

# Crocus baalbekensis K. Addam & M. Bou Hamdan sp. Nov and its three forms (IRIDACEAE), new endemic species and forms from Lebanon, joined the Lebanese Flora

## Abstract

*Crocus baalbekensis* K. Addam & M. Bou Hamdan sp. Nov is nominated as a novel species in addition to its three forms from Baalbek District, northeast of Lebanon. The new species resembles *Crocus allepicus* and *Crocus hyemalis* but varies in terms of phytogeography, phenology, and some taxonomic structures such as (corm, tunic, leaves, and shape of the perianth, segment and others). Thousands of this new species were perceived in countless villages in the northern city of Baalbek. It grows in cold semi-arid climates in stony grasslands, tundra where trees are absent. Plant material and morphological analyses were done, measurements, colors, and other details given in the description are based on both herbarium and fresh materials. Morphological data were taken from more than 10 specimens.

The flower is 1-6, 30-40mm tall, white, fragrant (Fresia smell), corm oblong conical about 20-26mm x 14-20mm in diameter. Corm tunic 4-10 layers, brown, extended neck 10-20mm, great build-up of old tunics, coarse parallel fibers, not glued together, with cross-links. Leaves 4-12 (present at flowering), green, glabrous, white stripe about 1/4 of leaf keels, Spathe, 3-4, membranous white to pale yellow pipe. Outer perianth segment, 3, oblanceolate, abaxial side is colored by yellow, mottled by dark blue-violet, middle (1 to 3) stripe of dark violates veins continue to the segment, filament, 3, deep yellow, Anther, wide, arrow shape, longitudinally striped in black and yellow. Style 1, deep yellow to orange, sometimes striped by thinner black lines, divided to 3 stigmas, equal or longer than the stamen. Stigma (each one) is branched to 3-6 short strands. Voucher specimen (Holotype) is deposited in K. Addam's Herbarium Arts, Sciences and Technology University in Lebanon, Accession No.: 22-1-17-58-001. The three forms resemble *Crocus baalbekensis* but differ in the color of the tepals.

**Keywords:** crocus baalbekensis, *crocus baalbekensis* f. assiensis, bella, ornata, iridaceae, taxonomy, Baalbek region, Lebanon, Mediterranean

Volume 4 Issue 2 - 2019

Khodr Addam,<sup>1</sup> Mounir Bou-Hamdan,<sup>2</sup> Nisreen Sabbagh,<sup>2</sup> Jihad Takkoush,<sup>3</sup> Kamal Hout<sup>4</sup>

<sup>1</sup>Head, Integrative and Environmental Research Center, AUL Beirut, Lebanon

<sup>2</sup>Integrative Research and Environmental Center, AUL Beirut, Lebanon

<sup>3</sup>Dean of Business Research Center, AUL Beirut, Lebanon

<sup>4</sup>Department of PG Studies & Scientific Research, Global University Beirut, Lebanon

**Correspondence:** Khodr Addam, Head, Integrative and Environmental Research Center, AUL Beirut, Lebanon, Tel 009613204930, Email draddam@hotmail.com

**Received:** March 16, 2019 | **Published:** April 05, 2019

## Introduction

Iridaceae is a family of plants in order of *Asparagales*, which is named by a reference to irises, which means a rainbow that denotes an array of colors. There are 92 (66 accepted) genera with a total of 2244 species worldwide. It embraces a plethora of other renowned cultivated plants, such as Iris, Freesias, Gladiola and Crocus.<sup>1,2</sup> The genus *Crocus* Linnaeus is a scientifically challenging genus that belongs to the huge family of Iridaceae (1753:36) that is designated by its sophisticated and stylish flowers.<sup>3,4</sup> The name of the genus originates from the Latin word *crocatum* which means saffron yellow.<sup>5</sup> *Crocus* taxa have a central place among the geophyte plants. Due to their extravagant flowers, they are utilized as ornamental plants in the balconies, terraces and roof gardens (especially, *C. baytopiorum*, ssp. *mazziaricus*, ssp. *lycius* and ssp. *damascenus*).<sup>6</sup> *Crocus* is a vital plant used since thousands of years<sup>7</sup> whereby it owes to its high demand in dye, perfumery, pharmaceutical and flavoring industries.<sup>8</sup> It is also used in some countries as a main ingredient in making cheese and as a spice used in cooking. The extract of *Crocus* taxa has antitumor, antimutagenic and cytotoxic activities and it is recently used for treating Behçet and gut diseases, treatment of joint pains, and cancer. It was used also in Unani and Arabic medicine long time ago.<sup>6</sup>

