Article

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Epipactis palustris in the Eastern Mediterranean (Lebanon), a surprising peripheral micropopulation challenges us with its conservation

Abstract

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While *Epipactis palustris* has been documented for the first time in Lebanon (at Mount Lebanon Governorate), this presence in the Middle East outside its classical range questions us. The species is widely distributed through Europe until Central Asia, but this southernmost location is isolated from the Turkish nearest ones from at least 500 km. Its ecology is classical but very restricted to a punctiform habitat hosting other regional rarities. The orchids family is known to be the best wind dispersed of the vascular plants because of its vestigial seeds kept to a minimum. The sink-source metapopulation characteristic model of this species is debated and the issue for its regional conservation evocated.

Key words: distribution range limit, Marsh Helleborine, Plant Micro-Reserve, sink-source metapopulation, threatened species.

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Introduction

Epipactis palustris (L.) Crantz, commonly known as the marsh helleborine or swamp helleborine, is an orchid species belonging to the subfamily *Epidendroideae*. It is widespread across northern and central Europe, the Middle East, and Central Asia (Delforge 2006; POWO 2023). This species occurs in a variety of habitats including fens, damp meadows, swamp and stream margins, wet woodlands, and ditches (Summerhayes 1951).

E. palustris is characterized by robust stems reaching 30–80 cm tall, spirally arranged pleated leaves, and a one-sided inflorescence bearing several flowers with greenish-white tepals marked with purple veins (Delforge 2006). The flowers rely on insect pollinators, with wasps and bees being the primary visitors (Claessens & Kleynen 2011). After successful pollination, egg-shaped seed capsules are formed. The small, dust-like seeds lack endosperm and rely on fungal symbionts to germinate and develop (Rasmussen 1995).

Across its distribution, *E. palustris* has experienced declining populations primarily due to habitat loss from drainage of wetlands for agriculture, peat extraction, eutrophication, and groundwater depletion (Kull & Hutchings 2006). It is considered as "least concern" at European (Rankou 2011) and at global level (Matchutadze 2014) but near threatened or extinct in several parts of its range (Cheffings & Farrell 2005; Kull & Hutchings 2006). Conservation of existing populations and their sensitive wetland habitats is a high priority.

In Lebanon, 46 native orchid species have been recorded so far (Vela & Viglione 2015), but *E. palustris* had never been documented in the country before this report. The closest known populations are found in Turkey (Kreutz 2009). This substantial geographic separation makes this new record in Lebanon particularly noteworthy. The discovery contributes valuable data to the ongoing exploration of Lebanon's native orchid flora.

Materials and Methods

Floral surveys were conducted from July 25th to August 5th 2023, evolving the collection of both photos and samples of *Epipactis palustris*, along with a comprehensive survey of the associated vegetation. The photography of plant specimens was done using a Sony SLT-A55V camera with a Sony 50mm f/2.8 MACRO lens. The geographic coordinates of the specimens were acquired from the inbuilt GPS in the camera itself. Identification of the plants was achieved using relevant identification keys from applicable floras (Delforge 2006). Although floristic surveys extended to neighbouring areas, no other specimens of this orchid species were found. The vegetation survey has been done identifying the flora with "Nouvelle flore du Liban et de la Syrie" (Mouterde 1966-1984) and nomenctalure updated according to Plants of the World Online (POWO 2023).

Results

Epipactis palustris (L.) Crantz

Specimen examined

Baskinta, Mount Lebanon, from a moist area around a stream in a woodland, 1,210 m elevation; location coordinates: 33° 57' 4.03" N, 35° 46' 7.19" E on the 25th July 2023 by one of us MM. The specimens were found thriving in a shaded environment with moist substrates, situated within a *Pinus* and *Quercus* woodland area characterized by sandstone terrain (Table 1). While a total of five plants were located at the same location, only three were in a blooming state. It is noteworthy that no pollinators were observed during this observation. Nevertheless, during the last visit on August 18, 2023, it was observed that the three flowering plants had also produced fruit.

