Ecology/Ecología

Vegetation heterogeneity of black alder forests in and around El-Kala Biosphere Reserve, northeastern Algeria

Heterogeneidad de la vegetación de los bosques de aliso negro en y alrededor de la Reserva de la Biosfera El-Kala, noreste de Argelia

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Abstract
Background: Despite its ecological importance, the study of Algerian alder forests has been largely neglected, even though they represent the largest ones of their kind in North Africa. Moreover, few measures have been taken towards the protection of these ecosystems.
Questions: How many species are present in the Algerian alder forests? What is the effect of soil properties on species richness and diversity of inventoried plants? Are its spatial patterns related to soil variables variation?
Studied species: Polypodiopsida, Gymnospermae, and Angiospermae.
Study site and dates: El-Kala Biosphere Reserve (KBR) and surroundings, El-Tarf province, northeastern Algeria, from January 2016 to February 2017.
Methods: Twenty-eight localities were sampled using the relevé method. Soil samples were taken from three points at each site. The relationship between species richness and soil factors was statistically evaluated using multiple linear regression and multivariate statistical analysis.
Results: The inventory showed a total of 352 species that belong to 236 genera and 89 families. According to NMDS ordination, black alder forests were classified into two groups (marshy and hilly forests, and fluvial forests), in relation to plant species richness. No linear relationships between species richness and soil parameters were observed, except for OM ($P = 0.013$).
Conclusion: The present study demonstrated a relatively high plant diversity characterizing alder forests of this region. To some extent, such diversity is related to the heterogeneous distribution of plant species among different habitat types. Those factors that affect its zonation were identified, for this ecosystem, our study revealed that vegetation diversity is related to the spatial variation of soil variables.
Key words: *Alnus glutinosa*; Biosphere Reserve, Floristic richness, North Africa, Northeastern Algeria.

Resumen
Antecedentes: A pesar de su importancia ecológica, son pocos los estudios sobre los bosques de aliso en Argelia, los cuales constituyen los más grandes en África del Norte. Además, estos ecosistemas carecen de medidas de protección.
Preguntas: ¿Cuántas especies están presentes en los los bosques de aliso argelinos? ¿Qué efecto tienen los factores abióticos (características de suelo) sobre la riqueza de especies y la diversidad de plantas? ¿Están relacionados sus patrones espaciales con la variación de los factrores edáficos?
Especies estudiadas: Polypodiopsida, Gymnospermae y Angiospermae.
Sitio y años de estudio: Reserva de la Biosfera El-Kala (KBR), provincia de El-Tarf, nordeste de Argelia, desde enero de 2016 hasta febrero de 2017.
Métodos: Se muestreó la vegetación en 28 sitios de bosques de aliso negro (*Alnus glutinosa* (L.) Gaertn.). Además, se tomaron muestras de suelo de tres puntos en cada sitio. La relación entre la riqueza de especies y los factores ambientales se evaluó mediante regresión lineal múltiple y análisis estadístico multivariado.
Resultados: El inventario contiene en total 352 especies pertenecientes a 236 géneros y 89 familias. De acuerdo con los resultados de la ordenación NMDS, los bosques de aliso negro se clasificaron en dos grupos (bosques de pantano y de colina, y bosques fluviales), en relación con la riqueza de especies. No se observó ninguna relación lineal entre la riqueza de especies y los parámtetros de suelo, excepto para MO ($P = 0.013$).
Conclusión: El presente estudio demonstró que existe una diversidad de plantas relativamente alta en los bosque de aliso de esta región. En gran medida, esta diversidad está relacionada con la distribución heterogénea de las especies entre los diferentes hábitats. Se logró identificar cuáles factores afectan su zonación: para este ecosistema, nuestro estudio reveló que la diversidad de la vegetación está relacionada con la variación espacial de las variables edáficas.
Palabras clave: *Alnus glutinosa*; África del Norte; nordeste de Argelia; Reserva de la Biosfera; Riqueza florística.

Black alder (*Alnus glutinosa* (L.) Gaertn.) forests are ecosystems naturally widespread across all of Europe, from southern Scandinavia to the Mediterranean countries, including some regions of North Africa, namely northern Morocco and northeastern Algeria (Jalas & Suominen 1976, Kajba & Gracan 2003). Black alder forest is one type of broadleaved forest, and it has a broad but highly scattered distribution (it represents less than 1 % of forest cover in most countries). Despite this spatial configuration, the total population size of this species is not yet thought to approach threshold values to warrant its inclusion in a threatened category. Thus, the species is listed as Least Concern in the IUCN Red List (Shaw *et al.* 2014).

Black alder forest is a particular kind of wetland forest. Black alder occurrence is closely related to water availability and high atmospheric humidity during all phases of its reproductive cycle (Bensimon 1985). It commonly occurs in hilly regions, alongside streams and rivers banks, in damp marshy woods and riverside woodlands (Shaw *et al.* 2014). According to Claessens (2003), black alder forests occur in three main types of wetlands: (i) marshy or swampy sites with sodden soil throughout the year, which constitute the Alnetum community; (ii) riverside sites in which the soil in the rooting zone is well aerated during the growing season (Alno-Padion community); and (iii) hilly sites with high soil humidity (Carpinion community).

Black alder is recognized as an important contributor to forest structure in other wetland ecosystems, and it contributes to the services which they offer (Claessens 2003). For example, *Alnus glutinosa* plays a key role in biodiversity maintenance by offering habitats for specific flora and fauna, both on the tree itself and in the flooded root system (Dussart 1999). This ecosystem contributes to water filtration and purification in flooded soils (Pinay & Labroue 1986, Schnitzler-Lenoble & Carbiener 1993) because the root system of black alder helps control floods and stabilize riverbanks (Piégay *et al.* 2003).

In Algeria, few studies have been conducted on alder forests. This is regrettable, as these forests constitute the largest ones in North Africa (Belouahem *et al.* 2011, Bensettiti & Lacoste 1999, Géhu *et al.* 1994), and few measures have been taken to protect these ecosystems. In fact, only two sites benefit from indirect conservation measures, based on freshwater bird richness (alder forests of Tonga, and those of Ain Khiar, were classified as RAMSAR sites in 1983 and 2002, respectively).

Identifying species composition and the existing species assemblages, and examining how these species are distributed across the alder forest region in northeastern Algeria, are necessary steps prior to investigating the functioning and dynamics of these ecosystems. Algerian black alder forests represent an extremely original ecosystem of northern affinity throughout North Africa (Géhu *et al.* 1994) and are characterized by particular geomorphologic, edaphic, and climatic conditions (Morgan 1982). Hence, the main aims of this study were: (1) to inventory the floristic composition of alder forests in El-Kala Biosphere Reserve and its surroundings, (2) to investigate the effect of abiotic factors (soil properties) on species richness and diversity, and (3) to distinguish plant communities based on species composition and to define spatial patterns of these plant communities.

Materials and methods

Study area. The El-Kala Biosphere Reserve (KBR hereafter) was created in 1983 by governmental decree no. 83–462 of July 23rd, and classified as Biosphere Reserve by UNESCO on December 17th, 1990. KBR is located at the extreme northeast region of Algeria, specifically in the northeast of Numidia area, between 36° 56' N, 36° 34' N, and 8° 12' E, 8° 41' E (Figure 1), and it has a surface of 76,438 ha. Elevation at KBR ranges from 100 m a.s.l. near the Oued El-Kebir river, to 1,202 m a.s.l. at Mount El-Ghorra. KBR is characterized by a Mediterranean climate, with dry hot summers followed by wet warm winters. According to climatic data for 2005–2015, the minimum mean monthly temperature is 10 °C in February, whereas the maximum mean is 25 °C in July. Average total annual precipitation is 656 mm, with four months having precipitation < 30 mm (WorldClim, 2.0; Fick & Hijmans, 2017). Geology of KBR is characterized by two formations: the Quaternary, mainly represented by marine and river deposits, and the Miocene, including conglomerate sands and red clays, concentrated in the southeastern portion of the area (Joleaud 1936). Soils in the KBR are mainly brown washed with a variant of forest humus mull acidic Moder (Joleaud 1936).

