Biodiversity and Conservation (2007) 16:357–376
DOI 10.1007/s10531-005-3013-4

Species diversity, endemism and conservation of the family Caryophyllaceae in Greece

PANAYIOTIS TRIGAS[1], GREGORIS IATROU[2,*] and GIORGOS KARETSOS[3]

*[1]Ministry of Rural Development and Food, General Directorate of Development and Protection of Forests and Natural Environment, 31 Halkokondili str., 10432 Athens, Greece; [2]Department of Biology, Division of Plant Biology, University of Patras, 26500 Patras, Greece; [3]National Agricultural Research Foundation (N.AG.RE.F.), Forest Research Institute, Terma Alkmanos str., 11528 Ilisia, Athens, Greece; *Author for correspondence: (e-mail: iatrou@upatras.gr)*

Received 28 December 2004; accepted in revised form 9 September 2005

Key words: Biogeography, Caryophyllaceae, Conservation, Diversity, Endemism, Greece

Abstract. The family Caryophyllaceae includes world-wide 86 genera and approximately 2100 species. Greece is one of its most important centres of diversity and endemism. A total of 428 Caryophyllaceae taxa are distributed in Greece, 161 of them being endemic to the Greek political territory. The endemic element represents approximately 5% of the global diversity of the family at the species level. The aim of this paper is to discuss the distribution patterns of the Greek endemic Caryophyllaceae, as well as those with a limited distribution range to the neighbouring areas of the Balkans and Anatolia, on the basis of the phytogeographical regions of Greece in order to identify the important regions for their conservation. The majority of the Greek endemic Caryophyllaceae (64.6%) are distributed in only one single phytogeographical region, or even a smaller area indicating the extremely restricted distribution ranges of the endemic plants in Greece. Actually 83 Greek endemic Caryophyllaceae can be grouped on cytotaxonomic criteria. Most of them belong to the category of schizoendemics (91.6%), indicating that the endemism of Caryophyllaceae in Greece has mainly originated in an active way. Cluster analysis has been used to classify the phytogeographical regions according to their floristic similarities. Two iterative complementarity methods were used to evaluate the importance of each phytogeographical region in the conservation of the endemic Caryophyllaceae in Greece. Peloponnisos, Kriti-Karpathos and Sterea Ellas are the most important phytogeographical regions in this respect, followed by North Central and North East. When adding the Balkan-Aegean-Anatolian endemics to the analysis, Peloponnisos, North Central, Kriti-Karpathos, North East and Eastern Aegean result as the most important areas. In every case, an elevated number of sites are required for the conservation of Caryophyllaceae in Greece, reflecting the great dissimilarities in the floristic composition of the various phytogeographical regions. The results provided by the different methods are compared. A catalogue of the Greek endemic Caryophyllaceae is appended.

Introduction

The widespread family Caryophyllaceae includes world-wide 86 genera and ca. 2100 species. The distribution of the family is mainly holarctic with a centre in the Mediterranean and the Irano-Turanian region, where 54 of the 86 genera occur (Bittrich 1993). According to a modern flora treatment (Strid and Tan

1997), and data included in even more recent publications, 428 Caryophyllaceae taxa (335 species and 93 subspecies) are present in Greece. Thus, the Caryophyllaceae taxa prospering in Greece represent almost 16% of the total family's diversity at the species level, including also a considerable number of subspecific taxa. Moreover, 104 species and 57 subspecies (161 taxa in total) are endemic to Greece, representing approximately 5% of the global diversity of Caryophyllaceae at species level.

Floristic data that cover the distribution of whole angiosperm families all over Greece are still scarce, as only two out of the nine planned volumes of Flora Hellenica have already been published and the data from other sources are fragmentary. The family Caryophyllaceae, included in the first volume of Flora Hellenica, is well represented in the Greek flora, including a comparatively high number of taxa and a considerable number of endemics consisting almost 37.6% of the family's diversity in the country. This percentage is higher than the national level of endemism that has been estimated to about 21% (Iatrou 1996). The high level of endemism indicates Greece, as a centre of Caryophyllaceae diversity the analysis which may gain conclusions that exceed the particular family and apply wider parts of the Greek flora.

Traditionally, species richness and levels of endemism have been considered to be among the leading criteria for defining conservation strategies (Lira et al. 2002; Dávila-Aranda et al. 2004). The selection of areas to be included in the existing nature protection scheme of Greece (National Forests, National Parks, Aesthetic Forests, etc.), as well as the sites that have been proposed for inclusion in the Natura 2000 European network, have always been carried out by *ad hoc* procedures, often influenced by the presence of a few charismatic or umbrella species, without any guarantee that they will adequately conserve regional biota. Quantitative procedures in order to identify priority areas for conservation of the Greek flora are still scarce (e.g. Dimitrakopoulos et al. 2004). The use of the distribution of the Caryophyllaceae taxa is a first effort to define conservation strategies based on quantitative procedures using floristic data in Greece.

The determination of the geographical distribution patterns of organisms is an essential requirement to propose strategies for their conservation. Based on this assumption, we aimed at an analysis of the distribution of the family Caryophyllaceae linked to the phytogeographical regions of Greece (Figure 3) as determined by Strid (1989). Based on this information, we identified those phytogeographical regions showing the highest species richness and endemism, and we discuss which of them should have priority in implementing conservation actions. The major benefit of implementing procedures is that each region has identified "target species" within the context of the conservation goals. This allows monitoring and management procedures to be focussed (Rebelo 1994). The fact that the boundaries of the 13 phytogeographical regions of Greece are strongly correlated with the boundaries of the 13 basic political units of Greece (Periferies) makes the results of this study useful for decision-making in the field of conservation of the Greek biota.

Methods

The main floristic and taxonomic source was the first volume of Flora Hellenica (Strid and Tan 1997), but more recent publications, which mainly refer to descriptions of new taxa (e.g. Constantinidis 1999; Greuter et al. 2002; Trigas and Iatrou 2004; Greuter and Raus 2004), are also included.

The distribution of the Caryophyllaceae taxa in the phytogeographical regions of Greece has been registered and elaborated, in order to identify hotspots on phytogeographical region level, for the total number of taxa, the Greek endemic taxa and the total number of the endemic taxa (Greek endemics + Balkan-Aegean-Anatolian endemics). We also provided an ordination of the phytogeographical regions of Greece, clustering them according to their floristic similarities. This analysis was performed twice, using the distribution of the total Caryophyllaceae taxa and the distribution of the Greek endemics. To identify hierarchical floristic similarities among the 13 phytogeographical regions, the Sørensen similarity coefficient and the average linkage (between groups) clustering method were used. The analyses were performed on a personal computer using the statistical package SPSS 12.0. The cartographic depiction of the results was performed using ArcView 8.3. A classification of the Greek endemic Caryophyllaceae into categories with cytotaxonomic criteria, according to Favarger and Contandriopoulos (1961), is also provided.

Complementarity analysis is an iterative selection technique that identifies how a target set of species can be conserved with the minimum number of sites (Pressey et al. 1993). In iterative procedures various scoring approaches can be used, such as species richness, endemicity scores, taxonomic diversity, etc. In order to evaluate the importance of each phytogeographical region for the conservation of the Greek endemic and the total endemic Caryophyllaceae, we used two complementarity methods. The first method used was that proposed by Vane-Wright et al. (1991) and emphasizes the total diversity. The second one was proposed by Rebelo (1994) and emphasizes rarity or endemism.

The method of Vane-Wright et al. (1991) selects areas to be protected based on total taxa richness. In this case, the following procedures were performed: (1) the phytogeographical region with the greatest number of taxa was selected and the taxa scored in it were dropped from the analysis; (2) the procedure was repeated with the remaining taxa (complement) that had not yet been selected in the former procedure; (3) when in further iterations two or more phytogeographical regions had the same complement, the phytogeographical region selected was that with the largest total number of taxa. If two or more phytogeographical regions still tied, the first phytogeographical region identified was selected; (4) the procedure finished when all taxa had been selected.

