



***Orchis troodi* (RENZ) P. Delforge, *Orchis sitiaca* (RENZ) P. Delforge and *Orchis anatolica* subsp. *albiflora* Subsp. Novo K. Addam & M. Bou-Hamdan, three new rare orchids joined the Lebanese flora**

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Abstract

Two new species and one subspecies (novo) from the Orchideaceae family related to *Orchis anatolica* group are found for the first time in Lebanon, *Orchis sitiaca* (Renz) P. Delforge in Mount Lebanon, *Orchis troodi* (Renz) P. Delforge and *Orchis anatolica* subsp. *albiflora* Subsp. Novo K. Addam & M. Bou-Hamdan in both Mount and North Lebanon. Morphologically, these species (wrt P. Delforge) resemble *Orchis anatolica*, but differ in some taxonomic and other details such as the size of the flower, color of sepals and growth altitude. The study discusses, examines, and provides taxonomic description and pertinent information photographs founded all over 16 years of field work. Observations, fresh collections, two specimens and one holotype are also included.

Keywords: orchideaceae; *Orchis anatolica* Boiss; *Orchis sitiaca* (Renz) P. delforge, *Orchis troodi* (Renz) P. delforge, *Orchis anatolica* subsp. *albiflora* Subsp. Novo K. Addam & M. bou-hamdan., location, taxonomy; biodiversity; flora; lebanon; mediterranean

1. Introduction

One of the richest and largest species plant families of angiosperms (880 genera and more than 22,000 accepted species) is the Orchidaceae ^[1]. An orchid is any wild native genus that occurs in temperate regions ^[2]. It is characterized by a tuberous root that looks like a 'testicle', which explains its nomenclature (based on Greek language orkhis means literally 'testicle'). The stem is fleshy and erected bearing a spike of typical flowers with different colors. They have long engaged the attention of biologists and scientists by their identification, morphology, hypogean organs, reproductive biology (pollination) and diversity ^[3, 4]. One of their hidden effective uses is their medical process which is used in traditional medicine for treating several diseases such as circulatory, diabetes, cancer and others ^[5, 6]. Orchids are cosmopolitan flowering plants distributed among all continents. They comprise a great variety of habitats ranging from deserts and swamps to arctic regions. They are divided into two categories: the epiphytic and terrestrial. The later one constitutes the larger group of this family ^[7].

The Mediterranean Basin is a reserve for many unique and endemic native orchids that includes a well-known global center of plant diversity ^[8]. Its biodiversity's hotspot is not only the second largest hotspot, but is also the largest of the five Mediterranean-climate regions in the world which covers more than 2 million square kilometers. As for the plant diversity, the Mediterranean Basin holds the third richest hotspot ^[9]. It has around 30,000 plant species and more than 13,000 which are not found elsewhere or are endemic to the hotspot, yet many more are being discovered each year ^[10].

In the East Mediterranean, specifically the Levantine uplands, Lebanon is located within a recognized center of this plant diversity ^[7]. Though its small size (Area 10452 km², distance from the north to the south of the country is 180 km and 50 km from east to west), its exceptional high percentage of the native floras makes this country so unique ^[10].

Lebanon's distinctive Mediterranean climate, geological breaching and topographical diversity are the main factors that characterize Lebanon as a significant reserve for various sporadic, native and endemic species (particularly some of the very rare endemic orchids) ^[11, 12]. Moreover, this country is one of the most inspiring spots of conservation in the world.

Mount Lebanon is one of the regional hotspots where *Orchis sitiaca* Fig. 3, *Orchis troodi* Fig. 4 and *Orchis anatolica* subsp. *albiflora* Subsp. Novo K. Addam & M. Bou-Hamdan Fig. 5 are found. It includes an extraordinary level of endemism among plant species whereby some new discoveries are published and others, though found, remain under-observation ^[13, 14].

