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New contribution on the vascular flora of the Aegean Island of Chalki (Archipelago of Rhodes, Aegean Sea)

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ABSTRACT

This note is an integration to the study, started in August 2014, of the vascular flora of the Island of Chalki. Special emphasis has been done on the chasmophytic flora which has shown a remarkable richness in terms of endemic species, common to the island and to the SE Aegean Sea, including the west coast of Turkey. Some limestone north-facing cliffs, located on the northern and southern sides of Chalki, have been investigated. It has been tried to develop a reasoned reading on the micro-distribution of the chasmophytic flora of Chalki, taking into account parameters such as morphology of the cliffs, altitude, solar radiance, grazing. Grazing has especially proved a substantial factor, that has affected on confinement of some species in inaccessible sites such *Erica manipuliflora* Salisb. (Ericaceae) and *Medicago arborea* L. (Fabaceae), which are not necessarily chasmophytic species. The almost exclusive finding of chamaephytes and hemicryptophytes in these types of habitats characterized by extreme edaphoclimatic conditions, showed the remarkable specialization as well as the rarity of these species.

KEY WORDS

Chalki; chasmophytic flora; grazing; suffruticose chamaephyte; vertical cliffs.

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INTRODUCTION

The Aegean Island of Chalki is part of the Dodecanese Archipelago (SE Aegean); is located between the islands of Rhodes (SW), Tilos (SE) and Karpathos (NE). Its geographical coordinates are: 36°13'44.49" N; 27°34'18.74" E. Has a length of 10 km, a width of 4 km and an area of 28,125 km² (Fig. 1). Administratively Chalki is part of Rhodes Regional Unit. The Municipality of Chalki includes several uninhabited offshore islands like Alimia, Krevati, Nisaki, Kolofona, Pano Prasouda, Trag-

ousa, Strongyli, Agios Theodoros, Maelonisi (Iliadis, 1950).

Chalki appears as a mountainous and rocky island, consisting mainly of massive and hard limestone, ceroid limestone (that give rise to rendzinas) and siliceous limestone (Desio, 1923; 1924a; 1924b; 1928). The highest peak is represented by Mount Profitis Ilias (578 m). The coastline is very articulate and rich in gorges and steep limestone cliffs mainly in the north and southsides. The island is essentially arid, and lacks of superficial hydrography with an extremely low presence of under-

ground water. The climate of Chalki is dry and warm with strong northern winds. The absence of a weather station on the island, did not allow the elaboration of climate data. The first botanical researches on Chalki were made during the 19th century, starting with Mayor & Barbey (1894). Investigations of Rechinger (1943) Rechinger & Rechinger (1951) and of the zoologist Werner followed. An important contribution to the knowledge of Chalki's flora was given by Carlström (1987), in a study project on the flora and phytogeography of SE Greece and SW Turkey. To Tzanoudakis & Kollmann (1991) is referred the discovery of a new species for the island: *Allium chalki*. Also in the same year Rackham & Vernicos (1991) studied the ecological history and future perspectives of Chalki. Finally, the investigations carried out by Biel & Tan (2009), led to the discovery of some new taxa for the island. Recently was published a contribution on orchid flora of Chalki, where is described a new species for the island: *Ophrys chalkae* (Hirth & Spaeth, 2010).

MATERIAL AND METHODS

For detecting altitude and geographic coordinates has been used a satellite tracking device Garmin

GPS III Plus. The names of the local places mentioned in the text, faithfully follow the map of Chalki produced by Anavasi (2008).

The floristic data presented in this article come from collections and field observations made by the authors in Chalki in two different times: in August 2014 and April 2015. The field investigations carried out in April, lasted four days. It was possible integrate the previous checklist, relatively modest, due to the extreme drought of the research period. For the data collected in August 2014 see Cattaneo & Grano (2015). Specimens of the collected species are deposited in the herbarium of the authors: Cattaneo (HCC). For the determination of plant material was mainly used Rechinger (1943, 1949), Rechinger & Rechinger (1951), Davis (1965-1988), Tutin et al. (1964-1980, 1993), Pignatti (1982), Strid & Tan (1997, 2002, 2009), Lafranchis & Sfikas (2009), Dimopoulos et al. (2013).

For the taxonomic-nomenclatural definition of the taxa have been taken into consideration Greuter et al. (1984-1989), Dimopoulos et al. (2013) and the database "Euro + MedPlantbase (<http://www.emplantbase.org/home.html>). The division and the denomination of the families were taken from Dimopoulos et al. (2013). In the vascular plant inventory families, genera and species are in al-

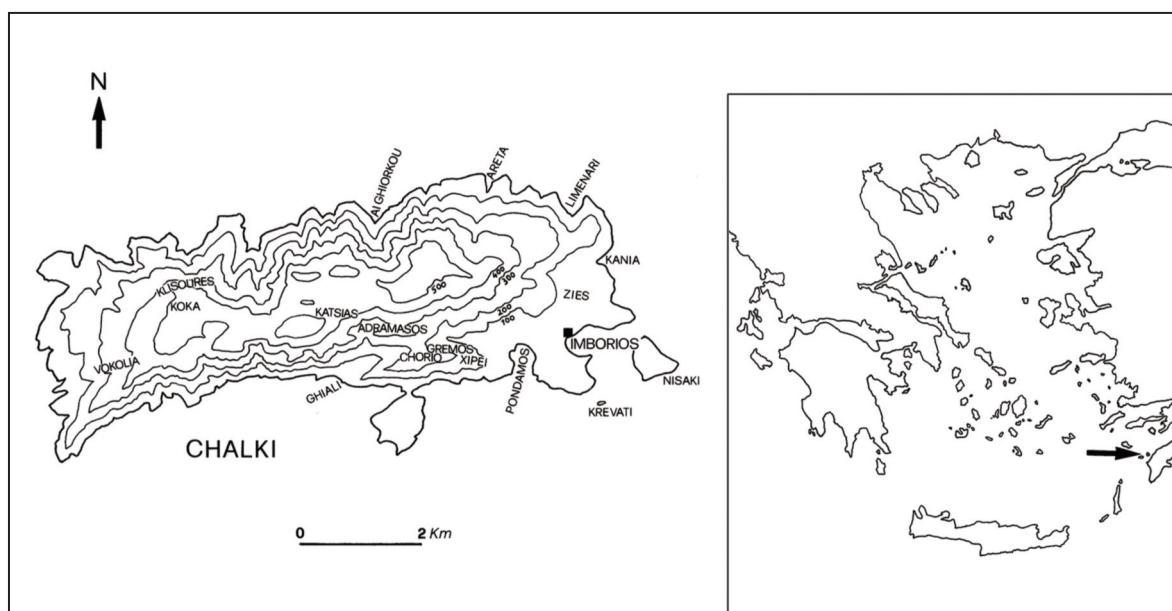


Figure 1. Map of Chalki Island, Archipelago of Rhodes, Aegean Sea.

