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A project for the preservation of *Zelkova abelicea (Ulmaceae),* a threatened endemic tree species from the mountains of Crete

Abstract

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Zelkova abelicea, a Tertiary relict species, is today restricted to Crete where it is scattered in all the main mountain massifs. It is a threatened species of which few old, fertile trees remain, and it is important that it be preserved. Heavy overgrazing now prevents the development of shrubby individuals into trees and jeopardizes regeneration through the seldom germinating seeds. The species has been studied for eight years, both in situ in its natural stands and in cultivation. In-vitro cloning using leaves, twigs, roots, seeds, and seedlings proved difficult due to bacterial infection of nearly all plants. Just one of a hundred seedlings was not contaminated and was thus suited for vegetative propagation. Based on this study, concrete steps of a project for the preservation, multiplication and afforestation of *Zelkova* are devised.

Introduction

Zelkova abelicea (Lam.) Boiss. is of considerable scientific interest as an E. Mediterranean Tertiary relict species. Until recently (when a second, even rarer species was discovered in Sicily and described as *Z. sicula* by Di Pasquale & al. 1992) it was considered as the sole extant European representative of the otherwise Asian genus *Zelkova* of the *Ulmaceae.* It is endemic to Crete, where it is restricted to the mountains.

Whereas thousands of small individuals can be found, only very few stands of mature trees have survived, probably no more than 50-100 individuals in total. These trees may be several hundred years old, 10 m high or taller, and may exceed 1 m in circumference of the trunk. They are of vital importance for the survival of the species, as their natural seed production may be used for the multiplication of the plants in cultivation.

Fire is by far the most important threat to the *Zelkova* trees, and to Cretan forests in general, being able to destroy forever many hectares of woodlands in a matter of hours. Another severe danger for the *Zelkova* trees is their potential use as fire-wood.

Mediterranean botanists have recognized the great importance of preserving *Zelkova abelicea* in Crete as a matter of urgency. The 253 participants from 22 countries at the VI

OPTIMA Meeting in Delphi 1989 resolved "to support endeavours to safeguard rare species by special action plans, such as the protection and propagation of the few surviving adult stands of *Zelkova abelicea* by means of local measures and through multiplication of stocks of the species in nurseries" (Phitos & Greuter 1991: 37).

Ecology

The effects of the hot and dry Mediterranean summer season are markedly mitigated in the Cretan mountains. The high amounts of winter precipitation (1000 to 2000 mm) saturate the soil so that edaphic conditions will remain humid throughout the summer (for details on physical properties of soils, see Egli 1988).

Zelkova trees are of considerable ecological importance. The species is confined to the main mountain regions of Crete, which consist of limestones of different series and ages. The main soil types are rendzinas, orthic luvisols, eutric and dystric cambisols. The best stands of *Zelkova* usually stock on north-facing slopes or flat valley bottoms, where edaphic and hydrological conditions are most favourable. There, deep soils of the eutric and dystric cambisol types can be found that are humiferous and rich in clay (for details of soil systematics, see Egli 1993). Most often these places are heavily overgrazed by sheep and goats, which permits to observe the reaction of *Z. abelicea* to excessive grazing pressure (see below).

Distribution

Zelkova abelicea is widely spread over all four mountain massifs of Crete (Fig. 1), especially in the Levka Ori and Dhikti mountains, and with some stands on the Psiloritis (incl. Kedhros) and Afendis Kavousi ranges. In some places, as on the north-facing slopes towards the Omalos plain (Levka Ori), Mt Kedhros (Psiloritis), Mt Lazaros (Dhikti) and in the Mirthos valley (Dhikti), the species forms fairly dense stands of trees and shrubs. However, really large trees about 10 m tall and with 1 m of stem circumference are rare and restricted to a few places.

With few exceptions the altitudinal range of *Zelkova* is comprised between 900 m and 1700 m a.s.l., thus fully coinciding with the mountain forest belt of Crete. The extant trees are probably last remnants from a former mountain forest. The species can still be found in many of the ecologically suitable places. The great number of dispersed and often isolated occurrences, when no fertile fruits are produced, are a distributional pattern that points to a much less fragmented former distribution in the Cretan mountains.

Bottema (1980, and pers. comm.) reported 2 % of *Ulmus* pollen in Cretan cores dating from 10,090 to 8,000 B.C., and cannot exclude a confusion with *Zelkova* pollen.

In the *Flora of Cyprus,* Meikle (1977, 1985) discusses an old, doubtful record of *Zelkova abelicea* from Cyprus, possibly due to misidentification or confusion. We explored the corresponding area in Cyprus in early spring 1993 without finding either *Zelkova* itself or any places with conditions comparably favourable to those known of the Cretan occurrences. Confirmation of the old Cyprus record of *Z. abelicea* is thus highly unlikely.

