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The effectiveness of seed-banked material in *ex situ* cultivation: an example from Cyprus

Abstract

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About 10% of the indigenous vascular plant flora of Cyprus has been cultivated in order to test how many taxa can be grown *ex situ*. In about two thirds of the tested taxa cultivation was successful. Generally, taxa showing high germination rates in seed bank testing routines succeeded but exceptions could lead to problems in conservation efforts. Drafting of garden protocols, at least for rare, endemic and endangered taxa is highly recommended.

Key words: *Ex situ* Conservation, seed banks, Mediterranean flora.

Introduction

The storage of diaspores, whether of endangered, endemic or other species, in seed banks has reached new levels in recent years. Large collections such as the Millennium Seed Bank now preserve seeds of up to 32,000 taxa (Royal Botanic Gardens, Kew 2013). To adopt measures for the reintroduction of threatened species into their natural habitats is part of the official policy of the "Convention on Biological Diversity" (CBD secretariat 2013). Increasingly, ex situ conservation takes the form of seed banking. Prolific literature exists on the conservation of diaspores (see summary by Smith & al. 2003). An increasing number of seed banks justifies their activities, inter alia, by conserving and providing material for reintroductions and population reinforcements resp. But this is in obvious contrast to the very small number of studies dealing with the question as to whether or not all or at least the endangered and endemic taxa of a certain region can be grown successfully ex situ. Apart from routine testing of germination rates rarely any measures are documented about the question as to which taxa can be cultivated ex situ.

This raises the fundamental question of whether the expectations of conservationists associated with the storage of seeds can be fulfilled at all. Previous studies show that in the case of reintroductions, seedlings, or better adult plants, should be preferred instead of sowing seeds (see Godefroid & al. 2011; Drayton & Primack 2012). However, seed banks and garden facilities are often located far away from the places

of origin; the culture must take place under suboptimal conditions. For numerous taxa, cultivation experiments have never been made or results must be excerpted from the literature. For the majority of Euro-Mediterranean species, there are no autecological studies and no garden culture protocols. In many of the species cultivated in recent decades, apparently no documentation, either in public or in internal databases, has been made. Knowledge about successes or failures gets lost. Also in reintroduction and population reinforcement projects resp., there are reasonable grounds to suspect that failures are rarely published and that the success rate is relatively low (Godefroid & al. 2011; Drayton & Primack 2012). In addition, hardly any long-term monitoring determining success or failure of such projects is run. So, there are many unclarified issues.

Cyprus was chosen as a test case because the long-term objective of a cooperative project with Cypriot partners is to store seeds of all vascular plants occurring on the island in the "Dahlem Seed Bank" (Berlin). Initially, the project was focusing on endemic and endangered taxa. About 500 accessions were collected from 370 taxa (as of January 2013). Though not all accessions meet the requirements of long-term storage, mostly because of too-low numbers of seeds, material of a relatively high percentage of the vascular flora was available.

Materials and methods

Cultivation took place since 1996, primarily from 2010 to 2012 in the Botanic Garden Berlin-Dahlem. Selection of cultivated taxa was partly due to chance and partly through exploitation of synergies with other ongoing projects (karyological and taxonomic studies). The gardeners entrusted with the cultivation were familiar with Mediterranean taxa and have been treating a large number of species in the past decades. Sowing was carried out in early spring, in some species also in the autumn. In the summer, further cultivation in pots was performed outdoors, and in the case of drought-tolerant taxa also all year round in greenhouses. Edaphic and other ecological features were taken into account if possible, but no serpentinites were used (see below). The cultivation of a species was considered successful when plants (whether annuals or perennials) grew to a stage favourable for reintroductions.