Description

The present study reveals the discovery of plant specimens characterized by a robust stem, attaining a height of around 46 cm. The leaves, arranged in a spiral phyllotaxy, exhibit dimensions ranging from 5 to 15 cm in length and 2 to 4 cm in width, presenting an oblong-ovate to oblong-lanceolate morphology with an acute apex and a concave adaxial surface (Fig. 1).

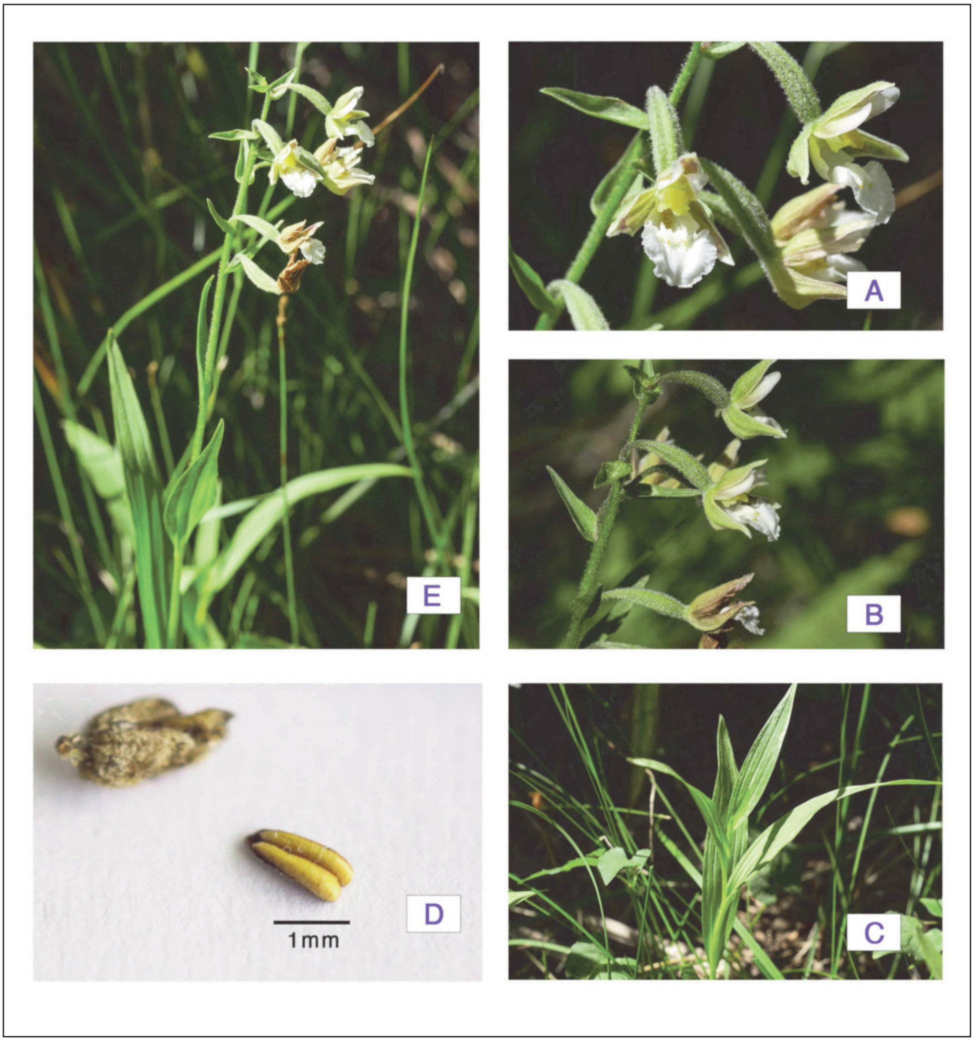

Fig. 1. *Epipactis palustris*, Baskinta, Lebanon 26th of July 2023 (photos by Mounir Maalouf). A. Close-up of the flower; B. Inflorescence; C. Distribution of the leaves on the stem; D. Pollinia; E. Habit.

