Zelkova abelicea (Ulmaceae) in Crete: floristics, ecology, propagation and threats

Authors: Søndergaard, Poul, and Egli, Bernhard R.

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POUL SØNDERGAARD & BERNHARD R. EGLI

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Abstract

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Field work during twenty years in the mountains of Crete has disclosed that the endemic deciduous tree *Zelkova abelicea* is more abundant than hitherto reported. The number of mature and old trees is estimated to reach several hundreds, while *Z. abelicea* scrub browsed by sheep and goats comprises thousands of individuals. The species is extremely resistant to browsing and regenerates by suckers after forest fires. *Z. abelicea* suckers freely and suckering is an efficient way of propagation in the wild, while natural regeneration by seed was very rarely seen. Root cuttings from all four mountain ranges of Crete were taken to Denmark and 50 % successfully rooted. Best results were obtained with root cuttings taken in late autumn. Branch cuttings of newly matured shoots from young plants were rooted with good results when taken after midsummer. *Z. abelicea* has been grown outdoors in milder areas of Scandinavia during five years with only insignificant frost damage after cold winters. Currently it is not threatened with extinction but remains vulnerable.

Key words: Greece, Kriti, flora, conservation, cultivation.

Introduction

"Vulnerable. It occurs, usually in shrubby form, scattered in all four main mountain ranges of Kriti. Only about 50-100 large and regularly fruiting specimens still remain in a few places. These sites are normally heavily overgrazed by sheep and goats which prevents the growth of seedlings." Such was the status in 1995 for the Cretan endemic deciduous tree, *Zelkova abelicea* (Lam.) Boiss., reported by B. Egli in "The Red Data Book of Rare and Threatened Plants of Greece" (Phitos & al. 1995: 526-527). His judgment was based on more than ten years of studies of doline soils and their vegetation in the mountains of Crete (Egli 1993). Altogether 170 sample plots were studied, distributed over the four main mountain ranges of Crete, Levka Ori, Psiloritis (including Kedhros), Dhikti and Afendis Kavousi, at 700-2400 m elevation. Due to the abundance of water in and around dolines, this is a preferred location for *Z. abelicea* (Ambelitsia, the Greek common name, Sarlis 1987), which is a temperate element in the Cretan flora. During his

trekking from doline to doline Egli often came across stands of Ambelitsia and decided to initiate a detailed survey of the species, when he had finished his doctorate in 1993. In 1995 Poul Søndergaard was invited to join the project, which was combined with a detailed survey of the forest vegetation of western Crete (Egli 1998).

The Ambelitsia belongs to the elm family, *Ulmaceae*. It is found only in the mountain ranges of Crete at 800-1700 m elevation and most often around 1200-1400 m. A closely related species, *Zelkova sicula* Di Pasquale & al. was recently discovered in Sicily (Di Pasquale & al. 1992). These are the only two representatives of the genus *Zelkova* in Europe. A historical record of *Z. abelicea* from Cyprus by K. G. T. Kotschy could not be confirmed, so that the species is to be regarded as endemic to Crete (Andrews 1993 and own investigations in Cyprus).

During centuries the forests of Crete have been under strong pressure from extraction of timber and fuel wood and particularly from grazing and browsing. Forest fires are also a recurring plague. Together these factors created a patchwork of different successional stages difficult to fit into phytosociological systems. However, the mountain vegetation of Crete (above 1000 m) has not undergone the irreversible changes caused by commercial forestry and agriculture in many other countries. The island's mountain flora seems sufficiently resilient to be able to re-establish new combinations probably similar to the original plant cover and without serious losses of tree species. The Ambelitsia is found in places with a good and relatively constant supply of water. Very often it grows together with *Acer sempervirens* L., from which it can be difficult to distinguish from a distance, and particularly before the leaves are out. *Quercus coccifera* L. often grows together with the Ambelitsia. In the Levka Ori one finds Ambelitsia and *Cupressus sempervirens* L. growing together, while *Pinus brutia* Ten. normally grows either at elevations too low or in conditions too dry to accompany the Ambelitsia.

Based on extensive field work in Crete, Greuter (1975) i.a. gave a description of the vegetation zone in which the Ambelitsia occurs. He underlines the absence of a deciduous zone of *Quercus pubescens* Willd. in Crete, which in most of the northern Mediterranean countries forms an important belt between the sclerophyllous zone and the upper conifer zone and in which the Ambelitsia would have been a natural component.

