

Greek Tulips

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From an ornamental viewpoint, tulips are famous clonally propagated crops. This research focuses on 15 wild-growing Greek tulip species including 11 range-restricted species, i.e., six Greek endemics and five Balkan or Aegean endemics and subendemics, among which seven are currently threatened with extinction (two Critically Endangered, three Endangered and two Vulnerable). The results of this study on the Greek tulips showed that there are both well-established value chains and gaps in the market regarding the “botanical tulips” of Greece.

Keywords: biodiversity ; botanic gardens ; e-commerce ; Greek flora ; Liliaceae ; phylogenetic resources ; seed banks ; Tulipa

1. Introduction

The electronic plant trade over the Internet has been largely facilitated by social media and communication platforms resulting to date in a popular new way of easy plant trade worldwide ^{[1][2][3][4][5][6][7][8][9][10][11]}. This kind of uncontrolled e-trade can have devastating effects to wild-growing populations, and thus may undermine conservation efforts both nationally and globally due to unrestrained overexploitation of local single-country endemics and/or threatened species ^{[2][3][9]}. Theoretically, when the international e-commerce of plants is performed under the provisions of the Nagoya protocol and the EU Directive 511/2014 which regulate sovereign rights over phylogenetic resources and concomitant Access and Benefit Sharing mechanisms for their sustainable exploitation, it may secure local phylogenetic resources, also offering support to domestic subsistence economies ^{[6][8][9][10][11][12]}.

Due to severe anthropogenic disturbance of wild habitats and under the threat of climate change, ex situ plant conservation serving as back-up of in situ conservation has become increasingly important over the last decades for the conservation of phylogenetic resources ^{[13][14][15][16][17]}. In this framework, botanic gardens (BGs) and seed banks (SBs) play a pivotal role in achieving effective species' conservation ^{[13][14]}, with their greatest concentration occurring in northern temperate regions (especially Europe) ^{[13][14]}. However, the need for such conservation initiatives is more intense in floristically diverse southern countries within this geographical context, and especially in the Mediterranean region which hosts many threatened plants ^{[15][18][19][20][21]}, and in countries which are relatively poorly resourced in conservation facilities compared to less diverse northern ones ^[14]. Furthermore, BGs and SBs often house in man-made environments several socioeconomically important plants from around the globe. Therefore, they may be considered as sources of valuable donor material and species-specific propagation and cultivation know-how, activating considerable opportunities for the sustainable exploitation of phylogenetic resources in the short-term, medium-term or long-term ^{[12][22][23]}. This applies to major crop plants, including widely appreciated ornamentals such as tulips, but also to neglected and underutilized plants such as local endemics confined to specific regions ^{[12][22]}.

In general, the domestication of wild-growing plants with interesting properties associated with plant rarity or endemism (uniqueness) has been extremely appreciated by the ornamental-horticultural sector, since the latter is always in quest of and sourcing for unique new crops with attractive features ^{[6][22][24]}. In this context, tulips are famous ornamental plants worldwide since the Middle Ages ^{[11][24]}, and currently in Europe they are associated with a turnover of about half a billion euros yearly with increasing trends ^[24]. As a result of this long-lasting appreciation, to date there are hundreds of traded hybrid tulip varieties raised through breeding strategies from a few ancestral East Mediterranean and/or Asiatic species to satisfy commercial needs, as well as several nonimproved species of the genus *Tulipa* that are used for ornamental reasons, mainly by plant enthusiasts and garden lovers.