The inflorescence of the specimens is a one-sided raceme, with 3 to 5 flowers gracefully oriented in one direction. The flowers measuring 2–2.5 cm in diameter, initially campanulate but gradually expanding. Coloration varies from creamy white to pure white, frequently adorned with violet-red or brown streaks.

The flowers are devoid of scent. The labellum, akin in size to the outer perianth segments, showcases a cup-shaped basal half with two erect triangular lobes on each side. The distal half is broadly elliptical, rounded, or truncate at the apex.

Table 1. List of plants and trees inventoried in the station of *Epipactis palustris*.

In the stream near the *E. palustris*	**In the surrounding woody area**
Dactylorhiza phoenissa (B.Baumann & H.Baumann) P.Delforge	*Achnatherum bromoides* (L.) P.Beauv.
Drosera rotundifolia L.	*Anacamptis morio* subsp. *syriaca* (E.G.Camus) H.Kretzschmar, Eccarius & H.Dietr.
Campanula peregrina L.	*Atocion reuterianum* (Boiss. & C.I.Blanche) Frajman
Osmunda regalis L.	*Cistus salviifolius* L.
Rhododendron ponticum var. *brachycarpum* Boiss.	*Cistus umbellatus* subsp. *libani* Demoly
Asplenium onopteris L.	*Dactylorhiza romana* subsp. *romana* (Sebast.) Soó
Juncus effusus L.	*Dianthus strictus* subsp. *multipunctatus* (Ser.) Mouterde ex Greuter & Burdet
Blechnum spicant (L.) Roth	*Epipactis helleborine* (L.) Crantz, sensu lato
Clinopodium vulgare subsp. *orientale* Bothmer	*Juniperus deltoides* R.P.Adams
Teucrium scordium subsp. *scordioides* (Schreb.) Arcang.	*Laurus nobilis* L.
	Linum trigynum L.
	Neotinea maculata (Desf.) Stearn
	Origanum ehrenbergii Boiss.
	Pilosella bauhini (Schult.) Arv.-Touv.
	Pinus halepensis Mill.
	Quercus cerris L.
	Romulea phoenicia Mouterde
	Romulea ramiflora Ten.
	Rubia tenuifolia var. *elliptica* (Boiss.) Ehrend.
	Rubus creticus Tourn. ex L.
	Styrax officinalis L.
	Teucrium divaricatum subsp. *divaricatum* Sieber ex Heldr.

Discussion

Distribution and dispersion

The recent discovery of *Epipactis palustris* in Lebanon is puzzling given the species' rarity in the southern Mediterranean region (Jacquemyn & al. 2014) the nearest known populations being over approximately 500 km away in the Malatya and Konya provinces, Turkey (Kreutz 2009; Bozkurt 2018).

- B6 / Malatya: Sürgü, W. Lüders, 5.6.1989 [≈500 km]
- B4 / Konya: Sultanhanı-Eşmekaya, 25 vi 1998, M. Vural 7840 (GAZI 32569!) [≈510 km]

Other meridional locations from southern Turkey and their areal distance from Baskinta (Fig. 2) (Davis, P. H. 1984).

- B7 / Tunceli: above Pülümür, 1900 m, D. 31595! [≈710 km]
- B9 / Bitlis: S. shore of Van G. nr Garzit, 1650 m, Renz 64591 [≈810 km]
- C9 / Hakkari: 2 km N.W. of Hakkari, 2000 m, Sorger 81-27-26! [≈820 km]

While *E. palustris*, like all orchids, is known to produce wind-dispersed seeds capable of covering long distances (Tackenberg & al. 2003; Vanden Broeck & al. 2014), this range falls toward the far end of documented dispersal distances for such a species (Cozzolino & al. 2003). Establishment of a population depends on finding scarce suitable habitat and mycorrhizal fungi that *E. palustris* relies on for germination (Rasmussen 1992). In lab experiments, only 30-89% of *E. palustris* seeds germinated even in suitable conditions (McKendrick & al. 2000). This suggests the probability of a seed dispersing from Turkey