Black alder forests of KBR have been widely altered by human activities (*e.g.*, cutting, burning, draining and/or dumping); since that region is immediately close to the sea, those related to tourism and leisure prevail. Thus, being a region with an agricultural vocation, other activities contribute to the disturbance of these areas (*i.e.*, the use of pesticides and the clearing of areas for agriculture).

Vegetation sampling. In order to investigate the floristic composition and spatial patterns of plant species assemblages in alder forests, surveys were conducted between 2016 and 2017 during the peak of vegetation development (spring and summer) (Ozenda 1982). During this time, 28 localities were sampled, which were representative of the three main substrates, *i.e.*, fluvial (Fl), swampy (Sw), and sandy (Sa).

The relevé method developed by the Zürich–Montpellier school for field vegetation studies (Braun-Blanquet 1964) was applied, by using at least the minimum area recommended for these vegetation types (16 m^2 for marshland vegetation, and 400 m^2 for species-poor forests). We collected species when encountered for the first time or whenever there was uncertainty on their identity. Specimens were identified using Quézel & Santa (1962).

The checklist of botanical families and species was organized alphabetically. Taxonomy and nomenclature follow the classification accepted by THE PLANT LIST database (The Plant List 2013), which is based on the APG III classification system for Angiosperms (APG III 2009). The updating and standardizing of species taxonomy and nomenclature according to APG III (2009) were guaranteed by
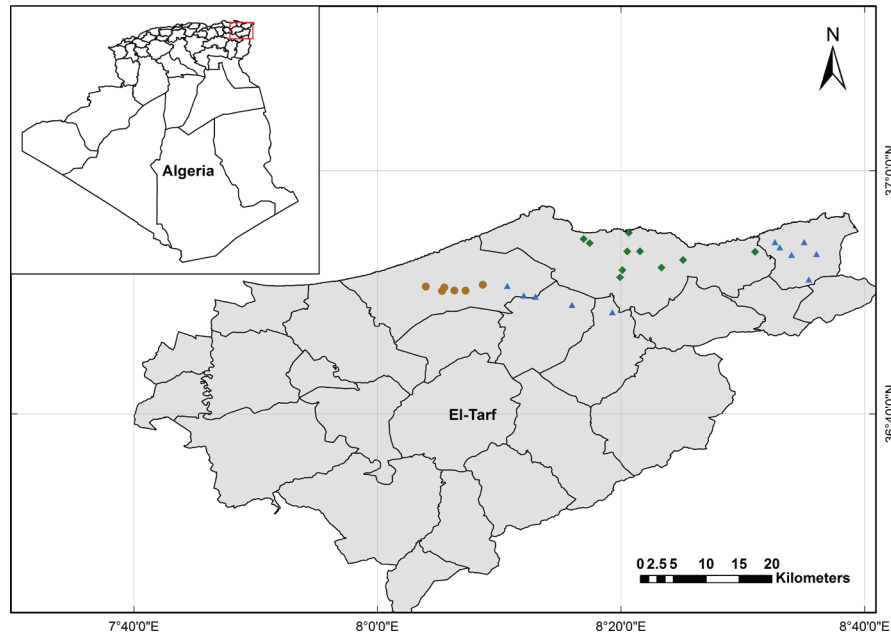
Figure 1. Map showing the location of El-Kala Biosphere Reserve (KBR) in northeastern Algeria (Projection system: GCS WGS 1984, coordinates in decimal degrees). Blue triangles indicate the exact location of fluvial sites (Fl), green polygones indicate swampy sites (Sw) and brown circles indicate sandy sites (Sa).

using the Taxonomic Name Resolution Service v4.0 program (TNRS 2016). Species life forms were assigned based on Whittaker's (1975) classification system, a modified version of Raunkiaer's (1934) original classification scheme, which includes the following categories: helophytes (He), amphiphytes (Am), phanerophytes (Ph), hemicryptophytes (Hec), therophytes (Th), geophytes (G), hydrophytes (Hy), chamaephytes (Ch), and epiphytes (Ep).

Soil sampling. Soil samples were obtained with 5 cm diameter cores taken from three points at each site. The soil was sampled to a depth of 25 cm. The three replicate samples were homogenized by hand mixing; large material (roots, stems, and pebbles) were hand-picked and discarded. Soil samples were air-dried and sieved with a 2 mm mesh for laboratory analyses. Soil analyses included determination of organic matter (OM) using incineration method, and pH electrical conductivity (EC) based on a 1:5 soil-water solution using pH/conductivity meter. Next, Practical Salinity (PS) was obtained from EC, according to Fofonoff &Millard (1983). In addition, total lime (TL) was determined using the titration method called 'calcimétrie de Bernard' (Fichaut 1989).

Data analyses. Plant diversity was evaluated using species richness (SR), defined as the total number of identified species (Magurran 2004). Further, percent relative richness (RR) was calculated for each family as the number of species contained in that family divided by the total number of species (SR). Occurrence frequency (Occ) was calculated for each species as the number of plots in which the species was recorded divided by the total number of sampled plots

(Magurran 2004). Bigot & Bodot (1973) distinguished four species groups according to their occurrences: very accidental species (Vac), with occurrence > 12.5 %; accidental species (Acc), with occurrence varying between 12.5 and 24 %; common species (Cmn), which occur in 25-49 % of records; and constant species (Cst), which are present in 50 % or more of the samples.

Accumulation curves were drawn to evaluate sampling efficiency and to envisage if plant species from the three habitat types (Fl, Sw, Sa) were well represented and could be used for reasonable and significant assessments (Chao & Chiu 2016). For all rarefaction/extrapolation (R/E) curves, we used 500 replicate bootstrapping runs to estimate 95 % confidence intervals, using the "iNEXT" package (Hsieh *et al.* 2016) in R version 3.4.0 (R Core Team 2017). Accumulation curves were calculated using EstimateS software version 9.1.0 (Colwell 2013).

Soil parameters were compared among the three habitat types through linear mixed effects models (LMMs). Diagnostic quantile-quantile plots, used to examine the appropriateness of the models, revealed a good fit of the data to a normal distribution. Response variables were soil properties, habitat as taken as a fixed effect, whereas Season was declared as a random effect. We also used Tukey contrasts for LMMs for post-hoc comparisons of the different habitat types. These analyses were performed using the 'lmer' function of the lme4 package version 1.1-12 (Bates *et al.* 2015), and the 'glht' function of the multcomp package (Hothorn *et al.* 2013) in R.

Multiple linear regression analyses were used to determine the signs of the relationships between species richness (SR)
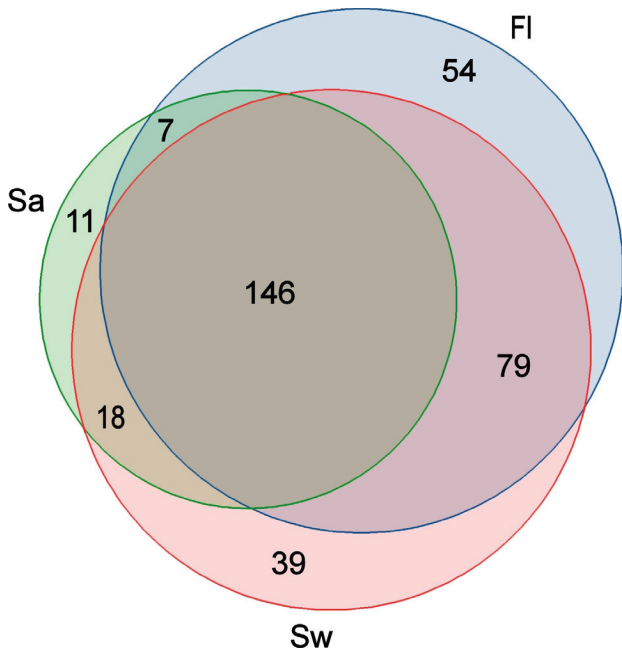
Figure 2. Venn diagram showing the distribution of species richness among the three habitat types. Each circle represents a habitat type (Fl, Fluvial; Sw, Swampy; Sa, Sandy).

thus if they could be considered as indicators of such habitats, we performed an indicator value analysis (Dufrene & Legendre 1997) using the "labdsv" package (Roberts 2016) in R. Taxa were considered good indicators if the indicator value was ± 0.25 (Dufrene & Legendre 1997).