In line with the foregoing studies related to the electronic trade ^{[3][7][11]}, the ex situ conservation of focal endemic plants ^[14] and the sustainable exploitation of neglected and underutilized phylogenetic resources ^[12], the study herein focuses on the wild-growing tulips of Greece. These phylogenetic resources comprise 15 *Tulipa* spp. which are nationally protected by the Greek Presidential Decree 67/1981, among which six are confined to the Greek territory (single-country endemics) and five are local Balkan or Aegean endemics and subendemics extending to adjacent countries. Seven of them are

assessed as threatened (two Critically Endangered, three Endangered and two Vulnerable) according to the criteria of IUCN (International Union for the Conservation of Nature) [25][26][27]. In an attempt to explore the extant value chain associated with the Greek tulips internationally and to define the extent of the current commercialization of Greek tulips over the internet, an overview of their global electronic trade is presented herein and concomitant conservation implications are discussed. To promote the repatriation initiatives of well-documented plant material acquired in Greece but housed abroad, the global ex situ conservation of Greek tulips is overviewed according to the PlantSearch facility of the Botanic Gardens Conservation International (BGCI). These efforts are envisaged in the frame of the newly launched efforts to create a national collection of wild Greek tulips, attempting to pave the way for the creation of a Greek national tulip collection and a sustainable value chain associated with them.

2. Electronic Trade of Greek Native Tulips

The traded Greek tulips are often classified by the nurseries involved as “botanical tulips” to contrast with commercialized hybrid tulips, thus reflecting their distinct origin. Botanical tulips (e.g., <https://www.gardenia.net/plant/tulipa-saxatilis-lilac-wonder-botanical-tulip>, etc. (accessed on 13 March 2021)) are ancestors of cultivated tulip hybrids and they are almost nonimproved by breeding strategies. Being evolved to adapt to natural conditions, quite often these botanical tulips are hardier and easier to grow compared to hybrids. When these are attractive but also rare, protected, and local endemic of specific regions, they are perceived by people as uncommon to them (or “exotic” due to their distant origin from other regions than those of the consumers), thus presenting a “new” attractive choice for the ornamental industry which is always “thirsty” for novel beauties [12].

Surprisingly, though not unexpectedly if previous research is considered [3][7][11], the UK dominates the electronic market over the internet related to the tulip bulb trade of Greek species, and this trend is followed by Dutch nurseries. Perhaps this dominance reflects the long-standing tradition of home gardening in UK and the developed industry [7]. In total, 11 Greek tulip species are readily available as bulbs over the internet; 10 of them are traded globally by 13 UK nurseries, five species are supplied from nine Dutch nurseries and two from others that are located in the USA (Table 1).

Table 1. Overview of the electronic trade and ex situ conservation of the 15 wild-growing Greek tulips (chorology, endemism, and protection status according to the official Vascular flora of Greece (<http://portal.cybertaxonomy.org/flora-greece/>) (accessed on 13 March 2021)) as well as species’ extinction risk assessments [25][26][27] and currently acquired accessions for their sustainable exploitation in the frame of the project TULIPS.GR.

Tulips (<i>Tulipa</i> spp.)	Endemism	Extinction Risk/Protection Status	Nurseries/Countries	BGs/Countries	Accs/Wild
<i>T. agenensis</i>	Irano-Turanian	No/GPD	2/1	9/6	1/1
<i>T. australis</i>	Mediterranean-SW Asiatic	No/GPD	5/1	4/4	3/2
<i>T. bakeri</i>	Greek (Cr)	CR [27]/GPD	13/2	3/1	3/2
<i>T. bithynica</i>	Balkan-Anatolia	No/GPD	No	1/1	1/1
<i>T. clusiana</i>	Irano-Turanian	No/GPD	8/2	22/9	2/1
<i>T. cretica</i>	Greek (Cr)	EN [27], *LC/GPD	3/1	9/5	4/3
<i>T. doerfleri</i>	Greek (Cr)	CR [27], VU [26]/GPD	1/1	2/2	2/2
<i>T. goulimyi</i>	Greek (Cr, Pe)	VU [25][27]/GPD	No	2/2	4/3
<i>T. hageri</i>	Greek (StE, Pe)	EN [27], *DD/GPD	4/2	9/6	No
<i>T. orphanidea</i>	Greek (StE, Pe)	EN [27]/GPD	8/2	15/8	4/3
<i>T. radii</i>	East Mediterranean	No/GPD	1/1	2/2	3/3
<i>T. rhodopea</i>	Balkan	No/GPD	No	2/2	2/2
<i>T. saxatilis</i>	South Aegean subendemic	No/GPD	7/2	26/12	5/4
<i>T. scardica</i>	Balkan	No/GPD	No	2/2	No
<i>T. undulatifolia</i>	Balkan-Anatolia	VU [25]/GPD	2/1	8/7	4/4