Phytogeographically, most *Crocus* species belong to and are distributed in the Mediterranean floristic basin including (Turkey, Cyprus, Syria, Lebanon, Jordan and Palestine), South Western Europe, South-Western parts of Asia, Western part of China and Irano-Turanian phytochorion.<sup>9-13</sup>

Genus *Crocus* (Iridaceae) comprises 235 taxa,<sup>14</sup> 221 species, and 97 subspecies<sup>15</sup> distributed in the Mediterranean region. The most essential monographic treatments of the genus *Crocus* Linnaeus (1753: 36) was published by Mathew (1982), "A Revision of the Genus *Crocus*", in which he divided it into two subgenera, two sections and 15 series.<sup>16</sup> The two subgenera are subgenus *Crocus* with extrose anthers and subgenus *Crociris* with introse anthers. *Crociris* encompasses only *Crocus banaticus* and the subgenus *Crocus* includes all the remaining species. The subgenus *Crocus* is also divided into two sections: section *Crocus* and section *Nudiscapus*, and each is again divided into Series a-f and g-o, respectively.<sup>17</sup>

The Genus *Crocus* is systematically problematic.<sup>3</sup> The taxonomy of *Crocus* is tremendously intricate due to the lack of vibrant idiosyncratic characters, the extensive variety of habitats, and the heterogeneity of the morphological traits and cytological data.<sup>18</sup> Detailed field, morphological, and molecular genetic studies on the

genus, particularly in Turkey, have recently doubled the number of taxa.<sup>19</sup> Additionally, they demonstrate that there are several difficulties at the infraspecific level. Genetic divergences between the known subspecies exposed that most of the subspecies must be categorized as species.<sup>20</sup> This problem is still unsettled among the scientists and the number of accepted taxa differs between different botanical scholars in this domain.

Lebanon is one of the most stirring spots of conservation in the world. It is a fundamental region in the Mediterranean basin where it boasts one of the uppermost densities of floral diversity. One of the most implausible features about this country is the presence of such biodiversity in a very restricted area. Lebanon occupies 0.007 % of the world's land surface area (10452km<sup>2</sup>) and is a home to 1.11% of the world's verified and classified plant species. Its unique Mediterranean climate, geological breeding and topographical diversity are the main aspects that portray it as a momentous reserve for innumerable sporadic, native and endemic species (predominantly some of the very rare endemic<sup>21</sup> which makes it one of the world's most prodigious spots for conservation.<sup>22</sup>

The topography of the country executes various micro-environments for both terrestrial and fresh water biodiversity. Most ecosystems, though, have narrow ranges and their biotypes are struggling for existence against a varying environment. There are five geomorphological regions in Lebanon: Coastal zone (up to 250m), Mount Lebanon range (above 250m to 3088m), Beqaa plain, Anti-Lebanon range (peaks at 2600m) and South Lebanon. The phytogeography of new crocuses is associated to the habitat, climate, and location of these two emblematic Mediterranean Lebanese regions (in Beqaa plain and Anti-Lebanon Range where the new species *Crocus baalbekensis* and all its related forms were found). Beqaa is a plain separating the Mount Lebanon and Anti-Lebanon ranges. It covers an 8-12km wide fertile corridor and is about 120km from North to South. The Anti-Lebanon range covers the Lebanese-Syrian borders and peaks at 2,600meters (Tallat Moussa). The slopes are usually gentler compared to Mount Lebanon. The southern sections of the Anti-Lebanon Range include Jabal el Cheikh (Mount Hermon), which intercepts rainwater and redistributes water into at least three focal watersheds across Lebanon, Syria and Palestine Figure 1.



Figure 1 Topography of Lebanon.