Results

Floristic composition. In total, we identified 354 species belonging to 238 genera and 89 families (Appendix 1). Poaceae (35 species), Fabaceae (31), Cyperaceae (24), Asteraceae (24), Caryophyllaceae (13), Ranunculaceae (13), Lamiaceae (12), Brassicaceae (11), Juncaceae (11), Plantaginaceae (10), and Apiaceae (9) were the most species-rich families, accounting together for 54.51 % of the total species richness. Fifty-four species were exclusive of fluvial sites (Fl), 39 of swampy sites (Sw), and 11 species of sandy sites (Sa); Fl and Sw shared 79 species, Sa and Sw shared 18 species, whilst Sa and Fl shared only seven species (Figure 2). Notably, 146 species occurred in all three habitat types.

Overall, the most species-rich genera were Carex (11 species), Juncus (10), Ranunculus (10), Trifolium (9), Vicia (5), Cyperus (4), Euphorbia (4), Plantago (4), Persicaria (4) and Silene (4), accounting together for 18.36 % of all species. Amongst the inventoried species only 13 (3 %) were endemic to North Africa, and two species were endemic to the study region (Hypericum afrum (Desf.) Lam. and Solenopsis laurentia (L.) C. Presl.).

Life form distribution. Therophytes were the most common life form (127 species, 35.88 %), while 98 species (27.68 %) were Hemicryptophytes, 52 (14.69 %) Phanerophytes, 20 (5.65 %) Geophytes, 19 (5.37 %) Helophytes, 17 (4.80 %) Hydrophytes, 11 (3.11 %) Chamaephytes, and 8 (2.26 %) were Amphiphytes (Figure 3). Bryophytes and Epiphytes were represented by one species only.

and soil characteristics (OM, EC, pH, PS, TL). Analysis of variance for regression was used to assess significance (Kozak *et al.* 2008). Next, Non-metric Multidimensional Scaling (NMDS) was used to set up the spatial pattern in the scattergram. The ordination was fitted using the metaMDS function with Jaccard distances and two dimensions in the vegan package in R (Oksanen *et al.* 2017). Finally, to evaluate whether species were associated with particular habitats, and
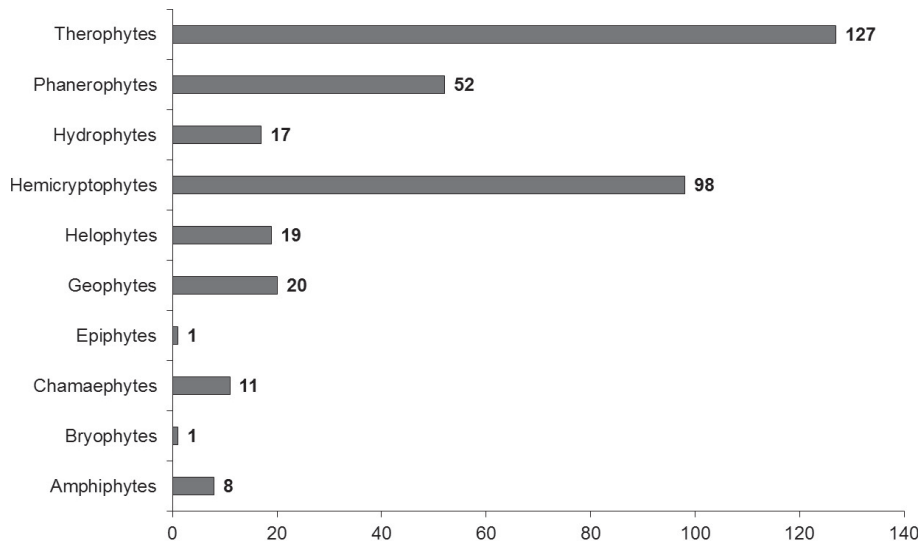

Figure 3. Life form frequency distribution in the flora recorded in the El-Kala Biosphere Reserve, norteastern Algeria.

Diversity and similarity. Species rarefaction curves revealed that the mean observed species richness was highest in fluvial and swampy sites, in contrast with sandy sites (Figure 4a), with 285, 282 and 182 species, respectively (Table 1). There was a strong overlap between fluvial and swampy sites, whilst sandy sites stood out for not having any floristic overlap with the other habitat types (Figure 4A, Table 1).

Figures 4B and 4C show that only four sampling units were necessary to reach 80 % of the estimated species richness for the sandy and swampy habitats, while five were required for the fluvial one.

The ordination based on species presence/absence achieved a stable two dimension solution (stress = 0.154) and enabled us to plot different habitats in a two-dimensional space (Figure 5). Sandy sites were quite homogeneous, concentrated together and visibly separated from the other habitats. Swampy sites were separated from the other habitats

with high heterogeneity and some level of overlapping with the fluvial ones. Finally, fluvial sites were instead poorly clustered and scattered among the others (Figure 5).

Relation of diversity to environmental factors. Variation in soil properties among the three habitat types was tested using Tukey contrasts for linear mixed models (LMMs). Soil pH differed significantly among habitat types (χ^2 = 9.9941; df = 2; P = 0.006). Tukey tests revealed that soil pH differs significantly between swampy and fluvial sites, on one hand, and between swampy and sandy sites, on the other (Figure 6A). Soil organic matter (MO) was highly different among the three habitat types (χ^2 = 2498.4; df = 2; P < 0.001). Post-hoc analysis showed that OM was highly different among the three habitat types (Fl-Sw, Sw-Sa, Fl-Sa; Figure 6B), in contrast with the other soil parameters, which showed homogeneity among habitats.

Figure 4. A. Sample-based rarefaction and extrapolation for plant species richness. **B.** Sample coverage as a function of sample size. **C.** Coverage-based rarefaction and extrapolation for plant species richness. Number of sampling units indicates the cumulative number of plots. Continuous and discontinuous lines in all panels represent rarefaction and extrapolation, respectively; the shaded areas represent the 95 % confidence interval. Fl, Fluvial sites; Sw, Swampy sites; Sa, Sandy sites.

Table 1. Summary of plant diversity at each habitat type (Fl = Fluvial; Sw = Swampy; Sa = Sandy, CI = Confidence interval, SD = Standard deviation).

	Fl	Sw	Sa
S(est) Mean ± SD	285 ± 5.85	282 ± 8.94	182 ± 7.59
95% CI Lower Bound	273.54	264.48	167.12
95% CI Upper Bound	296.46	299.52	196.88
Chao 2 Mean ± SD	323.82 ± 11.77	393.47 ± 29.91	266.42 ± 25.25
95% CI Lower Bound	306.7	348.48	229.57
95% CI Upper Bound	354.44	468.9	331.84
Jack 1 Mean ± SD	355.58 ± 18.59	373.8 ± 19.75	251.17 ± 8.11
Jack 2 Mean	366.72	425.53	288.37
Bootstrap Mean	321.07	323.05	213.18

Multiple linear regression analyses showed no linear relationships between species richness and soil parameters, except for OM ($P = 0.013$) (Table 2). ANOVA results confirmed this results, as significant variation in species richness was observed in relation to OM, but not with the four other parameters, namely pH, TL, EC, and PS (Table 3).

Indicator species analysis. Ten plant species were highly (indicator value > 0.25) and significantly ($P < 0.05$) indica-

tive of the three habitat types in the total dataset (Table 4). Among them, five were indicators of swampy sites, three more were indicators of the sandy habitat, and only two species were indicators of fluvial sites.