The method of Rebelo (1994) attempts to optimise a reserve system by selecting the areas according to an endemicity score (ES). The ES is the sum of each taxon's rarity value (in this study, the Greek endemic Caryophyllaceae taxa and the total endemic Caryophyllaceae taxa) present in each phytogeographical region. The rarity value of a particular taxon was calculated by dividing the total number of the phytogeographical regions by the number of phytogeographical regions where the particular taxon occurs. For the analysis we performed the following procedures in sequence: (1) the rarity value of each taxon and the ES of each phytogeographical region were determined; (2) the phytogeographical region with the highest ES was selected, and the taxa already scored in the selected phytogeographical region dropped from the analysis; (3) the procedure was repeated with only those taxa that had not yet been selected, which constituted the complement occurring in the phytogeographical regions not yet selected; (4) the procedure was replicated until all taxa were included at least once in the selected phytogeographical regions with higher ES. When the procedure yielded a tie, we gave preference to those phytogeographical regions with the largest number of endemic taxa.

Once the phytogeographical regions important for conservation of Caryophyllaceae were determined, the complementary value of each one was likewise determined. Thus, the cumulative numbers of total and endemic taxa contained in each selected phytogeographical region were provided.

Results and discussion

Diversity and general distribution patterns

The Caryophyllaceae flora of Greece is constituted of 428 taxa (335 species and 93 subspecies), belonging to 30 genera. The endemic element comprises 161 taxa and represents the 37.6% of the family's diversity in the country. In addition, 102 taxa (23.8%) have a restricted distribution range to Greece and the neighbouring areas of the Balkan Peninsula and/or Anatolia increasing the proportion of the taxa with a restricted distribution range to about 60% of the total family's diversity in Greece.

On the subfamily level, Caryophylloideae is the most diverse with 263 taxa in total (61.44%), while Alsinoideae (131 taxa or 30.6%) and Paronychioideae (34 taxa or 7.9%) follow. Caryophylloideae is also the subfamily richest in endemics, with 114 endemic taxa (43.34%). The endemism levels of Alsinoideae and Paronychioideae are lower, with 41 endemics (31.29%) and 6 endemics (17.64%), respectively.

Some Caryophyllaceae genera show remarkable diversity in Greece. *Silene* is by far the largest genus (148 taxa/58 of them endemic), followed by *Dianthus* (71/34), *Minuartia* (42/13), *Cerastium* (34/17), *Arenaria* (24/9) and *Petrorhagia* (18/9). The six largest genera contribute 78.7% to the total family's diversity in the country. The same genera are especially rich in endemics contributing almost 90% to the total Caryophyllaceae endemism in Greece. The small genus *Bolanthus* comprises ca. 12 species extending more or less continuously from Greece through S Anatolia to the coastal mountains of Syria, Lebanon and Palestine (Phitos 1997). It is represented by eight taxa in Greece, all of them endemic to the Greek political territory. On the contrary, about half of the Caryophyllaceae genera in Greece (16 genera or 53.3%) have no endemic taxa.

Although the taxa of Caryophyllaceae are distributed all over Greece, the largest concentration of them occurs in definite phytogeographical regions (Table 1). Sterea Ellas and North East are the richest phytogeographical regions, followed by North Central, Peloponnisos, N Pindos and S Pindos. These phytogeographical regions are important, not only by their richness in Caryophyllaceae, but also because they are among the floristically richest phytogeographical regions of the country (Strid 1993; Tan and Iatrou 2001). On the contrary, Kiklades, Ionian Islands and Northern Aegean have the smallest species diversity.

It is already known, that areas of high species richness do not always correspond with those of high endemism (Prendergast et al. 1993). Peloponnisos, Kriti-Karpathos and Sterea Ellas are the richest phytogeographical regions in endemics, regarding the Greek endemic Caryophyllaceae (Table 1). Peloponnisos and Sterea Ellas are also included in the group of the species rich regions. On the contrary, although Kriti is especially rich in endemics, both in absolute numbers and percentage, it is not among the floristically richest regions. The same pattern is also indicated for Western Aegean, Kiklades and Ionian Islands.

Using the distribution of the Greek endemic Caryophyllaceae to classify the phytogeographical regions of Greece, a tendency of partiality in favour of specific phytogeographical regions is noticed. Regions like Kriti, Peloponnisos and Kiklades, far away from the neighbouring countries of Greece in the Balkan Peninsula and Anatolia, tend to be especially rich in taxa with limited distribution range to the Greek political territory. On the contrary, regions in

Table 1. Species richness and endemism level of the Caryophyllaceae family in the 13 phytogeographical regions of Greece.

Phytogeographical region	Number of taxa	Number of Greek endemics/ endemism (%)	Balkan-Aegean-Anatolian endemics/ percentage (%)	Total number of endemics/ percentage (%)
Sterea Ellas	180	39/21.7	42/23.3	81/45.0
North East	180	15/8.3	48/26.7	63/35.0
North Central	175	19/10.9	51/29.1	70/40.0
Peloponnisos	166	52/31.3	33/19.9	85/51.2
Northern Pindos	129	11/8.5	41/31.8	52/40.3
Southern Pindos	127	15/11.8	37/29.1	52/40.9
Kriti-Karpathos	114	47/41.2	8/7.0	55/48.2
Eastern Aegean	113	13/11.5	26/23.0	39/34.5
East Central	110	12/10.9	24/21.8	36/32.7
Western Aegean	99	20/20.2	16/16.2	36/36.4
Northern Aegean	79	7/8.9	10/12.7	17/21.6
Ionian Islands	74	15/20.3	7/9.5	22/29.8
Kiklades	72	15/20.8	7/9.7	22/30.5

contact with neighbour countries, like North East, North Central, Northern Pindos and Eastern Aegean tend to be poorer in Greek endemics. These regions, although rich in species number, are underrepresented in the classification, if only the Greek endemic Caryophyllaceae are taken into consideration.

Many Caryophyllaceae taxa distributed in Greece have limited geographical distribution ranges in the neighbouring areas of the Balkan Peninsula and Anatolia. These taxa, referred as Balkan-Aegean-Anatolian endemics in this study, form a group that comprises 102 taxa (23.83%) belonging to the following subcategories: Balkan endemics (68 taxa or 15.88%), Balkan-Anatolian endemics (20 taxa or 4.67%) and Aegean-Anatolian endemics (14 taxa or 3.27%). They are mostly distributed in the phytogeographical regions of Greece that are adjacent to the other Balkan countries and Anatolia and they often are rare taxa with extremely restricted distribution ranges just confined to either side of the political borders in a small area (e.g. *Dianthus simulans*, *D. myrtinervius*, *D. arpadianus*, *Arenaria deflexa* subsp. *microsepala*, *A. luschanii*, *Gypsophila confertifolia*, etc.). The results obtained from the analysis of the distribution of the Balkan-Aegean-Anatolian endemics are shown in Table 1. As it was expected, Northern Pindos, North Central, Southern Pindos, North East and Eastern Aegean are the richest regions in species regarding the Balkan-Aegean-Anatolian element.

When the total number of endemics is taken into consideration (Table 1) a more even distribution of the endemics in the phytogeographical regions of Greece emerges. This fact emphasizes that not only the phytogeographical regions of Southern Greece and the Aegean already known to be rich in endemic and rare taxa, but also the phytogeographical regions of Northern Greece are important for the conservation of the endemic and rare Caryophyllaceae in Greece.