The climate of Lebanon is Mediterranean but with some particularities caused mainly by the topography. Predominantly westerly winds bring plentiful rain—principally in winter—while the summers are mainly dry. Coastal areas receive over 800mm of rain p.a., and most mountain areas over 1000mm. Most rain falls on the western slopes of the Lebanon range with the summits receiving less than lower areas. The Beqaa valley that is a part of the African Rift complex and Anti-Lebanon commonly receive less than 700mm and the Hermel semi-desert in the northern Beqaa less than 250mm which make these two regions (due to its geomorphology and microclimate) boast the biological wealth and survival of these new very rare crocuses.<sup>23</sup>

By and large, most species of this genus occur in Mediterranean climate described by a chilly or cold winter, rainy spring and autumn, and hot and dry summer. The developmental activity of the plant can be witnessed from autumn to spring; it survives the summer heat beneath the soil with its compact corm underground. Copious species begin to grow their aerial parts during the autumn rains and flower afterwards. Some flower simultaneously with leaf growth or soon thereafter, while others flower in the spring when it is warmer.<sup>3</sup>

Few are the scientists that worked on the Lebanese flora<sup>24–26</sup> and had cited the genus *Crocus* in general.<sup>27–30</sup> Pierre Edmond Boissier, a Swiss botanist, mentioned *Crocus gaillardotii* (Boiss. & Blanche) Maw and *Crocus hyemalis* var. *gaillardotii* Boiss. & Blanche Gard. Chron.

All the *Crocuses* that exist in Lebanon and were mentioned by them were: *Crocus aleppicus* Baker, *C. graveolens* Boiss. & Reut., *C. kotschyanus* K. Koch, *C. thiebautii* Mouterde, *C. hyemalis* Boiss. & Blanche., *C. pallasii* subsp. *pallasii*., *C. pallasii* subsp. *haussknechtii* (Boiss. & Reut. ex Maw) B.Mathew., *C. ochroleucus* Boiss. & Gaill., *C. vitellinus* Wahlenb., *C. haussknechtii* (Boiss. & Reut. ex Maw) Boiss., *C. cancellatus* Herb., *C. cancellatus damascenus* (Herb.) Mont, *C. cancellatus* subsp. *damascenus* (Herb.) B.Mathew., *C. cancellatus* var. *cilicius* Maw.

The new-found species is *Crocus baalbekensis* K. Addam & M. Bou-Hamdan sp. nov. The new-found forms are:

- A. *Crocus baalbekensis* f. *assiensis* K. Addam & M. Bou Hamdan f. nov
- B. *Crocus baalbekensis* f. *bella* K. Addam & M. Bou Hamdan f. nov
- C. *Crocus baalbekensis* f. *ornata* K. Addam & M. Bou-Hamdan f. nov

The aim of this study was to elucidate the taxonomical, anatomical, and ecological characters of the four *Crocus* taxa.

## Materials and methods

Observations were based on fresh materials of *Crocus baalbekensis* K. Addam & M. Bou Hamdan. Hundreds of these new species were observed in many villages in northern Baalbek. Morphological data on *C. baalbekensis* were obtained from the type locality (Makneh, Baalbek District), more than 10 in general. *Crocus* taxa lose most of their diagnostic characteristics when they dry; therefore we measured and evaluated all morphological characters from fresh forms. During our 22 years of field work, we found and registered all the species of *Crocus* that were mentioned to exist in Lebanon. The new described species were observed during our fieldtrips several times between

2017–2019. *Crocus baalbekensis* was discovered and pictured for the first time in 22/1/2017 by Mr. Mounir Bou-Hamdan in Makneh, Younine and Ras el Assi. All the forms were found to grow near the new discovered species at 25/12/2018.