ABBREVIATION	CHOROLOGICAL CATEGORY	CHOROLOGICAL CATEGORY DESCRIPTION
BK	Balkan	Taxa restricted to Balkan countries, occasionally extending to adjacent parts of SE Europe
BI	Balkan-Italian	Taxa restricted to Balkan countries and Italy
BA	Balkan-Anatolian	Taxa restricted to Balkan countries and to Asia minor (Anatolia), occasionally extending to S Ukraine (Crimea) adjacent Caucasian countries (Georgia, Armenia) or N Iraq
EM	E Mediterranean	Taxa restricted to the E Mediterranean, occasionally extending to S Italy or adjacent Caucasian countries
WM	W Mediterranean	Taxa restricted to the W Mediterranean, extending to eastern countries
Me	Mediterranean	Taxa with a circum-Mediterranean distribution including Portugal, occasionally extending to the Caucasus area and N Iran
MA	Mediterranean-Atlantic	Taxa restricted to maritime W Europe and the Mediterranean
ME	Mediterranean-European	Taxa restricted to the Mediterranean and temperate Europe, occasionally extending to NW Africa and the Caucasus area
MS	Mediterranean-SW Asian	Taxa distributed in one or more Mediterranean countries and extending to SW and C Asia
Eu	European	Taxa with a distribution all over Europe
EA	European-SW Asian	European taxa (occasionally reaching N Africa) with a distribution extending to SW Asia, occasionally reaching C Asia
ES	Euro-Siberian	Taxa with main distribution in temperate Eurasia (occasionally reaching the Caucasus area)
Pt	Paleotemperate	Taxa of extratropical Eurasia including the Himalaya and E Asia, not (or at most marginally) extending to North America
ST	Subtropical-Tropical	Taxa widespread in the warmer regions of both hemispheres
Co	Cosmopolitan	Taxa distributed in all continents
Endem.	Endemic	Taxa with a distribution restricted to the territory of Greece
Neotrop.	Neotropical	Taxa with wide distribution
Pantrop.	Pantropical	Taxa with wide distribution

Table 1. Chorological categories used in the checklist (extrapolated by Dimopoulos et al., 2013).

phabetical order. Life-form categories are based on Raunkiaer (1934), while chorological types (Table 1) are based mainly on information provided by Dimopoulos et al. (2013). Plant species introduced on the island were divided into cultivated (CULT), casual (CAS), naturalized (NAT) and invasive (INV). Where possible is provided an estimate of the local frequency of taxa listed by the initials F (= frequently), R (= rare) and L (= localized). The species collected in the second time, are marked in the floristic inventory by an asterisk (*).

RESULTS

As previously mentioned (Cattaneo & Grano, 2015), Chalki looks like a calcareous island, with a maximum height that do not exceed 600 m above sea level and with few flat areas located in the central part of the island. Probably the most interesting aspect of the island is given by vertical cliffs of massive limestone and deep gorges along the coastline, except for the oriental side. The presence of these vertical cliffs allowed the growth of a rare and highly specialized chasmophytic flora. Several species are endemic with a distribution area limited to the island and to the SE Aegean, including W Turkey. The rest of the island is characterized by a kind of flora essentially phryganic with prevalence of chamaephytes and nano-phanerophytes, as *Sarcocapnos spinosum*, *Salvia fruticosa*, *Origanum onites*, *Thymbra capitata*, *Teucrium capitatum*, *Euphorbia characias* and *E. dendroides*.

Phanerophytes are almost absent or otherwise restricted to the areas used to olive and oak cultivation. The vegetation of the vertical limestone cliffs on the coastline and in the interior, is characterized by a prevalence of chamaephytes, hemicryptophytes and, lastly, of geophytes. It has been observed that the distribution of the saxatile flora, is closely related to several factors including: nature and morphology of the rocky habitats; altitudinal gradient; presence or absence of solar radiation; grazing.

Therefore it was made a distinction between: A) Species found only in the crevices of limestone vertical cliffs north-facing and shady, at altitudes between 300 and 400 m above sea level; B) Species observed either on vertical cliffs, or on sloping limestone rocks, at altitudes between 100 and 300 m above sea level, with partial exposition to solar

radiance; C) Chasmophytic species that grow among different kind of rocks, at altitudes below 100 m, which present heterogeneous requirements of solar radiation (Table 2).

Investigated sites

During the second botanical survey carried out in April 2015, were examined more carefully cliffs located on north side of Chalki in the sites of Klisoures, Kamenos Spilios, Areta and cliffs located in the south of the island in sites of Pano and Kato Gremos. These cliffs have shown a remarkable floristic richness in terms of endemics. However, at the time of the investigation several species had not yet reached blooming, so the identification was not possible. Many chasmophytic species, in fact, developed adaptive strategies in harsh environments, such as an increased lignification and delay in reaching the reproductive stage, enabling them greater longevity (Davis, 1951).

Klisoures and Kamenos Spilos

The north-facing limestone cliffs of Klisoures, are characterized by a considerable verticality. They are located a bit interior from the north coastline and reach altitudes of about 500 m above sea level. They are almost constantly in shadow and exposed to strong northerly winds. There is a small presence of sheep and goats grazing due to the too steep environment. Suffruticose chamaephyte is the dominant life form and, thereafter, the scapose hemicryptophyte.

