Article

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Contribution to the study of the plant diversity in communities with *Quercus alnifolia* in Cyprus

Abstract

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The Cyprus endemic species *Quercus alnifolia* grows at an altitudinal range of 600–1525 m, mainly as a shrub. It is one of the most ecologically important endemic species of Cyprus. This species forms communities that extend throughout the entire Troodos Mountain range, and it appears either in pure stands, or in mixture with other taxa or even, as an understorey in pine stands. The priority habitat type of Annex I of the Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora "Scrub and low forest vegetation with *Quercus alnifolia* - 9390", is characterized by arborescent *Q. alnifolia*-dominated formations (pure stands). This habitat type occurs in the central Troodos range, where it has a relatively wide distribution. In the present study, a detailed inventorying of the plant communities with *Q. alnifolia* has been realised in three different Natura 2000 sites of Cyprus: National Forest Park of Troodos, "Koilada Kedron - Kampos", and Machairas Forest. Surveys to sample the plant composition and communities at field scale and at elevations ranging from 1070 m to 1380 m, were performed during 2020 and 2021. An average number of 19 different plant taxa have been registered on each one of the 36 sampling plots. 107 plant taxa have been recorded on the sampling plots and an analysis of the floristic composition has been conducted. Low intensity pressures have been recorded on *Q. alnifolia* communities, across the sampling areas. The conservation status of the communities with *Q. alnifolia* is favourable and significant regeneration of the species has been recorded. The need to monitor these forests and their intrinsic floristic diversity, is underlined since there seems to be a gap in the Mediterranean vegetation survey recent scenario.

Key words: endemism, endemic habitat type, Troodos Mountains, vegetation.

Introduction

Quercus alnifolia Poech (Poech 1842: 12) is a Cyprus endemic plant species (Anagiotos & al. 2012), which grows on volcanic geological substrate and its presence is copious in the central hilly area of Troodos (Neophytou & al. 2011), on altitudes of 400–1.800 m (Loizides 2011). Concerning its taxonomy, *Q. alnifolia* was traditionally placed in Sect. *Cerris* (Camus 1938; Schwarz 1936), but it groups with the closely related species *Q.*

aucheri and *Q. coccifera* and belongs to ilicoid oaks (Sect. *Ilex*) (Menickij, 1984; Denk & Grimm 2010); as a putative ancestor of the kermes oaks (*Q. coccifera* s. l.) (Hipp & al 2020). Sclerophyllous oaks of *Quercus* Group *Ilex* (Denk & Grimm 2010) are an emblematic feature of many relevant Mediterranean forest habitats (Blondel & Aronson 1999) and currently include the two narrow Eastern Mediterranean endemics, *Q. alnifolia* Poech. and *Q. aucheri* Jaub. et Spach. and the widespread *Q. ilex* L. and *Q. coccifera* L., four sympatric species that share ecological preferences (Vitelli & al. 2017). This new taxonomical position of *Q. alnifolia* is very important, since its ecological positioning served as a major driver for evolution and this is mandatory to understand the entire communities with *Q. alnifolia*, with major outputs for biodiversity conservation.

Quercus alnifolia is an endemic high evergreen shrub (usually multi-branched) or small tree that can reach up to 10 m (EUR27–European Commission. 2007; Loizides 2011; Anagiotos & al.2012). It has been appointed as the national tree of Cyprus and it has been listed in the IUCN Red List of Threatened Species as Least Concern in 2015 (Gorener & Beech 2017). *Q. alnifolia* is also protected by the national forest law and by the Habitat directive 92/43/EEC (Anagiotos & al. 2012). This species is of great ecological importance to Cyprus, as it is one of the most essential components of the forest landscape in the greater Troodos Mountain range; it also prevents soil erosion and its acorns are a major source of nutrition for fauna and micro-fauna (EUR27–European Commission. 2007; Petrou & al. 2015). *Q. alnifolia* forms pure stands (habitat type 9390*) or it is established as understorey to stands of *Pinus nigra*, *Pinus brutia*, *Cedrus brevifolia* and other Mediterranean shrubs (Loizides 2011; Petrou & al. 2015; Milios & al. 2021).

The habitat type "Scrub and low forest vegetation of *Quercus alnifolia* (9390)" is an endemic and a priority habitat type of Annex I, Directive 92/43/EEC (EUR27–European Commission 2007). This habitat type occurs in the central Troodos range, where it has a relatively wide distribution (PLANT-NET CY Project, n.d.), it can be found on rocky, steep, and smooth mountain slopes, mainly on diabase as a substrate (Andreou & al. 2010). Through the project "Establishment of a Plant Micro-Reserve Network in Cyprus", a plant micro-reserve that hosts a representative stand of this habitat type has been established within the Natura 2000 site of "Koilada Kedron-Kampos" (PLANT-NET CY Project, n.d.; Kadis & al. 2010). Among the main pressures affecting this habitat type are recreational activities, and disturbance of natural habitats (PLANT-NET CY Project, n.d.).

A review of the available literature focusing on the plant communities of Cyprus and on those with *Quercus alnifolia,* shows that more phytosociological research is needed since even studies that are focused on mountainous ecosystems are limited (Barbero & Quézel 1979, 1989; Costa & al. 1984; Géhu & al. 1990; Brullo & al. 1997; Brullo & al. 2001, 2005; Sotiriou & Gerasimidis 2009; Sotiriou 2010; Wagensommer 2017; Şekerciler & Ketenoğlu 2019). Concerning communities with *Quercus alnifolia*, Barbero & Quézel (1979) described the alliance *Quercion alnifoliae* and the associations *Querco alnifoliae - Pinetum brutiae* Barbéro & Quézel 1979 and *Querco alnifoliae-Crepidetum fraasii* Barbéro & Quézel 1979. Preislerová & al. (2022) mention the alliance *Quercion alnifoliae* Barbero et Quézel ex Bergmeier, Mucina & Theurillat in Willner & al. (2015), that is an alliance endemic to the island of Cyprus, but shares many species with woody formations of *Quercus, Pinus, Pistacia* and *Styrax* elsewhere in the Eastern Mediterranean (Willner & al. 2015). Mesomediterranean evergreen endemic golden oak forests of Cyprus (Mucina &

al. 2016) belong to this alliance and are present on dry, alkaline oligotrophic-mesotrophic substrate and present late spring-summer phenological optimum and late-successional status (FloraVeg.EU 2022).