## Results and discussion

### Description of *Crocus baalbekensis* K.Addam & M. Bou-Hamdan sp. nov

Flower 1-6, (30-40) mm tall, white, opened wide with star like form, and extremely very fragrant (Fresia smell) and it was observed that it attracts the bees a lot. Corm oblong conical about 18-26mmx14-20mm in diameter, corm tunic is of 4-10 layers of brown extended neck 10-20mm, great build-up of old tunics, coarse parallel fibers, not glued together, with cross-links and become thinner in the inner layers, stolon forming corms are absent, roots are white-creamy and branched, leaves (present at flowering) 4-12, 50-110mmx0.8-1.2mm, green, looking glabrous but in fact the two faces of the leaf have sporadic micro appendages chiefly on the edges, and very fine fluff on the upper face, white stripe about 1/4 of leaf keel, rarely narrower, leaf cross-section is T-shape, central nearly trapezoidal keel and 2 average length lateral arms with their margins recurved towards the keel, keel has a small notch in the middle and lamina is wider than the leaf keel but less than twice, spathe, 3-4, membranous white to pale yellow pipe with diagonal head shape, each perianth tube is covered by two inner membranous white spathe that reach the perianth throat, perianth tube is white =1.2... 1.6 As long as the perianth segments. The perianth segments are 20-26 mm tall of white flower, 6 lanceolate tepals, acute tepal of apex shape, deep yellow throat, very fragrant mostly in the evening, outer perianth segment, 3, oblanceolate, 20–26mm x 4.2-5.4mm, abaxial side is colored by yellow till one third of the tepal, mottled by dark blue–violet, three stripes (rarely one) with dark violet veins (sometimes mottled by pale yellow between the violet veins) starts from the base of the tepal and ends at its apex, all segment heads are blotched by dark blue–violet, adaxial side is white with deep yellow area that covers approximately one third of segment bottom. Inner perianth segment, 3, white oblanceolate segments 18–24mm x 5-7mm, deep yellow area covers approximately one third of segment bottom in both sides, one third of the abaxial side of the of segment bottom is covered by deep blue - violet lanceolate strip with branching veins, throat, deep yellow color covers one third of the length of the perianth segments (the colors and the strips on the tepal disappear when they reach the tube. The tube that lies under the perianth has a pure white color), filament, 3, deep yellow, (papillose to densely pubescent especially towards basis) covered by micro glandular appendages 4-7mmx0.6-0.8mm (diameter), anther, 3, 7-10mmx1.2-1.8mm, wide, arrow shape, longitudinally striped in black and yellow, style (at perianth segments) 1, deep yellow to orange, 14-22mmx0.4-0.8mm (sometimes striped by thinner black lines), divided to 3 stigmas, equal or longer than the stamen, stigma (each one) is branched to 3-6 short strands, pollen yellowish orange, seeds, 2.8-3.6mmx2.2-2.6mm (diameter), ellipsoid, small, black, large head, small pointed tail and coarse surface (Figures 2–7).

### Description of the three forms

All the forms have the same description of *Crocus baalbekensis* but they differ in their outer and inner perianth.

### Description of *Crocus baalbekensis* f. *assiensis* K.Addam & M. Bou Hamdan f. nov.

**Outer perianth:** The abaxial side is colored by yellow, mottled by dark blue, violet (even light black sometimes) at the base of the

segments (max one third) with more discontinuous veins at the base of the segments. The rest two thirds of the tepal up to the top is clear white (sometimes a middle strip (slightly defined) seen very difficult from the base to the top of the tepal.



Figure 2 Whole Plant of *Crocus baalbekensis* and its corm.



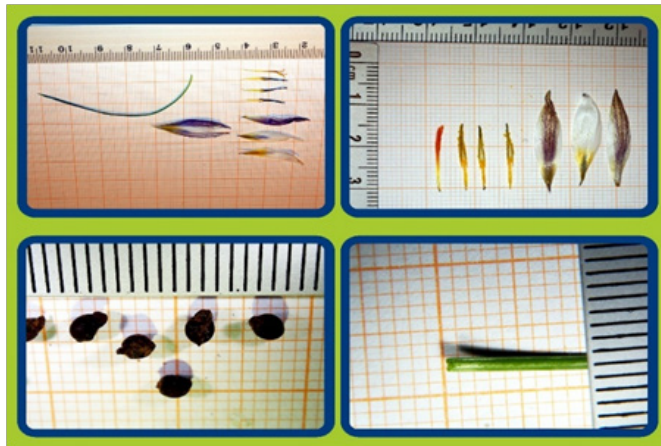
Figure 3 Whole Plant of *Crocus baalbekensis*.



Figure 4 Taxonomic Dissection of *Crocus baalbekensis* Whole plant, Leaves, Tepals, Filament, Style and Corm.

### Inner perianth

The abaxial side colored by yellow, mottled by dark blue – violet (even light black sometimes) at the base of the segments (always less than one third) (Figure 8).