The therophytes are scarce, except for a prevalence of procumbent therophytes, while geophytes have a limited distribution exclusively among the ledges. These cliffs of Klisoures host a very interesting chasmophytic flora, characterized by endemics and relic species, all concentrated at an altitude between 400 and 500 m. These data confirm what is reported in literature, namely in the Aegean islands there's an increase of endemics in the thermo-mediterranean zone between 0 and 600 m above sea level (Georghiou & Delipetrou, 2010).

The plant communities in Klisoures are rather fragmented, with individuals spaced from each other, factor that probably involves a negligible radical competition (Davis, 1951). As said before the predominant life form is suffruticose chamae-

CHASMOPHYTIC SPECIES	CAT. A	CAT. B	CAT. C
<i>Asplenium burgaei</i>			*
<i>Asplenium ceterach</i>			*
<i>Cystopteris fragilis</i>			*
<i>Allosurus acrosticus</i>			*
<i>Anogramma leptophylla</i>			*
<i>Selaginella denticulata</i>			*
<i>Crithmum maritimum</i>			*
<i>Hellenocarum multiflorum</i>	*		
<i>Seseli crithmifolium</i>	*		
<i>Centaurea lactucifolia</i>		*	
<i>Helicrysum orientale</i>	*	*	
<i>Inula verbascifolia</i>	*	*	
<i>Lactuca viminea</i>		*	*
<i>Phagnalon rupestre</i> subsp. <i>graecum</i>		*	*
<i>Ptilostemon chamaepeuce</i>	*	*	
<i>Scorzonera cretica</i>	*		
<i>Fibigia lunarioides</i>		*	
<i>Matthiola incana</i>		*	
<i>Campanula delicatula</i>			*
<i>Campanula hagielia</i>		*	
<i>Capparis spinosa</i>			*
<i>Arenaria deflexa</i>		*	
<i>Cerastium comatum</i>		*	
<i>Dianthus fruticosus</i> subsp. <i>rhodius</i>	*		
<i>Paronychia macrosepala</i>			*
<i>Silene fruticosa</i>		*	
<i>Rosularia serrata</i>		*	*
<i>Sedum litoreum</i>		*	*
<i>Umbilicus albido-opacus</i>		*	
<i>Umbilicus rupestris</i>		*	*
<i>Cephalaria squamiflora</i>	*		

CHASMOPHYTIC SPECIES	CAT. A	CAT. B	CAT. C
<i>Erica manipuliflora</i>	*		
<i>Medicago arborea</i>	*		
<i>Ballota acetabulosa</i>	*	*	*
<i>Micromeria juliana</i>		*	*
<i>Origanum calcaratum</i>	*		
<i>Origanum onites</i>	*	*	*
<i>Rhamnus lycioides</i> subsp. <i>oleoides</i>	*	*	*
<i>Asperula tournefortii</i>	*		
<i>Galium canum</i> subsp. <i>ovatum</i>	*	*	
<i>Valantia hispida</i>		*	*
<i>Verbascum propontideum</i>	*	*	
<i>Parietaria cretica</i>		*	*
<i>Cymbalaria microcalyx</i>	*	*	
<i>Cymbalaria longipes</i>	*	*	

Table 2. Chasmophytic species found in the Aegean Island of Chalki (Archipelago of Rhodes).

- Category A: species found only in the crevices of limestone vertical cliffs north-facing and shady, at altitudes between 300 and 400 m above sea level.
- Category B: species observed either on vertical cliffs, or on sloping limestone rocks, at altitudes between 100 and 300 m above sea level, with partial exposition to solar radiance.
- Category C: chasmophytic species that grow among different kind of rocks, at altitudes below 100 m, which present heterogeneous requirements of solar radiation.

phyte. The woodiness of these pioneer plants is a strategy and an adaptive response to physical and environmental stress. Such structure provides higher longevity to these species subject to extreme edaphoclimatic conditions (barren and rocky soil, strong wind, etc.). Most of the chasmophytic species observed in Klisoures are located in not reachable positions from grazing. This is, doubtless, an essential element for understanding the micro-distribution of the chasmophytes in these rocky sites and in general the macro-distribution of Chalki's flora (Cattaneo & Grano, 2015). On these cliffs were found three specimens of *Erica manipuliflora*,

element normally characterizing the Greek phrygana, but not detected in Chalki in previous investigations. The exclusive presence of this species only in this site, indicates that through the years the selective pressure made from grazing was critical in Chalki, which would have confined this species, as well as other taxa, in sites difficult to reach by animals. Probably *Erica manipuliflora* in previous times had a wider distribution in the island, while at present it is almost extinct. It might be expected such a theory also concerning *Medicago arborea*, whose presence in Chalki is limited to very few individuals exclusively among the overhanging rocks of the Kamenos Spilios (cave located east of Klisoures at 396 m above sea level; coordinates: 36°13' 89"N; 27°32'47"E).

Regarding taxa found among the cliffs of Klisoures, were confirmed chasmophytic species observed in August of 2015 such as: *Asperula tournefortii*, *Cephalaria squamiflora*, *Dianthus fruticosus* subsp. *rhodius*, *Galium canum* subsp. *ovatum* (Fig. 2), *Helicrysum orientale*, *Inula verbascifolia*, *Origanum calcaratum*, *Seseli crithmifolium*, *Cymbalaria microcalyx* (Fig. 3), *Ptilostemon chamaepeuce*, *Verbascum propontideum*. To these were added *Cymbalaria longipes*, *Hellenocarum multiflorum*, *Cerastium comatum*, *Scorzonera cretica*, *Valeriana asarifolia* (Cattaneo, 2015). This kind of saxatile flora is setting up ravines and crevices of limestone rocks formed from atmospheric agents. On the other hand, in the ledges and into the pockets of land formed in the cavities of the rock, grows a chomophytic vegetation (bulbous geophytes) whose most characteristic species are: *Urginea maritima*, *Gagea graeca*, *Umbilicus rupestris*, *Umbilicus albido-opacus*, *Allium subhirsum*, *Asphodelus fistulosus*, *A. ramosus*, etc...

In fact, within the ledges they accumulate debris forming a layer very shallow, not suitable for the establishment of species with deep roots, but suitable for the development of geophytes (Davis, 1951).