Fig. 2. The spatial separation between the nearest records in Turkey (Sürgü, Sultanhanı-Eşmekaya, Pülümür, Bitlis, Hakkâri), and Baskinta, Lebanon.

and producing a mature plant in Lebanon is extremely slim even if not impossible. Akin to *Liparis loeselii* (L.) Rich., which Waud & al. (2017) found to be a mycorrhizal generalist capable of opportunistically associating with various fungal partners to induce seed germination, if *E. palustris* exhibits similar flexibility in its mycorrhizal associations, the availability of compatible mycorrhizal fungi may not necessarily be a limiting factor for its establishment and persistence in Lebanon.

Nevertheless, the small population size of just 5 individuals observed for *E. palustris* in Lebanon is concerning. Oostermeijer & Hartman (2014) found that populations of *L. loeselii* frequently went locally extinct after just 1-5 years, suggesting high turnover rates driven by environmental stochasticity. This finding highlights the potential vulnerability of small orchid populations like *E. palustris* to environmental changes and stochastic events, underscoring the implications for the population's long-term viability and the need for concerted conservation efforts.

Under natural conditions, *E. palustris* likely requires winter chilling for dormancy break and spring germination (Rasmussen 1992), with seedlings needing 3–6 undisturbed years before flowering (Summerhayes 1951). The suitable nutrient-poor, moist to wet substrates

(Jacquemyn & al. 2014) indicate this Lebanese population could be relictual and not necessarily recently colonized. Nevertheless, the small population size of just 5 individuals, in stark contrast to the thousands found in established populations (Esfeld & al. 2008; Vanden Broeck & al. 2014), points toward a recent founding event. Additionally, *E. palustris* lacks dormancy mechanisms and cannot persist solely as a soil seed bank for extended periods (Rasmussen & al. 2015), making long-term persistence without above-ground individuals less likely. However, habitat loss and degradation over time may have caused a previously established population to dwindle to such a small size (Lienert & al. 2002). Additionally, if this area has not been thoroughly surveyed in the past, a relictual population may have been present but overlooked until now (Fischer & Stöcklin 1997). Relictual populations often exhibit genetic divergence from other populations (Hollingsworth & Dickson 1997), thus genetic analysis comparing this population to others could yield evidence about its origin.

Several remarkably similar discoveries have been recently reported in Northwestern Africa, marking another southern limit for Eurasian forest orchids: *Neottia nidus-avis* (L.) Rich. in Tunisia (El Mokni & al. 2010), *Cypripedium calceolus* L. and *Epipactis microphylla* (Ehrh.) Sw. in Algeria (Nemer & al. 2019; Bougaham & al. 2020). Unfortunately, at this time, no field survey has been conducted to argue in favor of either the relictual population or the recent founding event. On the contrary, the long-term persistences of the very reduced and/or unique subpopulation of *Neottia nidus-avis* (Madoui 2019) and of *Cephalanthera rubra* (L.) Rich. (Rebbas & al. 2023) in Algeria have been documented. Finally, a third kind of contrasted situation can be reported for the forest orchid *C. damasonium* (Mill.) Druce and the wetland orchid Spiranthes aestivalis (Poir.) Rich. in Algeria. Both have not been seen again from their unique historical locality (Quézel & Santa 1962) despite extensive research in their respective localities (De Bélair & al. 2005; Hamel & Meddad-Hamza 2016; Beghami & al. 2015; Ait Medjber & al. 2023).

Pollination ecology

We still know very little about the pollination ecology in Lebanon, except that flowers were pollinated during summer in 2023. In Sweden "Ants, bumble bees and hover flies were the most frequent visitors, but they generally played a minor role as pollinators. Solitary wasps (*Eumenidae*) were the most important pollen vectors although only present at low frequencies." (Nillsson 1978). In the Netherlands, "*Epipactis palustris* (L.) Crantz was visited by honeybees, sawflies, parasitic hymenopterans, ants, hoverflies and other flies" (Brantjes 1981), the most of them being pollinators as well. In Poland, Jakubska-Busse & Kadej (2008) observed "the behaviour of visiting and pollinating insects (mainly *Apidae* and *Syrphidae*) consisting of moving mostly within one inflorescence (or neighbouring inflorescences)". They also reminded that the construction of the flower of *E. palustris* fosters self-pollination and that in the population they examined vegetative reproduction dominates.