Sotiriou (2010) and Sotiriou & Gerasimidis (2009) showed that *Quercus alnifolia* participates in the following plant associations: i) *Querco alnifoliae-Pinetum brutiae, ii) Querco alnifoliae-Pinetum pallasianae, iii) Querco alnifoliae-Crepidetum fraasii, iv) Paeonio masculae-Pinetum pallasianae, v) Sorbo creticae-Pinetum pallasianae and v) Alno orientalis - Platanetum orientalis*. In the first three associations, *Q. alnifolia* participates as a characteristic species and those associations, belong to the class *Quercetea ilicis* Br. - Bl. ex de Bolos y Vayreda 1950 and to the order *Quercetalia ilicis* Br. - Bl. 1936 em. Rivas – Martinez 1975.

This study has been conducted in the framework of a thesis concerning to the comparison of plant and invertebrates communities in formations with *Quercus alnifolia* and it aims to contribute to the available knowledge on plant diversity in plant communities with *Quercus alnifolia* in Cyprus, in three Natura 2000 protected areas. This study aims at contributing to a detailed inventory of the plant taxa that participate in the plant communities of *Q. alnifolia* on the "Chrysovrysi" linear trail at the National Forest Park of Troodos, on the part of the European E4 trail that traverses the site "Koilada Kedron - Kampos" and on Machairas Forest.

Materials and Methods

Study Areas

Three study areas (Fig. 1) were selected for the study of the composition of *Quercus alnifolia* communities. They belong to the Mediterranean Biogeographical Sub-Region (Rivas Martines & al. 2014; Hadjipanayiotou 2017a, 2019a, 2019b) and to the Natura 2000 network of protected areas. The main criterion consisted of the fact that this species is common almost throughout the entire Troodos Mountain Range (TMR). Consequently, the following three sites were selected as they cover the central, the western and the eastern parts of the distribution of the species respectively. The National Forest Park of Troodos (site code: CY5000004) is located in the center of the TMR, the site "Koilada Kedron - Kampos" (site code: CY2000008) is in the central part of Pafos forest (Dasos Pafou), that is located towards the western part of the TMR and Machairas Forest (site code: CY2000004) at the eastern part of the TMR. In the following sections, each study area will be addressed separately.

National Forest Park of Troodos

The National Forest Park of Troodos (NFP of Troodos) (Fig. 1b) has an area of about 9,009 ha (0.97% of Cyprus), it consists of plutonic rocks, and it extends from an altitude of 700 m (Saitas area), to an altitude of 1951 m (Chionistra peak) (Hadjipanayiotou, 2019b). The vegetation of this area is dominated by *Pinus brutia* forests at the lower altitudes and *Pinus nigra* forests at the higher altitudes (> 1200 m) (Game and Fauna Service & Ministry of Interior 2016). Precipitation at the NFP of Troodos spans from 660 mm at the lower parts and surpasses 1100 mm at its highest altitude (Xofis & al. 2020).

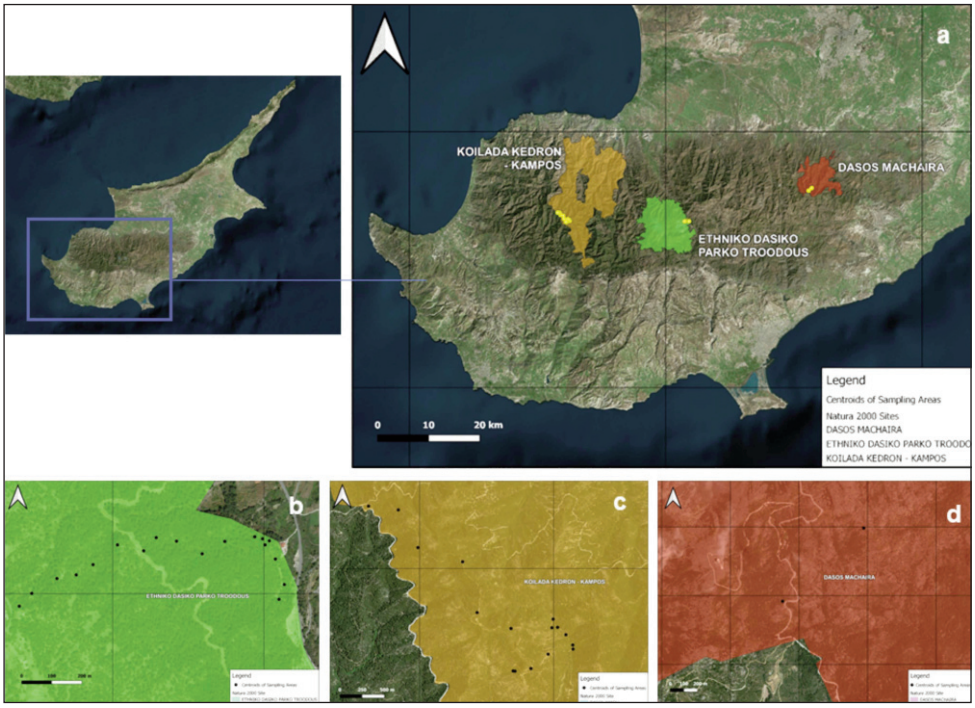

Fig. 1. **a**. The three study areas, on the island of Cyprus and the centroids of the sampling plots. **b**. at the "Chrysovrysi" trail of the National Forest Park of Troodos. **c.** at part of the European E4 trail of the site "Koilada Kedron - Kampos". **d.** at the site "Machairas Forest".

Additionally, the Saitas weather station, the hottest month is July and the coldest is February, with average daily temperatures of 26.5 °C and 8.4 °C respectively (Xofis & al. 2020).