Phytogeographical regions of Greece—StE: Sterea Ellada; Pe: Peloponnese; Cr: Crete; CR: Critically Endangered; EN: Endangered; VU: vulnerable; DD: data deficient; LC: least concern (according to criteria of the International Union for the Conservation of Nature) [25][26][27]; * Global IUCN Red List (www.iucnredlist.org (accessed on 13 March 2021)); No: absence of information; GPD: Included in the Greek Presidential Decree 67/1981; BG: Botanic gardens; Accs: Total accessions documented; Wild: independent collections from a wild-growing population in a given locality.

Bulbs of most of the Greek tulip species are actually sold out every season according to the nurseries' websites (namely stated as "out of stock"). As anticipated [3][7][11], it was not possible to determine the extent of this e-trade in terms of quantities dispatched [3][11][17]. Regularly, on the webpages of more than half of the nurseries involved there are specific "want lists" or "wish lists" (>15 nurseries) to inform customers promptly in order for the nurseries to be able to schedule and dispatch the requested materials. On the other hand, this also means that the customer may request a certain species that might not be available on the nurseries' websites. Based on these demands, the nurseries are supposed to try to find and deliver the requested materials, either from collaborating nurseries or elsewhere [3][7][11]. None of these nurseries inform, however, about the original provenance of the traded materials. In this way, it is not known whether the traded plants are raised yearly from initial cultivated stocks, or if these materials have been sourced or collected directly or partly from wild habitats (some of them or sometimes). Of course, no nursery webpage states how and when the initial plant material (mother plants) was obtained. At least some of the nurseries' websites state that they make regular collecting trips around the world [11], e.g., <https://seedsofpeace.info/> (accessed on 13 March 2021). To this end, it has been suggested that perhaps a network of local collaborating collectors is activated upon such requests to try to find the selected materials, however without any authorization to collect and purchase tulip bulbs and/or seeds (see discussion in [3][7][11]). When true, such pressure exerted on local endemic and/or threatened species may have devastating effects on wild-growing populations.

There is a wide variety of prices for dispatched quantities (5–1000 bulbs) ranging from £0.16–0.50/bulb for the protected *T. bakeri* A. D. Hall which is a Cretan single-island endemic (e.g., <https://www.rosecottageplants.co.uk/tulipa-bakeri-lilac-wonder/p525> (accessed on 13 March 2021)) to £1.50/bulb and £2.60/bulb for *T. clusiana* DC. and *T. australis* Link, respectively (1 £ = 1.16 € as of 1/3/2021).

Greek tulip seeds are rather hard to find over the internet, and when these are located, they are quite a lot more expensive in respect to bulbs. For example, the Mediterranean *T. australis* is currently available as seeds (packet) in UK at £2.85. The Irano-Turanian *T. agenensis* DC. as well as the protected and threatened (Table 1) Cretan endemics *T. bakeri* <https://seedsofpeace.info/product/tulipa-bakeri/> (accessed on 13 March 2021)) and *T. cretica* Boiss. & Heldr. (<https://seedsofpeace.info/product/tulipa-cretica/> (accessed on 13 March 2021)) are to be found only in an Israeli nursery; seeds of each of these three tulips are sold at 5 € for 10, 12 or 15 individual seeds, respectively. This high price of 0.3–0.5 € per individual seed is almost equivalent sometimes to that of the traded individual bulb (compare with above-mentioned prices of *T. bakeri*).