Threats and conservation

In sum, while long-distance dispersal cannot be ruled out, the specific habitat requirements suggest this Lebanese population could be relictual. Further demographic and genetic analysis to compare it to Turkish populations are needed to determine its origins and viability. Regardless, this population of *Epipactis palustris* in Lebanon is threatened by urbanistic spread. In the *Guiding design and general detailed System for the area of Baskinta* (2002) the area where *E. palustris* population was found is classified as D1 (mixed-used development that includes residential and commercial uses). At around 175 m to the west and of the site there are some human constructions. Another construction is situated 200 m above the site, adjacent to the stream leading to *E. palustris*. Protecting *E. palustris*'s habitat and searching for other occurrences in Lebanon should be a priority for the preservation of this orchid.

Eriksson (1996) was the first one to claim "Short-lived or highly habitat specialized plants with good dispersal tend to build up metapopulations, i.e. systems of local populations and non-occupied but potentially suitable sites, interconnected with dispersal, and in a continuous flux of local colonization and extinction.". At this stage of our knowledge, the species is not globally threatened and was assessed as LC / Least Concern (Matchutadze 2014) but a regional assessment for Lebanon should obviously result to an opposite category like, probably, CR / Critically Endangered. But regional assessments have to consider, at a second step, the existence of conspecific populations outside the region that may affect the risk of extinction within the region should be investigated : "In most cases, this will mean downgrading the category met by the global criteria, because populations within the region may experience a rescue effect from populations outside the region". Actually, it clearly depends on the following factors: 1) Whether the regional population is the target of significant immigration of propagules capable of surviving in the region; 2) Whether the immigration is expected to decrease; and 3) Whether the regional population is a sink (Gärdenfors & al. 2001). This is particularly true for plant species like orchids that share very abundant and very flying propagules (here seeds) comparably with the bryophytes spores: "In bryophytes, information on the effects of isolation of subpopulations is lacking. However, in general, those taxa with a large production of small diaspores are considered probably more easily spread […] and hence not so vulnerable to isolation through fragmentation of their habitats" (Hallingbäck & al. 2000). Additionally, for practical reasons, they recommend that, in most circumstances, a minimum distance between 100km and 1,000km for species with spores can indicate severe fragmentation. We believe that Eurasiatic terrestrial orchids with high production of wind dispersed small seeds share this problematics. In Lebanon, where western winds are dominant (cf. https://world-weather.info/archive/lebanon/beyrouth/#t0 consulted at 19/3/2024), it concerns preferably the South-Eastern European or Southern Anatolian sources of propagules. The minimum we can say is that both in Greece and Turkey (Kreutz 2009; Tsiftsis & Antonopoulos 2017) *Epipactis palustris* is mainly limited in the norther mountains because already at their southern limit of distribution. Thus, most probably, the immigration of propagules is naturally extremely low., even if not impossible as already concluded before.

Next challenges

In any case, in such a peculiar sink-source metapopulation context, a pluriannual monitoring from the field is needed for knowing the population trend and for understanding the medium-term dynamics of the *E. palustris* population and even of its habitat.

As already argued by Tremblay & al. (2006): "A major difficulty applying the metapopulation approach to orchid conservation is identifying empty sites suitable for colonization". In this context, we would need to know at least a bit more about the local guild of potential pollinator insects.

In conclusion, contacting the owner of the concerned field and its upstream basin could help to better anticipate the species conservation against the urbanistic problematics. A classification as a "plant micro-reserve" (Lumbreras 2001) already tested at Lebanese level in the same area near Baskinta (cf. https://www.cepf.net/resources/documents/involuntary-resettlement-safeguard-baskinta, consulted at 19/3/2024) would be a very optimistic outcome.

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