The ecological importance of the NFP of Troodos, can be deducted, interalia, from the fact that it hosts 11 Annex 1 habitat types, of which four, are priority habitat types with good to excellent conservation status (Mazaraki & al. 2013). Also, the habitat type 6460*: Peat grasslands of Troodos can only be found in this specific area and nowhere else in the world (Mazaraki & al. 2013). Moreover, the NFP is the most important forest ecosystem of the island, and it hosts more than 750 plant taxa (40% of the total flora of Cyprus) and 70 of those are Cypriot endemics (50% of the total Cypriot endemics) (Kounnamas & Andreou 2022). Lastly, it has been classified as one of the 13 "Plant Diversity Hot Spots" in the Mediterranean (Hadjipanayiotou 2019b).

Sampling surveys took place at the "Chrysovrysi" linear trail, which extends for ca. 1.5 km, with its starting point just outside of the Amiantos village and ending point approaching the Amiantos Mines. These sampling surveys were realized at specific spatial intervals of 100 m, while alternating left and right, from the previous recording to the next one and they were 18 in number.

Koilada Kedron - Kampos

The area of "Koilada Kedron - Kampos" (Fig. 1.c) is located in the central part of Pafos forest, it occupies an area of 18258 ha, on the diabase rocks of the Troodos ophiolite (Hadjipanayiotou 2017a). Pafos Forest, extends from small altitudes near sea level, to altitudes reaching 1352 m (Tripylos peak). In the greater area of the Pafos forest, the mean yearly rainfall is 1060 mm, the mean daily maximum temperature (August) and the mean daily minimum temperature (December) are 33.6 °C and 3.9 °C respectively (PLANT-NET CY Project, n.d.). *Pinus brutia* forests constitute the dominant vegetation of "Koilada Kedron - Kampos", as they cover ca. 86% of the area (PLANT-NET CY Project, n.d.), however 12 other habitat types can be found there as well, like the endemic habitat type 9590* (*Cedrus brevifolia* forests) (Christodoulou & al. 2017).

The site of "Koilada ton Kedron-Kampos" has an extensive natural habitat that hosts a large number of species of plants and animals (Hadjipanayiotou 2017a). The endemic species *Cedrus brevifolia* forms the endemic priority habitat type 9590*, which only grows in the Forest of Paphos, on the Troodos Mountain range (Christodoulou & al. 2017). The site hosts 36 plants that are endemic to Cyprus, three of which are listed in Annex II Dir. 92/43/EEC: *Ranunculus kykkoensis*, *Phlomis cypria* and *Arabis kennedyae* (PLANT-NET CY Project, n.d.; Hadjipanayiotou 2017a).

Sampling surveys took place at the part of the European E4 trail that traverses the site "Koilada Kedron - Kampos". This portion of the trail extends for ca. 6 km. These sampling surveys were realized at specific spatial intervals of 600 m, while alternating left and right, from the previous recording to the next one and they were 16 in number.

Machairas Forest

Machairas Forest (Figure 1d) occupies an area of 4428 ha, it extends from an altitude of 400 m to an altitude of 1423 m (Kionia peak) (Hadjipanayiotou 2019a), and it consists of igneous rocks of the Troodos ophiolite and in particular,of the sheeted dyke complex (diabase) (Tsintides & al. 2012). Pure *Pinus brutia* stands, dominate starting from the lowest altitudes up to the peak of Kionia. Precipation at Machairas Forest spans from 446 mm to 707 mm, whereas the mean daily temperatures are 30.5 °C and 3.6 °C, for August (hottest month) and December (coldest month) respectively (Hadjipanayiotou 2019a).

The continuous, well-preserved, and natural forest ecosystems and the great variety of habitats within them, highlight the site's ecological importance (Hadjipanayiotou 2019a). This site hosts 280 plant taxa, out of which 226 are indigenous (13% of the total indigenous flora of the island) and out of which 42 are endemics (29% of the total endemic flora of the island) (Tsintides & al. 2012). Lastly, it hosts almost the entirety of the population of the threatened plant species *Crocus hartmaniannus* (Hadjipanayiotou 2019a). Field surveys at the Machairas Forest took place at the most accessible spots, due to the accessibility restriction caused by very steep slopes.

Figures 1a, 1b, 1c and 1d were produced using QGIS software and shapefiles with all NATURA 2000 sites which were obtained from the European Environment Agency and the Greek Biotope/Wetland Centre (EKBY).

Plant Surveying Methodology

Field surveys to sample the plant species composition of communities with *Quercus alnifolia* at field scale were performed during May to September of 2020 and April to June of 2021, adapted from the Braun-Blanquet approach (Braun-Blanquet 1964, 1979; Rivas-Martínez 2005; Biondi 2011; Pott 2011). Thirty-six sampling plots were surveyed at the trails while alternating left and right, from the previous recording to the next one. In fact, recordings were made at specific spatial intervals different for each study area, as described in the above subsections. Recordings didn't only take place at these equidistant positions within the trails, but also at places where differentiations in plant composition (or coverage) of the communities were observed. At every place of recording, four corners were set, so as to have the exact coordinates of the sampling area and each sampling area had a surface of 100 m^2.

In order to collect easy-to-use data from the field concerning to the regeneration of *Quercus alnifolia* and the existence of individuals of different age, the vertical structure of the vegetation, was also investigated and partitioned as follows. The tree layer was divided by height into the classes T_1: 20-35 m, T_2: 10-20 m, T_3: 5-10 m and T_4: 0.5-5 m. The shrub layer was divided by height into the classes S_1: 2-5 m, S_2: 1-2 m and S_3: 0.1-1 m. The herb layer was not divided by height, and it includes plant taxa without woody parts, up to a height of one meter. Data recorded in situ at the sampling areas include plant cover, exposure, altitude, incline, chance of encountering stones and gravel, the degree of anthropogenic intervention, the height of vegetation layers, the cover of individual vegetation floors and finally, the degree to which the soil consists of fine grains.

Two hundred ninety-one specimens of plant taxa were collected, dried, and identified. The identification process was mostly carried out using the dichotomous key for plant genera provided by the Flora of Cyprus website (https://flora-of-cyprus.eu/), together with Flora of Cyprus (Meikle 1977, 1985). Data concerning vascular plants nomenclature and life-forms (phanerophytes (P), chamaephytes (Ch), hemicryptophytes (H), geophytes (G) and therophytes (T)) follow: Dimopoulos & al. (2013, 2016, https://portal.cybertaxonomy.org/flora-greece/intro), Stavrou & al. (2008), Flora of Israel Online (https://flora.org.il/en/en/) and Crivellaro (2012).