Areta

Areta looks like a deep gorge on the northern side of the island, highly beaten by northern winds. It is constituted by limestone cliffs that are located at lower altitude (100-200 m) than those of Klisoures. These cliffs are also characterized by strong verticality and, therefore, by scarce accessibility.

The eastern face of the gorge of Areta is totally in shadow, while the western face is partly exposed to the sunlight and has a certain degree of slope. The difficulty of investigation in this site did not allow to obtain an exhaustive overview of the chasmophytic species found there and a quali-quantitative analysis of life forms. The western face, the only accessible, has a certain degree of slope and insolation.

There have been found several procumbent endemic therophytes of SE Aegean Sea, as *Arenaria* sp., *Cerastium comatum* and procumbent and pulvinate chamaephytes as *Cymbalaria longipes* (Fig. 4), *Cymbalaria microcalyx*, *Galium canum*, *Anogramma leptophylla*. Chasmophytic species, such as *Campanula hagielia*, *Inula verbascifolia*, *Scorzonera cretica* (Fig. 5), *Ptilostemon chamaepeuce*, *Rosularia serrata* were also present, whose growth or existence is not restricted by solar radiance. Suffruticose chamaephytes and scapose hemicryptophytes observed with relative frequency on the shady cliffs of Klisoures such as *Asperula tournefortii*, *Cephalaria squamiflora*, *Origanum calcaratum*, *Seseli crithmifolium*, *Verbascum propontideum*, *Hellenocarum multiflorum*, here have not been found. As stated Davis (l.c.), the angle of slope is critical, since it directly affects the sunlight and the amount of rain that can be more or less absorbed by the soil (the more the angle is sloped the least water will be absorbed). In this regard it is also very important the exposure of a cliff. North-facing rocks will have a degree of sunlight almost irrelevant compared to northwest-facing rocks. These factors inevitably influence the distribution of chasmophytic community.

It is said that the north-west cliff of Areta presents a degree of sunlight, promoting the rooting of some chasmophytic species more heliophilous at the expense of other more shade-tolerant. Also the wind on this site has probably more impact than in the interior, and this fact could promote the growth of plant organisms with procumbent and pulvinate features. Finally, it was noted a more intense grazing, that may have played a decisive role in the presence or absence of certain species.

Pano and Kato Gremos

The north-facing limestone cliff placed in Pano and Kato Gremos are located on the southern side

of Chalki. Have various angles of slope and different exposure to the solar radiance. They reach an altitude of 200 m above sea level. Only on this site was found *Centaurea lactucifolia* (Fig. 6), exclusive endemic of some islands of the E Aegean including Rhodes and Chalki. It is an obligatory chasmo-

phyte, a probably relic of the Pliocene chasmophytic flora (Carlström, 1986). There is a significant polymorphism between the populations of *Centaurea lactucifolia*, which seems to be related to the different environments of the cliff where it grows. Therefore studying the populations of Chalki and



Figures 2–7. Vascular flora of Chalki Island. Fig. 2. *Galium canum* subsp. *ovatum*. Fig. 3. *Cymbalaria microcalyx*. Fig. 4. *Cymbalaria longipes*. Fig. 5. *Scorzonera cretica*. Fig. 6. *Centaurea lactucifolia*. Fig. 7. *Verbascum propontideum*.

Rhodes, the species above was split in *Centaurea halkensis* Mayor et Barbey (Chalki) and *Centaurea chorionensis* Hoffm.-Grob et Beauverd (Rhodes). However the lack of a real discontinuity between morphological variants, prevented the subdivision of the taxon at issue (Carlström, 1986). Most of the chasmophytic plants found on this site are suffructicose chamaephytes and scapose hemicryptophytes. Have been validated species observed in August 2014 including: *Centaurea lactucifolia*, *Phagnalon rupestre* subsp. *graecum*, *Ptilostemon chamaepeuce*, *Verbascum propontideum* (Fig. 7), *Helicrysum orientale*, *Inula verbascifolia*, *Oriaganum onites*. In addition are reported: *Silene fruticosa*, *Campanula hagielia*, *Matthiola incana*, *Fibigia lunarioides*, *Cymbalaria longipes*, *C. microcalyx*, *Scorzonera cretica*.

Vascular plant inventory of Chalki

The vascular plant inventory here presented, includes 225 taxa of which 104 have been added with the latest research carried out on the island.

PTERIDOPHYTAE

Family ASPLENIACEAE

**Asplenium burgaei* Milde - H ros - EM - L

Previous citations: Carlström (1987: 45)

**Asplenium ceterach* L. - H ros - EA - L

Previous citations: Carlström (1987: 45).

Family CYSTOPTERIDACEAE

**Cystopteris fragilis* (L.) Bernh. - H caesp - Co - R

Family PTERIDACEAE

**Adiantum capillus-veneris* L. - G rhiz - ST - R

**Allosurus acrosticus* (Balb.) Christenh. - G rhiz - Me - L

Previous citations: Carlström (1987: 44, sub *Cheilanthes acrostica* (Balb.) Tod.).

**Anogramma leptophylla* (L.) Link - T caesp - Co - R

Family SELAGINELLACEAE

**Selaginella denticulata* (L.) Spring - Ch rept - Me - L

Previous citations: Carlström (1987: 44).

GYMNOSPERMAE

Family CUPRESSACEAE

Cupressus sempervirens L. - P scap - CULT

Previous citations: Carlström (1987: 46).

Juniperus phoenicea L. - P scap - Me - L

Previous citations: Carlström (1987: 46).

Family PINACEAE

Pinus brutia Ten. - P scap - Me - L

Previous citations: Carlström (1987: 46).

ANGIOSPERMAE

Family AGAVACEAE

Agave americana L. - P caesp - CAS

Family AIZOACEAE

Aptenia cordifolia (L. f.) Schwantes - Ch suffr - CAS

Carpobrotus edulis (L.) N. E. Br. - Ch suffr - CAS

**Mesembryanthemum nodiflorum* L. - T scap - CAS

Previous citations: Carlström (1987: 63).

Family ALLIACEAE

**Allium subhirsutum* L. - G bulb - Me - L

Family AMARANTHACEAE

Amaranthus deflexus L. - H scap - CAS

Previous citations: Biel et Tan (2009: 434).