To date, we detected no availability over the internet regarding seeds for 11 of the Greek tulips (73.33%). Likewise, no bulbs were found as currently traded for 26.67% of the Greek tulips, i.e., the protected local Balkan subendemic *T. bithynica* Baker, the protected and threatened Greek endemic *T. goulimyii* Sealy & Turrill and the protected local Balkan endemics *T. rhodopea* (Velen.) Velen and *T. scardica* Bornm. (Table 1).

3. Current Sustainable Exploitation Challenges

The newly launched research project TULIPS.GR is focused on the ex situ conservation, domestication and sustainable exploitation of the 15 wild-growing Greek tulips. To this end, an integrated approach is followed beginning with well-documented collections performed with an authorized collection permit issued by the Greek ministry of Environment and Energy. Initially, as a first step towards the creation of a national collection of Greek tulips, the project has already documented and incorporated under ex situ conservation 12 accessions of eight wild-growing Greek tulips which were collected directly from wild-growing populations (Table 1, Figure 1, Figure 2, Figure 3 and Figure 4), prioritizing the nationally threatened species [25][26][27]. In an attempt to increase the genetic variability of Greek tulip germplasm, the project aims to collect over the next three years selected propagation material from as many spontaneous populations as possible, covering all wild-growing Greek tulip species.

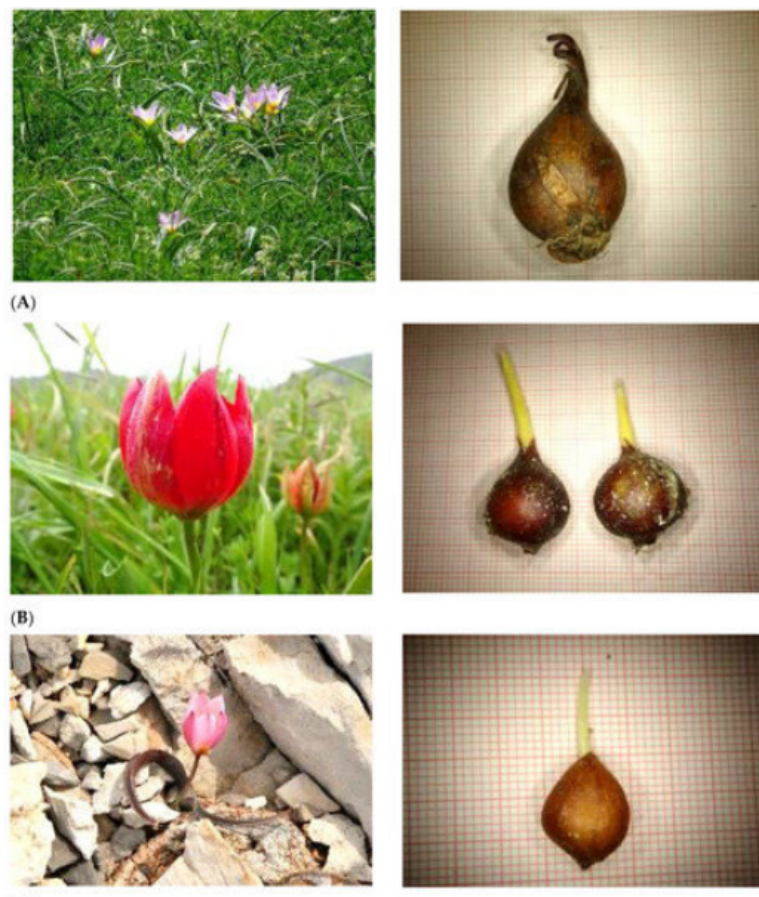


Figure 1. Wild-growing Greek tulips endemic to the island of Crete and individual bulbs collected for ex situ conservation in the frame of TULIPS.GR: (A) *Tulipa bakeri* and (B) *T. doerfleri* assessed as Critically Endangered ^[27], and (C) *T. cretica* (photo: V. Papiomytoglou) assessed as Endangered ^[27].

