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Phytogeographia Aegaea and the Flora Hellenica Database

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Abstract

The phytogeographical subdivision of the Aegean area established by RECHINGER (1943, 1950, 1951) has to a large extent been corroborated by more extensive data now available. Examples are given using data stored in the Flora Hellenica Database (c. 285,000 records). It is proposed that the name "Rechinger's line" be used for the interval between the Kiklades and the East Aegean Islands, which in fact constitutes the phytogeographical borderline between Europe and Asia.

Key Words: Flora of Greece, Aegean Islands, Kiklades; Flora Hellenica Database; phytogeography, borderline, Rechinger's line.

Zusammenfassung

Die von RECHINGER (1943. 1950, 1951) erstellte pflanzengeographische Einteilung des Ägäischen Gebietes wurde durch heute verfügbare umfassendere Daten weitgehend bestätigt. Beispiele aus der Flora Hellenica Database werden diskutiert. Für die Linie zwischen den Kykladen und den Ostägäischen Inseln, die tatsächlich die pflanzengeographische Grenze zwischen Europa und Asien darstellt, wird der Name "Rechinger-Linie" vorgeschlagen.

Introduction

In a series of important publications, RECHINGER (1943, 1950, 1951) laid the foundations of the prevailing phytogeographical subdivision of the Aegean area. Much floristic and biosystematic work has subsequently been carried out in the Aegean archipelago and adjacent mainland areas (cf. STRID 1996), and the purpose of this paper is to examine whether the patterns established by RECHINGER still hold in the light of more comprehensive data now available.

In floristic phytogeography, two fundamentally different approaches are possible and equally valid. One involves the statistical comparison of major elements of the flora (preferably the whole flora) in a given set of geographical regions. The other comprises detailed studies of variation patterns and evolution (preferably by experimental methods) in species complexes distributed throughout the regions concerned.

The Aegean archipelago has proved to be an ideal natural laboratory for studies of speciation. Several biosystematic investigations have been carried out on species groups with centres of diversity in this area, e.g. on *Erysimum* sect. *Cheiranthus* (SNOGERUP 1967a, b), *Nigella* (STRID 1970), *Malcolmia* (STORK 1972), *Allium* and *Scutellaria* (BOTHMER 1974, 1987), *Leopoldia* (*Muscari*) (BENTZER 1973) and on *Crepis* (KAMARI

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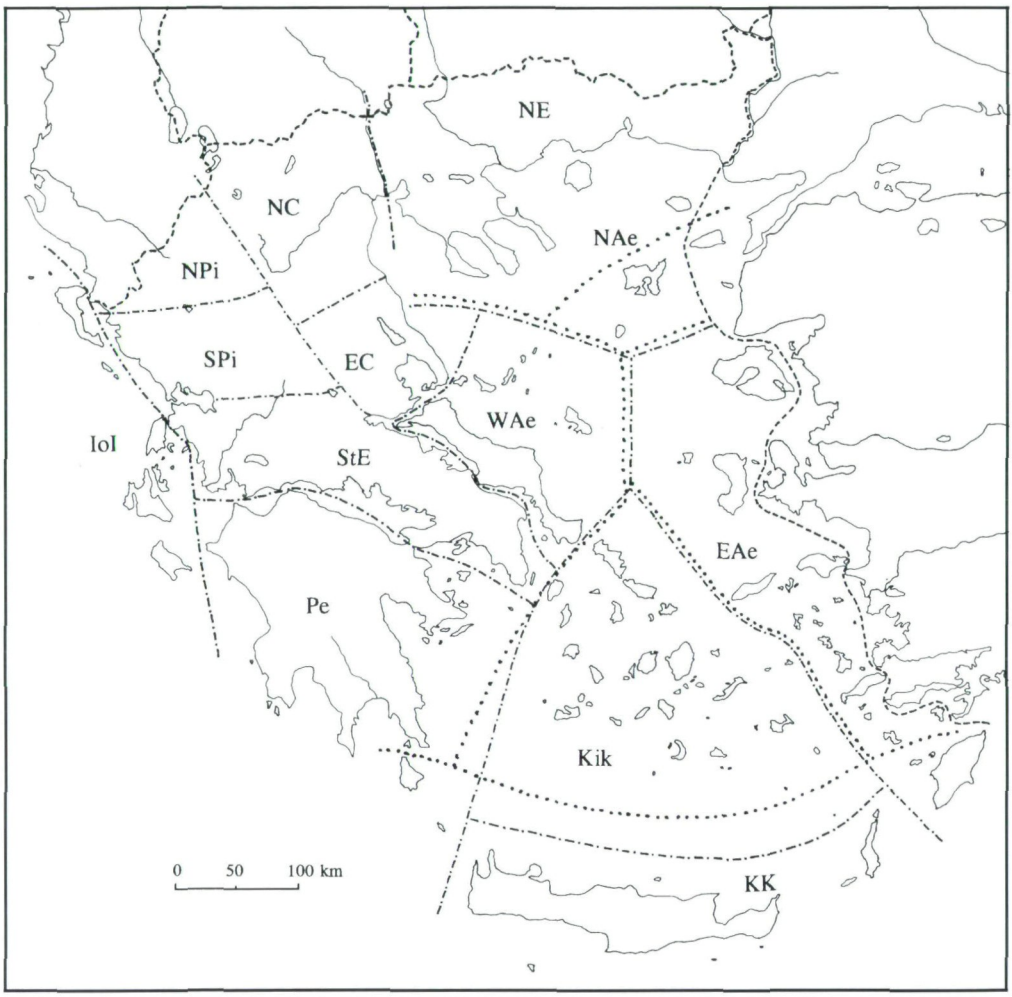