**Figure 5** Taxonomic Dissection of *Crocus baalbekensis*, Tepals, Leaf, Filament and Style.



**Figure 8** *Crocus baalbekensis* f. *assiensis*.

**Description of *Crocus baalbekensis* f. *bella* K. Addam & M. Bou Hamdan f. nov**

**Outer perianth**

The abaxial side is colored by yellow at the base (one third), mottled by blue - violet semi wide middle strip with branching veins that reach the top of the tepal.

**Inner perianth:** The abaxial side is colored by yellow at the base (one third), middle strip with branching veins that reach one third of the tepal, upper two third of the tepal is pure white (Figures 9&10).



**Figure 6** Taxonomic Dissection of *Crocus baalbekensis*, Corm.



**Figure 9** *Crocus baalbekensis* f. *bella*.

**Description of *Crocus baalbekensis* f. *ornata* K. Addam & M. Bou-Hamdan f. nov**

**Outer perianth:** The abaxial side of the whole width of the tepal is colored by yellow at the base till one third of it and continues in the middle only to reach the apex; whole surface of the tepal is covered by light violet veins.

**Inner perianth:** The abaxial side is colored by yellow at the base (one third), middle strip with branching veins that reach one third of the



**Figure 7** Taxonomic Dissection of the Leaves, *C. baalbekensis*, *C. aleppicus* and *C. hyemalis*.

tepal, upper two third of the tepal is pure white with the presence of small pale violet blotch at the apex (Figure 11).



Figure 10 *Crocus baalbekensis* f. bella.



Figure 11 *Crocus baalbekensis* f. ornate.

**Phenology:** *Crocus baalbekensis* and its three forms bloom from the middle of December till the middle of February.

**Location:** Location of *Crocus baalbekensis* K. Addam & M. Bou-Hamdan. *Crocus baalbekensis* was found in many villages in Baalbek District (Kaza) 700–1300m altitude.<sup>31</sup> The city of Baalbek is located between the peaks of the western chain of Mount Lebanon and the eastern chain of the Anti-Lebanon East of the Litani River in Lebanon's Beqaa Valley, about 89.3km (53min) far from of Beirut to the northeast.<sup>32</sup> The villages in which it was explored are:

- i. Makneh: lat 34.05838 lon 36.197262), Alt 1079m, 97.1km far from Beirut (Figure 12).
- ii. Younine: lat 34.104519 lon 36.246458, Alt 1044m, 102.7km far from Beirut (Figure 12).
- iii. Ras El Assi: lat 34.3521269 lon 36.3891515, Alt 693m, 136.3km far from Beirut (Figure 12).



Figure 12 Distribution of *C. baalbekensis* and its three forms in Lebanon.

Location of the three forms:

- a) *Crocus baalbekensis* f. *assiensis* K. Addam & M. Bou Hamdan f. nov, Rass el- Assi, lat 34.352780 long 36.388066, Alt 680m, 136.3km far from Beirut (Figure 12).
- b) *Crocus baalbekensis* f. *bella* K. Addam & M. Bou Hamdan f. nov, Younine, lat 34.119282 long 36.239869, Alt 1002m, 102.7km far from Beirut (Figure 12).
- c) *Crocus baalbekensis* f. *ornata*, Fakiha Lat 34.250726 Long 36.414499 Alt 1074m, 123.7km far from Beirut (Figure 12).

### Habitat

Cold semi-arid climates are characterized by rainless summers and wetter cold winters (temp -1 to 36°C) with some snowfall (annual rainfall rate 150-450ml), high elevations: 700-1200m (up to 1500m). When the blooming of *Crocus cannellatus* var. *damascenus* fades, the flowering of *Crocus baalbekensis* starts. No crocus from this family shares this place with *Crocus baalbekensis* during its phenology. It was remarkable that there was no propagation and presence of *C. baalabakensis* to the south of latitude 34.040000. Thousands of this new species are distributed on stony grasslands, dry rocky slopes, scrub clearings, tundra (absence of trees) in mountains with very dry soil in summer and semiwet during blooming. *C. baalbekensis* is distributed sporadically along the slopes, together with *Ixiolirion tataricum*, *Astrodaucus orientalis*, *Bupleurum postii*, *Echinophora tenuifolia*, *Eryngium desertorum*, *Scandix stellate*, *Eminium spiculatum*, *Aristolochia maurorum*, *Achillea fragrantissima*, *Anthemis scariosa*, *Artemisia herba-alba*, *Atractylis cancellate*, *Carthamus nitidus*, *Centaurea dumulosa*, *Centaurea virgata squarrosa*, *Cousinia postiana*, *Cousinia ramosissima*, *Filago contract*, *Filago desertorum*, *Koelpinia linearis*, *Phagnalon linifolium*, *Postia lanuginose*, *Scorzonera phaeopappa*, *Alkanna strigose*, *Gastrocotyle hispida*, *Lythospermum tenuiflorum*, *Onosma aleppica*, *Rochelia*