Paul Mouterd (1966) assessed the Flora of Lebanon 51 years ago ^[15]. In 1973, the floristic richness of Lebanon was estimated by Zohary at 2,600 plant species and 311 endemic species ^[16]. An approximate number of 212 species in this country partake an economic value and are considered as medicinal or edible crops ^[17]. In 1996, Lebanon had an approximate flora of 3,761 vascular plant species, whereby 38 of the mentioned were endangered and scarce and 92 were endemic; a report provided by the UNEP ^[18]. In 2009, Lebanon hosted more than 3,000 species of wild flora, as mentioned by Haber R.M. and Haber M.S ^[19].

In 2014, and according to Toameh and Toameh's calculations, the total number of Lebanese plants (trees and ferns included) was 2,612 species, 770 genera, 155 families and 58 unfound species by the authors which have been mentioned to exist in Lebanon previously by Mouterd P. and Post G.^[15, 17, 20]

Indeed, there is no exact data about the real number of existing flora in Lebanon. This is because some authors and researchers mentioned many species and number of floras in their books without any official (peer reviewed journals) publications or even any deposited specimens for these species in any herbarium in Lebanon to prove academically that they were found; we have only books with pictures.

Few researchers worked specifically in the domain of the Lebanese Orchidaceae family such as K. Addam and M. Bou-Hamdan^[12, 13, 21, 25], Krutz and Haber R, M. & Haber M.S. Haber & Haber wrote the only book that illustrated specifically the Lebanese orchids entitled "Orchids of Lebanon"^[21]. Many novelties were suggested for Lebanon, but without any further discussions between the parties^[22]. After spending six years searching for publications that might contain these new pictured species (mentioned in the book), we concluded that no publications were found or mentioned even in the book's bibliography for these authors regarding the new species^[12, 13, 19, 21, 25]. Some novelties found in the list written by Kreutz about the Lebanese orchids transpired to be a personal field inventory rather than an exhaustive compilation based on historical bibliography^[22].

In 2015, Vela, E. and Viglione wrote a proposal of a national checklist for the Lebanese Orchidaceae family^[22]. Indeed, this checklist needs to be updated because it does not contain a lot of new discovered and published species by K. Addam and M. Bou Hamdan before the proposal of Vela, E. and Viglione^[12, 13, 21, 25] as well as new world endemic records which we have recently validated after their proposal^[25]. These new discoveries were published after three years in 2015, 2016 & 2017. In addition, these three orchids issued in this publication are new. Nonetheless, we disagree with the classification of this checklist because it momentarily conflicts with our interest and the classification of P. Delforge^[36] and others^[41].

All the researchers who worked on the Lebanese flora in general or specifically on the Lebanese Orchidaceae family mentioned the presence of *Orchis anatolica* Fig. 4 in their books, but none of them mentioned the presence of other members and varieties related to this species^[15, 17, 19, 20].

Furthermore, the checklist of Vela, E. and Viglione for the Lebanese Orchidaceae family declared that in contrast to other countries such as Cyprus, Turkey and Crete, the varieties of *Androrchis anatolica* (Boiss.) D.Tyteca & E.Klein; *A. troodi* (Renz) D.Tyteca & E.Klein, *A. × sezikiana* (B.Baumann & H.Baumann) W.Foelsche & Jakely and *A. sitiaca* (Renz) D.Tyteca & E.Klein do not exist in Lebanon^[22].

Indeed, these two-rare existing worldwide mentioned varieties *Orchis troodi* (RENZ) P. DELFORGE and *Orchis sitiaca* (RENZ) P. DELFORGE, which were considered known in Cyprus and Crete only^[36], are not endemic anymore because they are found by Dr. Khodr Addam and Mounir Bou-Hamdan^[12, 13, 21].

All of these mentioned orchids in addition to the new discovered *Orchis anatolica subsp. albiflora* K. Addam & M.

Bou-Hamdan Subsp. Novo are related to the *Orchis anatolica* Boiss group.