The geographic distribution of the Greek endemic Caryophyllaceae allowed us to recognize relatively well-defined patterns. Table 2 shows the number of phytogeographical regions occurrence of each endemic taxon of Caryophyllaceae, based on a $\log_2$ scale (Preston 1948). Thus, we considered four sets of taxa, on the basis of their distribution patterns: (1) narrowly distributed (those taxa distributed only in a single phytogeographical region); (2) taxa distributed in two or three phytogeographical regions; (3) taxa distributed in four to seven phytogeographical regions; and (4) widely distributed taxa (recorded for 8 or more phytogeographical regions).

Table 2. Species frequencies of Greek endemic Caryophyllaceae, grouped on arithmetic scale units (x_2 scale or $\log_2$) according to their occurrences in the phytogeographical regions of Greece.

Number of phytogeographical regions	Endemic taxa
1	104
2–3	39
4–7	18
≥8	0

The first group includes the majority of the Greek endemic Caryophyllaceae (64.6%), indicating the extremely restricted distribution ranges of the endemic plants in Greece. Many taxa of the first group are known only from one or few localities in a single island or mountain massif, e.g. *Arenaria gionae*, *Cerastium theophrasti*, *Silene insularis*, *S. salamandra*, while others are known from just the type collection, e.g. *Herniaria degenii*, *Minuartia dirphya*, *Arenaria phitosiana*, *Paronychia bornmuelleri*, and *Cerastium illyricum* subsp. *crinitum*.

Classification of the endemic taxa

Favarger and Contandriopoulos (1961) first systematized the application of cytotaxonomic methods to the study of the endemism. Their classification method involves the cytotaxonomic study of the endemics and their corresponding taxa in order to establish the relationships between them by distinguishing passive endemism (palaeo- and patroendemics) from active endemism (schizo- and apoendemics). The clarification of the speciation processes leading to the formation of the endemics is the basis of this method.

The main problem using this method is the deficiency of sufficient cytotaxonomic data. The available data actually allow us to safely classify 83 out of the 161 Greek endemic Caryophyllacea with respect to the type of endemism. The majority of them are included in the category of schizoendemics while the categories of apoendemics, palaeoendemics and patroendemics follow by far. The corresponding percentages of the Greek endemic Caryophyllaceae categories that we have safely classified are: palaeoendemics 2.4%, patroendemics 3.6%, schizoendemics 91.6% and apoendemics 2.4%. The dominance of schizoendemics together with apoendemics shows that the endemism of Cayophyllaceae in Greece has originated in an active way. This does not mean that almost all the Greek endemic Caryophyllaceae are neoendemics. Some schizoendemics are ancient taxa (palaeoschizoendemics or relictual schizoendemics) and the Greek endemic Caryophyllaceae seem to form a mixture of ancient taxa, and taxa of recent origin.

Palaeoendemics

The category of palaeoendemics includes taxonomically isolated taxa, monospecific genera or sections. They are usually ancient taxa and their origin is obscure. Their present distribution, often of a relictual type, corresponds to the remains of a once larger area. This category includes the species *Cerastium runemarkii* and *Silene barbeyana*. The two species are taxonomically isolated. *S. barbeyana*, according to Greuter et al. (1997), belongs to the monospecific sect. *Barbeyanae* Greuter.

Patroendemics

Patroendemics are diploid endemics, which have given rise to more widespread polyploids. At least the diploid enters into the ancestry of the polyploid, perhaps through the intermediary of a schizoendemic which it first produced. They constitute, together with palaeoendemics, the ancient element of a flora.

Cerastium theophrasti, *Dianthus cinnamomeus* subsp. *cinnamomeus* and *Paronychia cephalotes* subsp. *thracica* belong to this category. Both palaeoendemics and patroendemics are distributed on islands, as well as in inland areas, indicating that not only the islands but also the mountainous massifs of the Greek mainland played a role in the survival of primitive Caryophyllaceae taxa.

Schizoendemics

Schizoendemics are the result of a gradual speciation or a simultaneous divergence from a parent. Related schizoendemics have the same chromosome number. Not all schizoendemics are of the same evolutionary significance. Some of them are taxa of recent origin and their evolution still continues (inchoative schizoendemism). Others, like palaeoendemics, have an old origin. The degree of speciation of schizoendemics, their relative isolation and severity of their requirements are the factors that define their age.

Schizoendemics form the largest group in the endemic Caryophyllaceae flora of Greece including 76 taxa. *Silene variegata* (vicariant taxon *S. caesia*) *Silene antri-jovis* (*S. saxifraga*), *Cerastium candidissimum* (*C. tomenosum*) and *Dianthus xylorrhizus* (*D. elegans*) are considered to be schizoendemic taxa of an old origin (relictual schizoendemics), as their differentiation and distribution indicate long isolation. The presence of relictual schizoendemics among the Greek endemic Caryophyllaceae is already known. The groups of *Petrorhagia grandiflora* – *P. dianthoides* – *P. thessala* (Iatrou 1985) and *Minuartia dirphya* – *M. parnonia* – *M. wettsteinii* (Trigas and Iatrou 2004) are characteristic examples of geographic vicariant species of an old origin dating back at least to Pliocene as their present distribution patterns indicate (Iatrou 1985; Trigas and Iatrou 2004).

Schizoendemics whose corresponding taxa are distributed in nearby areas have relatively recent origin and they can be characterized as neoschizoendemics. Their morphological differentiation is usually weak and they are mostly classified at subspecific level. However, in some cases they are recognized as already well-differentiated species. This category includes the majority of the schizoendemic Caryophyllaceae of Greece, e.g. *Arenaria runemarkii* (vicariant taxon *A. leptoclados*), *Arenaria aegaea* (*A. leptoclados*), *Cerastium illyricum* subsp. *illyricum* (*C. illyricum* subsp. *brachiatum*), *Silene italica* subsp. *peloponnesiaca* (*S. italica* subsp. *italica*), *Silene cephallenia* subsp. *cephallenia* (*S. cephallenia* subsp. *epirotica*), *Silene multicaulis* subsp. *sporadum* (*S. multicaulis* subsp. *multicaulis*), *Saponaria jagelii* (*S. calabrica*), *Dianthus serratifolius* subsp. *serratifolius* (*D. serratifolius* subsp. *abbreviatus*). Their corresponding taxa have usually restricted distribution ranges, but sometimes they are widely distributed taxa, e.g. *Arenaria runemarkii* – *A. leptoclados*. They often belong to groups (e.g. *Dianthus fruticosus* group, *Dianthus haematocalyx* group, *Silene saxifraga* group) that seem to have evolved in the Greek area directly dependant on historical factors.

Apoendemics

Apoendemics are polyploid endemics, which have arisen from widespread diploids or lower polyploid parents. This category includes *Silene aegaea* and *Dianthus cinnamomeus* subsp.*naxensis*. *Silene aegaea* is a rare allotetraploid which apparently originated from crosses between *S. sedoides* subsp. *sedoides* and *S. pentelica* (Greuter et al. 1997). The sympatric occurrence of the three taxa indicates a relatively recent origin for *S. aegaea*. *Dianthus cinnamomeus* subsp. *naxensis* is a tetraploid restricted to the Northern part of the island of Naxos, differing only in quantitative characters from the type subspecies which is diploid. These two apoendemic taxa can be considered neopolyploids according to Favarger (1975) and Greilhuber and Ehrendorfer (1988), because their relative diploid taxa are distributed in neighbouring areas.

Clustering of the phytogeographical regions

Two cluster analysis were made to group the phytogeographical regions of Greece. The first includes the 161 Greek endemic Caryophyllaceae and the second the total Caryophyllaceae taxa distributed in Greece (428 taxa). The majority of the Greek endemic Caryophyllaceae has a very restricted distribution range confined to only one phytogeographical region (Table 2) or even a smaller area like a mountain peak or a single island. This phenomenon is also common for the endemic taxa of many other families of the Greek flora. As a result, the values of the Sørensen similarity coefficient among the phytogeographical regions are remarkably low (Figure 1). The values are conspicuously higher, when the total Caryophyllaceae taxa are included in the analysis (Figure 2).