Results

Field observations

The Ambelitsia is a tree up to 15 m high with a diameter at breast height up to more than one meter. The tallest and largest tree seen in the Levka Ori measured 14.5 m in height and 1.18 m in diameter at 1.3 m. Counting of annual rings on cores from several trees suggested an age of more than 300 years for this individual. The leaves are oblong-ovate, 1-5 cm long, 0.5-2.5 cm wide, with 3-6 pairs of lateral lobes. In grazed areas browsing keeps it as a low dense shrub often less than 1 m tall, but nearly impenetrable because of its interlaced and very dense growth form. It shows a tendency to dimorphism, young browsed plants having leaves less than 2 cm long, while leaves up to 5 cm long are found only in the crowns of mature trees. It multiplies easily by suckers and often covers large areas with dense and impassable scrub. Some populations could be clones of very few individuals or even a single individual. Flowering was observed in the Levka Ori during mid May. Male flowers are arranged in dense clusters, while hermaphrodite flowers are solitary. Fruits are subglobose drupes, 5-6 mm in diameter. There seems to be a tendency for flowering and fruiting to follow a three-year cycle. Egli observed flowering in 1985, 1988, 1991 and 1994 and flowering was again observed in 1997. Of several hundred seeds collected in 1988 more than 95 % were empty. This proved to be the rule in the following years' collections. But there were exceptions. From 50 seeds collected on the ground in December 1998 about 20 germinated and produced young seedlings showing the auriculate cotyledons, similar to those found in the genus *Ulmus*. No seedlings or young plants were observed during four expeditions (1995-99). However, in spring 1992 Egli collected about 300 seedlings under old Ambelitsia trees in the Levka Ori.