Orchis anatolica's worldwide distribution was recorded in several countries such as "Greece, Cyprus, Lebanon, North Iraq, Northwest Iran, Turkey and East Aegean". Its dispersal was listed also by The Kew Gardens from Aegean Islands to Palestine and West Iran, Southeastern Europe, Greece, Kriti, Western Asia, Cyprus, East Aegean Islands, Iran, Iraq, Lebanon, Syria and Turkey^[35]. Nonetheless, *Orchis anatolica* is fairly distinctive though it may be confused with *Orchis sitiaca* and *Orchis troodi* but not with *Orchis anatolica subsp. albiflora* K.Addam & M. Bou-Hamdan Subsp. Novo^[38].

However, *Orchis troodi* (as its name suggests) was first described by Renz (1929) as *Orchis anatolica var. troodi* Renz. and was found in Troodos mountains of central Cyprus^[39]. In 1990, P. Delforge viewed this variety as a distinct species endemic to Cyprus and named it *Orchis troodi* (Renz) P.Delforge, (its official and accepted nomenclature now)^[40, 44].

Whereas, *Orchis sitiaca* was first described by Renz (1932) as *Orchis anatolica var. troodi* Renz^[41] P. Delforge viewed this variety as a distinct species endemic to Crete and named it *Orchis sitiaca* (Renz) P.Delforge, (its official and accepted nomenclature now)^[39, 45].

Yet, *Orchis anatolica subsp. albiflora* K.Addam & M. Bou-Hamdan Subsp. Novo is designated for the first time in this publication. Multiple researchers mentioned this subspecies to be either a form of *Orchis anatolica* (white color) or an *Orchis anatolica var. leucantha* (the variety was pictured and stated online as a rare orchid in Rhodes Island whereby the name of the scientist who discovered them was not mentioned)^[24].

Moreover, we could not find any publication for *Orchis anatolica var. leucantha* in any official journal or international plant list. Hence, we do not agree with both nomenclatures for the following two reasons: it should not be listed as a variety since there is a scarce difference from *Orchis anatolica* and there are few differences present in its form. Therefore, we decided to consider it as a subspecies.

2. Materials and Methods

Tens of *Orchis troodi* were found in many places in Lebanon by Dr. K. Addam and M. Bou-Hamdan. This species was found and pictured for the first time in village Btekhneh (Mount Lebanon) at 7/III/2004 but was not identified then. In 2013, *Orchis troodi* was recognized and diagnosed and while looking in the pictures archive till 2017, its distribution was traced all over Lebanon.

About four *Orchis sitiaca* were uncovered by Dr. Addam at 29/IV/2016 in Kornail (Mount Lebanon). This species of orchids is very rare (in Lebanon) and very difficult to discover, distinguish and diagnose during the field work searching due to its resemblance to *Orchis anatolica*. The main problem was to find *Orchis sitiaca* as hundreds of *Orchis anatolica* species surround it.

Orchis troodi was acknowledged after 13 years of field work while *Orchis sitiaca* was identified immediately from the first look in the field a year earlier (2016) whereas *Orchis anatolica subsp. albiflora* was recognized in 2013.

2.1 Voucher Specimen and Holotype

Three dried samples voucher specimen of two new species

and one holotype were deposited in K. Addam's Herbarium Arts, Sciences and Technology University in Lebanon.

Voucher specimens

Orchis sitiaca, collection number (29-04-16-78-001), collected by Dr. Addam at 29/IV/2016. Fig. 1 b

Orchis troodi collection number (15-05-17-78-001), collected by Dr. Addam at 15/V/2017. Fig. 1 c

Holotype

Orchis anatolica subsp albiflora collection number (06-04-13-78-001), collected by Dr. Addam at 6/IV/2013. Fig. 1 a

The prevailing deposited herbarium material was recognized, scrutinized, and recorded as a matter of its distribution. Fig. 1



Fig 1: The Dried Herbarium Material Specimens and Holotype

2.2 Pictures

The pictures were captured by Dr. K. Addam and M. Bou-Hamdan.