Amaranthus hybridus L. - T scap - CAS

Previous citations: Biel et Tan (2009: 434).

Family AMARYLLIDACEAE

Pancratium maritimum L. - G rhiz - Me - R

Family ANACARDIACEAE

Pistacia atlantica Desf. - P scap - MS - L

Previous citations: Carlström (1987: 67).

Pistacia lentiscus L. - P scap - Me - L

Previous citations: Carlström (1987: 67).

Pistacia terebinthus L. - P scap - Me - CULT

Schinus molle L. - P scap - CULT

Family APIACEAE

**Cachrys cristata* DC. - H scap - Me - F

Previous citations: Carlström (1987: 83).

Crithmum maritimum L. - Ch suffr - ME - L

Previous citations: Carlström (1987: 84).

- Ferula communis*** L. subsp. ***glauca*** (L.) Rouy et Camus - H scap - Me
Previous citations: Carlström (1987: 84).
****Foeniculum vulgare*** Mill. - H scap - Me
Previous citations: Carlström (1987: 83).
****Hellenocarum multiflorum*** (Sm.) H. Wolff - H scap - Me - L
****Lagoecia cuminoides*** L. - T scap - ME
Previous citations: Carlström (1987: 82).
****Scaligeria napiformis*** (Spreng.) Grande - H scap - EM
Previous citations: Carlström (1987: 82, sub *S. cretica* (d'Urv.) Vis.).
Seseli crithmifolium (DC.) Boiss. - H scap - Endem. - R
Smyrnium perfoliatum L. - H bienn - ME - L
****Tordylium apulum*** L. - T scap - Me
Previous citations: Carlström (1987: 84).
****Torilis leptophylla*** (L.) Rchb. f. - T scap - EA
- Family APOCYNACEAE
Nerium oleander L. - P caesp - Me - R
- Family ARACEAE
Dracunculus vulgaris Schott - G rhiz - Me
Previous citations: Carlström (1987: 117).
- Family ARECACEAE
Phoenix canariensis Chabaud - P scap - CULT
Phoenix theophrasti Greuter - P scap - EM - L
Previous citations: Rackham & Vernicos (1991).
- Family ASPARAGACEAE
Asparagus aphyllus L. subsp. ***orientalis*** (Baker) P.H. Davis - G rhiz - EM
Previous citations: Carlström (1987: 117).
- Family ASPHODELACEAE
****Asphodelus fistulosus*** L. - G rhiz - Me
Previous citations: Carlström (1987: 118).
****Asphodelus ramosus*** L. - G rhiz - Me
Previous citations: Carlström (1987: 118).
- Family ASTERACEAE
****Anthemis arvensis*** L. - T scap - Co
****Anthemis chia*** L. - T scap - Me - L
Previous citations: Carlström (1987: 90).
****Anthemis rigida*** Heldr. - T scap - EM - L
- Previous citations: Carlström (1987: 89).
****Asteriscus aquaticus*** (L.) Less. - T scap - ME - R
Atractylis cancellata L. - T scap - Me
Previous citations: Carlström (1987: 93).
Carlina corymbosa L. - H scap - Me - F
Previous citations: Carlström (1987: 93).
Carlina tragacanthifolia Klatt - H scap - EM - R
Previous citations: Carlström (1987: 93).
Carthamus dentatus (Forssk.) Vahl - T scap - Me
Carthamus lanatus L. - T scap - Me
Centaurea lactucifolia Boiss. - H scap - Endem. - R
Previous citations: Rechinger (1951: 164); Carlström (1987: 92).
****Cichorium pumilum*** Jacq. - T scap - MS
Previous citations: Carlström (1987: 94).
****Crupina crupinastrum*** (Moris) Vis. - T scap - EA
Previous citations: Carlström (1987: 92).
Dittrichia viscosa (L.) Greuter - Ch scap - Me
Echinops spinosissimus Turra - H scap - Me - F
Previous citations: Carlström (1987: 93).
Erigeron canadensis L. - T scap - NAT
****Geropogon hybridus*** (L.) Sch. Bip. - T scap - Me
Previous citations: Carlström (1987: 94).
****Glebionis coronaria*** (L.) Spach - T scap - Me
Previous citations: Carlström (1987: 90, sub *Chrysanthemum coronarium* L.).
****Glebionis segetum*** (L.) Fourr. - T scap - Me
Previous citations: Carlström (1987: 90, sub *Chrysanthemum segetum* L.).
Helichrysum orientale (L.) Vaill. - H scap - EM - L
Previous citations: Major & Barbey in Rechinger (1943: 613); Carlström (1987: 88).
****Helichrysum stoechas*** (L.) Moench - Ch suffr - Me - L
Previous citations: Carlström (1987: 87).
****Hyoseris scabra*** L. - T ros - Me
Previous citations: Carlström (1987: 94).
Inula verbascifolia (Willd.) Hausskn. - Ch suffr - BI - F
****Lactuca viminea*** (L.) J. Presl et C. Presl - H bienn - Pt - R
Lactuca serriola L. - H scap - Pt
Previous citations: Carlström (1987: 95).
Notobasis syriaca (L.) Cass. - T scap - Me
Previous citations: Carlström (1987: 91).
Pallenis spinosa (L.) Cass. - T scap - Me
Previous citations: Carlström (1987: 87).
Phagnalon rupestre L. (DC.) subsp. ***graecum*** (Boiss. et Heldr.) Batt. - Ch suffr - Me
Previous citations: Carlström (1987: 87).

- Picnomon acarna** (L.) Cass. - H scap - Pt - F
Ptilostemon chamaepeuce (L.) Less. - Ch frut - EM - L
 Previous citations: Carlström (1987: 91).
***Scorzonera cretica** Willd. - H scap - Endem. - R
 Previous citations: Carlström (1987: 94).
***Scorzonera elata** Boiss. - H scap - EM
 Previous citations: Carlström (1987: 94).
Senecio vulgaris L. - T scap - Pt
Sonchus arvensis L. - H scap - ES
***Sonchus asper** (L.) Hill - H bienn - Pt
 Previous citations: Carlström (1987: 95).