The first dendrogram (Figure 1), based on the distribution of the Greek endemic Caryophyllaceae, allows to identify two sets of phytogeographical

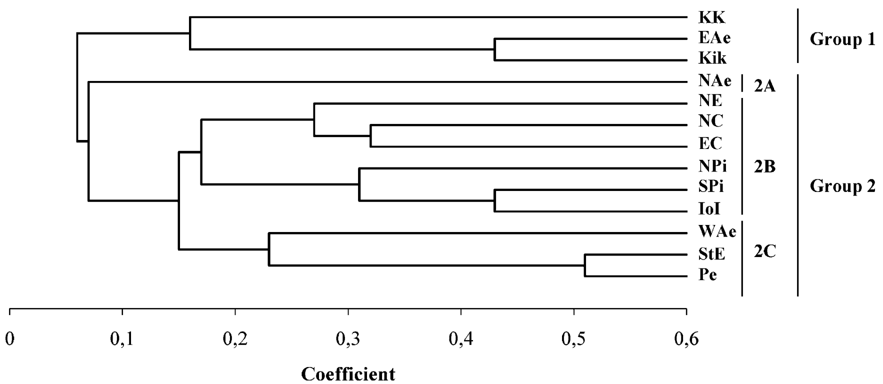

Figure 1. Floristic similarities among the 13 phytogeographical regions of Greece based on the distribution of the Greek endemic Caryophyllaceae. Similarity coefficient used: Sørensen; clustering method: Average Linkage (Between Groups).

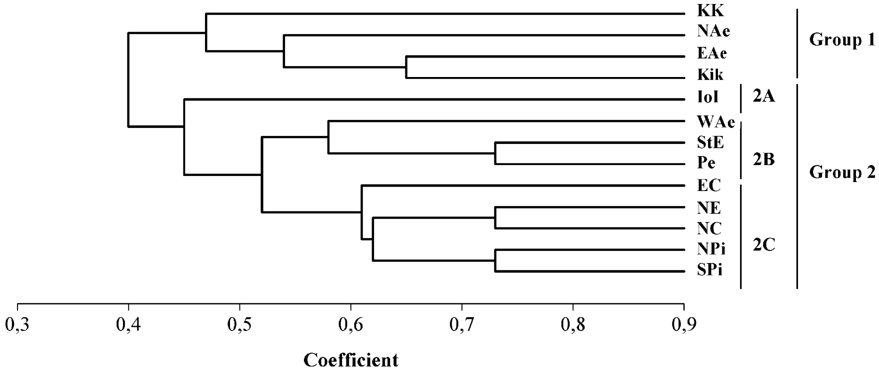

Figure 2. Floristic similarities among the 13 phytogeographical regions of Greece based on the distribution of the total Caryophyllaceae taxa. Similarity coefficient used: Sørensen; clustering method: Average Linkage (Between Groups).

regions (Figure 3). The first set includes the phytogeographical regions of Central and Southern Aegean (KK, EAe, Kik), reflecting the geological history and the special island conditions of these regions. Rechinger's line (Strid 1996) that separates the Kiklades from the Eastern Aegean Islands seems to insufficientlyreflect possible migration of the Greek endemic Caryophyllaceae (similarity coefficient value 0.43). The possibility of long distance migration cannot be ruled out, although it is more plausible to presume that the species were present at their existing locations before the break-up of the Central Aegean land bridge during Pliocene.

The second set includes the remaining phytogeographical regions and it is divided in three subsets. The first subset includes only the Northern Aegean phytogeographical region, which seems to be well differentiated with respect to the distribution of the Greek endemic Caryophyllaceae. The second subset includes the phytogeographical regions of Central and Northern Greece (SPi, NPi, EC, NC, NE) and the Ionian Islands. The later seems to have stronger floristic similarities to the mainly mountainous Northern and Southern Pindos than to the phytogeographical regions of Sterea Ellas and Peloponnisos (Figure 1). The third subset links the phytogeographical regions of Peloponnisos, Sterea Ellas and Western Aegean. The close phytogeographical connection of Peloponnisos and Sterea Ellas is already known, as the Gulf of Corinth that separates them seems to form only a weak phytogeographical barrier (Strid 1986; Iatrou 1986). The intense floristic similarities between Sterea Ellas and the Western Aegean, especially the island of Evvia, have also already been noticed (Trigas 2003). The three phytogeographical regions are geographically close to each other and they share similar ecological features.

The second dendrogram is based on the distribution of the total Caryophyllaceae taxa of Greece (Figure 2). The presence of many widely distributed taxa, some of them weeds that are present in all phytogeographical regions, resulted in the significant increase of the coefficient values. It also allows to

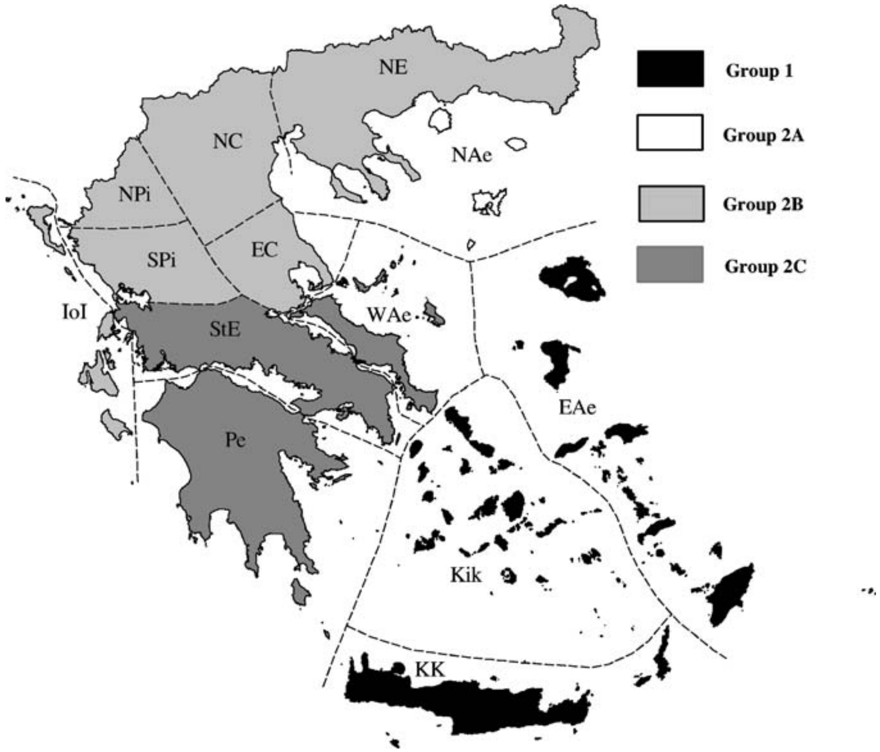

Figure 3. Groups of phytogeographical regions derived from the cluster analysis, based on the distribution of the Greek endemic Caryophyllaceae. The 13 phytogeographical regions of Greece: Peloponnisos (Pe), Sterea Ellas (StE), Southern Pindos (SPi), Northern Pindos (NPi), Ionian Islands (IoI), East Central (EC), North Central (NC), North East (NE), Northern Aegean (NAe), Western Aegean (WAe), Kiklades (Kik), Eastern Aegean (EAe), Kriti-Karpathos (KK).

identify two sets of phytogeographical regions (Figure 4). The first set includes the phytogeographical regions of the Aegean (KK, NAe, EAe, Kik), reflecting the similar island conditions and the human influences in these areas. The second set is divided in three subsets. The first includes only the Ionian Islands. The second subset links together Peloponnisos, Sterea Ellas and Western Aegean that form a well defined group with strong floristic similarities. The third subset includes the phytogeographical regions of Central and Northern Greece (SPi, NPi, EC, NC, NE) that also seem to form a well-defined group.