3. Results

In this study *Orchis sitiaca* (RENZ) P. DELFORGE), *Orchis troodi* (RENZ) P. DELFORGE and *Orchis anatolica var. albiflora* Subsp. Novo. K. ADDAM & M. BOU-HAMDAN are discovered, identified, and added to the Lebanese flora for the first time. They resemble *Orchis anatolica* but differ in some taxonomic attributes.

3.1 Species description

Orchis anatolica (RENZ) Fig. 2

10-40cm tall; stem reddish-brown; 3-6 rosette dark green spotted violet oblong to lanceolate basal leaves, membranous reddish bracts pointed at the tip, nearly as long as ovary; lax inflorescence lax, up to 2-15 flowers (up to 25), rich purple, pale pink to violet, rarely white; sepals elongated oval to lanceolate, veined, forming a hood with petals that are slightly concave, lip 3-lobed 8-12mm x 8-13mm, center convex, grooved, lateral lobes broad, often curved forward; median lobe near rhomboidal [36].

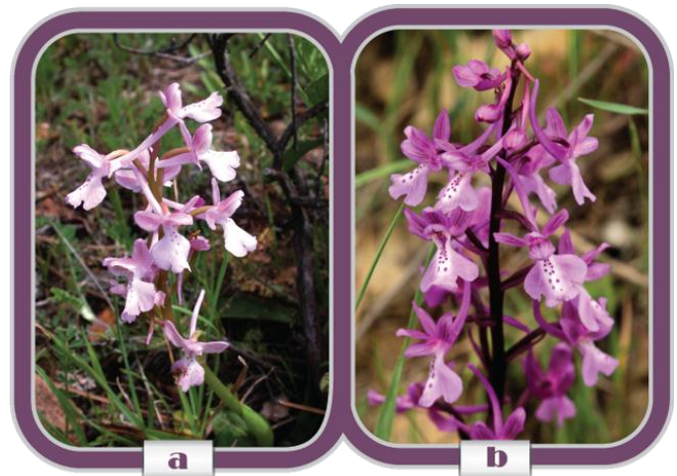


Fig 2: *Orchis anatolica* (RENZ)

Orchis sitiaca (RENZ) P. DELFORGE Fig. 3

It resembles *Orchis anatolica* but it is more robust, 8-35cm tall; leaves up to 14cm long, greyish-green, marked to unmarked, shiny, bracts greener, lower longer than ovary while upper shorter, inflorescence near lax, 3-16 flowers, white to purple color; sepals elongated, center of the lateral sepals blotched green; petals more acuminate; lip very convex, deeply 3-lobed narrower and smaller proportionally, center, often yellowish; lateral lobes turned down under the lip; median lobe longer than lateral, spur horizontal, long, often spindly, tip ascendant [36].



Fig 3: *Orchis sitiaca* (RENZ) P. DELFORGE

Orchis troodi (RENZ) P. DELFORGE Fig. 4

It resembles *Orchis anatolica* but its habitat is also more robust, larger in all parts, 15-50cm tall, stem reduced red wash, leaves broadly oval, pale green, less spots, lower bracts ± equal to ovary, inflorescence near lax to dense, 3-18 flowers, larger, paler, pink to purplish, turning dark carmine on withering. Lateral sepals broadly oval, inside washed or blotched green in the center, 7-11mm x 3.5-5mm. Dorsal sepal often near erect, lip wedge-shaped, proportionally larger, spreading to convex, deeply 3-lobed, up to 17mm x 22mm. The center is whitish to yellowish, spotted on the lower two-thirds. The lateral lobes near anacquadangular, rounded,

broad, median lobe bilobed to scalloped, unmarked, spur 20-25mm (very long), lays horizontal (sometimes) Fig. 4c but mostly it bends strongly upwards to almost vertical (even curved) Fig. 4a, b. ^[36].