Discussion

Through this investigation, we were able to produce a substantial checklist of the vascular flora occurring in alder forests of
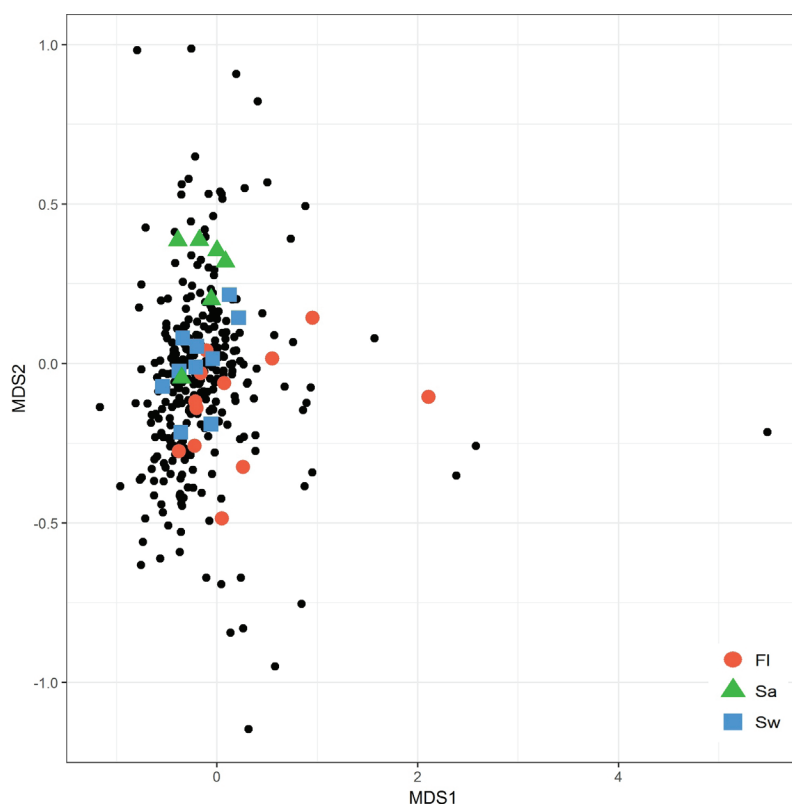

Figure 5. Non-metric multidimensional scaling ordination (NMDS) biplot of habitat (color figures) and species (black dots). Fl, Fluvial sites; Sw, Swampy sites; Sa, Sandy sites.
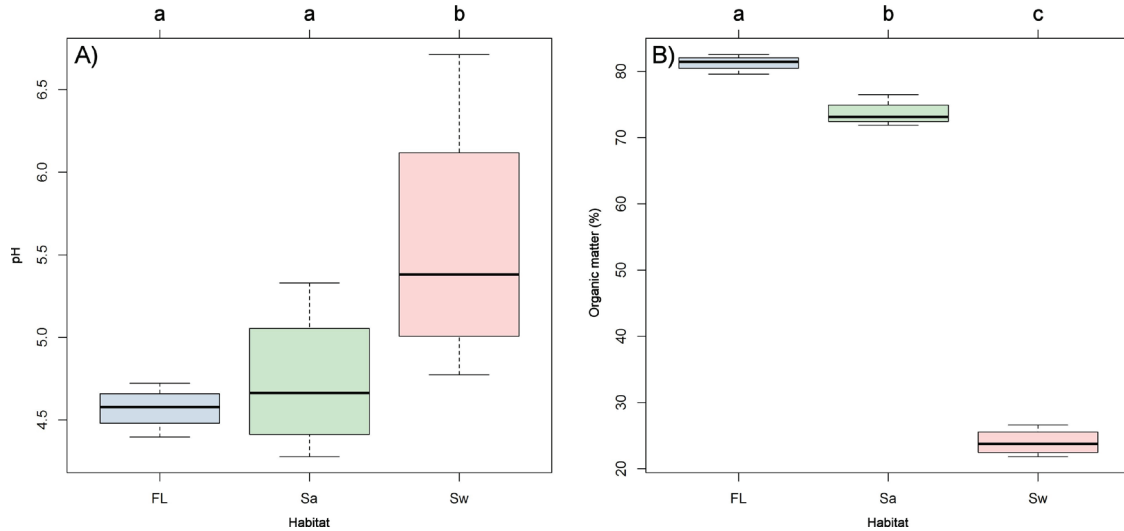
Figure 6. A. Box-plots of variation in pH and **B.** Organic matter (± 95 % CI) in the three sampled habitats. The letters indicate the statistical groupings (Tukey's post-hoc tests); box-plots with the same letter are not significantly different.

KBR. This checklist contributes to our understanding of those species that can thrive in these forest type, which characteristically become flooded for a long time every year, thus representing one of the exceptional wetlands in North Africa.

According to Quézel (1978), the most diverse families represented in the Mediterranean North African flora are Poaceae, Fabaceae, Cyperaceae, Asteraceae, Juncaceae, Ranunculaceae, and Brassicaceae, and our results agree with this statement. However, a noticeable discrepancy arises when comparing our study with that of Ghahreman *et al.* (2006), conducted in the northeastern Mediterranean region (Caspian lowlands), in which they report Rosaceae, Papilionaceae, Asteraceae, Cyperaceae, Brassicaceae, Lamiaceae, Scrophulariaceae, Apiaceae, Ranunculaceae, Aspidiaceae, Polygonaceae, and Liliaceae as the families having the largest species richness. Moreover, in terms of genera our results also differ from those reported by the same study, in which Asteraceae (11 genera), Poaceae (10 genera), Rosaceae (9 genera), Lamiaceae (8 genera), Apiaceae (5 genera) and Liliaceae (5 genera) were reported to be the best-represented families, and Carex (9 species), Rubus (6), Cardamine (5), Ranunculus (5), Veronica (5), Polystichum (4), Dryopteris (3), Equisetum (3), Geranium (3), Poa (3), and Solanum (3)

were listed as the most speciose genera in alder forests. In turn, Bensettiti (1995) stated that the high abundance of Poaceae and Cyperaceae in alder forests reflects the degradation of some parts of these habitats into marshy prairies.

The life form spectrum of the KBR flora, dominated by therophytes, characteristically reflects the influence of the Mediterranean bioclimate (Medjahdi *et al.* 2009). Raunkiaer (1934) defined the Mediterranean climate type as a 'therophyte climate' (as therophytes are plants that remain in the soil as seeds during a certain period, whereas the vegetative parts are annual). This definition is based on the fact that all species with this life form account for over 50 % of the Mediterranean flora (Raven 1971). This proposition of Raunkiaer was confirmed by Cain (1950) in California, and by Quézel (1978) in North Africa. Nonetheless, this generalization was refuted in Chile, the Cape Region of South Africa and South Western Australia, where therophytes are normally absent and only appear in the immediate post-fire periods or after abundant rains (Blondel & Aronson 1995). In northeastern Mediterranean alder forests (Caspian lowlands), Ghahreman *et al.* (2006) found that geophytes were the dominant life form, accounting for 30 % of studied flora, followed by phanerophytes (22 %), therophytes (21 %), hemicryptophytes

Table 2. Multiple linear regression models used to test the dependence of diversity variables on environmental variables.

Diversity measure	Independent variables	Estimate	SE	t	F	R^2_{adj}
	EC	-17,577.715	21,592.463	0.424	0.08	0.180
	pH	-571.11	299.307	0.069		
Species richness	TL	-134.385	166.441	0.428		
	MO	-13.462	5.021	0.013		
	PS	43,944.74	48,410.323	0.373		

Table 3. ANOVA results of the multiple linear regression

Diversity measure	Independent variables	Mean ± SE	df	Sum sq	Mean sq	*F*	*P*
	EC	0.491 ± 0.006	1	170	169.9	0.049	0.826
	pH	4.95 ± 0.088	1	12,761	12,760.8	3.697	0.067
Species richness	TL	2.568 ± 0.072	1	35	34.9	0.010	0.920
	MO	59.187 ± 5.083	1	23,145	23,144.9	6.705	0.016
	PS	0.214 ± 0.003	1	2,844	2,844.4	0.824	0.373
	Residuals		22	75,941	3,451.9		

(17 %), hydrophytes (9 %), and chamaephytes (1 %). Usually, the high incidence of therophytes in plant communities is a result of increasing aridity (Barbero *et al.* 1989), and as in the present study, therophytes were the most common life form; their ample presence can be attributed to the habitats characterized by seasonal immersion/flooding, which are favorable to the development of annual plants capable of germinating and growing faster under harsh conditions (Hammada *et al.* 2004). Therefore, and due to their low ecological requirements, therophytes inhabit numerous habitats types (Gomaa 2012). In addition, the therophyte life form represents the eventual phase of degradation in xeric habitats, as it is frequently linked to environmental perturbations by grazing (Quézel 2000). The high rate of hemicryptophytes in all habitats is typical for pasture flora (Vitasović-Kosić & Britvec 2007). In turn, the low percentage of chamaephytes in alder forests reflects the low light intensity in the understory and the occurrence of long flood periods in these habitats (Thomas 1975).