Taxonomy, nomenclature and definition of endemism follow Hand & al. (2013), while the classification of endangered species follows Tsintides & al. (2007)

Results and observations

During the study period, 168 taxa from 37 families were cultivated (10.3% of the indigenous flora of Cyprus; Hand & al. 2013), in some cases several accessions of the same taxon, with repeats in several years. Of these 168 taxa tested, cultivation was successful in 114 taxa (68%); in 54 taxa (32%) the efforts were without success. Among the successfully tested taxa were 46 endemics (40%), 8 near-endemics (8%) and 59 non-

Table 1: Numbers of taxa from Cyprus cultivated in the Botanic Garden Berlin-Dahlem (RDB = Red Data Book Cyprus).

cultivation successful	114 (68%)	46 endemic (40%)	37 RDB taxa (32%)
		9 near-endemic (8%)	
		59 not endemic (52%)	77 not RDB taxa (68%)
cultivation not successful	54 (32%)	28 endemic (52%)	23 RDB taxa (43%)
		26 not endemic (48%)	31 not RDB taxa (57%)

endemics (52%). For species without success, the percentage was similar: 28 endemics (52%) and 26 non-endemics (48%). More details are given in tables 1 and 2.

Several aspects deserve more detailed consideration (see also Table 2).

Species with high germination rates above 80% were predominantly cultivated successfully. There are few exceptions as regards high germination rates, e.g., the endemic *Euphorbia veneris*, which has been grown repeatedly in Cyprus, for example in the Botanical gardens in Athalassa and Amiantos. On the other hand, in the group of taxa with low germination rates (up to 20%) positive deviations can be found: the micro-endemic *Limonium mucronulatum* (world population less than 700 plants, Tsintides & al. 2007) could be cultivated easily.

Serpentine bedrocks play an important role in the geology of Cyprus, the evolution of endemic species and their distribution. Apart from the endemic taxa that are obligately serpentinophytic, some other non-endemics that are bound to serpentine in Cyprus (e.g. *Lactuca triquetra*) belong to this group. Some other accessions come from serpentine areas but belong to geologically indifferent taxa (see Table 2). In the cultivation experiments, no heavy-metal-containing substrates have been used. However, cultivation has been successfully carried out in 17 serpentinophytic taxa (53%), whereas 15 such taxa (47%) could not be successfully cultivated. Although the sample size is small, a significantly lower success rate compared to the overall context can be observed. It was also observed that several species managed to survive up to about 2 years; examples are *Teucrium cyprium* and *Euphorbia cassia* subsp. *rigoi*. In the extremely rare serpentine endemic *Crypsis hadjikyriakou*, all efforts to establish ex situ cultivation failed (Raus & Scholz 2004).

Most geophytes, mostly monocots, can easily be grown by using living material (bulbs, rhizomes). In some species it may be the more successful way to start ex situ cultivation. Even in dicots (in the traditional sense) this should been taken into consideration in some genera. To name but one example: In the recently described endemic *Scaligeria alziarii*, which usually shows very rich fruit production in situ, all attempts to grow plants from diaspores failed. Finally, it proved that it can be easily grown by using rhizome fragments. For another species of the genus, the Greek endemic *S. moreana*, Engstrand (1970) mentioned no successful germination at all. The genus may serve as an example to demonstrate that seed banking alone may not help in conservation issues unless more is known about the ecology of a species.

Table 2. Taxa from Cyprus cultivated in the Botanical Garden Berlin-Dahlem.