Biology, growth, and propagation

General statements on the biology of *Zelkova abelicea* can be found in Sarlis (1987) and Meikle (1985). Only new data are reported here:

Chromosome number. – The chromosome number of *Zelkova abelicea* is $2n = 28$ (Fig. 2). The same number is known for other species of the genus, such as *Z. carpinifolia* (Pall.) Dippel, and for nearly all species of *Ulmus.*

Plant growth. – *Zelkova abelicea* grows very slowly, especially in the first and second year of the seedling phase. The analysis of stem cross-sections shows that the slow initial increase (year-rings of about 0.2 to 0.3 mm) lasts for approximately 30 years, after which time the annual increase rises to about 1 mm.

Reaction to grazing. – Observations in the surroundings of shepherds' huts show that *Zelkova abelicea* can grow successfully even in heavily overgrazed areas. The species is able to multiply by suckers sprouting from the roots of older plants. This characteristic explains the relatively dense shrub stands formed by *Zelkova.* Vegetative multiplication prevails over reproduction by seed, and it alone is successful in severely grazed areas.

Winter habit. – Even in winter, without leaves, it is possible to distinguish *Zelkova abelicea* in the field from other, similar trees or shrubs, such as *Acer sempervirens* L., *Crataegus* spp., *Pyrus spinosa* Forssk., and *Rhamnus prunifolia* Sm., by the following characteristics:

- large trees of *Zelkova abelicea* have a distinctive, typically slender crown shape;
- *Zelkova abelicea* has very slender, sympodially growing twigs with alternate leaves. When small trees are grazed heavily at the bottom they produce very long twigs ("whip shoots") at the top;
- in spring the leaves unfold later than in any of the other species, and in autumn they are usually shed earlier;
- shrubby *Zelkova abelicea* shows a rounded shape under grazing: the slender young shoots are grazed off completely, and only the inward-directed shoots remain, so that the plant's circumference is built of a harness of old, thick twigs (in contrast to *Acer* and *Rhamnus,* where only the young leaves are grazed and the pointed, hard, outwardly directed new shoots remain;

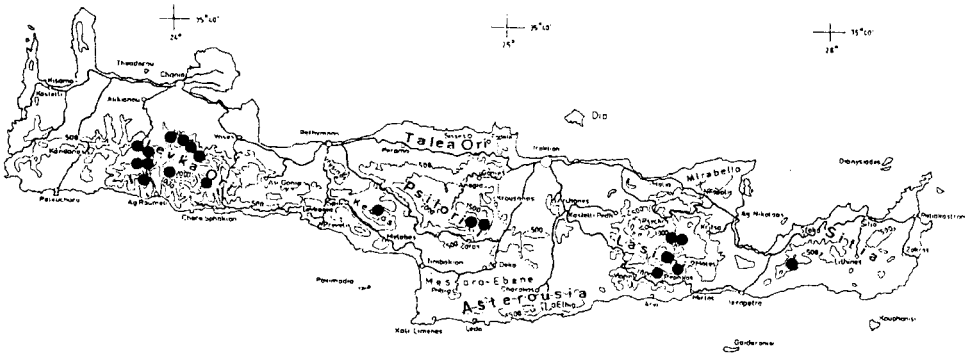

Fig. 1. Map of the total known distribution of *Zelkova abelicea.*

- the bark peels off scale-wise in thin layers, leaving a pattern of differently coloured, greyish to dark and bright brownish spots;
- the colour of the tree is reddish-brown from a distance (in *Acer* it is whitish).

Fruit set. – The fruits are nuts and fall off together with the annual shoot on which they are formed, with the dry leaves still attached helping to disperse the diaspores. This happens at the end of October and in November when little other food is available. Ants (particularly *Messor structor* Latreille) carry thousands of *Zelkova* nuts to their nests and open them to feed on.

The species seems to have a three years cycle of high fruit production. Such mast years were 1985, when seedlings were grown in the greenhouse from seeds for the first time; 1988 when the first few wild-growing seedlings were found in the Omalos-region of western Crete; and most recently 1991, when also the weather was favourable, with plenty of rain and consequent good water supply in summer. In that last year billions of seeds were produced even on relatively young trees only about 4-6 m high and 30-50 years old.

Natural reproduction and ex-situ multiplication

The main problem with natural reproduction of the species is that few seeds will germinate. Such seedlings as may be formed are sensitive to harsh conditions during the first weeks after germination. Any surviving plants will only grow slowly in the first years. Because of the intensive grazing by stock, almost all juvenile plants will be destroyed. Forestry stations, botanical research institutes and botanic gardens have therefore an important role to play by attempting to germinate the seeds ex situ and nurse the plantlets during their first years, until they can be reintroduced under supervision into selected areas of their native habitat.