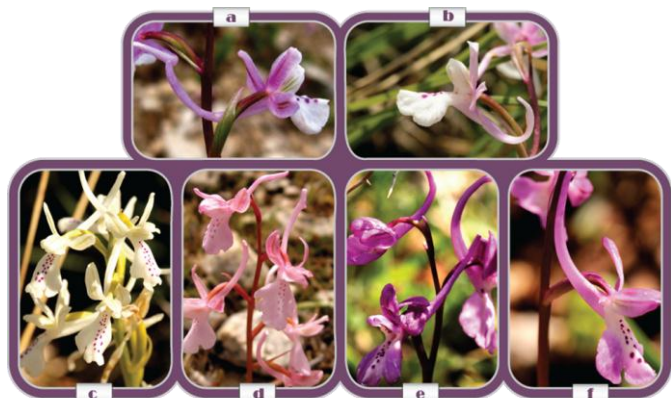


Fig 2: *Orchis troodi* (RENZ) P. DELFORGE

***Orchis anatolica albiflora* Subsp. Novo. K. ADDAM & M. BOU- HAMDAN. Fig. 5**

It resembles *Orchis anatolica* 8-20 cm tall; stem light oil yellowish; 3-5 rosette light green and not spotted oblong to lanceolate basal leaves, membranous white bracts pointed at the tip, nearly as long as an ovary; very lax inflorescence lax, 2-6 white flowers unspotted. The sepals are elongated oval to lanceolate, veined light oil yellow, forming a hood with petals that are slightly concave, lip 3-lobed, center convex, and long, narrow grooved, lateral lobes broad, folded down and touching each other below the lip, median lobe near rhomboidal (when spread), the spur is long and wide. The size of the flower is in general smaller than *Orchis troodi* and bigger than *Orchis anatolica*.



Fig 5: *Orchis anatolica albiflora* Subsp. Novo. K. ADDAM & M. BOU- HAMDAN.

3.2 Habitat

***Orchis anatolica*:** prefers dry to moist substrates, full sun to mid-shade on slightly acidic to alkaline, grassy areas in

garrigue, very often between pine trees in full sun but not under them in the shade, open stony places in difficult environmental factors. This interesting orchid grows from 100 m 1956 m alt ^[36].

***Orchis sitiaca*:** grows side by side to *Orchis anatolica* but only in garrigue, open stony places but not in the shade in pine woods. It prefers dry to moist slightly acidic to alkaline soils. ^[37] It is remarkable that in contrast to *Orchis anatolica* this species grows above 1450 m alt.

***Orchis troodi*:** grows with *Orchis anatolica*, prefers full sun to mid-shade, in bright mixed pine and deciduous forests, often accompanied by *Dactylorhiza romana*. Most occurrences lay at heights from 1067 m to 1477 m ^[36].

***Orchis anatolica subsp. Albiflora*:** grows with *Orchis anatolica* and *Orchis troodi*, prefers dry to moist, slightly acidic to alkaline soils and full sun to mid-shade, in bright mixed pine and deciduous forests. Most occurrences lay at heights from 828 m to 1477 m.

3.3 Phenology

- *Orchis anatolica* from the end of January (174 m alt.) to the end of May (1955 m alt.).
- *Orchis troodi* from the end of February (824 m alt.) to the end of May (1477 m alt.).
- *Orchis sitiaca* from April to May (1450 m alt.).
- *Orchis anatolica subsp. albiflora* from April (828 m alt.) to the end of May (1477 m alt.).

3.4 Distribution and Location

▪ ***Orchis anatolica***

In more than 220 places ranges from 100m (Shwaifat) to 1956.5m (Arz Bcharri).