Family	species / subspecies	cultivation successful	Endemic	Red Data Book Category	coll. on serpentine	germination rate up to 20%	germination rate > 80%
Alismataceae	*Damasonium bourgaei* Coss.	no	no				
Amaranthaceae	*Bosea cypria* Autran & Schinz	yes	yes				
Amaryllidaceae	*Allium cupani* subsp. *cyprium* Meikle	yes	yes				
Amaryllidaceae	*Allium junceum* Sm.	yes	near-endemic				
Amaryllidaceae	*Allium orientale* Boiss.	no	no				
Apiaceae	*Bupleurum sintenisii* Huter	no	yes				
Apiaceae	*Bupleurum trichopodum* Spruner & Boiss.	yes	no				
Apiaceae	*Cachrys scabra* (Fenzl) Meikle	no	no	Endangered (EN)			
Apiaceae	*Dichoropetalum* kyriakae (Alziar & Hadjik.) Hand & Hadjik.	no	yes	Endangered (EN)	X		
Apiaceae	*Ferula cypria* Post	no	no	Vulnerable (VU)			
Apiaceae	*Ferulago cypria* H. Wolff	no	yes				
Apiaceae	*Glaucosciadium cordifolium* (Boiss.) B. L. Burtt & P. H. Davis	yes	no				
Apiaceae	*Pimpinella cypria* Boiss.	yes	yes				
Apiaceae	*Scaligeria alziarii* Hand & al.	no	yes				
Apiaceae	*Smyrnium connatum* Boiss. & Kotschy	no	no				
Apiaceae	*Tordylium carmeli* (Labill.) Al-Eisawi	yes	no				
Apocynaceae	*Cyprinia gracilis* (Boiss.) Browicz	yes	near-endemic				
Asparagaceae	*Bellevalia nivalis* Boiss. & Kotschy	yes	near-endemic				
Asparagaceae	*Hyacinthella millingenii* (Post) Feinbrun	no	yes				
Asparagaceae	*Ornithogalum trichophyllum* Boiss. & Heldr.	no	no	Vulnerable (VU)			
Asteraceae	*Achillea cretica* L.	yes	no	Vulnerable (VU)			
Asteraceae	*Anthemis plutonia* Meikle	yes	yes		X		
Asteraceae	*Anthemis tricolor* Boiss.	yes	yes				
Asteraceae	*Carthamus caeruleus* L.	no	no	Critically endangered (CR)			
Asteraceae	*Centaurea akamantis* T. Georgiadis & Hadjik.	no	yes	Endangered (EN)			
Asteraceae	*Crepis pusilla* (Sommier) Merxm.	yes	no	Vulnerable (VU)			
Asteraceae	*Cynara makrisii* Hand & Hadjik.	no	yes	Vulnerable (VU)			
Asteraceae	*Gundelia tournefortii* L.	yes	no	Endangered (EN)			
Asteraceae	*Helichrysum stoechas* subsp. *barrelieri* (Ten.) Nyman	yes	no				
Asteraceae	*Hirtellina lobelii* (DC.) Dittrich	yes	no	Data deficient (DD)			

Table 2. continued.