Results

All data concerning to the plant species composition of communities with *Quercus alnifolia* and the abiotic information for each sampling plot are included in the Electronic Supplementary File 1: Tables S1 and S2. Table S1 presents the vertical structure of the vegetation and reveals the dynamic conservation status of *Q. alnifolia* since very young and young individuals of *Quercus alnifolia* were present on almost all the plots (on the shrub and herb layers) and ESF1: Table S2 presents a global table with all plant taxa registered on each sampling plot and their coverage. The number of taxa registered on each sampling plot is between 8 and 33 (mean number 19.4). The dominant trees height was 10m-35m (mean height 24.7m) on the sampling plots of the "Chrysovrysi" trail of the National Forest Park of Troodos, 5m-30m (mean height 14.6m) on the sampling plots of the European E4 trail of the site "Koilada Kedron - Kampos" and 3m-6m (mean height 4.5m) on the sampling plots of "Machairas Forest".

Quercus alnifolia communities, recorded across the 36 sampling plots include 107 plant taxa, belonging to 57 families and 91 genera. Among these taxa there are 14 endemic (13.3%) plants, belonging to 11 families and 13 genera. The richest families for all taxa recorded, are *Asteraceae*, *Fabaceae*, *Lamiaceae*, *Poaceae*, *Brassicaceae* and *Rubiaceae* (Fig. 2). These families represent 10.5% of the families and 42% of the taxa registered on all the sampling plots (Fig. 2). For the endemic taxa, the richest is the family of *Lamiaceae* (29%).

Concerning to the life forms of all the taxa registered, therophytes predominate with 35% followed by phanerophytes (26%) and hemicryptophytes (22%) (Fig. 3). There are differences on these proportions regarding the three areas of the sampling plots since phanerophytes are represented by 35% on "Chrysovrysi" trail and 24% on the other two areas, hemicryptophytes by 27% on "Chrysovrysi" trail and 16-19% on the other two areas, as also therophytes are represented by 18% on the sampling plots of "Chrysovrysi" trail, but 44% and 39% on "Koilada Kedron - Kampos" and on "Machairas Forest", respectively.

The frequency of appearance of the different taxa on the sampling plots of Table S2, is presented on ESF1: Fig. S1. *Quercus alnifolia* may dominate or coexist on the sampling areas together with the tree species *Pinus brutia* or the Cyprus endemic *Cedrus brevifolia.* Among the taxa recorded with high to medium frequency of appearance on the sampling plots are also *Rubia tenuifolia, Arbutus andrachne, Cistus creticus, C. salviifolius,* the endemics *Pterocephalus multiflorus, Thymus integer, Rubia laurae, Scutellaria cypria, Arenaria rhodia* subsp. *cypria,* etc. Additionally, Table 1 presents the 14 endemic taxa recorded on the sampling plots and their frequency of appearance on them.

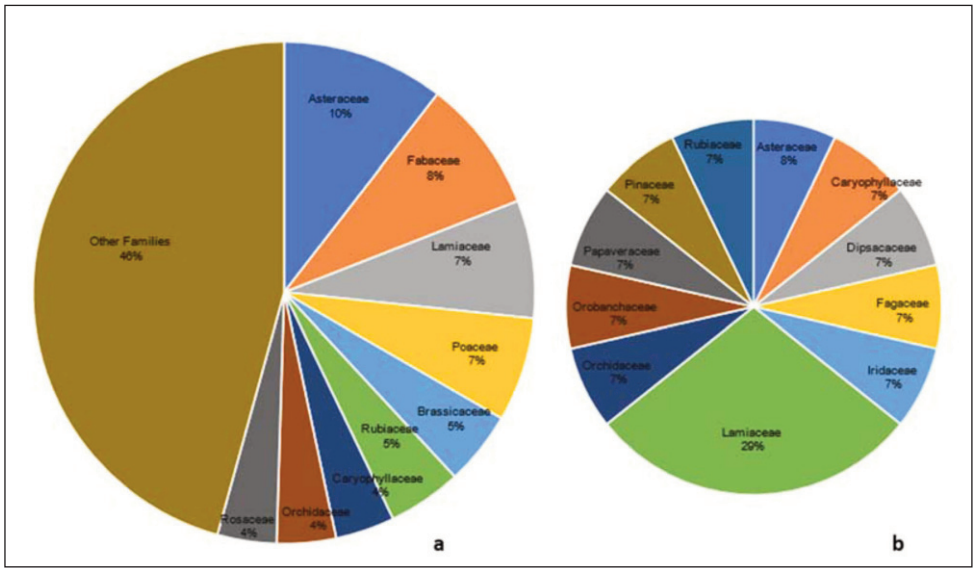

Fig. 2. Taxonomic richness by Family, including all taxa (**a**) and endemic taxa (**b**).