disperma, *Chorispora purpurascens*, *Erucaria boveana*, *Malcolmia crenulate*, *Malcolmia exacoides*, *Matthiola longipetala*, *Matthiola damascene*, *Capparis spinosa parviflora*, *Cleome ornithopodiodes*, *Ankyropetalum coelesyriacum*, *Gypsophila ruscifolia*, *Convolvulus galacticus*, *Telmisa microcarpa*, *Euphorbia aleppica*, *Euphorbia petiolate*, *Astragalus roussaeanus*, *Astragalus tribuloides*, *Medicago radiates*, *Erodium gaillardotii*, *Crocus cancellatus damascenus*, *Ballota damascene*, *Biebersteinia multifida*, *Salvia palaestina*, *Stachys nivea*, *Stachys palaestina*, *Thymus syriacus*, *Colchicum deserti syriaci*, *Scilla hanburyi*, *Alcea damascene*, *Malva neglecta*, *Orchis collina*, *Roemeria hybrida*, *Adonis dentata*, *Consolida orientalis*, *Consolida pusilla* and *Lygia pubescens* (Figure 13).



**Figure 13** Views of the habitat of *C. baalbekensis* and its forms.

**Etymology:** The subspecies *Crocus baalbekensis* K. Addam & M. Bou-Hamdan sp. nov. epithet is attributed to Baalbek city. The form - *Crocus baalbekensis* f. *assiensis* epithet is attributed to river Al Assi. *Crocus baalbekensis* f. *bella* and *Crocus baalbekensis* f. *ornata* epithet is attributed to the beauty of the perianth segment.

### Voucher Specimen

Four dried sample voucher specimens (Holotypes) were deposited in K. Addam's Herbarium Arts, Sciences and Technology University in Lebanon.

**Holotype 1:** *Crocus baalbekensis* K. Addam & M. Bou-Hamdan sp. nov., Accession No.: 22-1-17-58-001, collected by Mr. Mounir Bou-Hamdan at 22/I/2017.

**Holotype 2:** *Crocus baalbekensis* f. *assiensis* K. Addam & M. Bou-Hamdan f. nov., Accession No.: 25-12-18-58-001, collected by Mr. Mounir Bou-Hamdan at 25/XII /2018.

**Holotype 3:** *Crocus baalbekensis* f. *bella* K. Addam & M. Bou-Hamdan f. nov., Accession No.: 25-12-18-58-002, collected by Mr. Mounir Bou-Hamdan at 25/XII /2018.

**Holotype 4:** *Crocus baalbekensis* f. *ornata* K. Addam & M. Bou-Hamdan f. nov., Accession No.: 25-12-18-58-003, collected by Mr. Mounir Bou-Hamdan at 25/XII /2018 (Figure 14).

*Crocus baalbekensis* K. Addam & M. Bou-Hamdan looks like *Crocus aleppicus* Bake and *Crocus hyemalis* Boiss. & Blanche but they have some dissimilarities in their phytogeography, phenology,

and taxonomy. *Crocus baalbekensis* is a winter crocus while *Crocus aleppicus* is an autumn one. *Crocus baalbekensis* grows only in regions where the annual rainfall rate is low (150-450ml per year) coupled with harsh environmental conditions, whereby this annual rate is high (600-700ml per year) in the regions of *C. aleppicus* and very high (1000-1200ml per year) in the regions of *C. hyemalis*.



**Figure 14** Holotypes of *C. baalbekensis* (a), f. *assiensis* (b), f. *bella* (c) and f. *ornata* (d), Deposited in K. Addam's Herbarium AUL (Lebanon).