Fig. 1: Division of Greece into 13 floristic regions as adopted for the Flora Hellenica project (broken lines). The dotted lines show Rechinger's phytogeographical subdivision of the Aegean area.

1976). By and large, they have tended to corroborate RECHINGER's phytogeographical subdivision of the area. The following account, however, will concentrate on purely floristic data of the kind available to RECHINGER.

Phytogeographical subdivision of Greece and the Aegean area

Fig. 1 shows the 13 regions adopted for the Flora Hellenica project, as well as the subdivision of the Aegean area according to RECHINGER (1943). Of particular interest is the recognition of the Kiklades (in a phytogeographical sense) as a block of islands separated to the west, south and east, and also the separation of the South Aegean region comprising

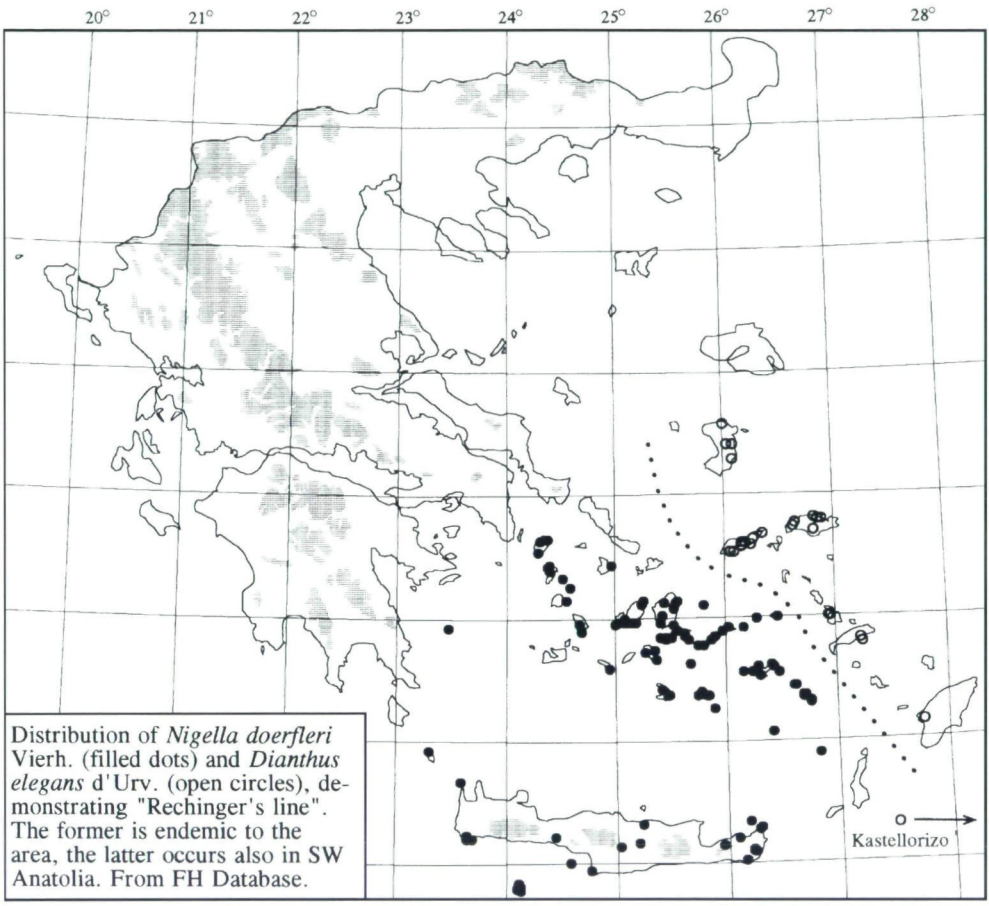

Fig. 2: Rechinger's line, the phytogeographical borderline between Europe and Asia in the Aegean area.