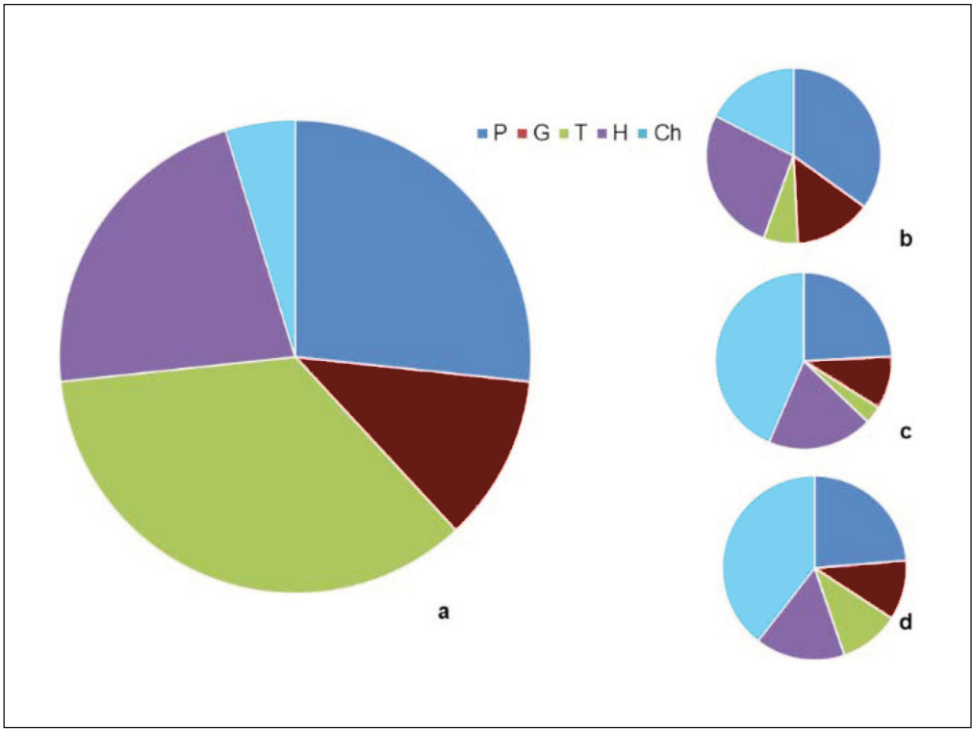

Fig. 3. Life form spectrum of all taxa recorded across **a**. all three study areas, **b**. the National Forest Park of Troodos, **c**. the site "Koilada Kedron - Kampos" and d. Machairas Forest. Abbreviations: P = phanerophytes, Ch = chamaephytes, H = hemicryptophytes, G = geophytes and T= therophytes.

Discussion

The island of Cyprus is a part of the Mediterranean Basin Biodiversity Hotspot (Myers & al. 2000), and it is characterized by great biodiversity, as well as a high endemism rate (Şekerciler & Ketenoğlu 2019). This study focused on the Cyprus national tree, the emblematic Cyprus endemic *Quercus alnifolia* and the composition of the plant communities with *Q. alnifolia* at elevations ranging from 1070 m to 1380 m, in three NATURA 2000 areas. The inventory of the composition and structure, together with the existing knowledge, is very important for the monitoring of the conservation status of its populations and of the *Q. alnifolia* dominated communities that form the endemic and priority habitat type 9390 included in Annex I of the Directive 92/43/EEC.

The conservation status of the plant communities with *Quercus alnifolia* on the studied areas, roughly examined in this study, seems to be favourable. Exceptional natural regeneration was observed for the species, where individuals of different age and seedlings were detected across almost all sampling plots that this species was recorded in. Pressures affecting the plant communities of *Q. alnifolia* on the areas studied, are of low intensity and are mainly related to visitors' recreational activities and garbage dumping. It is also

Table 1. Cyprus endemic taxa recorded on the sampling plots, their life-form, the sampling area they were found in (National Forest Park of Troodos, "Koilada Kedron - Kampos" and/or Machairas Forest) and their frequency of appearance on the sampling plots (%).

Family	Taxon	Life-form	Recorded in present study	
			Sampling Area	Frequency (%)
Asteraceae	*Lactuca cyprica* (Rech. f.) N. Kilian & Greuter	H	KKK	11.1
Caryophyllaceae	*Arenaria rhodia subsp. cypria* (Holmboe) McNeill	T	All sampling areas	19.4
Dipsacaceae	*Pterocephalus multiflorus* Poech	T	NFP & MF	50
Fagaceae	*Quercus alnifolia* Poech	P	All sampling areas	100
Iridaceae	*Gladiolus triphyllus* (Sm.) Ker-Gawl.	G	NFP & KKK	8.3
Lamiaceae	*Thymus integer* Griseb.	P	NFP & KKK	25
Lamiaceae	*Scutellaria cypria* Rech.f.	H	All sampling areas	22.2
Lamiaceae	*Scutellaria cypria* subsp. *elatior* (Meikle) Hand	H	All sampling areas	13.9
Lamiaceae	*Mentha longifolia* subsp. *cyprica* (Heinr. Braun) Harley	H	KKK	2.8
Orchidaceae	*Epipactis troodi* H. Lindb.	G	KKK	2.8
Orobanchaceae	*Odontites cyprius* Boiss.	C	NFP	5.5
Papaveraceae	*Papaver paphium* M. V. Agab. & al.	T	KKK	5.5
Pinaceae	*Cedrus brevifolia* (Hook. f.) A. Henry	P	KKK	8
Rubiaceae	*Rubia laurae* (Holmboe) Airy Shaw	H	NFP	8

noteworthy that about 9.2% of Cyprus' endemics plants can be found on the area studied taking part on the structure of the communities with *Q. alnifolia*.

Quercus alnifolia can colonize remote rocky slopes with high inclination and *Q. alnifolia* communities contribute to soil stabilization and erosion prevention and establish extensive life-friendly environments in areas where other tree species can't survive (Rivas-Martinez 2005; Sotiriou 2010; Loizides 2011). The number of plant taxa registered on each sampling plot differs, with a mean number of 19 taxa, decreasing when the inclination of the plot and tree/shrub coverage are higher and augmenting when the inclination and the tree/shrub coverage are lower as was expected according *Q. alnifolia* communities' ecology.

Plant diversity is considerable at the family, genera, species level and in terms of life forms. Sotiriou & Gerasimidis (2009) mentioned reduced proportions of therophytes in sampling plots from their phytosociological study on the National Forest Park of Troodos, a result similar to the results of this study, where therophytes have a percentage of 18% since phanerophytes and hemicryptophytes predominate with 62%. Stavrou & al. (2008) in their research on the site "Koilada – Kedron Kampos" found that therophytes was the dominant life-form (49.76%), which is the case for this study as well (44%), however the proportions of phanerophytes and hemicryptophytes together are lower than those of the National Forest Park of Troodos and represent 43% of the taxa recorded. It's important to state that therophytes are quite abundant in these forests and this fact enhances the probability of forest areas being more interventioned or perturbed, and that the lower frequency of nanophanerophytes reflects a problematic around land use changes, that drive vegetation from the climaxic stages.