Complementary analysis

In order to evaluate the importance of each phytogeographical region for the conservation of the Greek endemic and the total endemic Caryophyllaceae, the complementarity methods proposed by Vane-Wright et al. (1991) and Rebelo

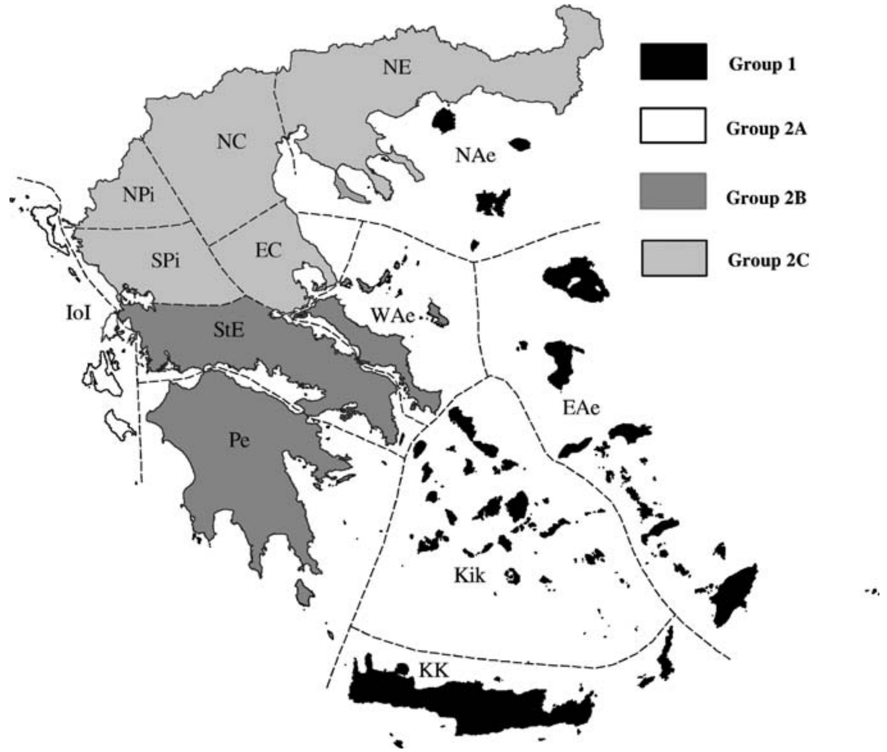

Figure 4. Groups of phytogeographical regions derived from the cluster analysis, based on the distribution of the total Caryophyllaceae taxa.

(1994) have been used. The results obtained from the two complementarity analyses for the Greek endemic Caryophyllaceae were strongly consistent (Table 3). In both cases the same 11 phytogeographical regions were required to establish an adequate conservation strategy that can secure the protection of the Greek endemic Caryophyllaceae. Southern Pindos and East Central are the only regions rejected from the analysis in both methods. This practically means that all the Greek endemic Caryophyllaceae they host, are also distributed and could be conserved in some other region(s).

The phytogeographical regions of Peloponnisos, Kriti-Karpathos and Sterea Ellas are the most important for the conservation of the Greek endemic Caryophyllaceae, as they host 65.2% of the endemics. North Central and North East follow in the hierarchical arrangement. The unexpected low placing of the Aegean phytogeographical regions, except Kriti-Karpathos, in the hierarchical arrangement indicates their auxiliary role in the conservation of the Greek endemic Caryophyllaceae.

The only difference observed between the two methods is the hierarchical arrangement of some phytogeographical regions. Peloponnisos was replaced

Table 3. Hierarchical arrangement of the phytogeographical regions of Greece according to the results obtained with the iterative methods of Vane-Wright et al. (1991) and Rebelo (1994), using the distribution of the Greek endemic Caryophyllaceae. The numbers in parentheses correspond to the accumulated taxa in each iteration.

Phytogeographical region	Vane-Wright et al.'s method	Phytogeographical region	Rebelo's method
Peloponnisos	52 (52)	Kriti-Karpathos	47 (47)
Kriti-Karpathos	37 (89)	Peloponnisos	42 (89)
Sterea Ellas	16 (105)	Sterea Ellas	16 (105)
North Central	14 (119)	North Central	14 (119)
North East	11 (130)	North East	11 (130)
Western Aegean	7 (137)	Western Aegean	7 (137)
Eastern Aegean	7 (144)	Northern Pindos	7 (144)
Northern Pindos	7 (151)	Eastern Aegean	7 (151)
Ionian Islands	4 (155)	Ionian Islands	4 (155)
Kiklades	3 (158)	Kiklades	3 (158)
Northern Aegean	3 (161)	Northern Aegean	3 (161)

by Kriti-Karpathos at Rebelo's method in the top of the arrangement, because of the high number of local endemic taxa in the latter. The results are also strongly correlated with the general distribution patterns of endemism shown in Table 1. They suggest a distribution pattern of the endemism in Greece already known and revealed from previous authors (Rechinger 1965; Iatrou 1986; Strid 1993; Tan and Iatrou 2001): Southern Greece and especially the phytogeographical regions of Kriti-Karpathos, Peloponnisos and Sterea Ellas are especially rich in endemic elements. The causes of this pattern must be looked for in historical factors such as isolation in connection with paleogeographic events and a peninsula effect in the southern part of mainland Greece.

According to the results of the two complementarity methods for the total endemic Caryophyllaceae, the same 11 phytogeographical regions are required for the conservation of the endemics (Table 4). The repeated rejection of Southern Pindos and East Central, although the large group of the Balkan-Aegean-Anatolian endemics have been added to the analysis, confirms the low complementary value of these regions. Their geographic position in the centre of the Greek mainland seems to be correlated to the above results. The majority of the Greek endemic taxa tend to concentrate in the southern parts of the Greek mainland, while most of the Balkan endemic taxa tend to concentrate in the northern parts. Although Southern Pindos and East Central are relatively rich in endemic taxa, they seem to be poor in unique elements, like local endemic taxa. The absence of isolation conditions, both geographical and ecological, from their neighbouring phytogeographical regions seems to have strongly influenced this phenomenon.

The results obtained from the complementarity analysis for the total endemics, however, have shown remarkable differences of those obtained from the Greek endemic Caryophyllaceae (Table 4). Although Peloponnisos and Kriti-Karpathos keep their position to the top of the list, the upgrading of North Central, North East and Eastern Aegean phytogeographical regions in the hierarchical arrangement was expected. These regions are adjacent to other Balkan countries (Bulgaria, F.Y.R.O.M., Albania) and Anatolia, with which they share many locally restricted species. These species, although not endemic to Greece, often have an extremely restricted distribution range confined to either side of the political borders and their inclusion in the analysis make the hierarchical arrangement of the phytogeographical regions more objective.

Conclusions

The family Caryophyllaceae is well represented in the Greek flora, both in terms of the total species diversity and the number of the endemic taxa. The Greek endemic Caryophyllaceae represent approximately 5% of the global diversity of the family at the species level, establishing Greece as one of the most important areas for the conservation of the family's diversity globally. Moreover, the analysis of the endemic taxa with cytotaxonomic criteria, together with the distribution analysis of their vicariant taxa, show that they represents a mixture of ancient taxa conserved mainly in the islands and the high mountains, directly associated with historical factors, as well as of taxa of recent origin. The evolution of the latter actually continues, in some cases, under the influence of adaptive radiation and genetic drift. Thus, Caryophyllaceae seem to be a representative family of the Greek flora, well reflecting past and present features of the phytogeography of the area. The analysis of their species diversity, endemism and distribution pattern leads to a useful

Table 4. Hierarchical arrangement of the phytogeographical regions of Greece according to the results obtained with the iterative methods of Vane-Wright et al. (1991) and Rebelo (1994), using the distribution of the total endemic Caryophyllaceae. The numbers in parentheses correspond to the accumulated taxa in each iteration.