▪ ***Orchis sitiaca***

Falougha: N 33° 50' 26" EO 35° 44' 521" 1433m, N 33° 50' 126" EO 35° 43' 116", 1451m alt. located in Baabda District (Qada'a), an administrative division of Mount Lebanon Governorate. (Mohafazah), 38.4 km far from Beirut. Map 1d

▪ ***Orchis troodi***

Bcharri: N 34 17 498 EO 35 65 156, alt 1212 m, located in Bsharri District of the North Governorate. 108.7 km far from Beirut. Map 1f

Ehden: N 34 18 104 EO 35 58 232, alt 1477.74 m, located in Zgharta District (Qada'a), an administrative division of North Lebanon Governorate (Mohafazah). Map 1g

Ras el haref: N 33 50 521 EO 35 41 229, 1064.4m alt, located in Baabda District (Qada'a), an administrative division of Mount Lebanon Governorate (Mohafazah). 28.3 km far from Beirut. Map 1a

Mshikha: N 33 52 447 EO 35 44 458, 824m alt, located in Matn District (Qada'a), administrative division of Mount Lebanon Governorate (Mohafazah) 36.4 km far from Beirut. Map 1e

Hmmana Mdayrij: N 33 48 20 EO 35 43 47 Alt 1275m. located in Baabda District (Qada'a), an administrative division of Mount Lebanon Governorate (Mohafazah) 33.5 km far from Beirut. Map 1c

▪ ***Orchis anatolica subsp. albiflora***

Bcharri N 34 17 498 EO 35 65 156 Alt 1212 m, N 34 17 497 EO 35 56 148 Alt 1211 m.

Map 1f

Ehden N 34 18 104 EO 35 58 232 Alt 1477.74 m. Map 1g

Bzebdine N 33 52 166 EO 35 44 366 Alt 828 m. located in Baabda District (Qada'a), an administrative division of Mount Lebanon Governorate (Mohafazah) 30.7 km far from Beirut.

Map 1h



Map 1: Distribution of *Orchis sitiaca*, *Orchis troodi* and *Orchis anatolica subsp. albiflora* in Lebanon

4. Status and Threat

The orchid family (Orchidaceae) is one of the most diverse floras within the angiosperms [26]. However, this diversity is harmonized with scarcity whereby most orchid species are either threatened or endangered in the wild [27]. Compared to any other plant family, Orchidaceae has a high number of threatened genera which comprises the most threatened species [28]. It is also one of the reasons this family consists of the largest threatened number of taxa in nature [29]. The relative rarity of this family members resulted in special conservation status and protection in many countries [30]. For many reasons, Orchids is considered a proper group for documenting changes in the presence and distribution of species. It is portrayed as a rich and ecologically diversified group; particularly found in the Mediterranean region [31]. Some species are widely distributed whereas others are somehow narrowly endemic [32]. Orchids are particularly vulnerable to changes in climate and land cover due to their dependence on both pollinators and fungal symbionts [33, 34].

In Lebanon, various factors are threatening the orchids. This unique flora is damaged and spoiled by tourists, urban expansion and proliferation of summer resorts in the mountains, political instability, wars, overcollection of the aromatic and medicinal herbs, overgrazing, and forest fires. [18].

Orchis anatolica is considered threatened, endangered and extinct in many Lebanese neighboring countries such as Syria,

Palestine, Jordan and even Turkey [35, 42, 43]. *Orchis anatolica* is still “common” in Lebanon unlike the discovered *Orchis sitiaca*, *Orchis troodi* and *Orchis anatolica subsp. albiflora* Subsp. Novo which are very rare in Lebanon and even in the places found for the first time such as Crete and Cyprus. After the discovery of *Orchis sitiaca* and *Orchis troodi* in Lebanon, these two species are not endemic anymore to Crete and Cyprus [23, 36, 37].

5. Discussion

Orchis anatolica is fairly distinctive but may be confused with *Orchis sitiaca*, *Orchis troodi* and *Orchis anatolica subsp. albiflora* which are rarely distinguished. Morphologically, these species are very similar to *Orchis anatolica* as they share the same distribution area and have the same blossoming time at an altitude of 850 m and more in Lebanon. Contrastingly, their blossoming in the habitats of Cyprus and Crete is after the fade of *Orchis anatolica* [37].