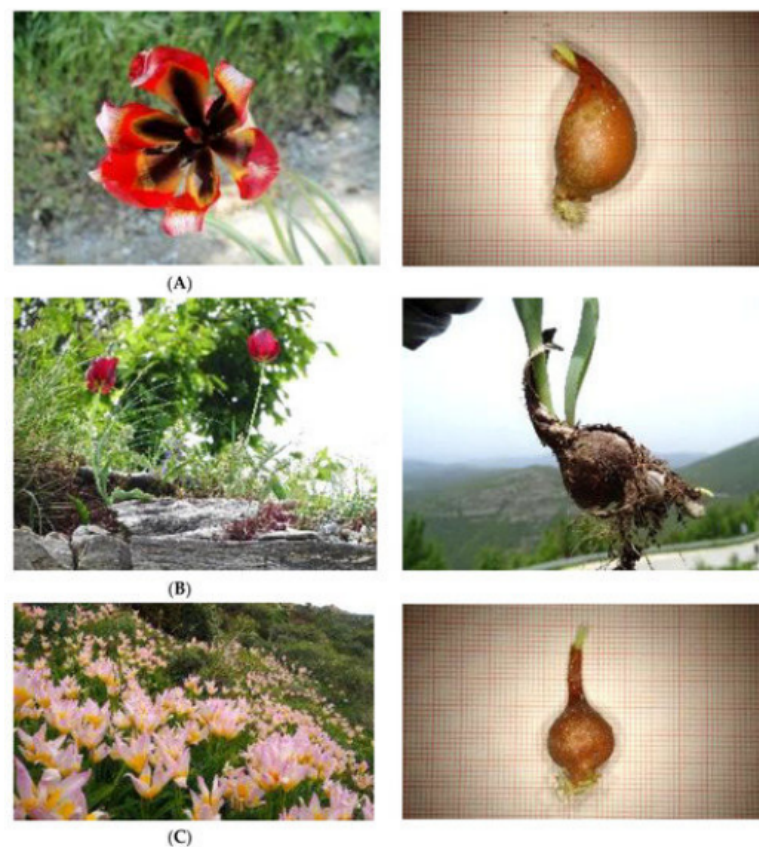


Figure 2. Wild-growing, range-restricted Greek tulips and individual bulbs collected for ex situ conservation in the frame of TULIPS.GR: (A) *Tulipa bithynica* and (B) *T. rhodopea* endemic to southern Balkans and/or Anatolia (Balkan subendemic); (C) *T. saxatilis* (photo: M. Avramakis, Natural History Museum of Crete) endemic to major south Aegean islands (Crete, Karpathos, Rhodes) and south-western Turkey (south Aegean subendemic).



Figure 3. (A) Wild-growing individuals of the Mediterranean *Tulipa australis* at the summit area of Mt Vermion, Northern Greece; (B) underground individual bulb; and (C) repatriated well-documented bulbs of the same species from the Gothenburg Botanical Garden, Sweden that were originally collected close to the summit area of Mt Vourinos, northern Greece in 2001.