*C. baalbekensis* flourish in the region of city of Baalbek, located between the peaks of the western chain of Mount Lebanon and the eastern chain of the Anti-Lebanon to the northeast. It was noteworthy that we did not find the existence of *C. aleppicus* in the northern city of Zahleh. *C. aleppicus* exists in the southern of Zahleh towards the west of Bekaa in massive presence whereby *C. hyemalis* grows at the slopes of the western chain of Mount Lebanon (Figure 13).

### *Crocus baalbekensis* is extremely fragrant especially in the evening (Fresia smell)

Corm is oblong conical about 18-26mmx14-20mm in diameter, tunic great build-up of old tunics 4-10 layers, coarse parallel fibers, unglued together, with cross-links and become thinner in the inner layers. The presence of the high number of the tunic layers explain the relationship between corm and the harsh environmental conditions and medium (very dry, low humidity because the annual rainfall rate is very low (150-450ml per year) in which the *C. baalbekensis* strives. They act like a protector for the corm from dryness by preventing the evaporation of water and liquids from it (Figure 15).

Leaves (present at flowering) 4-12, 50-110mmx0.8-1.2mm central nearly trapezoidal keel and 2 average length lateral arms with their margins recurved towards the keel, keel has a small notch in the middle and lamina is wider than the leaf keel but less than twice, each perianth tube is covered by two inner membranous white spathes that

reach the perianth throat (Figure 7). Perianth tube white = 1.2... 1.6 As long as perianth segments, outer perianth segment, 3, oblanceolate, 20–26mmx4.2–5.4mm, abaxial side is colored by yellow till one third of the tepal, mottled by dark blue–violet, three stripes (rarely one) with dark violates veins (sometimes mottled by pale yellow between the violet veins) starts from the base of the tepal and ends at its apex, all segment heads are blotched by dark blue–violet, adaxial side is white with deep yellow area that covers approximately one third of segment bottom, anther, 3, 7–10mmx1.2–1.8mm, wide, arrow shape, longitudinally striped in black and yellow, style (at perianth segments) 1, deep yellow to orange, 14–22mmx0.4–0.8mm (sometimes striped by thinner black lines), divided to 3 stigmas, equal or longer than the stamen. Stigma (each one) is branched to 3 - 6 short strands (Figures 2–7,15,16).



**Figure 15** Corm's Dissection of *C. aleppicus*, *C. baalbekensis* and *C. hyemalis*.

### *Crocus aleppicus*

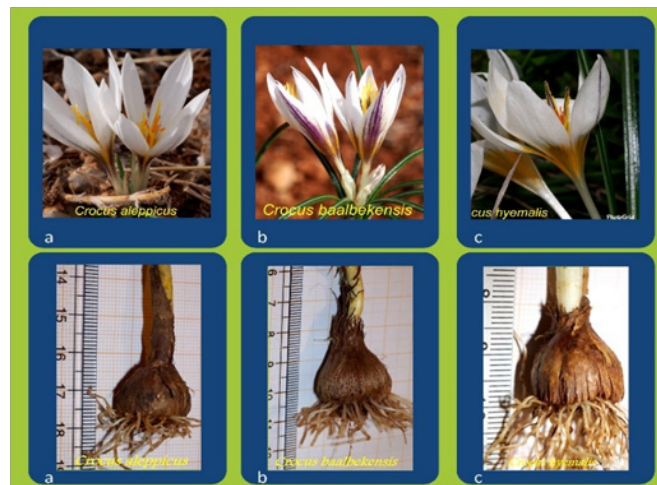
The shape of the corm is narrowly ovoid of 10mm in diameter, brown tunic fibers parallel only in the lower part, upper part membranous, striated with numerous parallel veins. The outer is more or less lacerated, especially at the base, and sometimes becoming almost entirely fibrous-reticulated, slightly prolonged along the scape. The layers of the tunic are maximum four layers and this explains the relationship between their number and the rate of annual rain fall which is high (600-700ml per year), flower small, tepal with apices obtuse or triangular but not acute, 5-7mm wide, white, more or less veined with dark blue, sometimes a little orange at the base, leaves 4 to 7, 0.5-1.5mm, filaments long enough for the genus with yellowish anthers, orange stigmas, style red or orange, anthers yellow (Figure 16).<sup>32,33</sup>