the island arc from Kithira in the west to Rodos in the east. RECHINGER was the first to point out clearly that the East Aegean islands are phytogeographically distinct from the Kiklades. Subsequent floristic projects (Flora Europaea, Flora of Turkey and the East Aegean Islands) recognized this interval as the phytogeographical border between Europe and Asia. It is here proposed that it be referred to as "Rechinger's line" (fig. 2) akin to the well-known "Wallace's line" separating the Oriental and Australian zoogeographical regions.

The Flora Hellenica Database

A series of databases have been established in connection with the forthcoming Flora Hellenica. The largest of these is the Specimen Database currently comprising c. 285,000 records for individual herbarium collections, literature reports or field notes.

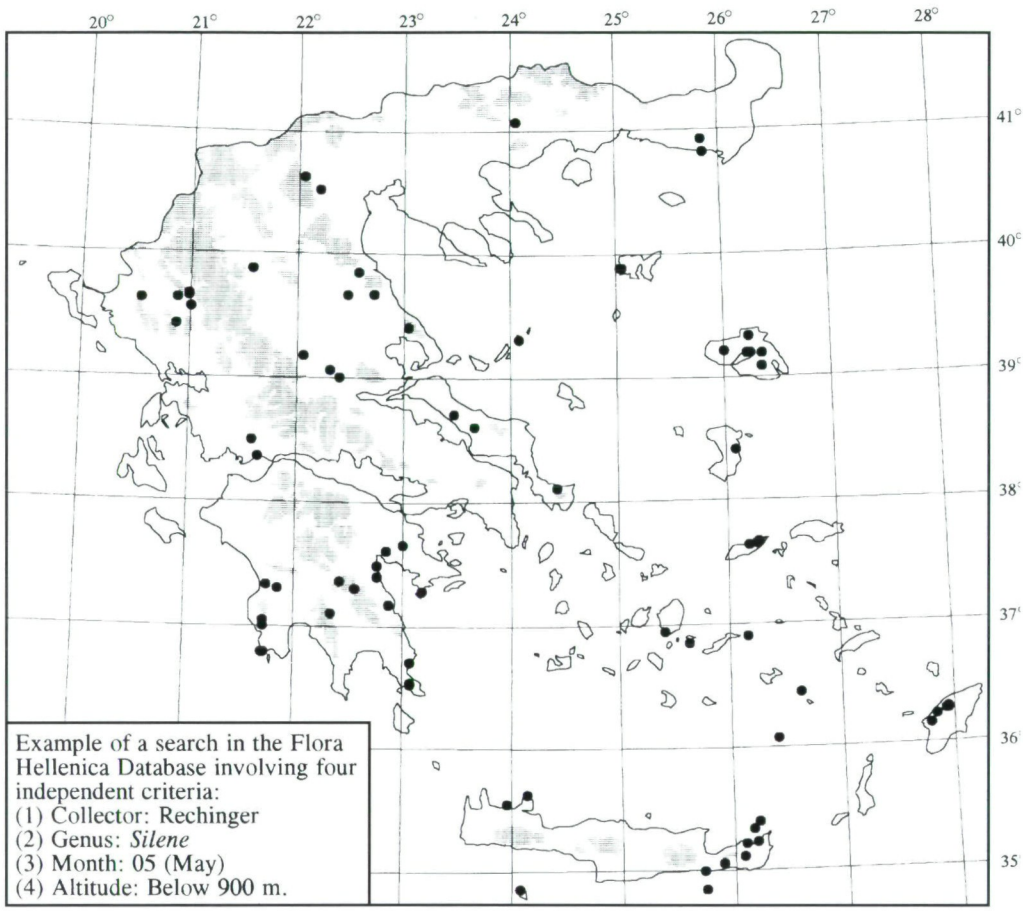

Fig. 3: Example of a search among 285,000 records in the Flora Hellenica Database. With standard PC equipment, maps such as this can be produced and printed in a few minutes.