Family BERBERIDACEAE

- *Leontice leontopetalum** L. - H scap - MS
 Previous citations: Carlström (1987: 48)

Family BORAGINACEAE

- *Anchusa aegyptiaca** (L.) A. DC. - T scap - EM - L
 Previous citations: Carlström (1987: 102).
Echium parviflorum Moench - T scap - Me
 Previous citations: Carlström (1987: 103).
Heliotropium hirsutissimum Grauer - T scap - EM
 Previous citations: Carlström (1987: 101).

Family BRASSICACEAE

- *Biscutella didyma** L. - T scap - Me
 Previous citations: Carlström (1987: 51).
***Fibigia lunarioides** (Willd.) Sweet - Ch suffr - Endem. - R
 Previous citations: Carlström (1987: 51).
***Hirschfeldia incana** (L.) Lagr.-Foss. - T scap - EA
 Previous citations: Carlström (1987: 50).
***Malcolmia nana** (DC.) Boiss. - T scap - MS - R
***Matthiola incana** (L.) R. Br. in W.T. Aiton - Ch suffr - ME - L
 Previous citations: Carlström (1987: 53).
***Matthiola sinuata** (L.) R. Br. in W.T. Aiton - H scap - ME - L
***Sinapis arvensis** L. - T scap - ES
 Previous citations: Carlström (1987: 50).

Family CACTACEAE

- Opuntia ficus-indica** (L.) Mill. - Ch suffr - Neotrop.

Family CAESALPINIACEAE

- Ceratonia siliqua** L. - P scap - Me - R

Previous citations: Carlström (1987: 67).

Family CAMPANULACEAE

- *Campanula delicatula** Boiss. - T scap - EM - L
 Previous citations: Carlström (1987: 67).
***Campanula drabifolia** Sm. in Sibth. et Sm. - T scap - EM - L
***Campanula hagielia** Boiss. - H scap - EM - L
 Previous citations: Carlström (1987: 67).
***Legousia pentagonia** (L.) Druce - T scap - EM
 Previous citations: Carlström (1987: 67).

Family CAPPARACEAE

- Capparis spinosa** L. - NP - Me - L
 Previous citations: Carlström (1987: 54)

Family CARYOPHYLLACEAE

- Arenaria deflexa** Decne. - T rept - EM - R
 Previous citations: Carlström (1987: 55).
Arenaria cf. luschanii Mc Neill - T rept - EM - R
***Cerastium comatum** Desv. - T rept - EM - R
 Previous citations: Carlström (1987: 57).
Dianthus fruticosus L. subsp. *rhodius* (Rech. f.) Runemark - Ch suffr - Endem. - R
 Previous citations: Carlström (1987: 58).
***Paronychia macrosepala** Boiss. - H caesp - EM - L
 Previous citations: Carlström (1987: 60).
***Polycarpon tetraphyllum** (L.) L. - T scap - MS
 Previous citations: Carlström (1987: 57).
***Silene fruticosa** L. - Ch suffr - Me - R
 Previous citations: Carlström (1987: 59).
***Silene sedoides** Poir. - T scap - Me - L
 Previous citations: Carlström (1987: 59).

Family CHENOPODIACEAE

- Salsola tragus** L. - T scap - Pt / Co
 Previous citations: Carlström (1987: 62, sub *S. kali* L. subsp. *tragus* (L.) Nyman).

Family CISTACEAE

- *Cistus creticus** L. - NP - Me - R
***Fumana arabica** (L.) Spach - Ch suffr - Me
 Previous citations: Carlström (1987: 54).
***Fumana thymifolia** (L.) Webb - Ch suffr - Me
 Previous citations: Carlström (1987: 54).

Family CONVOLVULACEAE

- **Convolvulus althaeoides* L. - H scand - Me
Previous citations: Carlström (1987:100).
Convolvulus elegantissimus Mill. - H scand - Me
*i_C*Convolvulus scammonia* L. - H scand - EM
Previous citations: Carlström (1987: 100).
*i_C*Cuscuta planiflora* Ten. - T par - Me
Previous citations: Carlström (1987:101).
Ipomoea indica (Burm.) Merr. - G rhiz - Pantrop.

Family CRASSULACEAE

- Rosularia serrata* (L.) A. Berger in Engl. et Prantl - Ch succ - EM - R
Previous citations: Carlström (1987: 81).
*i_C*Sedum litoreum* Guss. - T scap - Me - F
Previous citations: Carlström (1987: 81).
*i_C*Umbilicus albido-opacus* Carlström - G bulb - Endem. - R
Previous citations: Carlström (1987: 81).
Umbilicus rupestris (Salisb.) Dandy - G bulb - MA - F

Family CUCURBITACEAE

- **Bryonia cretica* L. - H scand - EM
Previous citations: Carlström (1987: 80).
Ecballium elaterium (L.) A. Rich. - G bulb - MS

Family DIPSACACEAE

- Cephalaria squamiflora* (Sieber) Greuter - Ch suffr - Me - R
*i_C*Knautia integrifolia* (L.) Bertol. - T scap - Me - F
Previous citations: Carlström (1987: 86)

Family ERICACEAE

- Erica manipuliflora* Salisb. - Ch suffr - Me - R

Family EUPHORBIACEAE

- Andrachne telephiooides* L. - Ch suffr - MS
Chrozophora tinctoria (L.) A. Juss. - T scap - MS
*i_E*Euphorbia acanthothamnos* Heldr. et Sartori ex Boiss. - Ch frut - EM - L
Previous citations: Carlström (1987: 112).
Euphorbia chamaesyce L. - T rept - ME
Euphorbia characias L. - NP - Me - F
Euphorbia dendroides L. - NP - Me - F
Euphorbia nutans Lag. - T caesp - L - CAS
Previous citations: Biel & Tan (2009: 435, sub *Chamaesyce nutans* (Lag.) Small.).
*i_E*Euphorbia peplus* L. - T scap - Co
Previous citations: Carlström (1987: 113).