Seeds have been collected every year since 1985. Germination and growth of the plants from seed (and also of suckers from root pieces) were studied at the Institute for Systematic Botany at the University of Zurich. About 10 % of the seeds of selected large trees germinated and developed into small trees.

In 1991, the most favourable year for fruit set, more than 50,000 seeds – also from smaller trees – were collected and sown, but with little success: only about 20 seeds

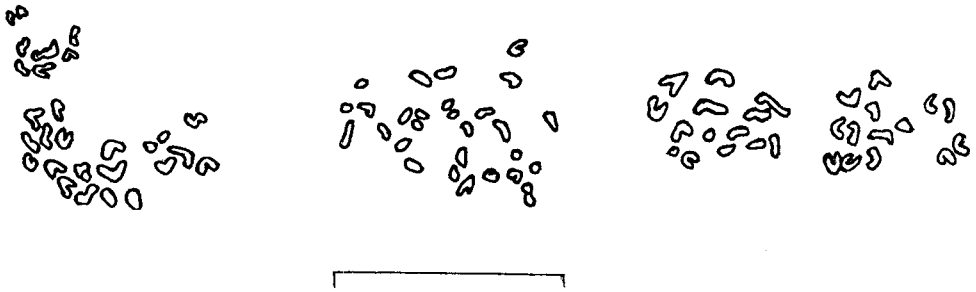

Fig. 2. Somatic metaphase plates of *Zelkova abelicea* from the Omalos plain, W. Crete, showing $2n = 28$ chromosomes. – Scale bar = 10 µm.

grew to seedlings. Yet, thousands of wild-growing seedlings were found in the Omalos region in spring 1992. About 300 of them were collected and taken to Switzerland, two-thirds to be planted in the greenhouse and one-third for in vitro multiplication in the laboratory.

In spring 1992 some areas in the White Mountains were fenced to protect the seedlings from grazing by stock. Unfortunately, in autumn no seedlings were found to have survived within the fences, and but a single one outside. All the thousands of others were killed by summer drought and/or grazing damage. Considering that other, much faster growing plantlets, as of *Berberis cretica* L., were seldom found it is plausible that the very delicate seedlings of *Zelkova abelicea* have hardly any chance to survive. Nevertheless, as the one exception demonstrates, survival is possible.

Multiplication of *Zelkova abelicea* in vitro, in collaboration with the laboratory of Wyss Samen & Pflanzen AG, was tried unsuccessfully using various plant materials: shoots, leaves, roots, and seed. Of the 100 seedlings collected in Crete in spring 1992, all but one were bacterially infected and died after some time. The single surviving, non-infected seedling served as source for multiplication by cloning, giving rise to some hundred in vitro cultures. The single problem that remains to be solved to date is that the cultures do not so far regenerate roots.

Zelkova abelicea afforestation project in Crete: progress and outlook

Field studies. – The field study of *Zelkova abelicea,* now completed, and much improved our knowledge of the biology, ecology and distribution of the species in the mountains of Crete.

Laboratory studies. – The in-vitro propagation studies are well advanced. The problem of root development and of transfer from the laboratory to field conditions have yet to be solved.

Plant production. – As soon as the laboratory studies are completed, the production of some thousands of *Zelkova abelicea* plants by cloning can be started, to obtain material for bulking up the native populations. Once standardized plant production is working, it can be transferred to suitably equipped Cretan university or forestry services.

Public awareness. – The next step will be to start a campaign for public support of the *Zelkova* project, in the years to come:

- political authorities must be contacted and convinced of the need to preserve the few remaining adult stands of *Zelkova*;
- the last remnants of large tree stands must be singled out as natural monuments;
- the large trees must be preserved from being felled or damaged, e.g. by providing financial support to the owners of such trees or places (usually shepherds) for their protecting the trees as well as collecting fresh seed;
- discussions with the people living in the neighbourhoods, as well as a public campaign in the Cretan press, are to inform the whole island population of the value and importance of these trees;

- in parallel, exhibitions on the Cretan mountains, their forests, and especially *Zelkova*, with concomitant public lectures, will have to be organized in various places in Crete;
- a political decision to grant effective legal protection to *Zelkova abelicea* may eventually be obtained.

Field collection of plant material. – Seeds from various places of all mountain massifs will have to be collected in the seasons to come, and alternating spring expeditions for the collecting of some thousand of seedlings in the same places will have to be organized. The seedlings are to be nursed locally in collaboration with the competent forestry services.

Pilot afforestation project. – After some years in the nurseries, the young trees are to be transplanted to selected, suitably protected afforestation areas. Plants should be placed into the trust of shepherds and farmers, to be planted near their huts and estates and grown under the supervision of the owners. Monitoring of the young plantations and advising of local people will be necessary.

Regular production and afforestation programme by the forest services. – The planning of such a regular afforestation programme must be based on the knowledge gained during the pilot phase, and will depend on the availability of financial support. It will have to span several decades.

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