Asteraceae	*Klasea cerinthifolia* (Sm.) Greuter & Wagenitz	yes	no					
Asteraceae	*Lactuca cyprica* (Rech. f.) N. Kilian & Greuter	no	yes					
Asteraceae	*Lactuca tetrantha* B. L. Burtt & P. H. Davis	yes	yes	Vulnerable (VU)	X			
Asteraceae	*Lactuca triquetra* (Labill.) Boiss.	yes	near-endemic		X			
Asteraceae	*Lactuca viminea* (L.) J. Presl & C. Presl	yes	no					
Asteraceae	*Mantisalca salmantica* (L.) Briq. & Cavill.	yes	no	Critically endangered (CR)				
Asteraceae	*Ptilostemon chamaepeuce* subsp. *cyprius* (Greuter) B. Slavík & Chrtek	yes	yes					X
Asteraceae	*Scorzonera troodea* Boiss.	no	yes		X			
Asteraceae	*Senecio glaucus* subsp. *cyprius* Meikle	yes	yes					
Asteraceae	*Taraxacum holmboei* H. Lindb.	yes	yes	Vulnerable (VU)	X			
Asteraceae	*Tyrimnus leucographus* (L.) Cass.	yes	no					
Berberidaceae	*Leontice leontopetalum* L. subsp. *leontopetalum*	yes	no					
Boraginaceae	*Cynoglossum montanum* subsp. *extraeuropaeum* Brand	yes	no		X	X		
Boraginaceae	*Cynoglossum troodi* H. Lindb.	yes	yes	Vulnerable (VU)	X			
Boraginaceae	*Myosotis minutiflora* Boiss. & Reut.	no	no	Vulnerable (VU)	X			
Boraginaceae	*Nonea philistaea* Boiss.	no	no					
Boraginaceae	*Onosma gigantea* Lam.	no	no	Critically endangered (CR)				
Brassicaceae	*Aethionema arabicum* (L.) DC.	yes	no	Vulnerable (VU)		X		
Brassicaceae	*Alyssum minutum* DC.	no	no	Near threatened (NT)				
Brassicaceae	*Arabis cypria* Holmboe	yes	yes					
Brassicaceae	*Arabis kennedyae* Meikle	yes	yes	Endangered (EN)				
Brassicaceae	*Arabis purpurea* Sm.	yes	yes		X			
Brassicaceae	*Brassica hilarionis* Post	no	yes	Endangered (EN)				
Brassicaceae	*Eruca sativa* Mill.	yes	no					
Brassicaceae	*Microthlaspi natolicum* subsp. *sporadium* F. K. Mey.	yes	no		X			
Brassicaceae	*Noccaea cypria* (Bornm.) F. K. Mey.	yes	yes		X			X
Campanulaceae	*Campanula fastigiata* Schult.	yes	no					
Campanulaceae	*Campanula podocarpa* Boiss.	yes	near-endemic	Regionally extinct (RE)	X			
Campanulaceae	*Solenopsis antiphonitis* Hadjik. & Hand	yes	yes	Endangered (EN)				
Campanulaceae	*Solenopsis bivonae* (Tineo) M. B. Crespo & al.	yes	no		X			
Caryophyllaceae	*Arenaria saponarioides* Boiss. & Balansa	yes	near-endemic		X			
Caryophyllaceae	*Dianthus cyprius* A. K. Jacks. & Turrill	yes	yes					X
Caryophyllaceae	*Dianthus strictus* subsp. *troodi* (Post) Greuter & Burdet	yes	yes					X
Caryophyllaceae	*Gypsophila linearifolia* (C. A. Mey. & Fisch.) Boiss.	no	no	Critically				

Table 2. continued.