Each record includes several fields such as name of species, collector, collecting number, date, herbaria, nomos, eparchia, island, mountain, altitude, locality and geographical coordinates (degrees and minutes of latitude and longitude). By means of a graphics programme, dot maps can be automatically produced. The painstaking task of registering material for the database has mainly been carried out by Britt Snogerup in Lund and by the author and co-workers in Copenhagen. Great care has been taken in data validation to minimize errors with respect to spelling of names, identification of localities, etc.

The total number of Greek herbarium specimens and published literature records is estimated at over 500,000, and the Specimen Database is thus far from complete. It is, however, sufficiently large to be useful in the context of quantitative phytogeography, and the main advantage is the speed and ease with which data can be handled. A map

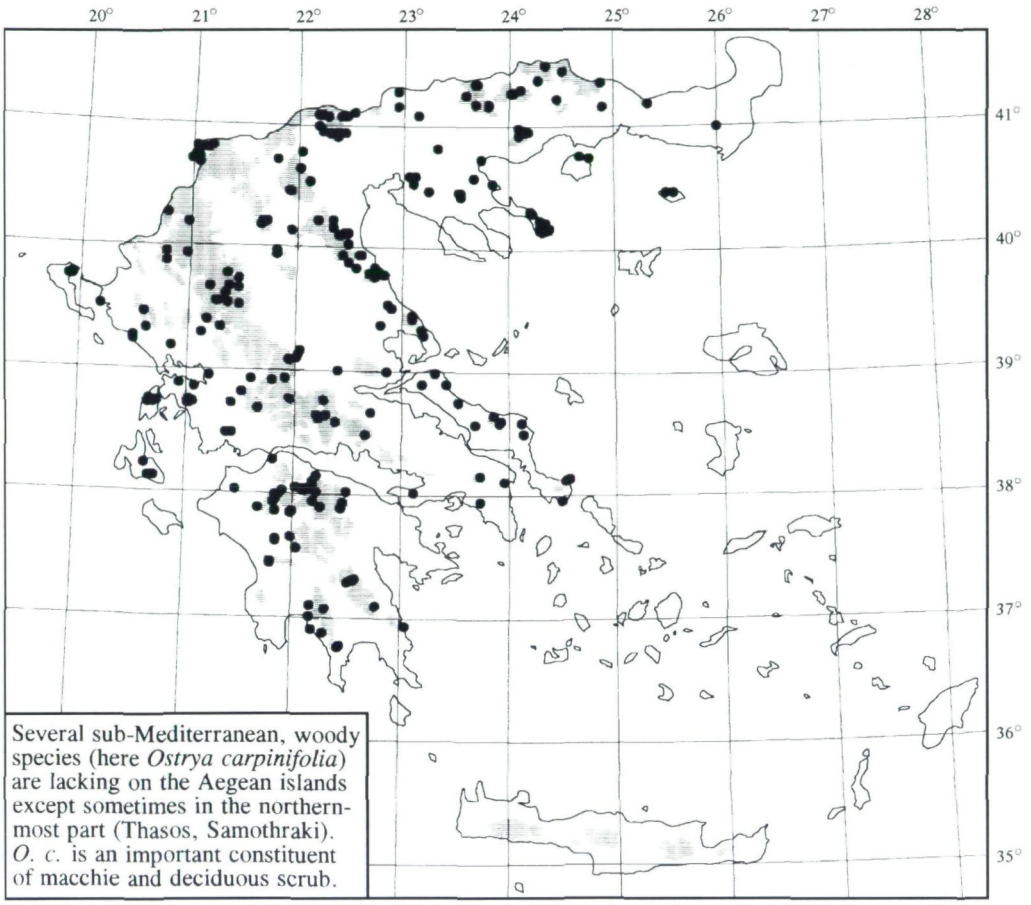

Fig. 4: Distribution of *Ostrya carpinifolia*, one of the many continental species of Greece which do not extend to the central and southern Aegean area.

such as the one in fig. 3, which would have been virtually impossible to produce manually, can be extracted and printed within minutes. The following examples will show how phytogeographical patterns revealed by means of data extracted from the electronic database compare to those established by Rechinger without access to such tools and partly on a more intuitive basis.

Floristics and phytogeography of southern Greece

As currently registered in the Flora Hellenica Database, the total number of species in the area comprising Peloponnisos, the Kiklades, Kriti-Karpathos and the East Aegean islands is 3575. The numbers for the four individual regions are: Pe 2503, Kik 1520, KK 1798 and EAe 2200.