However, *Orchis sitiaca* Fig. 3 shares various similarities with *Orchis troodi* Fig. 4 like preferring faintly acid to neutral sub-soil and avoiding calcareous ground, showing morphological resemblances to *Orchis anatolica* Fig. 2 and sharing the distribution area as well as having the same flowering times and growing at higher altitude.

On the other hand, *Orchis troodi* differs from *Orchis sitiaca* and *Orchis anatolica* in size, with the former plant being a significantly more robust orchid, carrying larger and longer flowers in a generally looser inflorescence and a curved spur near vertical and often ascendant.

Orchis sitiaca has three main attributes that distinguishes this species from the three aforementioned orchids: center of the lateral sepals blotched green, petals more acuminate, lip very convex, deeply 3-lobed narrower and smaller proportionally from the others.

Regarding the stems, *Orchis anatolica subsp. albiflora* is distinguished easily from others: stem light oil yellowish, unspotted light green basal leaves, inflorescence very lax, 2-6 unspotted white flowers, narrow grooved, lateral lobes broad, folded down and touching each other below the lip, in general smaller than *Orchis troodi* and bigger than *Orchis anatolica*.

Orchis anatolica subsp. albiflora differs from *Orchis troodi f. alba* by its flower and stem. The flower's size of *Orchis troodi f. alba* is bigger and contains spots with a reddish-green stem. While *Orchis anatolica subsp. albiflora* has yellowish-green stem. The *Orchis anatolica subsp. albiflora* differs from *Orchis anatolica f. alba* by its flower and stem. The flower's size of *Orchis anatolica subsp. albiflora* is, in general, smaller than *Orchis troodi* and bigger than *Orchis anatolica*. The flower of *Orchis anatolica* contains spots with a reddish-green stem while *Orchis anatolica subsp. albiflora* has a yellowish-green stem.

5.1 Recommendations

Orchis troodi, *Orchis sitiaca* and *Orchis anatolica subsp. albiflora* Subsp. Novo are challenging to find as they are infrequent, very rare and endangered in Lebanon.

Many problems have shown to be essential factors in endangering the existence of these species... We recommend some solutions for these existing problems that need to be stopped and eliminated but before that we need to determine

the:

- Threatening factors
- Preventions against threatening factors

The essential threatening factors that need to be recommended are:

- Intensive grazing pressure from the native and introduced mammalian herbivores, in addition to the range of native and those introduced species from domestic stock such as sheep, goats and cattle, have widely affected all kinds of flora species and especially the orchids.
- The fast urbanization in the regions where these species are discovered might lead to their extinction. Development of land for housing has led to the clearance of large areas of bushlands and forests that host these species.
- Inappropriate fire regimes such as wildfires, barbecue fires, home fires or garbage fires have led to burning hundreds of orchids in Lebanon every year ^[46].
- Agriculture and plantation which is due to the new agriculture (especially olive cultivation) as well as the regional development and land use change in rocky mountains and other places that threaten the existence of flora in general and orchids in particular.

The prevention against these threatening factors should be done through raising awareness by hosting educational and social events, newsjacking, and distributing brochures...etc. The awareness campaigns should be implemented for people in general and village men/women in particular.

6. Conclusion

Two new species of the Orchideaceae family, *Orchis troodi* (RENZ) P.DELFORGE, *Orchis sitiaca* (RENZ) P. DELFORGE) and one new world record *Orchis anatolica subsp. albiflora* Subsp. Novo K.Addam & M. Bou-Hamdan joined the Lebanese flora and specifically the *Orchis anatolica* group.

After 14 years of fieldwork observing the three aforementioned orchids, their existence was proved by their multitude of locations, illustrated morphological description and phenology. Two voucher specimens for the species (*Orchis troodi* and *Orchis sitiaca*) and one holotype for *Orchis anatolica subsp. albiflora* (represented dried samples) of the plants were deposited in K. Addam's Herbarium Arts, Sciences & Technology in Lebanon collected by Dr. K. Addam and identified by M. Bou-Hamdan & K. Addam.

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