ; LG (Total unrefined silt) ; SF (Total fine sand) ; SG (Total unrefined sand) ; A (Clay total) ; MO (Total organic matter) ; N (Total nitrogen) ; C/N (Report total carbon and total nitrogen) ; CV (Coefficient of variance).

Conclusion

The current knowledge on the ecological habitat of *Ruscus hypophyllum* allows determining very precisely the limits of presence of this species in the north-west of Tunisia. This species in Kroumirie is best established in medium altitude, low slope and south facing stations. This species prefers clayey soils and requires a low mineral content. It is observed on a wide range of pH between 3.3 and 7.3. In our study area, the rainfall increases by 0.7 mm/m of altitude and the southern exposure is warmer, hence the positive effect on the natural vegetation. The degree of inclination of the land or the slope can have an effect on the establishment of *Ruscus hypophyllum*. Finally, this work shows the interest of targeted studies on a species and its environment, in order to understand its ecological habitat and to deduce specific silvicultural rules. The example of *Ruscus hypophyllum provides* food for thought on the dynamics of ecosystems in Kroumirie. These results constitute a basis for understanding the functioning of Tunisian forests.

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