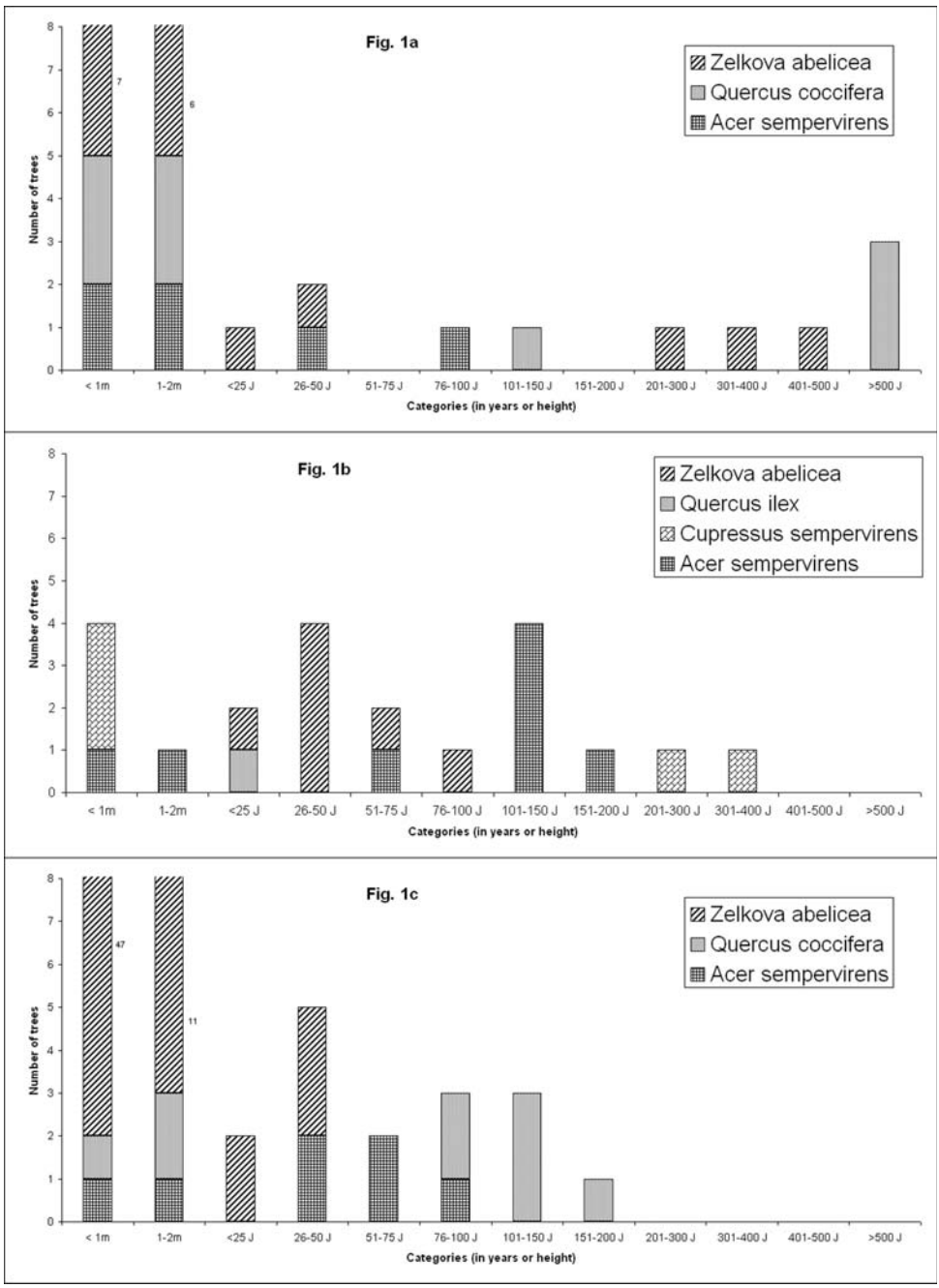

Fig. 1. Structure of forest stands in the mountains of western Crete (Levka Ori) with *Zelkova abelicea, Acer sempervirens, Cupressus sempervirens, Quercus coccifera* and *Q. ilex* – a: graduated forest, plot 70 (southern border of Omalos plain); b: graduated forest, plot 37 (hills south of Zourva-Theriso); c: young to middle-aged forest, plot 66 (northeastern border of Omalos plain). – Trees smaller than 2 m are in height classes, trees higher than 2 m in age classes determined by the annual rings.

Zelkova abelicea as a component of the forests of Crete

Vegetation mapping in the district of Chania in western Crete (Egli 2000) showed Ambelitsia to be the dominant tree species only in some special areas, along the timberline on the northwestern slopes of the Levka Ori, west of Xyloskala at the Omalos plain and at the western slopes of Mt Pachnes. The study of 565 Ambelitsia individuals in the field shows an extraordinary high proportion (80 %) of young trees (below 2 m height) compared to the other tree species in the forests (*Cupressus sempervirens* 38 %, *Acer sempervirens* 50 %, *Quercus coccifera* 55 %, *Pinus brutia* Ten. 44 %, *Phillyrea latifolia* L. 65 %). This can be related to the strong tendency of Ambelitsia to multiply by suckers. Although there is quite a number of young forest plants of Ambelitsia present, studies (Egli 1998) have shown a lack of trees aged 50 years or less in areas of heavy grazing, compared to the age distribution of Ambelitsia in areas without disturbance.

Detailed investigations (Egli 2000) of forest plots of 50 × 4 m with measurement of all included trees and calculation of their age from wood samples and cores show that the forests of western Crete are generally composed of several tree species (see Fig. 1). The age classes suggest changes in the species composition. Three different types of forests including Ambelitsia are recognized:

a) Graduated age structures with old stands of *Quercus coccifera* and Ambelitsia followed by younger trees of *Acer sempervirens* and Ambelitsia (Fig. 1a).
b) Graduated age structures with an old stand of *Cupressus sempervirens* changing into an *Acer sempervirens* forest followed by younger Ambelitsia with again *Cupressus* as treelets (Fig. 1b).
c) Middle-aged *Quercus coccifera* forest followed by pioneer *Acer sempervirens* and Ambelitsia trees and a high number of Ambelitsia treelets (Fig. 1c).

Propagation and cultivation

The plants collected in 1992 were raised in Switzerland and distributed to different places, e.g. to the University of Zürich and to different locations in Crete. In August 1993 20 plants were taken to Denmark and grown at the Hørsholm Arboretum (accession number 526-1993). During the first years they were kept in an unheated glasshouse and in 2000 were transplanted to the arboretum area, where they have survived without being damaged during the following four winters. During following years seeds were collected and brought to germination, but most of them did not germinate until the second year. Due to the sporadic and very limited occurrence of good seeds, in-vitro cultivation from seedlings was tried (M. Oberholzer, Institut für angewandte Biologie, Bern, unpublished). This was successful except that rooting has not yet been achieved in the trials.

The most reliable method for collecting propagules of Ambelitsia in the field is by taking root cuttings from suckers. This was done both during spring and autumn. Particularly good results were obtained with material collected during a visit in early December 1998. Conditions for keeping the root cuttings alive during transport to Denmark were more favourable than in late spring. Experiments made at the Hørsholm Arboretum between 1995 and 1998 with shoot cuttings taken from young plants showed that this is a good and easy way of multiplying Ambelitsia in the nursery. Experiments with branch cuttings taken from plants of collection 526-1993 were initiated at Hørsholm, Denmark in 1995. Later experiments in 1998 and 1999 gave best growth results with 10 cuttings from each of 10 plants taken at the beginning of August. 47 plants were obtained from the 100 cuttings, while only 6 plants were obtained from 100 cuttings taken at the beginning of July. An experiment with a few branch cuttings taken from mature trees in Crete was not successful in producing plants.