Phytogeographical region	Vane-Wright et al.'s method	Phytogeographical region	Rebelo's method
Peloponnisos	85 (85)	Kriti-Karpathos	55 (55)
North Central	49 (134)	Peloponnisos	68 (123)
Kriti-Karpathos	38 (172)	North East	45 (168)
North East	25 (197)	Eastern Aegean	24 (192)
Eastern Aegean	23 (220)	North Central	27 (219)
Sterea Ellas	14 (234)	Sterea Ellas	15 (234)
Northern Pindos	12 (246)	Northern Pindos	12 (246)
Western Aegean	7 (253)	Western Aegean	7 (253)
Ionian Islands	4 (257)	Ionian Islands	4 (257)
Kiklades	3 (260)	Kiklades	3 (260)
Northern Aegean	3 (263)	Northern Aegean	3 (263)

conclusion that exceeds the particular family and may also apply to other parts of the Greek flora.

The data that are relevant to the distribution of the family Caryophyllaceae (Table 1) show that there is no correlation between the geographical distribution patterns of total species diversity of the family and the Greek endemic taxa. Peloponnisos and Sterea Ellas are the only phytogeographical regions rich in both total species diversity and Greek endemics. North Central and North East are especially rich in total species diversity but clearly poor in Greek endemics. The picture is the opposite for the Kriti-Karpathos area. This means that some phytogeographical regions are important to protect the total diversity, while others are important to protect the endemic taxa. The results remarkably differ when the total number of the endemics (Greek endemics + Balkan-Aegean-Anatolian endemics) is taken into consideration. In this case, the results show a correlation between the geographical distribution patterns of total species diversity of Caryophyllaceae and the total endemic taxa. Based only on raw data, however, protected areas in the whole country are necessary to establish effective protection strategies for the family, an administrative goal almost impossible to reach.

The cluster analyses of the distribution data for the Greek endemic and the total Caryophyllaceae taxa help to establish two phytogeographical region groupings (Figures 3 and 4). Three stable groups were derived from the analyses. The first group consists of Kriti-Karpathos, Kiklades and Eastern Aegean and represents the main areas of the Aegean Archipelago. The second group links together Peloponnisos, Sterea Ellas and Western Aegean, reflecting the recent (postglacial) geographic isolation of these areas and the similar ecological conditions they share. The third group links together North East, North Central, Northern Pindos, Southern Pindos and East Central; all these regions are strongly affected by the intense presence of the Balkan floristic elements. The remaining phytogeographical regions (Ionian Islands and Northern Aegean) belong to different groups, depending on the distribution data respectively used.

Regarding the sensitive group of the Greek endemic taxa, their often restricted distribution ranges (Table 2), as it is also indicated from the extremely low values of the Sørensen similarity coefficient among the phytogeographical regions of Greece (Figure 1), also suggest the need of protected areas in most parts of the country, in order for them to be protected. The protection of specific habitat types rich in endemics is perhaps a better justifiable approach, according to the scheme derived from the cluster analyses.

Iterative methods seem to be an effective way to establish conservation priorities for the endemic Caryophyllaceae. The results derived from the two complementarity methods demonstrate that the 11 out of the 13 phytogeographical regions of Greece are necessary for establishing an effective protection strategy for the endemic Caryophyllaceae. Southern Pindos and East Central were rejected from the analyses of both Greek and total endemics, emphasizing the low complementary value of these region, regarding the distribution of the endemic Caryophyllaceae. Five phytogeographical regions (Pe, KK, StE, NC, NE) contain 80.7% of the Greek endemics and 81.0% of the total endemics, indicating that conservation efforts should mostly focus on these regions. A more detailed analysis of the distribution patterns of the endemic Caryophyllaceae would further reduce the regions necessary for their conservation. For example, 33 out of the 50 (66.0%) Greek endemic Caryophyllaceae of Peloponnisos are distributed and could be conserved in the mountainous massifs of Taygetos and Parnon in Southern Peloponnisos. This example suggests that although our study was done at phytogeographical region level, the results show some potential guidelines to start efficient conservation efforts aimed to protect these endemic plants.

A long way has to be covered, and additional biological and ecological information on most of the taxa, including data on their population status and complete knowledge of their distribution patterns, are necessary to establish effective conservation priorities for the endemic Caryophyllaceae in Greece. In particular, the extremely restricted distribution ranges of most of the endemic Caryophyllaceae taxa seem to be a thorny problem on the way to their conservation. The restricted distribution range seems to be a general phenomenon of the endemic plants in Greece, making their effective *in situ* protection, from an administrative point of view, difficult and unfavourable. A network of protected areas like the already existing Natura 2000 European network, in combination with a network of micro-reserve systems, as well as the *ex situ* protection of selected taxa (in botanical gardens and seed banks), seem to be the proper scheme for the effective conservation of the endemic Caryophyllaceae in Greece and the Greek endemic plants in general.

Appendix

List of the endemic taxa of Caryophyllaceae in Greece, their category of endemism and their distribution in the phytogeographical regions of Greece.

Agrostemma githago L. subsp. *thessalum* (Bornm.) Greuter; EC, NC
Arenaria aegaea Rech. fil.; schizoendemic; KK, Kik, EAe
A. filicaulis subsp. *teddii* (Turrill) Strid; NE
A. fragillima Rech. fil.; schizoendemic; KK
A. gionae L.-Å. Gustavsson; StE
A. guicciardii Boiss.; KK, Pe, StE, IoI, EAe
A. leucadia Phitos & Strid; schizoendemic; IoI
A. peloponnesiaca Rech. fil.; schizoendemic; Pe, IoI
A. phitosiana Greuter & Burdet; WAe
A. runemarkii Phitos; schizoendemic; EAe
Bolanthus chelmicus Phitos subsp. *chelmicus*; Pe
B. chelmicus subsp. *meteoricus* Phitos; SPi, NC
B. creutzburgii Greuter; schizoendemic; KK
B. fruticulosus (Bory & Chaub.) Barkoudah; Pe
B. graecus (Schreb.) Barkoudah; schizoendemic; Kik, StE, NC, WAe