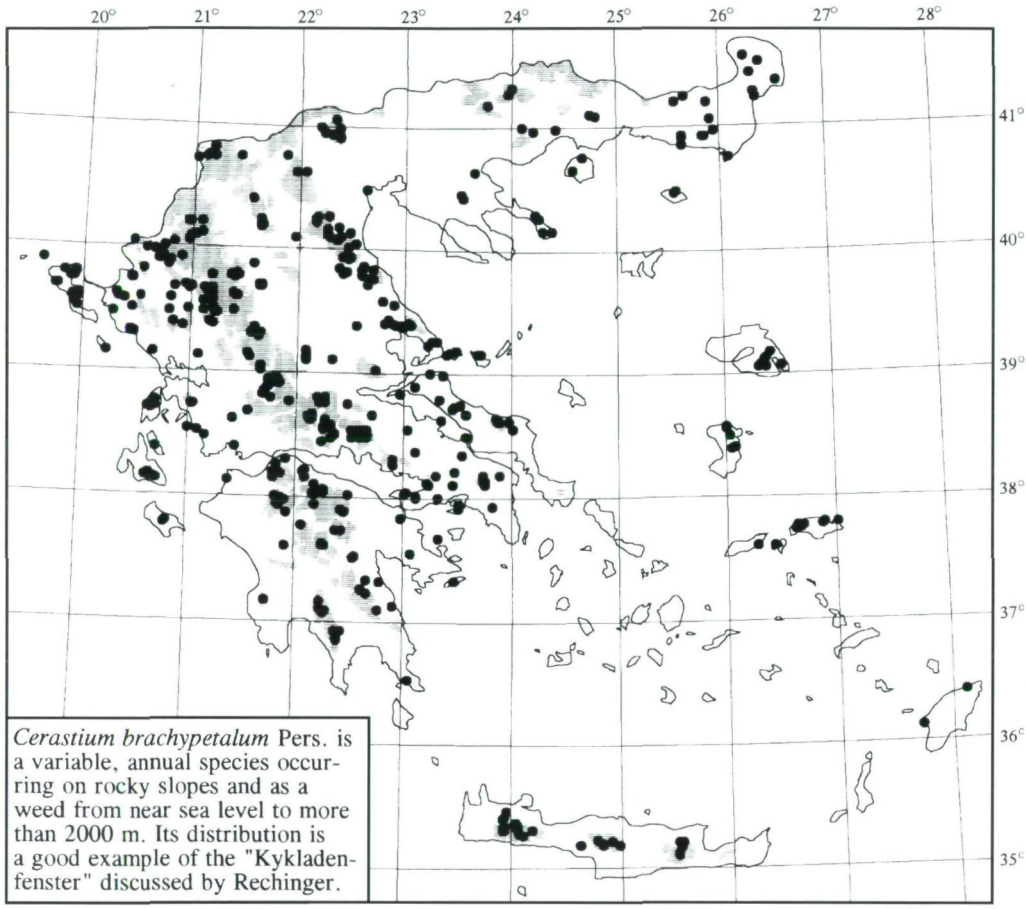

Fig. 5: Distribution of *Cerastium brachypetalum*, demonstrating a gap in the central Aegean area ("Kykladenfenster").

Although these figures are impressively high by Central and North European standards, they are not the highest in Greece. Of the 13 regions recognized for Flora Hellenica the richest floristically is the North East (comprising the mainland east of the river Axios) with 2949 species, with North Central and Northern Pindos also having figures well above those for the more southerly regions included in the present comparisons.

Of the total 3575 species, 999 are ubiquitous, i.e. occur in all four regions. When the latter are subtracted, the numbers of non-ubiquitous (and phytogeographically more meaningful) species are as follows:

Pe:	1504	(60.1 %)	KK:	799	(44.4 %)
Kik:	521	(34.3 %)	EAe:	1201	(54.6 %)

The percentage figures in parentheses indicate the proportion of non-ubiquitous species to the total number of species in the region, and are thus a measure of the "uniqueness"

of the flora. It is not surprising that the Kiklades, with a somewhat impoverished flora, scores low in this respect, but it is unexpected that Kriti and Karpathos - a region well known for its many endemics - should score only slightly higher. Evidently, the endemic element is outweighed by a large number of widespread species, mainly of more or less trivial lowland habitats. Peloponnisos has a significantly higher proportion of non-ubiquitous species; most of these are "continental" species occurring also further north in Greece and the Balkan Peninsula, but not extending to the Aegean area, many of them being mountain or forest plants; *Ostrya carpinifolia* (fig. 4) is an example of this distribution pattern. Particularly remarkable is the high percentage figure (54.6) for the East Aegean islands. This is strong indication of the fact that these islands have a large Anatolian element not crossing "Rechinger's line".