				endangered (CR)				
Caryophyllaceae	*Minuartia sintenisii* (H. Lindb.) Rech. f.	no	yes		X			
Caryophyllaceae	*Petrorhagia cretica* (L.) Heywood & P. W. Ball	yes	no					
Caryophyllaceae	*Saponaria cypria* Boiss.	no	yes		X			
Caryophyllaceae	*Saponaria orientalis* L.	no	no	Vulnerable (VU)	X			
Caryophyllaceae	*Silene alexandrina* (Asch.) Danin	yes	no					
Caryophyllaceae	*Silene fraudatrix* Meikle	yes	yes					
Caryophyllaceae	*Silene fuscata* Link ex Brot.	yes	no	Critically endangered (CR)				
Caryophyllaceae	*Silene galataea* Boiss.	no	yes					
Caryophyllaceae	*Silene gemmata* Meikle	yes	yes	Vulnerable (VU)				
Caryophyllaceae	*Silene kotschyi* Boiss.	yes	no	Endangered (EN)				
Caryophyllaceae	*Silene laevigata* Sm.	no	yes					
Caryophyllaceae	*Stellaria cilicica* Boiss. & Balansa	yes	no					
Caryophyllaceae	*Telephium imperati* subsp. *orientale* (Boiss.) Nyman	no	no		X	X		
Caryophyllaceae	*Velezia rigida* L.	yes	no					
Cistaceae	*Cistus creticus* L.	yes	no					
Cistaceae	*Cistus parviflorus* Lam.	yes	no					
Cistaceae	*Helianthemum ledifolium* (L.) Mill. subsp. *ledifolium*	no	no					
Cistaceae	*Helianthemum ledifolium* subp. *lasiocarpum* (Jacques & Herincq) Nyman	no	no	Endangered (EN)				
Cistaceae	*Helianthemum sanguineum* (Lag.) Dunal.	no	no	Endangered (EN)				
Crassulaceae	*Sedum cyprium* A. K. Jacks. & Turrill	yes	yes					
Crassulaceae	*Sedum lampusae* (Kotschy) Boiss.	yes	yes					
Crassulaceae	*Sedum microstachyum* (Kotschy) Boiss.	no	yes	Vulnerable (VU)	X			
Cyperaceae	*Cyperus cyprius* Post	no	yes	Vulnerable (VU)				
Dipsacaceae	*Lomelosia cyprica* (Post) Greuter & Burdet	yes	yes					
Euphorbiaceae	*Euphorbia cassia* subsp. *rigoi* (Freyn) Holmboe	yes	yes		X			
Euphorbiaceae	*Euphorbia hierosolymitana* Boiss.	yes	no	Vulnerable (VU)	X			X
Euphorbiaceae	*Euphorbia hirta* L.	yes	no					
Euphorbiaceae	*Euphorbia veneris* M. S. Khan	no	yes					X
Fabaceae	*Astragalus caprinus* subsp. *laniger* (Desf.) Maire	yes	no					
Fabaceae	*Astragalus cyprius* Boiss.	yes	yes					X
Fabaceae	*Astragalus macrocarpus* subsp. *lefkarensis* Kirchhoff & Meikle	yes	yes	Vulnerable (VU)				
Fabaceae	*Hedysarum cyprium* Boiss.	no	yes	Vulnerable (VU)				
Fabaceae	*Lathyrus clymenum* L.	yes	no					
Fabaceae	*Onobrychis venosa* (Desf.) Desv.	yes	yes					X
Fabaceae	*Trifolium argutum* Banks & Sol.	yes	no	Near threatened (NT)				

Table 2. continued.

Fabaceae	*Trifolium boissieri* Soy.-Will. & Godr.	yes	no					
Fabaceae	*Trifolium campestre* subsp. *paphium* Meikle	yes	yes	Near threatened (NT)				
Fabaceae	*Trifolium grandiflorum* Schreb.	yes	no					
Fabaceae	*Vicia lunata* (Boiss. & Balansa) Boiss.	yes	near-endemic					
Fagaceae	*Quercus coccifera* L.	yes	no					
Fagaceae	*Quercus infectoria* subsp. *veneris* (A. Kern.) Meikle	yes	no					
Geraniaceae	*Erodium crassifolium* L'Hér.	yes	no	Vulnerable (VU)				X
Hypericaceae	*Hypericum repens* L.	no	yes					
Hypericaceae	*Hypericum triquetrifolium* Turra	no	no			X		
Lamiaceae	*Acanthoprasium integrifolium* (Benth.) Ryding	no	yes					
Lamiaceae	*Acinos exiguus* (Sm.) Meikle	yes	yes		X			
Lamiaceae	*Acinos troodi* (Post) Leblebici subsp. troodi	no	yes	Vulnerable (VU)	X			
Lamiaceae	*Ajuga orientalis* L.	no	no					
Lamiaceae	*Micromeria chionistrae* Meikle	yes	yes					
Lamiaceae	*Micromeria cristata* (Hampe)Griseb. subsp. cristata	yes	no	Endangered (EN)				
Lamiaceae	*Micromeria microphylla* (d'Urv.) Benth.	yes	no					
Lamiaceae	*Nepeta troodi* Holmboe	no	yes		X			
Lamiaceae	*Origanum cordifolium* (Benth.) Vogel	no	yes	Vulnerable (VU)				
Lamiaceae	*Origanum majorana* L.	yes	yes					
Lamiaceae	*Phlomis brevibracteata* Turrill	yes	yes	Vulnerable (VU)				
Lamiaceae	*Phlomis cypria* subsp. *occidentalis* (Meikle) Hand	yes	yes	Vulnerable (VU)				
Lamiaceae	*Rosmarinus officinalis* L.	yes	no					
Lamiaceae	*Salvia dominica* L.	yes	no	Vulnerable (VU)				
Lamiaceae	*Salvia lanigera* Poir.	yes	no					
Lamiaceae	*Salvia veneris* Hedge	yes	yes	Vulnerable (VU)				
Lamiaceae	*Salvia willeana* (Holmboe) Hedge	no	yes		X			
Lamiaceae	*Satureja thymbra* L.	yes	no	Endangered (EN)				
Lamiaceae	*Scutellaria sibthorpii* (Benth.) Halácsy	yes	yes					
Lamiaceae	*Sideritis cypria* Post	yes	yes	Endangered (EN)				
Lamiaceae	*Teucrium creticum* L.	yes	no					
Lamiaceae	*Teucrium cyprium* Boiss.	yes	yes		X			
Lamiaceae	*Teucrium karpasiticum* Hadjik. & Hand	yes	yes					
Lamiaceae	*Teucrium kyreniae* (P. H. Davis) Hadjik. & Hand	yes	yes	Least concern (LC)				
Lamiaceae	*Teucrium micropodioides* Rouy	yes	yes					
Lamiaceae	*Teucrium salaminium* Hadjik. & Hand	yes	yes					X