- **Euphorbia valerianifolia* Lam. - T scap - EM - R
Previous citations: Carlström (1987: 112).
Ricinus communis L. - P scap - CULT

Family FABACEAE

- Anagyris foetida* L. - P scap - Me - F
Previous citations: Carlström (1987: 67).
*i_H*Hippocratea biflora* Spreng. - T scap - MS
Medicago arborea L. - P caesp - Me - R
*i_T*Trifolium campestre* Schreb. in Sturm - T scap - EA
Previous citations: Carlström (1987: 72).
*i_T*Trigonella corniculata* (L.) L. subsp. *balansae* (Boiss. et Reut.) Lassen - T scap - EM
Previous citations: Carlström (1987: 74, sub *Trigonella balansae* Boiss. et Reut.).

Family FAGACEAE

- Quercus coccifera* L. - P caesp - Me - R
Quercus ilex L. - P caesp - Me - L

Family GENTIANACEAE

- **Centaurium tenuiflorum* (Hoffmanns. et Link) Fritsch - T scap - ME
Previous citations: Carlström (1987: 99).

Family GERANIACEAE

- **Geranium robertianum* L. - T scap - Co
Previous citations: Carlström (1987: 65).

Family HYACINTHACEAE

- Drimia aphylla* (Forssk.) J.C. Manning et Goldblatt - G bulb - EM - F
Previous citations: Carlström (1987: 119, sub *Urginea maritima* (L.) Baker).
*i_M*Muscari comosum* (L.) Mill. - G bulb - ME
*i_O*Ornithogalum narbonense* L. - G bulb - Me

Family HYPERICACEAE

- Hypericum empetrifolium* Willd. - Ch suffr - EM - L

Family IRIDACEAE

- **Iris germanica* L. - G rhiz - EA - L
Previous citations: Carlström (1987: 122).

Family LAMIACEAE

- Ballota acetabulosa* (L.) Benth. - Ch frut - BA - F
Previous citations: Carlström (1987: 107).

**Lamium moschatum* Mill. - T scap - EM

Previous citations: Carlström (1987: 107).

**Marrubium vulgare* L. - H scap - EA

Previous citations: Carlström (1987: 108).

Mentha spicata L. - H scap - EA - L

Micromeria juliana (L.) Rchb. - Ch suffr - Me - F

Previous citations: Carlström (1987: 109, sub *Satureja juliana* L.).

Origanum calcaratum Juss. - Ch suffr - Endem. - R

Previous citations: Carlström (1987: 108).

Origanum onites L. - Ch suffr - Me - F

Previous citations: Carlström (1987: 108).

**Prasium majus* L. - Ch frut - Me

Previous citations: Carlström (1987: 107).

Salvia fruticosa Mill. - Ch frut - EM - F

Previous citations: Carlström (1987: 109).

**Salvia verbenaca* L. - H scap - MA

Previous citations: Carlström (1987: 109).

**Salvia viridis* L. - T scap - Me

Previous citations: Carlström (1987: 109).

Satureja thymbra L. - Ch frut - Me

Teucrium capitatum L. - Ch suffr - Me - L

Previous citations: Carlström (1987: 106, sub *T. polium* L.).

Thymbra capitata (L.) Cav. - Ch suffr - Me - F

Previous citations: Carlström (1987: 109, sub *Coridothymus capitatus* (L.) Reichb. fil.).

Family LILIACEAE

**Gagea graeca* (L.) Irmisch - G bulb - BA

Previous citations: Carlström (1987: 121).

Family LINACEAE

**Linum strictum* L. - T scap - Me

Previous citations: Carlström (1987: 65).

Family MALVACEAE

**Malva cretica* Cav. - T scap - Me

Previous citations: Carlström (1987: 64).

**Malva neglecta* Wallr. - T scap - EA

Previous citations: Carlström (1987: 64).

Family MELIACEAE

Melia azedarach L. - P scap - CULT

Family MIMOSACEAE

Acacia cyanophylla Lindley - P scap - CULT

Acacia retinoides Schlecht. - P scap - CULT

Family MORACEAE

Ficus carica L. - P scap - CULT

Ficus retusa L. - P scap - CULT

Family MYRTACEAE

Eucaliptus camaldulensis Dehnh. - P scap - CULT

Family OLEACEAE

Olea europaea L. var. *europaea* - P scap - CULT

Family ORCHIDACEAE

**Anacamptis pyramidalis* (L.) Rich. - G bulb - Eu

Previous citations: Carlström (1987: 124); Hirth & Spaeth (2010: 593).

**Anacamptis sancta* (L.) R.M. Bateman, Pridgeon et M.W. Chase - G bulb - EM

Previous citations: Carlström (1987: 124, sub *Orchis sancta* L.).

Family OROBANCHACEAE

**Orobanche pubescens* d'Urv. - T par - Me

Previous citations: Carlström (1987: 106).

**Phelipanche mutelii* (F.W. Schultz) Pomel - T par - Pt

Family OXALIDACEAE

Oxalis corniculata L. - H rept - Pt / Co

**Oxalis pes-caprae* L. - G bulb - CAS

Family PAPAVERACEAE

Glaucium flavum Crantz - H scap - ME - R

Previous citations: Carlström (1987: 48).

**Papaver apulum* Ten. - T scap - BI

**Papaver rhoeas* L. - T scap - Pt

Previous citations: Carlström (1987: 49).

Family PLANTAGINACEAE

Plantago albicans L. - H ros - Me

Previous citations: Carlström (1987: 111).

**Plantago coronopus* L. - H ros - MA - F

Previous citations: Carlström (1987: 110).

Family POACEAE

Andropogon distachyos L. - H caesp - ST - F

Previous citations: Major & Barbey in Rechinger (1943: 808); Carlström (1987: 135).

**Avena barbata* Link in Schrad. - T scap - Me
Previous citations: Carlström (1987: 129).

**Avena fatua* L. - T scap - MS

Avena sterilis L. - T scap - MS

Previous citations: Carlström (1987: 129).

Briza maxima L. - T scap - ST

Previous citations: Carlström (1987: 133).

Bromus madritensis L. - T scap - MS

Previous citations: Carlström (1987: 129).

Hordeum murinum L. - T scap - MS

Hyparrhenia hirta (L.) Stapf - H caesp - ST - F
Previous citations: Carlström (1987: 135).

Lagurus ovatus L. - T scap - Me

Previous citations: Carlström (1987: 130).