According to the NMDS results, we were able to classify our study sites into two major groups, namely the marshy and the hilly (swampy-sandy) black alder forests, and the fluvial forests, in relation to plant species richness. This result is not surprising since Thomas (1975) had already shown that this dichotomy is the result of differences in the length of the flood period (seven to twelve months for hilly and marshy forests, whilst inundation only occurs during the flood season in fluvial alder forests), water level and light intensity. The spatial arrangement of the vegetation in this type of wetlands is not accidental; rather, it is the result of the interaction of numerous ecological factors, including abiotic, biotic, or anthropogenic (Alvarez-Rogel *et al.* 2007, Minggagud & Yang 2013).

Soil supply levels are important variables for plant diversity and community structure. Some features of plant community organization, such as composition and diversity of plant functional types, also affect plant productivity, maintenance, and soil fertility (Tilman *et al.* 1996). Soil pH is a relevant factor for plant development; it affects nutrient availability, toxicity, and microbial activity, and it exerts a direct effect on the protoplasm of plant root cells (Larcher 1980, Marschner 1986). Gould & Walker (1999) found a correlation between plant richness and pH; in their model, species richness declined when soil pH was at its acidic and alkaline extremes, which may be related to the nutrient availability and toxicity. In acidic soils, Al^{3+}, Cu^{2+}, Fe^{3+}, Mn^{2+} ions increase to toxic levels for the bulk of plant species (Wolf 2000). Alkaline soils (pH > 8) have a tendency to be poor in Zn, Fe, Cu, K and Mn (Marschner 1986). Different plant species may not be as adaptable and thus they could need a narrow range of pH to live (Leskiw 1998). There is evidence that forest soils must be somewhat acidic for the nutrient resource to be stable (Leskiw 1998); yet, this does not seem to be the case in the present study, as no significant relationship was found between soil pH and richness.

Our study revealed a significant effect of soil organic matter on species richness. Soil organic matter contributes to soil fertility by providing nutrients and increasing both cation exchange and water holding capacity (Brady & Weil 1999). Few species can tolerate nutrient deficiency (Austin 2002). As resource availability increases, more species can persist and henceforth species richness increases.

The study of the vegetation of black alder forests in KBR allowed us to produce a more complete inventory of the plant community, and to better understand the distribution of vegetation across the area, as well as to identify those factors that affect its zonation. For this ecosystem, our study revealed a vegetation of relatively high diversity that is related to the variation of soil parameters. Black alder forests of KBR are predominantly disturbed by human activities, especially

Table 4. Plant species with a significant indicator value at El-Kala Biosphere Reserve, northeastern Algeria. Habitat type abbreviations as in Table 2.

Species	Habitat type	Indicator value	*P*
Stellaria media	Fl	0.416	0.009
Rosa sempervirens	Fl	0.416	0.014
Cotula coronopifolia	Sw	0.578	0.007
Genista ferox	Sw	0.469	0.013
Anthoxanthum odoratum	Sw	0.423	0.023
Fumaria capreolata	Sw	0.375	0.047
Clematis cirrhosa	Sw	0.300	0.043
Vicia narbonensis	Sa	0.476	0.017
Dipsacus fullonum	Sa	0.416	0.020
Raphanus raphanistrum	Sa	0.365	0.048

those related to tourism and leisure (*e.g.*, cutting, burning, draining and/or dumping), which explains the degradation state of the ecosystem. Hence, more conservation efforts focused on these habitats should be made, supplemented with quantitative studies, in order to reduce anthropic activities and their impacts on the El-Kala Biosphere Reserve.

Acknowledgements

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Appendix 1. Systematic list of plant species inventoried in the El-Kala Biosphere Reserve (northeastern Algeria), along with their life form, frequency of occurrence (Occ) and scale of occurrence (Occ scale) (Acc: Accidental, Cmn: Common, Cst: Constant, Vac: very accidental). Life forms: He, Helophyte; Am, Amphiphyte; Ph, Phanerophyte; Hec, Hemicryptophyte; Th, Therophyte; G, Geophyte; Hy, Hydrophyte; Ch, Chamaephyte; Ep, Epiphyte.

Family (RA %) Species	Life form	Occ (%)	Occ scale
Acanthaceae (0.28)			
Acanthus mollis L.	He	7.1	Vac
Alismataceae (0.56)			
Alisma plantago-aquatica L.	Am	75	Cst
Baldellia ranunculoides Parl.	Am	10.7	Vac
Alliaceae (0.28)			
Allium triquetrum L.	He	78.6	Cst
Amaranthaceae (0.56)			
Alternanthera sessilis (L.) DC.	He	39.3	Cmn
Amaranthus graecizans L. subsp. *sylvestris* (Vill.) Asch.	Am	7.1	Vac
Anacardiaceae (0.28)			
Pistacia lentiscus L.	Ph	35.7	Cmn
Apiaceae (2.54)			
Apium crassipes Rchb.f.	Am	14.3	Acc
Apium nodiflorum (L.) Lag.	Am	78.6	Cst
Daucus carota L. subsp. *maritimus* Batt.	Hec	28.6	Cmn
Daucus carota L. subsp. *maximus* (Desf.) Ball.	He	60.7	Cst
Daucus virgatus (Poir.) Maire	Hec	17.9	Acc
Eryngium barrelieri Boiss.	He	3.6	Vac
Oenanthe globulosa L.	Hc	3.6	Vac
Torilis arvensis (Huds) Link.	Th	3.6	Vac
Torilis nodosa (L.) Gaertn.	Th	3.6	Vac
Apocynaceae (0.28)			
Nerium oleander L.	Ph	39.3	Cmn
Araceae (1.41)			
Arum italicum Mill.	G	14.3	Acc
Arisarum vulgare O. Targ. Tozz. subsp. *exertum* Maire & Weiller	G	57.1	Cst
Colocasia esculenta (L.) Schott.	G	17.9	Acc
Lemna minor L.	Hy	28.6	Cmn
Wolffia arrhiza (L.) Horkel ex Wimm.	Hy	7.1	Vac
Araliaceae (0.28)			
Hedera helix L.	Ph	85.7	Cst
Arecaceae (0.28)			
Chamaerops humilis L.	Ph	21.4	Acc
Aristolochiaceae (0.28)			

Family (RA %) Species	Life form	Occ (%)	Occ scale
Aristolochia paucinervis Pomel	He	3.6	Vac
Asparagaceae (0.85)			
Asparagus acutifolius L.	Ph	21.4	Acc
Prospero autumnale (L.) Speta	G	7.1	Vac
Ruscus hypophyllum L.	Ch	39.3	Cmn
Aspleniaceae (0.28)			
Asplenium adiantum-nigrum L.	He	7.1	Vac
Asteraceae (6.78)			
Anthemis arvensis L.	Th	21.4	Acc
Aster squamatus (Spreng.) Hieron.	Hec	35.7	Cmn
Bellis annua L.	Hec	92.9	Cst
Centaurea calcitrapa L.	Hec	10.7	Vac
Centaurea napifolia L.	Hec	3.6	Vac
Chamaemelum mixtum All.	Th	75	Cst
Coleostephus myconis (L.) Cass ex Rchb.	Th	32.1	Cmn
Conyza bonariensis (L.) Cronquist.	Th	17.9	Acc
Cotula coronopifolia L.	He	50	Cst
Crepis vesicaria subsp. *taraxacifolia* (Thuill.) B.Boivin	Hec	10.7	Vac
Dittrichia graveolens (L.) Greuter	Th	7.1	Vac
Dittrichia viscosa L. Greuter	Ch	14.3	Acc
Echinops spinosissimus Turra	Hec	7.1	Vac
Filago pygmaea L.	Th	7.1	Vac
Galactites tomentosa Moench	Th	60.7	Cst
Hypochaeris radicata subsp. *platylepis* (Boiss.) Jahand. & Maire	Hec	32.1	Cmn
Lactuca viminea J. Presl & C. Presl	Hec	14.3	Acc
Logfia gallica Coss. & Germ.	Th	7.1	Vac
Plagius maghrebinus Vogt and Greuter	Th	3.6	Vac
Scolymus hispanicus L.	Hec	17.9	Acc
Senecio leucanthemifolius Poir.	Th	17.9	Acc
Sonchus asper (L.) Hill.	Th	3.6	Vac
Tolpis barbata (L.) Gaertn.	Th	14.3	Acc
Xanthium spinosum L.	Th	25	Cmn
Athyriaceae (0.28)			
Athyrium filix-femina (L.) Roth.	Hec	64.3	Cst
Betulaceae (0.28)			
Alnus glutinosa (L.) Gaertn.	He	100	Cst
Boraginaceae (1.98)			
Borago longifolia Poir.	Th	3.6	Vac