About 100 plants were obtained partly by root cuttings collected in the four mountain ranges in Crete (Levka Ori, Psiloritis incl. Kedhros, Dhikti and Afendis Kavousi) and partly by shoot cuttings taken from young plants in Denmark and rooted at the Hørsholm Arboretum.

In April 2001 a total of 102 plants were transferred to the Saerheim Research Centre 25 km south of Stavanger in Norway. The Centre is located 5 km from the North Sea, at 80 m altitude.

Not a single plant was seriously damaged during the following four winters at Saerheim. In October 2004 the plants were again transferred, to a garden 30 km south of Bergen and 150 km north of Stavanger. During 2003 and 2004 a number of plants were distributed to botanical collections in Denmark and Norway. Of the 65 plants transferred in October 2004 only one plant died during the following winter 2004/05 (Table 1, see electronic supplement to this paper on the homepage of Willdenowia under volume 36).

In a field experiment in the spring of 1995, 18 plants (each around 30 cm tall) were transplanted from Switzerland to several places in Crete: 6 plants were planted in a grazed area at Limnakaro above the Lassithi plain at 1150 m, 4 in a garden in the Lassithi plain at 850 m, 2 in a grazed area at Kallergi hut at 1680 m east of the Omalos plain, 1 in a garden in the Omalos plain at 1050 m; the remaining 5 were given to institutes in Chania close to sea level. In the grazed areas two plants died in the first two years, while the others remained small (between 20 to 30 cm) due to grazing, but thickened at the stem. The plants kept in gardens and watered grew up to 3-4 m in height.

Zelkova abelicea, a hardy species

The survival of Ambelitsia over five years out of doors in Scandinavia proves its good hardiness. The scattered occurrences of the species in Crete suggests that the populations are relicts from a former more widespread temperate forest type in the mountains of Crete with a supposedly close relationship to the eastern Euxine-Hyrcanian floristic provinces. *Zelkova carpinifolia* (Pall.) Dippel occurs in E Anatolia through Armenia to parts of the Caucasus and in the Elburz Mts (Davis 1982: 648-649). The remaining four or five species of the genus, except *Z. sicula,* are all natives of E Asia. Like *Z. abelicea,* also *Z. carpinifolia* suckers freely (Andrews 1993) and the fertile shoots break off at maturity and fall to the ground with fruits and withering leaves attached (Spoelberch 1993), just as we have observed in *Z. abelicea.*

Many big trees of Ambelitsia were found near the upper forest limit, often together with *Berberis cretica* L. This may indicate that in periods with cooler climates, *Zelkova abelicea* has formed an upper deciduous forest belt above the *Acer sempervirens-Cupressus sempervirens-Quercus coccifera* zone with *Berberis cretica* as an important component.

Zelkova abelicea and the Dutch Elm Disease (D.E.D.)

As a close relative to the elms, *Zelkova abelicea* was considered vulnerable to attacks by the D.E.D. (Simmons 1979). However, recent observations at the Royal Botanic Gardens, Kew, show that the two specimens at Kew are growing healthily without any signs of D.E.D. (T. Kirkham, pers. comm. 2004). A specimen at the Royal Horticultural Society Garden at Wisley is just reaching a trunk girth which could prove attractive to the elm bark beetle, *Scolytus scolytus* (C. Gorton, pers. comm. 2004). If Ambelitsia proves resistant to D.E.D. it could become important in breeding programmes for such resistance more generally in the *Ulmaceae.* In itself it is an attractive species for horticulture in mild-temperate climates. A considerable variation is observed in the plants raised so far and there seem to be good possibilities for selecting attractive growth forms.

Zelkova abelicea, a threatened species?

Twenty years of reconnaissance in the mountains of Crete have shown that Ambelitsia is not a threatened species. The authors estimate the number of trees (more than 5 m tall) in the four mountain ranges to be several hundreds with an overwhelming majority in the Levka Ori and many in the Dhikti massif. In addition there are thousands of individuals forming bushes and often growing in very dense scrubland. Ambelitsia is very resistant to browsing and re-sprouts from the roots after forest fires. However, a future threat could be the expanding new roads, which are being constructed in the mountains of Crete, often with financial support from the European Union. They make it easier to extract trees for timber and fuel wood if no protective mea-

sures are taken. So if not threatened, the Ambelitsia must still be considered vulnerable and should maintain its present status in "The Red Data Book of Rare and Threatened Plants of Greece" (Phitos & al. 1995).

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Addresses of the authors:

Dr Poul Søndergaard, Hatvikvegen 59, N-5200 Os, Norway.

Dr Bernhard R. Egli, Hohlenbaumstrasse 61, CH-8200 Schaffhausen, Switzerland.