Appendix. Continued

B. intermedius Phitos; WAe
B. laconicus (Boiss.) Barkoudah; schizoendemic; Pe
B. thymifolius (Sm.) Phitos; StE, EC, NC, NE, WAe
Bufonia stricta (Sm.) Gürke subsp. *stricta*; KK, Pe, StE, WAe
B. stricta subsp. *cecconiana* (Bald.) Rech. fil.; KK
Cerastium brachypetalum subsp. *atheniense* (Lonsing) P. D. Sell & Whitehead; StE, WAe
C. brachypetalum subsp. *corcyrense* (Möschl) P. D. Sell & Whitehead; IoI, SPi, NPi
C. brachypetalum subsp. *pindigenum* (Lons.) P. D. Sell & Whitehead; StE, SPi, NPi, EC, NC
C. brachypetalum subsp. *doerfleri* (Hayek) P. D. Sell & Whitehead; KK
C. candidissimum Correns; Pe, StE, IoI, SPi, EC, WAe
C. deschatresii Greuter et al.; KK
C. illyricum Ard. subsp. *illyricum*; schizoendemic; IoI
C. illyricum subsp. *brachiatum* (Lonsing) Jalas; schizoendemic; Pe, IoI
C. illyricum subsp. *crinitum* (Lonsing) P. D. Sell & Whitehead; StE
C. moesiacum subsp. *glutinosum* (Halácsy) Strid; NAe
C. pedunculare Bory & Chaub.; Pe
C. runemarkii Möschl & Rech. fil.; palaeoendemic; Kik, WAe
C. scaposum Boiss. & Heldr. subsp. *scaposum*; KK
C. scaposum subsp. *peninsularum* Greuter et al.; KK
C. smolikanum Hartvig; NPi
C. theophrasti Merxm. & Strid; patroendemic; NC
C. vourinense Möschl & Rech. fil.; NPi, NC
Dianthus androsaceus (Boiss. & Heldr.) Hayek; Pe
D. biflorus Sm.; Pe, StE, SPi, EC, WAe
D. cinnamomeus Sm. subsp. *cinnamomeus*; patroendemic; KK, Kik
D. cinnamomeus subsp. *naxensis* Runem.; apoendemic; Kik
D. corymbosus Sm.; Schizoendemic; EC, NC, NE
D. desideratus Strid; WAe
D. diffusus Sm.; Kik, Pe, StE, WAe
D. fruticosus L. subsp. *fruticosus*; Kik
D. fruticosus subsp. *amorginus* Runem.; schizoendemic; KK, Kik
D. fruticosus subsp. *carpathus* Runem.; KK
D. fruticosus subsp. *creticus* (Tausch) Runem.; schizoendemic; KK
D. fruticosus subsp. *karavius* Runem.; EAe
D. fruticosus subsp. *occidentalis* Runem.; schizoendemic; KK, Pe, IoI
D. fruticosus subsp. *rhodius* (Rech. fil.) Runem.; EAe
D. fruticosus subsp. *sitiacus* Runem.; schizoendemic; KK
D. gracilis subsp. *xanthianus* (Davidov) Tutin; NE
D. haematocalyx subsp. *phitosianus* Constantinidis; schizoendemic; StE
D. haematocalyx subsp. *pruinosus* (Boiss. & Orph.) Hayek; StE, EC
D. haematocalyx subsp. *ventricosus* Maire & Petitm.; schizoendemic; StE
D. ingoldbyi Turrill; NE
D. juniperinus Sm. subsp. *juniperinus*; schizoendemic; KK
D. juniperinus subsp. *aciphyllus* (Ser.) Turland; schizoendemic; KK
D. juniperinus subsp. *bauhinorum* (Greuter) Turland; KK
D. juniperinus subsp. *heldreichii* Greuter; schizoendemic; KK
D. juniperinus subsp. *idaeus* Turland; KK
D. juniperinus subsp. *kavusicus* Turland; KK
D. juniperinus subsp. *pulviniformis* (Greuter) Turland; KK
D. mercurii Heldr.; Pe
D. serratifolius Sm. subsp. *serratifolius*; schizoendemic; Pe, StE
D. serratifolius subsp. *abbreviatus* (Halácsy) Strid; schizoendemic; Pe

Appendix. Continued

D. sphacioticus Boiss. & Heldr.; KK
D. stamatiadae Rech. fil.; NC
D. strymonis Rech. fil.; NE
D. tymphresteus (Boiss. & Spruner) Boiss.; schizoendemic; Pe, StE
D. xylorrhizus Boiss. & Heldr.; schizoendemic; KK
Gypsophila nana Chaub. & Bory; KK, Pe, StE
Herniaria degenii (F. Herm.) Chaudhri; NAe
H. parnassica subsp. *cretica* Chaudhri; KK, Pe
Minuartia athoa (Griseb.) Kamari subsp. *athoa*; NE
M. athoa subsp. *neoiraklitsa* Kamari; NE
M. attica subsp. *idaea* (Halácsy) Kamari & Constantinidis; schizoendemic; KK, EAe
M. confusa (Boiss.) Maire & Petitm.; Pe, StE
M. dirphya Trigas & Iatrou; schizoendemic; WAe
M. favargeri Iatrou & Georgiadis; schizoendemic; Pe
M. graminifolia subsp. *brachypetala* Kamari; NC
M. greuteriana Kamari; NE
M. parnonia (Kamari) Iatrou &al.; schizoendemic; Pe
M. pichleri (Boiss.) Maire & Petitm.; schizoendemic; Pe
M. pseudosaxifraga (Mattf.) Greuter & Burdet; schizoendemic; NPi
M. setacea subsp. *olympica* Kamari; NC
M. wettsteinii Mattf.; schizoendemic; KK
Paronychia albanica subsp. *graeca* Chaudhri; Pe, StE, IoI, SPi, NPi, NC, NE
P. bornmuelleri Chaudhri; NAe
P. cephalotes subsp. *thracica* Chaudhri; patroendemic; SPi, NC, NE
Petrorhagia candica P. W. Ball & Heywood; KK
P. dianthoides (Sm.) P. W. Ball & Heywood; schizoendemic; KK
P. fasciculata (Margot & Reuter) P. W. Ball & Heywood; schizoendemic; KK, Pe, StE, IoI, SPi
P. glumacea (Bory & Chaub.) P. W. Ball & Heywood; schizoendemic; Pe, SPi
P. graminea (Sm.) P. W. Ball & Heywood; schizoendemic; Pe, IoI, SPi
P. grandiflora Iatrou; schizoendemic; Pe
P. illyrica subsp. *taygetea* (Boiss.) P. W. Ball & Heywood; schizoendemic; KK, Pe
P. ochroleuca (Sm.) P. W. Ball & Heywood; schizoendemic; StE
P. phthiotica (Boiss. & Heldr.) P. W. Ball & Heywood; schizoendemic; Pe, StE
Saponaria aenesia Heldr.; IoI
S. jagelii Phitos & Greuter; Pe
Silene adelphiae Runem.; Kik
S. aegaea Oxelman; apoendemic; Kik, EAe
S. ammophila Boiss. & Heldr. subsp. *ammophila*; schizoendemic; KK
S. ammophila subsp. *carpathae* Chowdhuri; schizoendemic; KK
S. antri-jovis Greuter & Burdet; schizoendemic; KK
S. auriculata Sm.; Pe, StE
S. barbeyana Boiss.; palaeoendemic; StE
S. cephallenia Heldr. subsp. *cephallenia*; schizoendemic; IoI
S. congesta Sm.; schizoendemic; Pe, StE, SPi
S. conglomeratica Melzh.; Pe
S. corinthiaca Boiss. & Heldr.; Kik, Pe, StE, WAe
S. cythnia (Halácsy) Walters; schizoendemic; Kik, EAe
S. dirphya Greuter & Burdet; schizoendemic; WAe
S. echinosperma Boiss. & Heldr.; Pe
S. fabaria subsp. *domokina* Greuter; schizoendemic; StE, SPi, EC
S. flavescens subsp. *dictaea* (Rech. fil.) Greuter; KK
S. gigantea. subsp. *hellenica* Greuter; Pe, StE, WAe