Family (RA %) Species	Life form	Occ (%)	Occ scale
Borago officinalis L.	Th	7.1	Vac
Cerinthe major L.	Th	10.7	Vac
Echium plantagineum L.	Hec	50	Cst
Myosotis ramosissima Rochel.	Th	14.3	Acc
Myosotis sicula (Guss).	Th	7.1	Vac
Pardoglossum cheirifolium (L.) E.Barbier & Mathez	Hec	39.3	Cmn
Brassicaceae (3.11)			
Alliaria petiolata (M.Bieb) Cavara & Grande	Hec	25	Cmn
Biscutella didyma L.	Th	14.3	Acc
Brassica procumbens O.E. Schultz	Th	10.7	Vac
Capsella bursa-pastoris (L.) Medik.	Th	14.3	Acc
Cardamine hirsuta L.	Th	3.6	Vac
Malcolmia ramosissima Thell.	Th	10.7	Vac
Nasturtium officinale R. Br.	Hec	71.4	Cst
Raphanus raphanistrum L.	Th	17.9	Acc
Rorippa amphibia Besser	Hec	3.6	Vac
Sinapis arvensis L.	Th	32.1	Cmn
Sinapis pubescens L. subsp. *pubescens*	Th	10.7	Vac
Callitrichaceae (0.28)			
Callitriche obtusangula Le Gall ex Hegelm.	Hy	85.7	Cst
Campanulaceae (1.41)			
Campanula alata Desf.	Am	3.6	Vac
Campanula dichotoma L.	Th	14.3	Acc
Campanula rapunculus L.	Hec	3.6	Vac
Legousia falcata (Ten.) Fritsch	Th	3.6	Vac
Solenopsis laurentia C. Presl.	Th	50	Cst
Caprifoliaceae (0.85)			
Dipsacus fullonum L.	He	14.3	Acc
Fedia cornucopiae (L.) Gaertn.	Th	25	Cmn
Viburnum tinus L.	Ph	7.1	Vac
Caryophyllaceae (3.67)			
Cerastium glomeratum Thuill.	Th	46.4	Cmn
Cerastium semidecandrum L.	Th	42.9	Cmn
Illecebrum verticillatum L.	Th	7.1	Vac
Paronychia argentea Lamk.	Hec	25	Cmn
Polycarpon tetraphyllum L.	Th	21.4	Acc
Silene coeli-rosa (L.) Godr.	Th	50	Cst
Silene colorata Poir.	Th	10.7	Vac

Family (RA %) Species	Life form	Occ (%)	Occ scale
Silene gallica L.	Hec	17.9	Acc
Silene vulgaris subsp. *vulgaris* (Moench.) Garcke.	Hec	3.6	Vac
Spergula arvensis L.	Th	35.7	Cmn
Spergula fallax E.H.L. Krause	He	17.9	Acc
Spergularia bocconei (Sheele) Asch. & Graetn.	Th	21.4	Acc
Stellaria media (L.) Vill	Th	85.7	Cst
Ceratophyllaceae (0.28)			
Ceratophyllum demersum L.	Hy	14.3	Acc
Chenopodiaceae (0.28)			
Chenopodium album L.	He	14.3	Acc
Cistaceae (0.85)			
Cistus monspeliensis L.	Ph	3.6	Vac
Cistus salviifolius L.	Ch	21.4	Acc
Halimium halimifolium Willk	Ph	14.3	Acc
Compositeae (0.28)			
Hyoseris radiata L.	Hec	17.9	Acc
Convolvulaceae (0.85)			
Calystegia sepium (L.) R.Br	Ph	82.1	Cst
Convolvulus althaeoides L.	G	3.6	Vac
Convolvulus arvensis L.	G	3.6	Vac
Crassulaceae (0.28)			
Umbilicus rupestris (Salisb.) Dandy	Hec	7.1	Vac
Cupressaceae (0.56)			
Juniperus oxycedrus L.	Ph	10.7	Vac
Taxodium distichum (L.) Rich.	Ph	3.6	Vac
Cyperaceae (6.78)			
Carex distans L.	Hec	3.6	Vac
Carex divulsa Stoks.	Hec	7.1	Vac
Carex elata All.	Hec	28.6	Cmn
Carex flacca Shreb.	Hec	7.1	Vac
Carex paniculata L.	Hec	3.6	Vac
Carex pendula Huds.	Hec	25	Cmn
Carex pseudocyperus L.	Hec	7.1	Vac
Carex punctata Gaudin	Hec	42.9	Cmn
Carex remota L.	Hec	92.9	Cst
Carex sylvatica Huds. subsp. *paui* A. Bolòs & O- Bòlos	Hec	3.6	Vac
Carex vulpina L.	Hec	3.6	Vac
Cladium mariscus (L.) Pohl.	G	25	Cmn

Family (RA %) Species	Life form	Occ (%)	Occ scale
Cyperus esculentus L.	Th	21.4	Acc
Cyperus flavescens L.	Th	3.6	Vac
Cyperus fuscus L.	Th	14.3	Acc
Cyperus longus L. subsp *eu-longus* Asch & Gr.	Hec	39.3	Cmn
Eleocharis palustris (L.) Roem. & Schult.	Hec	14.3	Acc
Fimbristylis squarrosa Vahl	Th	3.6	Vac
Fuirena pubescens (Lam.) Kunth	Hec	14.3	Acc
Isolepis cernua (Vahl) Roemer & Schultes	Th	67.9	Cst
Isolepis pseudosetacea (Daveau) Gand.	Th	10.7	Vac
Schoenoplectus corymbosus (Roem. & Schult.) A.Raynal	Th	3.6	Vac
Schoenoplectus lacustris (L.) Palla	Hy	17.9	Acc
Scirpoides holoschoenus (L.) Soják	Hec	7.1	Vac
Dioscoreaceae (0.28)			
Dioscorea communis (L.) Caddick & Wilkin	G	57.1	Cst
Dryopteridaceae (0.28)			
Thelypteris interrupta (Willd.) Iwats.	G	17.9	Acc
Equisetaceae (0.28)			
Equisetum ramosissimum Desf.	G	10.7	Vac
Ericaceae (0.56)			
Erica arborea L.	Ph	42.9	Cmn
Erica scoparia L.	Ph	25	Cmn
Euphorbiaceae (1.69)			
Chamaesyce peplis (L.) Prokn.	Th	7.1	Vac
Euphorbia biumbellata Poir.	Ch	7.1	Vac
Euphorbia helioscopia L.	Th	3.6	Vac
Euphorbia paralias L.	Ch	7.1	Vac
Euphorbia terracina L.	Ch	3.6	Vac
Ricinus communis L.	Ph	10.7	Vac
Fabaceae (8.76)			
Acacia dealbata Link	Ph	7.1	Vac
Acacia melanoxylon R.Br	Ph	3.6	Vac
Biserrula pelecinus L.	Ph	3.6	Vac
Calicotome villosa (Poir.) Link.	Ph	57.1	Cst
Cytisus villosus Pourr.	Ph	35.7	Cmn
Dorycnium rectum Ser.	Hec	60.7	Cst
Erophaca baetica Boiss.	Ph	7.1	Vac
Genista ferox (Poir.) Dum. Cours	Ph	28.6	Cmn
Lotus biflorus Desr.	Th	14.3	Acc