The presence of pre-forest mantles with *Arbutus andrachne*, *Crataegus monogyna* and some climbing taxa like *Asparagus acutifolius, Rubia* sp.pl.*, Rubus sanctus, Smilax aspera, Clematis cirrhosa* etc. enhances the forest typology and near-climax dynamics. This is incremented also by the presence of trees like *Acer obtusifolium, Cedrus brevifolia, Juniperus oxycedrus* subsp*. oxycedrus, Prunus* sp. pl., etc. The debate around being an edaphoxerophile vegetation series is also notorious by the presence of taxa like *Pistacia terebinthus, Quercus calliprinos* and the frequency of low shrubs like *Cistus* sp. pl. It is fundamental to mention that communities with *Quercus alnifolia* follow the edaphoxerophile concept of vegetation series brought by Rivas-Martinez (2005) since forest association and vegetation series of *Querco alnifoliae - Crepidetum fraasii* are related with the ultrabasic soils habitat and the climax of an edaphoxerofile series inside the geoseries complex. This complex includes the forest of *Q. boissieri* (*Anagyro foetidae- Quercetum boissieri*) in the bottom slope where there are well developed soils with no ecological limitations, while the *Querco alnifoliae - Crepidetum fraasii* is positioned alongside the also edaphoxerophile *Cedrus brevifolia* and *Pinus brutia* forests where they get intermixed in substrate permutations. Milios & al. (2021) mentioned the rare for Europe and the mediterranean, climax communities of the two Cyprus endemics *C. brevifolia* and *Q. alnifolia.* They proposed the development of silvicultural treatments for the conservation of the narrow Cyprus endemic *C. brevifolia* natural formations, also to areas where groups of *Q. alnifolia* sprouts (multi-stemmed plants) and seedlings – saplings of *Cedrus brevifolia* growing in most cases under the above and side shade of *Q. alnifolia*, with respect to both species' ecology. The development of site index curves for classification of *Q.alnifolia* trees to site qualities could be useful for the rational management and monitoring of natural habitats of the species (Petrou & al. 2015).

Detailed studies of plant communities' composition and structure contribute to the conservation planning of shrublands and forest ecosystems (Stavrou & al. 2008). The most ecologically important endemic species of Cyprus and a rare endemic relict with low genetic diversity (Vitelli & al. 2017), *Quercus alnifolia,* and its habitat type are unique in Europe and the Mediterranean. The need to monitor these forests and their intrinsic floristic diversity, seems to be a gap in the Mediterranean vegetation survey recent scenario and for this reason further and continuous studies, concerning monitoring and assessment of the conservation status of the species populations and plant communities, for their sustainable conservation, are crucial.

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References

Anagiotos, G., Tsakaldimi, M., & Ganatsas, P. 2012: Variation in acorn traits among natural populations of *Quercus alnifolia*, an endangered species in Cyprus. – Dendrobiology **68**: 3-10.

Andreou, M., Kadis, K., Georghiou, K., Koutsovoulou, K. & Thanos, C. A. 2010: Monitoring plan for the Plant Micro-Reserve of the habitat type '*9390 Scrub and Low Forest Vegetation of *Quercus alnifolia'* at the Natura 2000 site 'Koilada Kedron-Kampos'. – Athens.

Barbero, M. & Quézel, P. 1979: Contribution à l'étude des groupements forestiers de Chypre. – Doc. Phytosociol. **4:** 9-35.

— & — 1989: Contribution á l'étude phytosociologique des matorrais de Méditerranée orientale. Lazaroa **11:** 37-60.

Biondi E. 2011: Phytosociology today: Methodological and conceptual evolution. – Pl. Biosyst. **145:** 19-29. https://doi.org/10.1080/11263504.2011.602748

Blondel, J. & Aronson, J. 1999: Biology and wildlife of the Mediterranean region. – Oxford.

Braun-Blanquet J. 1964: Phlanzensoziologische, 3°ed. – Wien.

—1979: Fitosociología: Bases para el estudio de las comunidades vegetales [Phytosociology: bases for the study of plant communities]. – Madrid.

Brullo, S., Minissale, P. & Spampinato, G. 1997: La classe *Cisto-Micromerietea* nel Mediterraneo centrale ed orientale. – Fitosociologia **32:** 29-60.

—, Giusso del Galdo, G. & Guarino, R. 2001: The orophilous communities of the Pino-Juniperetea class in the Central and Eastern Mediterranean area. – Feddes Repert. **112(3/4):** 261-308.

—, — & — 2005: The orophilous dwarf-shrub vegetation of Mt Troodos (Cyprus). – Bot. Chronika **18(1):** 63-73.

Camus, A. 1938: Les chênes. Monographie du genre *Quercus*, **1.** – Paris.

Christodoulou, A., Papageorgiou, K., Makris, M., Tsintidis, T. & Xanthopoulos, G. 2017: Fire Protection Plan of the habitat 9590*. Project: LIFE15 NAT/CY/000850. – Athens [in Greek].

Costa, M., Géhu, J.-M., Peris, G. B., Biondi, E. & Arnold, N. 1984: Sobre la vegetacion termomediterranea litoral de la isla de Chipre. – Doc. Phytosociol., n. s., **8:** 365-376.

Crivellaro, A. 2012: Wood, bark and pith structure in trees and shrubs of Cyprus: anatomical descriptions and ecological interpretation. – PhD thesis, Univ. Padova.

Danin, A. & Fragman- Sapir, O. 2016: Flora of Israel Online. – https://flora.org.il/en/plants/ [Last accessed 10.9.2022]

Denk, T. & Grimm, G. W. 2010: The oaks of western Eurasia: Traditional classifications and evidence from two nuclear markers. – Taxon **59(2):** 351-366.

Dimopoulos, P., Raus, Th., Bergmeier, E., Constantinidis, Th., Iatrou, G., Kokkini, S., Strid, A. & Tzanoudakis, D. 2013: Vascular plants of Greece: An annotated checklist. – Englera **31:** 1-372.

EUR27–European Commission 2007: Interpretation manual of European Union habitats.

European Environment Agency. Natura 2000 End 2020 – Shapefile. Issued: 2021-07-23, Denmark: https://www.eea.europa.eu/data-and-maps/data/natura-12/natura-2000-spatial-data/natura-2000-shapefile-1 [Last accessed 10/9/2022]

FloraVeg.EU – Database of European Flora and Vegetation. – www.floraveg.eu [Last accessed 9/10/2022]

Game and Fauna Service & Ministry of Interior 2016: Management Plan of SPA Area "National Forest Park of Troodos". – Nicosia [in Greek].