Another and more precise measure of the uniqueness of the flora of a given region is the number and proportion of species occurring in that region only, and not in the three others. Such species are not necessarily endemic since they may well occur outside the four regions concerned, e.g. in Anatolia or Sterea Ellas. The number and percentage of species which are in this sense unique to one of the four regions are:

Pe:	595	(23.8 %)	KK:	225	(12.5 %)
Kik:	84	(5.5 %)	EAe:	492	(22.4 %)

It is noteworthy that in the Kiklades only 5.5 % of the species are not found in any of the adjacent three regions, confirming that the central Aegean flora is poor in unique elements. The 225 species (12.5 %) unique to Kriti and Karpathos are to a large extent local and regional endemics. In the case of Peloponnisos, the high number and percentage of species not found in any of the other three regions is partly explained by regional endemism, but mainly by the fact that many Peloponnesian species occur further north on the Greek mainland and the Balkan Peninsula, while being absent from the south and central Aegean area. In the East Aegean islands, the incidence of endemism is low, and the high number and percentage of unique species is again a reflection of the fact that many Anatolian species have their western borders at "Rechinger's line".

A significant number of species occurring on the Greek mainland, Kriti and the East Aegean Islands are absent in the central Aegean area; Rechinger referred to this gap as a "Kykladenfenster", citing *Cerastium brachypetalum* and the *Inula candida* group as examples of this distribution pattern. This is beautifully corroborated by the more comprehensive data now available (cf. the distribution of *Cerastium brachypetalum* in fig. 5).

Another way of demonstrating the importance of "Rechinger's line" is to count the number of species occurring in the East Aegean Islands but not in the Kiklades, and vice versa. No less than 895 species have been recorded from the East Aegean Islands but not from the Kiklades; in the opposite direction the figure is 216. *Dianthus elegans* is an example of the former distribution pattern, and *Nigella doerfleri* of the latter (fig. 2). Fig. 6 also shows the corresponding figures for Peloponnisos-Kiklades and Kriti/Karpathos-Kiklades.

As expressed here in purely numerical terms, the phytogeographical borderline between Peloponnisos and the Kiklades appears to be somewhat stronger than that between the East Aegean Islands and the Kiklades, but this is somewhat misleading because the Peloponnesian flora includes ecological elements scarcely present in the Kiklades, such as forest and alpine species. Had comparisons been restricted to Eu-Mediterranean