Table 2. continued.

Lamiaceae	*Thymus integer* Griseb.	yes	yes					X
Lentibulariaceae	*Pinguicula crystallina* Sm.	yes	near-endemic	Vulnerable (VU)				
Liliaceae	*Tulipa cypria* Stapf	no	yes	Endangered (EN)				
Lythraceae	*Lythrum hyssopifolia* L.	yes	no					
Malvaceae	*Malva multiflora* (Cav.) Soldano & al.	yes	no					
Myrtaceae	*Myrtus communis* L.	yes	no					
Papaveraceae	*Ceratocapnos turbinata* (DC.) Lidén	yes	no	Endangered (EN)				
Papaveraceae	*Corydalis rutifolia* (Sm.) DC.	no	yes		X			
Papaveraceae	*Papaver cyprium* (Chrtek & B. Slavík) M. V. Agab. & al.	yes	yes	Vulnerable (VU)				
Papaveraceae	*Papaver hybridum* L.	no	no					
Papaveraceae	*Papaver paphium* M. V. Agab. & al.	yes	yes					
Papaveraceae	*Papaver rhoeas* L. subsp. *rhoeas*	yes	no					
Papaveraceae	*Papaver setigerum* DC.	no	no					
Plantaginaceae	*Linaria simplex* Desf.	no	no					
Plantaginaceae	*Plantago bellardii* All.	no	no					
Plantaginaceae	*Plantago cretica* L.	yes	no					
Plantaginaceae	*Veronica bozakmanii* M. A. Fisch.	yes	no		X			
Plumbaginaceae	*Limonium mucronulatum* (H. Lindb.) Burdet & Greuter	yes	yes	Critically endangered (CR)		X		
Poaceae	*Lindbergella sintenisii* (H. Lindb.) Bor	yes	yes		X			
Poaceae	*Sclerochloa dura* (L.) P. Beauv.	yes	no	Vulnerable (VU)				
Polygonaceae	*Rumex cyprius* Murb.	yes	no					X
Polygonaceae	*Rumex vesicarius* L.	yes	no	Vulnerable (VU)				X
Ranunculaceae	*Nigella unguicularis* (Poir.) Spenner	yes	no	Least concern (LC)				
Ranunculaceae	*Ranunculus cadmicus* subsp. *cyprius* (Boiss.) Vierh.	no	yes		X			
Ranunculaceae	*Ranunculus kykkoensis* Meikle	no	yes	Vulnerable (VU)				
Ranunculaceae	*Staphisagria macrosperma* Spach	no	no	Data deficient (DD)				
Rosaceae	*Rosa micrantha* subsp. *chionistrae* (H. Lindb.) H. Reichert & Hand	yes	yes		X			
Rubiaceae	*Galium canum* Req.	yes	no					
Rubiaceae	*Valantia hispida* L.	yes	no					
Scrophulariaceae	*Scrophularia peyronii* Post	no	no					
Scrophulariaceae	*Verbascum levanticum* I. K. Ferguson	yes	no					
Scrophulariaceae	*Verbascum orientale* (L.) All.	yes	no	Critically endangered (CR)				
Valerianaceae	*Valerianella orientalis* (Schltdl.) Boiss. & Balansa	no	no					X
Valerianaceae	*Valerianella triceras* Bornm.	yes	near-endemic	Vulnerable (VU)				