Family (RA %) Species	Life form	Occ (%)	Occ scale
Lotus edulis L.	Th	3.6	Vac
Lupinus angustifolius L.	Th	21.4	Acc
Lupinus luteus L.	Th	3.6	Vac
Medicago orbicularis (L.) Bartal.	Th	3.6	Vac
Melilotus infestus Guss.	He	10.7	Vac
Ornithopus pinnatus (Mill) Druce.	Th	28.6	Cmn
Retama raetam subsp. *bovei* (Spach.) Talavera & P.E. Gibbs	Ph	3.6	Vac
Scorpiurus vermiculatus L.	Th	3.6	Vac
Trifolium angustifolium L.	Th	10.7	Vac
Trifolium arvense L.	Th	3.6	Vac
Trifolium campestre Schreb.	Th	25	Cmn
Trifolium micranthum Viv.	Th	3.6	Vac
Trifolium pratense L.	Hec	3.6	Vac
Trifolium repens L.	Hec	92.9	Cst
Trifolium resupinatum L.	Th	7.1	Vac
Trifolium squarrosum L.	Th	7.1	Vac
Trifolium subterraneum L.	Th	3.6	Vac
Vicia altissima Desf.	Th	3.6	Vac
Vicia hirsuta (L.) Gray.	Th	7.1	Vac
Vicia narbonensis L.	Th	25	Cmn
Vicia sativa L.	Th	28.6	Cmn
Vicia sativa L. subsp. *nigra* (L.) Ehrh.	Th	3.6	Vac
Fagaceae (0.85)			
Quercus canariensis Willd.	Ph	10.7	Vac
Quercus coccifera L.	Ph	25	Cmn
Quercus suber L.	Ph	50	Cst
Funariaceae (0.28)			
Funaria hygrometrica Hedw.	Bryophyte	32.1	Cmn
Gentianaceae (0.56)			
Centaurium erythraea Rafn.	Hec	14.3	Acc
Schenkia spicata (L.) Mans.	G	3.6	Vac
Geraniaceae (1.41)			
Erodium botrys (Cav.) Bertol.	Th	57.1	Cst
Erodium cicutarium (L.) l'Hér	Th	17.9	Acc
Geranium dissectum L.	Th	42.9	Cmn
Geranium molle L.	Th	35.7	Cmn
Geranium robertianum L.	Th	3.6	Vac
Hypericaceae (0.56)			

Family (RA %) Species	Life form	Occ (%)	Occ scale
Hypericum afrum Lam.	He	60.7	Cst
Hypericum perforatum L.	He	21.4	Acc
Hypolepidaceae (0.28)			
Pteridium aquilinum (L.) Kuhn.	G	89.3	Cst
Iridaceae (1.13)			
Iris planifolia (Mill.) Fiori & Paol.	G	3.6	Vac
Iris pseudacorus L.	G	78.6	Cst
Iris unguicularis Poir.	G	3.6	Vac
Romulea bulbocodium (L.) Sebast. & Maur.	G	7.1	Vac
Isoetaceae (0.56)			
Cephaloceraton histrix (Bory & Durieu) Gennari	Hec	10.7	Vac
Isoetes velata A. Braun.	Hy	25	Cmn
Juncaceae (3.11)			
Juncus acutus L.	Hec	10.7	Vac
Juncus articulatus L.	Hec	7.1	Vac
Juncus bufonius L.	Th	10.7	Vac
Juncus bulbosus L.	Hec	17.9	Acc
Juncus capitatus Weigel	Th	21.4	Acc
Juncus conglomeratus L.	Hec	17.9	Acc
Juncus effusus L.	Hec	46.4	Cmn
Juncus heterophyllus Dufour	He	14.3	Acc
Juncus maritimus Lam.	G	53.6	Cst
Juncus tenageia Ehrh. ex L.f.	Hec	60.7	Cst
Luzula forsteri DC.	Hec	3.6	Vac
Lamiaceae (3.39)			
Calamintha nepeta (L.) Savi.	Hec	3.6	Vac
Lamium bifidum Cirillo	Hec	7.1	Vac
Lamium purpureum L.	Th	3.6	Vac
Lavandula stoechas L.	Ch	10.7	Vac
Lycopus europaeus L.	Hec	75	Cst
Mentha aquatica L.	Hec	14.3	Acc
Mentha pulegium L.	Hec	75	Cst
Mentha suaveolens Ehrh.	Hec	96.4	Cst
Prunella vulgaris L.	Hec	7.1	Vac
Stachys arvensis L.	Th	42.9	Cmn
Stachys marrubiifolia Viv.	Th	7.1	Vac
Vitex agnus-castus L.	Ch	3.6	Vac
Lauraceae (0.28)			

Family (RA %) Species	Life form	Occ (%)	Occ scale
Laurus nobilis L.	Ph	39.3	Cmn
Lentibulariaceae (0.28)			
Utricularia vulgaris L.	Hy	7.1	Vac
Linaceae (0.28)			
Linum usitatissimum L. subsp *angustifolium* (Huds) Thell.	Th	7.1	Vac
Lythraceae (0.85)			
Lythrum hyssopifolia L.	Th	3.6	Vac
Lythrum junceum Banks & Sol.	Th	100	Cst
Lythrum salicaria L.	Hec	71.4	Cst
Malvaceae (0.56)			
Lavatera cretica L.	Th	7.1	Vac
Lavatera olbia L.	Ch	7.1	Vac
Moraceae (0.28)			
Ficus carica L.	Ph	78.6	Cst
Myrsinaceae (0.85)			
Anagallis arvensis L.	Th	60.7	Cst
Anagallis crassifolia Thore	Am	10.7	Vac
Anagallis monelli L.	Th	7.1	Vac
Myrtaceae (0.85)			
Eucalyptus camaldulensis Dehnh.	Ph	7.1	Vac
Eucalyptus gomphocephala D.C	Ph	3.6	Vac
Myrtus communis L.	Ph	57.1	Cst
Nympheaceae (0.28)			
Nymphaea alba L.	Hy	7.1	Vac
Oleaceae (0.85)			
Fraxinus angustifolia Vahl.	Ph	64.3	Cst
Olea europaea L. subsp. *oleaster* (Hoffmanns & Link) Negodi.	Ph	17.9	Acc
Phillyrea latifolia L.	Ph	35.7	Cmn
Onagraceae (0.85)			
Circaea lutetiana L.	G	3.6	Vac
Epilobium hirsutum L.	Hec	3.6	Vac
Ludwigia palustris (L.) Elliot	Th	82.1	Cst
Orobanchaceae (0.28)			
Bellardia trixago (L.) All.	Th	10.7	Vac
Osmundaceae (0.28)			
Osmunda regalis L.	Hec	64.3	Cst
Oxalidaceae (0.85)			
Oxalis corniculata L.	Hec	50	Cst