Géhu J. M. 2006: Dictionnaire de Sociologie et Synecologie végétales [Dictionary of Vegetal Sociology and Synecology]. – Berlin-Stuttgart.

— & Rivas-Martínez S. 1981: Notions fondamentales de phytosociologie [Fundamental Notions of Phytosociology]. – Pp. 203-234 in: Dierschke, H. (ed.), Syntaxonomie. Vaduz: Berichte Internationalen Symposien der Internationalen Vereinigung fur Vegetationskunde. – Vaduz.

—, Costa M. & Uslu T. 1990: Analyse phytosociologique de la végétation littorale des cotes de la partie Turque de l'ile de Chypre dans un souci conservatoire. – Doc. Phytosociol. **12:** 203-234.

Gorener, V. & Beech, E. 2017: *Quercus alnifolia*. *The IUCN Red List of Threatened Species* 2017: e.T194053A2295358. https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T194053A2295358.en. Accessed on 13 March 2022.

Greek Biotope/Wetland Centre 2020: NATURA 2000 Sites of Type B (SCI, SAC) of Cyprus http://185.17.146.157/layers/geonode:cy_natura_2000_ type_b/metadata_detail [Last accessed 10/9/2022]

Hadjipanayiotou C. 2017a: NATURA 2000 - STANDARD DATA FORM: KOILADA KEDRON - KAMPOS. Department of Environment. https://natura2000.eea.europa.eu/ Natura2000 /SDF.aspx?site=CY2000008[Last accessed 10/9/2022]

— 2017b: N2K CY2000006 standard dataforms—DASOS PAFOU (NATURA 2000 - STANDARD DATA FORM - DASOS PAFOU). Department of Environment. https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=CY2000006 [Last accessed 10/9/2022]

— 2019a: NATURA 2000 - STANDARD DATA FORM: DASOS MACHAIRA. https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=CY2000004 [Last accessed 10/9/2022]

— 2019b: NATURA 2000 - STANDARD DATA FORM: ETHNIKO DASIKO PARKO TROODOUS. Department of Environment. https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=CY5000004#top [Last accessed 10/9/2022]

Hand R., Hadjikyriakou G. N. & Christodoulou C. S. (eds) 2011: (continuously updated): Flora of Cyprus – a dynamic checklist. – http://www.flora-of-cyprus.eu/ [Last accessed 10/9/2022]

— , — & — 2019: Updated numbers of the vascular flora of Cyprus including the endemism rate. – Cypricola **13:** 1-6.

Hipp, A. L., Manos, P. S., Hahn, M., Avishai, M., Bodénès, C., Cavender-Bares, J., Crowl, A. A., Deng, M., Denk, T., Fitz-Gibbon, S., Gailing, O., González-Elizondo, M. S., González-Rodríguez, A., Grimm, G.W., Jiang, X.-L., Kremer, A., Lesur, I., McVay, J. D., Plomion, C., Rodríguez-Correa, H., Schulze, E.-D., Simeone, M. C., Sork, V. L. and Valencia-Avalos, S. 2020: Genomic landscape of the global oak phylogeny. – New Phytol. **226(4):** 1198-1212.

Kadis C., Pantazi Chr., Tsintides T., Christodoulou S. C., Thanos C. A., Georghiou K., Kounnamas C., Constantinou C., Andreou M. & Eliades N.-G. 2010: Establishment of a Plant Micro-reserve Network in Cyprus for the Conservation of Priority Species and Habitats. 1st International Bi-communal Conference on Biodiversity holding in Cyprus: 'TOP Biodiversity',Threats, Opportunities and Paces for Biodiversity, 3rd - 4th June. – Larnaca.

Kounnamas, C. & Andreou, M. 2022: Mapping and assessment of ecosystem services at Troodos National Forest Park in Cyprus. – One Ecosystem **7:** e77584.

Loizides, M. 2011: *Quercus alnifolia*: the indigenous Golden Oak of Cyprus and its fungi. – Field Mycology **12(3):** 81-88.

Mazaraki, S., Andreou, M. & Kadis, K. 2013: Educational Material – Project JUNIPERCY. – Nicosia. (In Greek)

Meikle, R. D. 1977: Flora of Cyprus, **1.** – Kew.

— 1985: Flora of Cyprus, **2.** – Kew.

Menickij, Ju. L. 1984: Duby Asii. – Leningrad.

Milios, E., Petrou, P., Pytharidis, K., Christou, A. K. & Eliades, N.-G.H. 2021: Assessment of How Natural Stand Structure for Narrow Endemic *Cedrus brevifolia* Henry Supports Silvicultural Treatments for Its Sustainable Management. – South-east Eur. For. **12(1):** 21-34.

Mucina, L., Bültmann, H., Dierßen, K., Theurillat, J. P., Raus, T., Čarni, A., Šumberová, K., Willner, W., Dengler, J., Gavilán García, R., Chytrý, M., Hájek, M., Di Pietro, R., Lakushenko, D., Pallas, J., Daniëls, F. J. A., Bergmeier, E., Santos Guerra, A., Ermakov, N., Valachovič, M.,

Schaminée, J. H. J. ysenko, T., Didukh, Y. P., Pignatti, S., Rodwell, J. S., Capelo, J., Weber, H. E., Solomeshch, A., Dimopoulos, P., Aguiar, C., Hennekens, S. M. & Tichý L. 2016: Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. – Appl. Veg. Sci. **19(Suppl. 1):** 3-264.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A. & Kent, J. 2000: Biodiversity hotspots for conservation priorities. – Nature **403(6772):** 853-858.

Neophytou, C., Dounavi, A., Fink, S., & Aravanopoulos, F. A. 2011: Interfertile oaks in an island environment: I. High nuclear genetic differentiation and high degree of chloroplast DNA sharing between *Q. alnifolia* and *Q. coccifera* in Cyprus. A multipopulation study. – Europ. J. For. Res. **130(4):** 543-555.