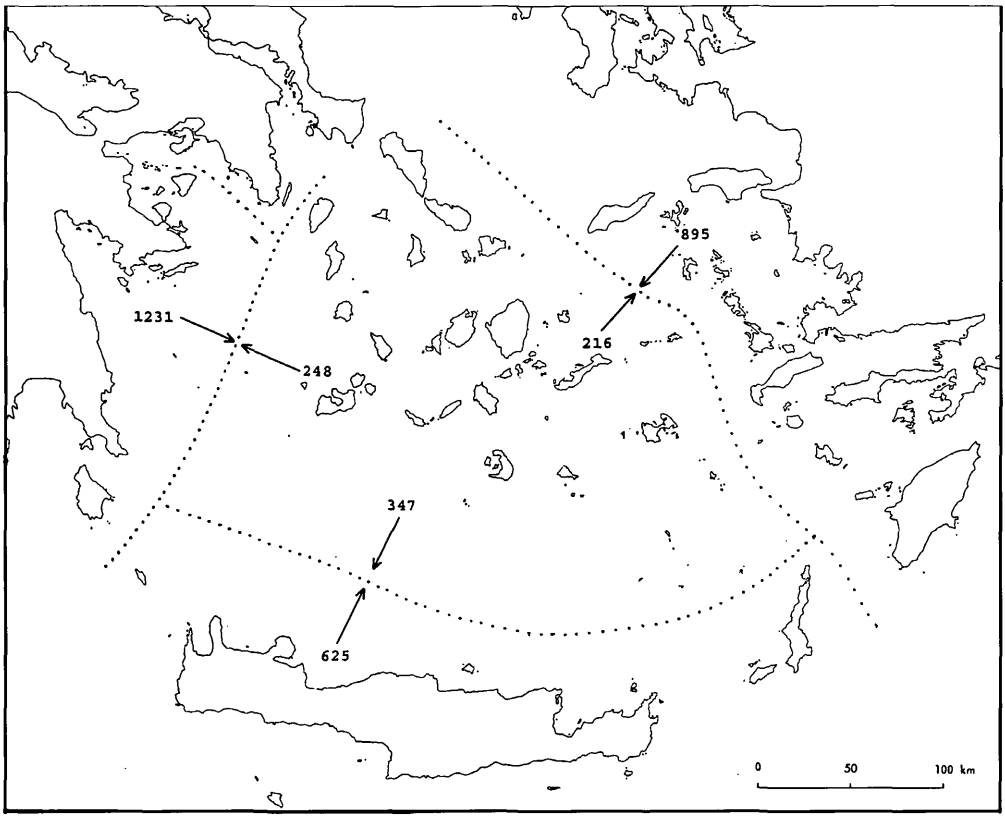

Fig. 6: Phytogeography of the central and southern Aegean area. Species occurring in one region, but not extending to the neighbouring one.

species (which at present there is no simple way of doing), the results would clearly have been different. If, on the other hand, the East Aegean region were to include a chunk of western Anatolia corresponding in size to half of Peloponnisos, the number of species occurring in this area but not in the Kiklades would presumably be twice as high as the present 895.

The phytogeographical position of Ikaria

The island of Ikaria is situated immediately east of "Rechinger's line", and its flora may be assumed to contain both East Aegean and Kikladian elements. Should it rather be ascribed to the Kiklades in a phytogeographical sense? In other words, should Rechinger's line have been drawn east of Ikaria rather than west of it?

To answer this question using data stored in the Flora Hellenica Database, the flora of Ikaria was compared with that of four other islands, two to the west (Andros and Naxos) and two to the east (Samos and Kos). The comparison involves the following steps:

(1) Complete species lists (not including hybrids) are drawn up for the five islands.
(2) Ubiquitous species, i.e. species occurring on all five islands and consequently lacking informational value in this context, are removed from the lists.
(3) The numbers of shared species are calculated for the island pairs Ikaria-Andros, Ikaria-Naxos, Ikaria-Samos and Ikaria-Kos.
(4) Shared species are expressed as a percentage of the number of species occurring on Ikaria itself. These are the percentage figures indicated on the map (fig. 7). For example, 61.8 % of the non-ubiquitous Ikarian species are also found on Andros, whereas 83.4 % are found on Samos.
(5) To compensate for the differences in species numbers on the "outlying" islands (the four with which Ikaria is compared), the percentage figures obtained in (4) are divided by the number of species on the outlying island and multiplied by 100. This operation results in the index values given in parentheses on the map.

The index is thus calculated according to the formula $i = \frac{C \times 100}{A \times B}$, where A and B are the numbers of species on the two islands being compared, and C is the number of shared species. In comparisons of this kind, where one island or some other operational unit is compared with two or more other such units, this index value is believed to be biologically more meaningful that the commonly used Simpson's index or Sørensen index. It should be noted, however, that the index values are relative in the sense that values obtained in one set of comparisons (e.g., between Ikaria and the other four islands mentioned above) are not directly comparable to those obtained from another, independent set of comparisons (e.g., between Kriti, Karpathos and Rodos, cf. below).

The results with respect to the phytogeographical position of Ikaria are quite unambiguous. Of the non-ubiquitous species occurring on Ikaria, 61.8 % are found also on Andros, 66.8 % on Naxos, 83.4 % on Samos and 28.5 % on Kos. Concentrating on Andros-Ikaria-Samos, we can thus observe that a higher percentage of Ikarian species have connections to the east than to the west. Since the total number of species on Andros is higher than on Samos, the difference will be even more pronounced when index values are calculated (6.96 and 13.31, respectively). Clearly, Ikaria has stronger phytogeographical connections with Samos than with Andros, and RECHINGER was correct in drawing his line west of Ikaria. Somewhat surprising is the low degree of similarity between Ikaria and Kos (index value 5.13); it can presumably be explained by a rather large number of south-east Aegean species reaching Kos but not Ikaria.

The south Aegean island arc

A similar comparison between the flora of Kithira and that of the adjacent territories of Peloponnisos and Kriti indicates that Kithira has considerably stronger connections with the former than with the latter (index values 3.98 and 1.20, respectively; cf. fig. 7). It is thus logical to include Kithira in the Peloponnisos region (as in Flora Hellenica) rather than referring it to the south Aegean area.