Paspalum distichum L. - G rhiz - Neotrop.

Setaria pumila (Poir.) Roem. et Schult. - T scap - Co

Family POLYGALACEAE

**Polygala venulosa* Sm. - H scap - EM

Family POLYGONACEAE

**Rumex bucephalophorus* L. subsp. *aegaeus*
Rech. f. - T scap - EM

**Rumex pulcher* L. - H scap - MS

Previous citations: Carlström (1987: 61).

**Rumex tuberosus* L. subsp. *creticus* (Boiss.)
Rech. f. - G bulb - EM

Family PORTULACACEAE

Portulaca oleracea aggr. - T scap - Co

Family POSIDONIACEAE

Posidonia oceanica (L.) Delile - I rad - Me

Family PRIMULACEAE

Anagallis arvensis L. - T rept - Co

Previous citations: Carlström (1987: 98).

Cyclamen graecum Link - G rhiz - EM

Family PUNICACEAE

Punica granatum L. - P scap - CULT

Family RANUNCULACEAE

Delphinium staphisagria L. - T scap - Me - L

Previous citations: Carlström (1987: 46).

Family RHAMNACEAE

Rhamnus lycioides L. subsp. *oleoides* (L.) Jahand.
& Maire - NP caesp - Me

Previous citations: Carlström (1987: 67, sub *R. oleoides* L. subsp. *oleoides*).

Family ROSACEAE

Prunus dulcis (Mill.) D.A. Webb - P scap - CULT
Sarcopoterium spinosum (L.) Spach - NP - EM - F
Previous citations: Carlström (1987: 79).

Family RUBIACEAE

Asperula tournefortii Spreng. - Ch suffr - EM
Previous citations: Carlström (1987: 115).

Galium canum Req. ex DC. subsp. *ovatum* Ehrend.
- Ch rept - Endem. - L

Previous citations: Carlström (1987: 115).

**Thelionum cynocrambe* L. - Me - T scap

Previous citations: Carlström (1987: 63).

**Valantia hispida* L. - T scap - Me

Previous citations: Carlström (1987: 116).

Family RUTACEAE

Ruta chalepensis L. - Ch suffr - Me

Family SCROPHULARIACEAE

**Verbascum mallophorum* Boiss. et Heldr. in Boiss.
- H bienn - BI

Verbascum propontideum Murb. - Ch suffr - EM - L
Previous citations: Major & Barbey in Rechinger (1943: 468); Hoffmann-Grobety in Rechinger (1943: 468); Rechinger & Rechinger (1951: 163); Carlström (1987: 103).

Verbascum sinuatum L. - H bienn - MS

Family SOLANACEAE

Hyoscyamus albus L. - H bienn - Me

Previous citations: Carlström (1987: 103).

Nicotiana glauca R.C. Graham - P scap - NAT

Previous citations: Carlström (1987: 103).

Solanum nigrum L. - T scap - CAS

Family TAMARICACEAE

Tamarix sp.

URTICACEAE

Parietaria cretica L. - T rept - EM

Previous citations: Carlström (1987: 113).

Parietaria judaica L. - H scap - EA

**Urtica pilulifera* L. - T scap - MS

Previous citations: Carlström (1987: 113).

Family VALERIANACEAE

Centranthus ruber (L.) DC. - Ch suffr - Me

**Valeriana asarifolia* Dufr. - H scap - R (first record for Chalki).

Family VERBENACEAE

Vitex agnus-castus L. - P caesp - MS

Previous citations: Carlström (1987: 106).

Family VERONICACEAE

Antirrhinum majus L. - Ch frut - WM

Cymbalaria microcalyx (Boiss.) Wettst. in Engl. et Prantl. - Ch rept - EM - R

Carlström (1987) reports for Chalki *C. microcalyx* subsp. *acutiloba*. Dimopoulos et al. (2013) don't give mention of this subspecies for the Aegean area, citing instead for the Eastern Aegean islands *C. microcalyx* subsp. *dodekanesi* Greuter and *C. microcalyx* subsp. *paradoxa* Gruter. Given the difficulty for determination of species at issue, it chooses to report only the nominal species.

**Cymbalaria longipes* (Boiss. et Heldr.) A. Cheval. - Ch rept - EM - R

Previous citations: Carlström (1987: 104).

**Misopates orontium* (L.) Raf. - T scap - ME

**Veronica cymbalaria* Bodard - T scap - Me

Previous citations: Carlström (1987: 105).

CONCLUSIONS

The north-facing limestone vertical cliffs with shady exposure and especially those inside gorges (less subject to climate changes), offer a stable habitat and refuge for chasmophytic plants. Unfavorable climatic changes during the Pleistocene, grazing pressure, competition with other species, would be the elements that through the ages would have led some species to settle in refuges, such as cliffs, ravines and crevices. On these sites suitable microclimatic conditions would allow the survival of these taxa. Such extreme and severe environments caused a hard selection between plant species, however a few of them increasing their chasmophytism degree and their woodiness have

managed to survive, responding optimally to new edaphoclimatic conditions. It is currently believed that in the Aegean islands, especially in the Cyclades, where insularity and mountainous appearance have played a decisive role in endemic plants, 43% of local endemic species are below 600 m, but there is also a significant percentage (20%) restricted to areas above 1000 m (Georghiou & Delipetrou, 2010).

Comes therefore natural to underline the remarkable correlation between chasmophytism and endemism, concept which had already been discussed by Kypriotakis & Tzanoudakis (2001) in the study of the chasmophytic flora of Crete. A similar situation is also evident in Chalki, where isolation and mountainous aspect have certainly played a key role in the presence of endemic species. Unfortunately the lack of gene flow due to the isolation of these colonies, leads to poor genetic variation (tendency toward homozygosity). For this reason if a negative character promoted for genetic drift in these populations, or anthropogenic climate changes occurred, these species would most likely be at risk of extinction (Davis, 1951). Rarity inevitably involves criticality. The presence, in fact, of rare plant species included in the Red List of the IUCN, as well as of a particular birdlife related to the cliffs of the island, allowed Chalki to be included in the Network Natura 2000 (GR 4210026) (<http://www.ypeka.gr/>).

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