Discussion

Overall, in about two-thirds of the species cultivation proved to be feasible. Similar results were also observed by Di Gristina & al. (2003), one of the few comparable studies in the Mediterranean area. This study was carried out "semi in situ", i.e. in the region of origin under nearly identical climatic conditions. Gücel & Yıldız (2008) tested 10 Cypriot endemics with a success rate of 50%.

However, the results also show that in some cases germination behaviour does not allow conclusions to be drawn regarding the feasibility of ex situ cultivation. In such cases, high expectations placed on seed banks by conservationists could not be fulfilled. The results regarding serpentinophytes and the comparison of germination rates and cultivability are not based on systematic approaches. They can only show initial tendencies: Serpentinophytic accessions are problematic to treat and only partially promising without special soil treatment. Species showing high germination rates in routine procedures in seed banks predominantly succeed in cultivation experiments. Exceptions are always to be expected and may complicate and prevent protection efforts in individual cases.

The present study could take into account about 10% of the Cypriot flora. In the years to come, an expanded selection of species will be tested. Unfortunately, there are no systematic surveys of which species of the Cypriot flora have been cultivated ever – a situation that probably applies to all countries of the Euro-Mediterranean area. Cyprus has so far no national botanical garden. In recent years, however, several collections were created in which an increasing number of taxa is successfully cultivated. These include the visitor center of the Athalassa National Forest Park and the "Troodos Botanical Garden A. G. Leventis". There are also numerous cases of taxomomic and karyological taxon-specific studies in which it can be inferred only indirectly that the cultivation succeeded (e.g. Brullo & al. 1993; Speta 1986; Teppner 2012). A considerable number of taxa, namely popular bulbous species such as taxa from the genera *Cyclamen* or *Tulipa*, can be found in private collections. Generally, cultivation experiences are described in gardeners' literature (e.g. for tulips Wilford 2006) but there is a lack of species-specific protocols. Even in many scientifically supervised botanical gardens, no systematic record of success and non-success in cultivation efforts is documented. In many cases, retirement of experienced gardeners leads to a loss of knowledge. Garden protocols documenting at least some basic issues could help to prevent this. There seem to be no national or international efforts to document such data for complete floras but only for a limited number of taxa, mostly endangered and rare species (see, e.g., Plant Gene Resources of Canada 2006, Royal Botanic Gardens, Kew 2013, Verband Botanischer Gärten 2013). A database compiling such knowledge on cultivation and propagation methods for all Euro-Mediterranean species of vascular plants would be desirable but is currently probably illusionary. Concrete proposals regarding documentation have not been followed up in the past. New detailed recommendations do not make much sense unless different Euro-Mediterranean organizations with a common interest in such matters agree. The implementation of an international database would face not only financial problems but also have to deal with the harmonization of database structures. For the time being, it can only be recommended to produce garden protocols in whatever form and to find ways to exchange them among interested partners, whether scientists or gardeners. Possibly, this short note may contribute to future discussions as regards linkages between interested partners.

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