The phytogeographical position of Karpathos was discussed by RAUS (1991), who concluded that connections are to the west rather than to the east, and that the Karpathos island group belongs phytogeographically to Europe and not to Asia. His results are corroborated by a comparison between the floras of Kriti, Karpathos and Rodos using

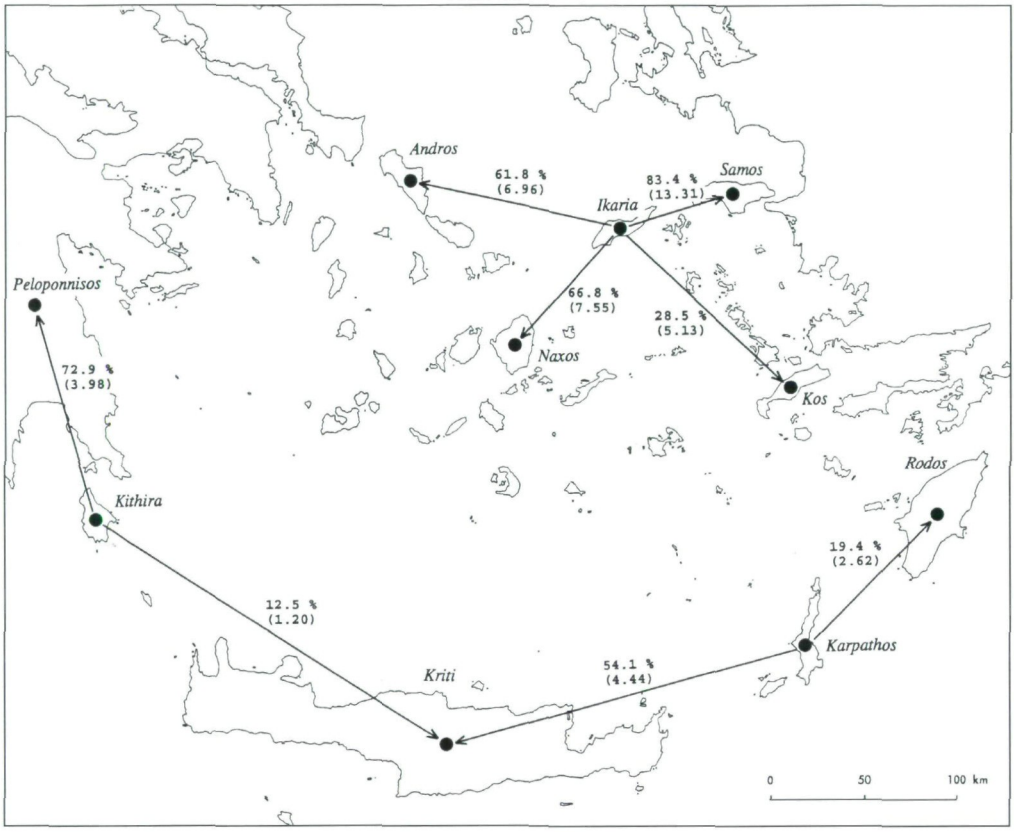

Fig. 7: Phytogeographical positions of Ikaria, Kithira and Karpathos. Further explanation in the text.

data extracted from the Flora Hellenica Database. In this comparison, 170 Karpathos species were found to be non-ubiquitous, meaning that they are absent from either Kriti, Rodos or both. Of these 170 species, 92 are found on Kriti and only 33 on Rodos. The percentage figures are 54.1 % and 19.4 %, and the corresponding index values 4.44 and 2.62, respectively (fig. 7). Flora Europaea recognized Kriti-Karpathos as a separate phytogeographical region, largely based on RECHINGER's data, and this practice was followed in TURLAND et al. (1993) as well as in the forthcoming Flora Hellenica.

The basic phytogeographical subdivision of the south Aegean island arc is now fairly well established. Kithira belongs phytogeographically to Peloponnisos, there are strong connections between Kriti and Karpathos, and the flora of Rodos has a significant Anatolian element.

Conclusion

RECHINGER'S phytogeographical subdivision of the Aegean area has stood the test of time; connections and intervals established some 50 years ago have proved, in the light of more comprehensive data, to be remarkably accurate. A specimen-based electronic

database established in connection with the Flora Hellenica project is expected to become an increasingly powerful tool in quantitative phytogeography. It will permit faster, simpler and more sophisticated analyses of distribution patterns than were previously possible.

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