Family (RA %) Species	Life form	Occ (%)	Occ scale
Oxalis floribunda Lehm.	Hec	7.1	Vac
Oxalis pes-caprae L.	Hec	14.3	Acc
Papaveraceae (0.56)			
Fumaria capreolata L.	Th	25	Cmn
Glaucium flavum Crantz.	Hec	3.6	Vac
Phytolaccaceae (0.28)			
Phytolacca americana L.	Hec	17.9	Acc
Plantaginaceae (2.82)			
Kickxia commutata (Rchb.) Fritsch.	Th	21.4	Acc
Linaria flava Desf.	Th	3.6	Vac
Linaria pinifolia Tell.	Th	67.9	Cst
Linaria reflexa Desf.	Th	17.9	Acc
Plantago crassifolia Forssk.	Th	3.6	Vac
Plantago lanceolata L.	Hec	32.1	Cmn
Plantago macrorhiza Poir.	Hec	21.4	Acc
Plantago major L.	Hec	10.7	Vac
Veronica agrestis L.	Th	35.7	Cmn
Veronica anagallis-aquatica L.	Hy	42.9	Cmn
Poacaeae (9.88)			
Agrostis stolonifera L.	Am	17.9	Acc
Alopecurus bulbosus Gouan	Hec	14.3	Acc
Anthoxanthum odoratum L.	Hec	32.1	Cmn
Arundo donax L.	Hec	14.3	Acc
Avena sterilis L.	Th	7.1	Vac
Brachypodium distachyon (L.) P.Beauv.	Hec	3.6	Vac
Brachypodium sylvaticum (Huds) P. Beauv.	Hec	14.3	Acc
Briza maxima L.	Th	10.7	Vac
Briza minor L.	Th	25	Cmn
Bromus sterilis L.	Th	3.6	Vac
Catapodium rigidum (L.) C.E. Hubb.	Th	3.6	Vac
Cynodon dactylon (L.) Pers.	Ch	7.1	Vac
Cynosurus elegans Desf.	Th	3.6	Vac
Cynosurus polybracteatus Poir.	Th	21.4	Acc
Dactyloctenium aegyptium (L.) Willd.	Th	3.6	Vac
Digitaria sanguinalis (L) Scop.	Th	32.1	Cmn
Echinochloa crus-galli (L.) P.Beauv.	Th	3.6	Vac
Eragrostis atrovirens (Desf.) Trin. var. *fontanesiano* Emb.Maire.	Hec	7.1	Vac
Glyceria fluitans (L.) R. Br.	Hy	32.1	Cmn

Family (RA %) Species	Life form	Occ (%)	Occ scale
Holcus lanatus L.	Hec	28.6	Cmn
Hordeum murinum L.	Th	39.3	Cmn
Lagurus ovatus L.	Th	7.1	Vac
Leersia oryzoïdes (L.) Sw.	He	14.3	Acc
Lolium multiflorum Lam.	Th	17.9	Acc
Mibora minima (L.) Desv.	Th	3.6	Vac
Panicum repens L.	Ch	46.4	Cmn
Paspalum distichum L.	Hec	14.3	Acc
Phragmites australis (Cav.) Steud.	Hy	35.7	Cmn
Piptatherum miliaceum (L.) Coss.	Hec	7.1	Vac
Poa annua L.	Th	57.1	Cst
Poa trivialis L.	Th	57.1	Cst
Polypogon monspeliensis (L.) Desf.	Th	21.4	Acc
Polypogon viridis (Gouan) Breistr.	Th	14.3	Acc
Puccinellia distans (Jacq.) Parl.	Hec	3.6	Vac
Rostraria hispida (Savi) Dogan	Th	10.7	Vac
Polygonaceae (1.98)			
Persicaria decipiens (R. Br.) K. L. Wilson	Th	57.1	Cst
Persicaria hydropiper (L.) Spach)	Th	7.1	Vac
Persicaria lapathifolia (L.) Delarbre	Th	89.3	Cst
Persicaria senegalensis (Meisn.) Soják	Th	3.6	Vac
Rumex bucephalophorus L.	Th	7.1	Vac
Rumex conglomeratus Murray	Hec	71.4	Cst
Rumex pulcher L.	Hec	14.3	Acc
Polypodiaceae (0.28)			
Polypodium cambricum L.	Ep	7.1	Vac
Potamogetonaceae (0.56)			
Potamogeton nodosus Poir.	Hy	28.6	Cmn
Potamogeton trichoides Cham. & Schltdl	Hy	10.7	Vac
Primulaceae (0.28)			
Cyclamen africanum Boiss. & Reut.	G	14.3	Acc
Pteridaceae (0.28)			
Adiantum capillus-veneris L.	Hec	7.1	Vac
Ranunculaceae (3.67)			
Clematis cirrhosa L.	Ph	10.7	Vac
Clematis flammula L.	Ph	21.4	Acc
Ficaria verna Huds.	G	25	Cmn
Ranunculus bulbosus L.	Hec	10.7	Vac

Family (RA %) Species	Life form	Occ (%)	Occ scale
Ranunculus flammula L.	Hec	21.4	Acc
Ranunculus hederaceus L.	Hy	28.6	Cmn
Ranunculus macrophyllus Desf.	Hec	71.4	Cst
Ranunculus muricatus L.	Th	42.9	Cmn
Ranunculus ophioglossifolius Vill.	Th	67.9	Cst
Ranunculus peltatus subsp. *baudotii* (Godr.) Meikle ex C.D.K.Cook	Hec	7.1	Vac
Ranunculus sardous Crantz.	Th	32.1	Cmn
Ranunculus sceleratus L.	Th	85.7	Cst
Ranunculus trichophyllus Chaix.	Hy	7.1	Vac
Rhamnaceae (0.28)			
Frangula alnus Mill.	Ph	28.6	Cmn
Rosaceae (2.26)			
Crataegus azarolus L.	Ph	3.6	Vac
Crataegus monogyna Jacq.	Ph	39.3	Cmn
Potentilla reptans L.	Hec	46.4	Cmn
Prunus avium (L.) L.	Ph	17.9	Acc
Rosa canina L.	Ph	3.6	Vac
Rosa sempervirens L.	Ph	17.9	Acc
Rubus ulmifolius Schott.	Ph	96.4	Cst
Sanguisorba verrucosa (Link ex G.Don) Ces.	Hec	3.6	Vac
Rubiaceae (1.13)			
Galium elongatum C.Presl	Hec	60.7	Cst
Galium scabrum L.	Hec	3.6	Vac
Rubia peregrina L.	Hec	78.6	Cst
Sherardia arvensis L.	Th	42.9	Cmn
Salicaceae (1.13)			
Populus nigra L.	Ph	3.6	Vac
Salix alba L.	Ph	50	Cst
Salix atrocinerea Brot.	Ph	21.4	Acc
Salix pedicellata Desf.	Ph	64.3	Cst
Salviniaceae (0.28)			
Salvinia natans (L.) All.	Hy	3.6	Vac
Scrophulariaceae (0.85)			
Scrophularia sambucifolia L. subsp. *mellifera* Maire	Hec	35.7	Cmn
Scrophularia tenuipes Coss & Durieu	Hec	10.7	Vac
Verbascum sinuatum L.	Hec	10.7	Vac
Selaginellaceae (0.28)			
Selaginella kraussiana (Kunze) A. Braun	He	3.6	Vac

Family (RA %) Species	Life form	Occ (%)	Occ scale
Smilacaceae (0.28)			
Smilax aspera L.	Ph	89.3	Cst
Solanaceae (1.13)			
Datura stramonium L.	Th	28.6	Cmn
Solanum dulcamara L.	Ph	32.1	Cmn
Solanum linnaeanum Hepper & P.-M.L.Jaeger	Hec	10.7	Vac
Solanum nigrum L.	Th	50	Cmn
Sphagnaceae (0.28)			
Sphagnum subsecundum var. *auriculatum* (Schimp.) Schlieph.	He	3.6	Vac
Tamaricaceae (0.28)			
Tamarix canariensis Willd.	Ph	7.1	Vac
Thymeleaceae (0.28)			
Daphne gnidium L.	Ph	17.9	Acc
Thyphaceae (0.28)			
Sparganium erectum L.	Hy	14.3	Acc
Ulmaceae (0.28)			
Ulmus minor Mill.	Ph	21.4	Acc
Urticaceae (0.56)			
Urtica dioica L.	Hec	14.3	Acc
Urtica membranacea Poir.	Th	3.6	Vac
Verbenaceae (0.28)			
Verbena officinalis L.	Hec	25	Cmn
Violaceae (0.28)			
Viola alba subsp. *denhardtii* (Ten.) W. Becker.	Th	7.1	Vac
Vitaceae (0.28)			
Vitis vinifera subsp. *sylvestris* (C.C.Gmel.) Hegi	Ph	67.9	Cst
Xanthorrhoeaceae (0.28)			
Asphodelus aestivus Brot.	Hec	28.6	Cmn