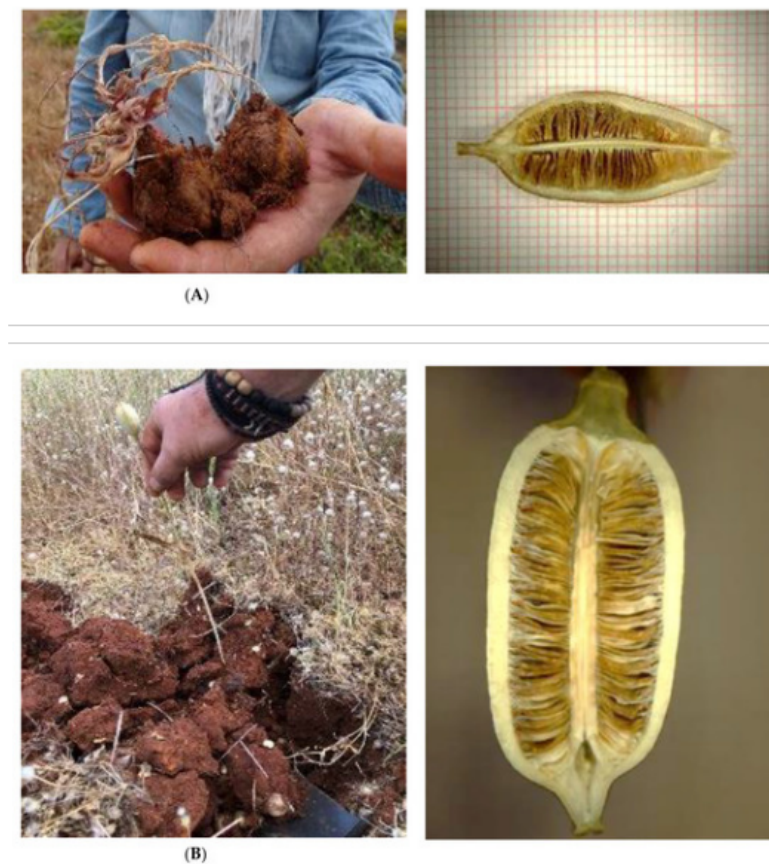


Figure 4. Dormant bulbs and capsules with ripe seeds collected for ex situ conservation from wild-growing and protected populations of Greek tulip species assessed as threatened with extinction ^{[25][27]}: (A) *T. goulimy*, a local endemic of Peloponnese, Kythira-Antikythira and west Crete, assessed as Endangered ^[27]; (B) *T. undulatifolia*, an endemic to Southern Balkans and west and central Anatolia (Turkey), assessed as Vulnerable ^[25].

Additionally, a repatriation initiative has been launched through the Balkan Botanic Garden of Kroussia (BBGK), Institute of Plant Breeding and Genetic Resources (Agricultural Organization Demeter) concerning the range-restricted and local endemic species of Greek tulips. This procedure involved personalised letters sent by e-mail to the curators of a dozen BGs holding Greek tulip species. However, almost none responded positively in this call by informing explicitly about the stored materials. However, the Gothenburg BG in Sweden responded immediately to this call by sending 20 well-documented accessions of nine Greek tulip species for repatriation in the BBGK; these materials were added to the new Greek national collection (Table 1, Figure 3). The repatriated materials from Sweden had been originally collected in the Greek territory at earlier times (1984–2009) by various famous botanists (e.g., A. Strid), and are currently under duplicated ex situ conservation for safety reasons (Swedish and Greek BGs). Some of the BGs contacted to date are not yet in a position of repatriating bulbs or seeds from tulips of Greek origin; however, some of these (e.g., Cambridge University BG) have already flagged their materials in order to be able to respond in the future. Additional requests will be made in the near future to more BGs holding accessions of tulips collected from Greece.

Furthermore, in an attempt to avoid trivial trial-and-error losses during propagation and cultivation procedures with domestic valuable phylogenetic resources, the selected material of five Greek tulip species (*T. australis*, *T. bakeri*, *T. cretica*, *T. orphanidea*, *T. saxatilis*) has already been purchased from specialized nurseries. This material has been obtained for e-commerce verification serving documentation purposes, and it will be used for basic experimentation and species-specific comparisons with wild type materials by molecular barcoding in the frame of TULIPS.GR ([Table 1](#)).

Overall, 38 documented accessions of 13 Greek tulip species are currently under evaluation in the frame of TULIPS.GR, 82% originating from the wild-growing populations of Greece. The experimentation in progress includes the development of species-specific propagation and cultivation protocols, study of mycorrhizal diversity, foliar symptoms diagnostics, fertilization regimes with innovative domestic organic fertilizers produced by Theofrastos company (<https://theofrastos.com/en/theofrastos-liquid-organic-fertilizers/>; accessed on 13 March 2021), as well as the development of a strategy for postharvest treatment.

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