Petrou, P., Kitikidou, K., Milios, E., Koletta, J. & Mavroyiakoumos, A. 2015: Site index curves for the golden oak species (*Quercus alnifolia*). – Bosque **36(3):** 497-503.

PLANT-NET CY Project. (n.d.). Scrub and low forest vegetation of Quercus alnifolia, *9390 - Establishment of a Plant Micro-reserve Netwrok in Cyprus for the Conservation of Priority Species and Habitats. Establishment of a Plant Micro-Reserve Network in Cyprus for the Conservation of Priority Species and Habitats. – http://www.plantnet.org.cy/scrub_and_low_forest_vegetation_of_quercus_alnifol-1.html [Last accessed 19/3/2022]

Poech, J. 1842: Enumeratio plantarum hucusque cognitarum insulae Cypri. – Charleston SC.

Pott R. 2011: Phytosociology – A modern geobotanical method. – Pl. Biosyst. 145: 9-18. https://doi.org/10.1080/11263504.2011.602740

Preislerová, Z., Jimenez-Alfaro, B., Mucina, L., Berg, C., Bonari, G., Kuzemko, A., Landucci, F., Marcenò, C., Monteiro-Henriques, T., Novák, P., Vynokurov, D., Bergmeier, E., Dengler, J., Apostolova, I., Bioret, F., Biurrun, I., Campos, J., Capelo, J., Čarni, A., Çoban, S., Csiky, J., Ćuk, M., Ćušterevska, R., Daniëls, F. J.A., De Sanctis, M., Didukh, Y., Dítě, D., Fanelli, G., Golovanov, Y., Golub, V., Guarino, R., Hájek, M., Iakushenko, D., Indreica, A., Jansen, F., Jašková, A., Jiroušek, M., Kalníková, V., Kavgacı, A., Kucherov, I., Küzmič, F., Lebedeva, M., Loidi, J., Lososová, Z., Lysenko, T., Milanović, Đ., Onyshchenko, V., Perrin, G., Peterka, T., Rašomavičius, V., Rodríguez-Rojo, M. P., Rodwell, J. S., Rūsiņa, S., Sánchez-Mata, D., Schaminée, J. H. J., Semenishchenkov, Y., Shevchenko, N., Šibík, J., Škvorc, Ž., Smagin, V., Stešević, D., Stupar, V., Šumberová, K., Theurillat, J., Tikhonova, E., Tzonev, R., Valachovič, M., Vassilev, K., Willner, W, Yamalov, S., Večeřa, M. & Chytrý, M. 2022: Distribution maps of vegetation alliances in Europe. – Appl. Veg. Sci. **25(1):** e12642. https://doi.org/10.1111/avsc.12642

QGIS Development Team 2021: QGIS Geographic Information System. – http://qgis.osgeo.org [Last accessed 10/9/2022]

Rivas-Martinez, S. 2005: Notions on dynamic-catenal phytosociology as a basis of landscape science. – Pl. Biosyst. 1**39(2):** 135-144. https://doi.org/10.1080/11263500500193790

Rivas-Martinez, S., Penas, Á., del Río, S., Sánchez Mata, D. & Díaz González, T. E. 2014: Biogeographic map of Europe. Third concise advance. – I Congreso de la Sociedad Española de Geobotánica (Gijón, 9-11 julio, 2014).

Şekerciler, F. & Ketenoğlu, O. 2019: Phytosociological study of forest, maquis and coastal vegetation of Karpaz Peninsula (Cyprus Island). – Phytocoenologia **49(3):** 287-307.

Sotiriou, A. 2010: Phytosociological Research of the National Forest Park of mountain Troodos of Cyprus. – PhD diss., Aristotle University of Thessaloniki [In Greek].

Sotiriou, A., & Gerasimidis, A. 2009: Contribution to the phytosociological research of *Pinus nigra* forests of the Troodos Mountain of Cyprus. – Pp. 308-313 in: Ivanova, D. (ed.), Plant, fungal and habitat diversity investigation, and conservation. Proceedings of IV Balkan Botanical Congress, 20–26 June 2006. – Sofia.

Stavrou, N., Voskarides, K., & Karagiannakidou, V. 2008: Floristic composition and phytogeographical research on the endemic *Cedrus brevifolia* forests in Cyprus. – Fl. Medit. **18:** 149-170.

Schwarz, O. 1936: Entwurf zu einem natürlichen System der Cupuliferen und der Gattung *Quercus* L. – Notizblatt Bot. Gart. Mus. Berlin-Dahlem, 1-22.

Tsintides, T., Alexandrou, C., Charalambous, A., Koutalianos, A., Christou, A., Loizou, L., Papageorgiou, K., Papadopoulos, M., Nicolaou, K., Georgiou, G., Christodoulou, A., Siamarias, N., Papachristoforou, T., Mesimeris, E., Aristokleous, G., Christodoulou, C., Constantinou, G., Kiriakou, T., Nicolaou, C., Kakouris, H., Papasavas, K., Nicolaides, M., Cleanthous, N. & Pitharides, K. 2012: Management Plan of National Forest Park of Machairas. February 2012: Department of Forests, Nicosia. http://natura.environment.moa.gov.cy/sxedia/CY2000004P.pdf [in Greek].

Vitelli, M., Vessella, F., Cardoni, S., Pollegioni, P., Denk, T., Grimm, G. M. & Simeone, M. C. 2017: Phylogeographic structuring of plastome diversity in Mediterranean oaks (*Quercus* Group *Ilex*, *Fagaceae*). – Tree Genetics Genomes **13:** 3. https://doi.org/10.1007/s11295-016-1086-8

Wagensommer, R. P. 2017: Phytosociological investigation on the thermo-chasmophilous vegetation of the Eastern Mediterranean territories. – Phd Thesys, University of Catania.

Willner, W., Theurillat, J.- P., Pallas, J. & Mucina, L. 2015. On the nomenclature of some high-rank syntaxa of European forest vegetation. – Phytocoenologia **45:** 175-181.

Xofis, P., Konstantinidis, P., Papadopoulos, I. & Tsiourlis, G. 2020: Integrating remote sensing methods and fire simulation models to estimate fire hazard in a south-east mediterranean protected area. – Fire **3(3):** 31.

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