Appendix. Continued

S. goulimyi Turrill; schizoendemic; Pe
S. grisebachii (Davidov) Pirker & Greuter; EC, NE, NAe
S. guicciardii Boiss. & Heldr.; StE
S. haussknechtii Hausskn.; schizoendemic; SPi, NPi
S. holzmannii Boiss.; schizoendemic; KK, Kik, Pe, StE, EAe
S. insularis Barbey; schizoendemic; KK
S. integripetala Bory & Chaub. subsp. *integripetala*; schizoendemic; Pe
S. integripetala subsp. *elaphonesiaca* Oxelman; schizoendemic; Pe
S. integripetala subsp. *greuteri* (Phitos) Akeroyd; schizoendemic; KK
S. integripetala subsp. *lidenii* Oxelman; schizoendemic; KK, Pe
S. intonsa Greuter & Melzh.; NPi
S. ionica Halácsy; schizoendemic; StE, IoI
S. italica subsp. *peloponnesiaca* Greuter; schizoendemic; Pe, StE
S. laconica Boiss. & Orph.; schizoendemic; Pe
S. linoides Otth; schizoendemic; Pe, StE, SPi, EC
S. melzheimeri Greuter; schizoendemic; NPi
S. multicaulis subsp. *sporadum* (Halácsy) Greuter & Burdet; schizoendemic; EC, NE, NAe, WAe
S. niederi Boiss.; Pe, StE, IoI, SPi, NPi, NC
S. nutabunda Greuter; Pe
S. oligantha Boiss. & Heldr. subsp. *oligantha*; schizoendemic; NC
S. oligantha subsp. *parnesia* Greuter; schizoendemic; StE
S. oligantha subsp. *pseudoradicosa* (Rech. fil.) Greuter; schizoendemic; WAe
S. orbelica Greuter; NE
S. orphanidis Boiss.; NE
S. parnassica subsp. *dionysii* (Stoj. & Jordanov) Greuter; schizoendemic; EC, NC
S. parnassica subsp. *vourinensis* Greuter; NC
S. pentelica Boiss.; Schizoendemic; Kik, StE, WAe, EAe
S. pinetorum Boiss. & Heldr. subsp. *pinetorum*; schizoendemic; KK
S. pinetorum subsp. *sphaciotica* Oxelman & Greuter; schizoendemic; KK
S. pusilla subsp. *chromodonta* (Boiss. & Reuter) Greuter; NC
S. pusilla subsp. *tymphaea* Greuter; NPi
S. salamandra Pamp.; schizoendemic; EAe
S. samothracica (Rech. fil.) Greuter; NAe, EAe
S. sartorii Boiss. & Heldr.; KK, Kik, Pe, StE, EAe
S. sedoides subsp. *runemarkii* Oxelman; schizoendemic; Pe
S. sieberi Fenzl; schizoendemic; KK
S. spinescens Sm.; schizoendemic; Pe, StE, WAe
S. taygetea Vierh.; schizoendemic; Pe
S. variegata (Desf.) Steudel; schizoendemic; KK
S. vulgaris subsp. *megalosperma* (Heldr.) Hayek; Pe, StE, NAe, WAe
S. vulgaris subsp. *vourinensis* Greuter; NC
Telephium imperati subsp. *pauciflorum* (Greuter) Greuter & Burdet; KK

References

Bittrich V. 1993. Caryophyllaceae. In: Kubitzki K., Rohwer J.G., Bittrich and V. (eds.), The Families and Genera of Vascular Plants II Flowering Plants Dicotyledons, Magnoliid, Hamamelid and Caryophyllid Families. Springer-Verlag, Berlin, New York, pp. 206–236.

Constantinidis Th. 1999. *Dianthus haematocalyx* subsp. *phitosianus* (*Caryophyllaceae*), a new serpentine endemic from Greece. Phyton (Horn, Austria) 39(2): 277–291.

Dávila-Aranda P., Lira-Saade R. and Valdés-Reyna J. 2004. Endemic species of grasses in Mexico: a phytogeographic approach. Biodivers. Conserv. 13: 1101–1121.
Dimitrakopoulos P.G., Memtsas D. and Troumbis A.Y. 2004. Questioning the effectiveness of the Natura 2000 special areas of conservation strategy: the case of Crete. Global Ecol. Biogeogr. 13: 199–207.
Favarger C. 1975. Cytotaxonomie et historie de la flore orophile des Alpes et de quelques autres massifs montagneux d' Europe. Lejeunia, ser. 2, 77: 1–44.
Favarger C. and Contandriopoulos J. 1961. Essai sur l' endémisme. Ber. Schweiz. Bot. Ges. 71: 384–408.
Greilhuber J. and Ehrendorfer F. 1988. Karyological approaches to plant taxonomy. ISI Atlas of Science. Anim. Plant Sci. 1: 289–297.
Greuter W., Pirker B. and Oxelman B. 1997. *Silene* L. In: Strid A. and Kit Tan (eds.), Flora Hellenica vol. 1. Koeltz Scientific Books, Königstein, Germany, pp. 239–323.
Greuter W., Böhling N. and Jahn R. 2002. The *Cerastium scaposum* group (*Caryophyllaceae*): three annual taxa endemic to Crete (Greece), two of them new. Willdenowia 32: 45–54.
Greuter W. and Raus Th. (eds.), 2004. Med-Checklist Notulae 22. Willdenowia 34: 71–80.
Iatrou G. 1985. *Petrorhagia grandiflora* sp. nov. (Caryophyllaceae) from Greece. Nord. J. Bot. 5: 441–445.
Iatrou G. 1986. Simvoli sti meleti tou endimismou tis chloridas tis Peloponnisou. PhD Thesis, University of Patras, Greece. (In Greek with an English summary).
Iatrou G. 1996. The richness and the rarity of the Greek Flora. In: Dafis S., Papastergiadou E., Georgiou K., Babalonas D., Georgiadis Th., Papageorgiou M., Lazaridou T. and Tsiaoussi V. (eds), Directive 92/43/ EEC. The Greek Habitat Project Natura 2000: An Overview. Life Contract B4-3200/94/756, Commission of the European Communities DG XI, The Goulandris Natural History Museum- Greek Biotope/ Wetland Centre. Thessaloniki, Greece, pp. 437–438.
Lira R., Villaseñor J.L. and Ortíz E. 2002. A proposal for the conservation of the family Curcubitaceae in Mexico. Biodivers. Conserv. 11: 1699–1720.
Phitos D. 1997. *Bolanthus* (Ser.) Reichenb. In: Strid A. and Kit Tan (eds), Flora Hellenica vol. 1. Koeltz Scientific Books, Königstein, Germany, pp. 325–329.
Prendergast J.R., Quinn R.M., Lawton J.H., Eversham B.C. and Gibbons D.W. 1993. Rare species, the coincidence of diversity hotspots and conservation strategies. Nature 365: 335–337.
Pressey R.L., Humphries C.J., Margules C.R., Vane-Wright R.L. and Williams P.H. 1993. Beyond opportunism: key principles for systematic reserve selection. Trend. Ecol. Evol. 8: 124–128.
Preston F.W. 1948. The commonness and rarity of species. Ecology 29: 254–283.
Rebelo A.G. 1994. Iterative selection procedures: centres of endemism and optical placement of reserves. Strelitzia 1: 231–257.
Rechinger K.H. 1965. Der Endemismus in der griechischen Flora. Rev. Roum. Biol. 10: 135–138.
Strid A. 1986. The mountain flora of Greece with special reference to the Anatolian element. Proc. Royal Bot. Soc. Edinb. 89B: 59–68.
Strid A. 1989. The "Flora Hellenica" Project. Bot. Chron. 10: 81–94.
Strid A. 1993. Phytogeographical aspects of the Greek mountain flora. Fragm. Flor. Geobot. Suppl. 2(2): 411–433.
Strid A. 1996. Phytogeographia Aegaea and the Flora Hellenica Database. Ann. Naturhist. Mus. Wien 98(Suppl.): 279–289.
Strid A. and Tan K. (eds.), 1997. Flora Hellenica vol. 1. Koeltz Scientific Books, Königstein, Germany.
Tan K. and Iatrou G. 2001. Endemic Plants of Greece I. The Peloponnese. G. Forlag, København.
Trigas P. 2003. Contribution to the study of the endemism of the flora of the island of Evvia (W Aegean, Greece). PhD Thesis, University of Patras, Greece. (In Greek with an English summary).
Trigas P. and Iatrou G. 2004. A new species of *Minuartia* (*Caryophyllaceae*) from the island of Evvia (Greece). Nord. J. Bot. 23(4)
Vane-Wright R.I., Humphries C.J. and Williams P.H. 1991. What to protect? Systematics and the agony of choice. Biol. Conserv. 55: 235–254.