### *Crocus hyemalis*

It has an extreme scent of honey even on dull days. The shape of corm is ovoid 12.7mm-16.7mm, tunic of fine silky membrane, splitting up at the base about 1mm from base only to 1/3 of the tunic) into narrow fiber-like subdivisions, leaves 4-7, the keel one - third the width of the blade, the lateral channels without ridges, spathe 38.1mm the inner spathe ligulate, the outer tubular, exceeding the sheathing leaves, and reaching nearly to the throat, throat deep golden almost orange, which shows through the translucent petals to the outside. The tepals are long, broad, white, and veined with rich purple lines towards the base, anthers orange and black about twice the length of the orange filament, style orange, divided with up to 15 branches.

In *Crocus hyemalis* var. *foxii* Maw ex Boiss.

The anthers are black while in *Crocus hyemalis* var. *gaillardotii* Boiss. & Blanche style dividing at the level of the base of the white anthers and produce into pale orange capillary stigmata which scarcely reaches the level of the anthers.<sup>33</sup> All the aforementioned descriptive taxonomic facts disclose the immense differences of the corm, tunic, leaves, segments, anthers, and style between both crocuses and our new *C. baalbekensis* (Figure 16).



**Figure 16** Differences Between Tepals, Leaves and Corms of *C. aleppicus*(a), *C. baalbekensis* (b) and *C. hyemalis* (c).

### Recommendations

*Crocus baalbekensis* K. Addam & M. Bou Hamdan sp. nov

While most crocusologists lament the loss of habitat and species, only few actions are undertaken on the ground to obstruct the loss of crocus biodiversity. Therefore, a multitude of actions must be underscored and bolstered in order to helping reverse the trend politically, technically, and financially. Luckily, our new record is abundant in thousands and exists safely due to the following conditions:

- i. The presence of exceedingly difficult environmental conditions as it grows in regions such as high mountains and rocky places.
- ii. The place lies on remote mountain terrains that make the access difficult.
- iii. The precarious political conditions particularly reaching the Syrian borders where the war is in action.
- iv. The absence of ecotourism as well as sport and touristic activities.

### Measurements

- a. Funding to safeguard, research, and appropriately manage and monitor such areas.
- b. Sharing of plants, seeds, and pollen among crocus farmers and botanical gardens.
- c. Raising awareness by hosting educational and social events, news jacking, and distributing brochures. These awareness campaigns should be carried out for people in general and village men/women in specific to thwart fires that might occur because of the garbage thrown by people in these mountains.

- d. Highlighting the significance of implementing avid research about the new world records of this genus (crocus) in this rural area due to the fact that there might be an abundance of it.<sup>31–33</sup>

## Conclusion

A new world record *Crocus baalbekensis* K. Addam & M. Bou Hamdan sp. nov and its three forms *Crocus baalbekensis* f. *assiensis* K. Addam & M. Bou Hamdan f. nov, *Crocus baalbekensis* f. *bella* K. Addam & M. Bou Hamdan f. nov, *Crocus baalbekensis* f. *ornata* K. Addam & M. Bou-Hamdan f. nov joined the Lebanese flora and precisely the Iridaceae family. The validation for the existence of this new form was verified by illustrated morphologic description, more than 20 years of field work and three years of observation, phenology, a host of locations, the existence of numerous quantities of the new species. The voucher specimen (representative dried sample) of the plant was deposited in K. Addam's Herbarium in Arts, Sciences and Technology University in Lebanon and was collected and identified by Mr. M. Bou-Hamdan.

## Acknowledgments

The team would like to thank Dr. Mustafa Hamzah, the Chairman of the Board of Trustees at the Arts, Sciences and Technology University in Lebanon (AUL) and Dr. Adnan Hamzah, the President of AUL for their committed support of this research for a period lasting 15 years. We would also like to thank Dima Al Asadi, the AUL research member and Mrs. Souad Itani for her help in drawing the illustrations.

## Conflicts of interest

The authors declared there is no conflict of interest.

## References

- Christenhusz MJ, Byng JW. The number of known plants species in the world and its annual increase. *Phytotaxa*. 2016;261(3):201–217.
- Coşkun F, Selvi S, Satil F. Phylogenetic relationships of some Turkish *Crocus* (Iridaceae) taxa based on morphological and anatomical characters. *Turkish Journal of Botany*. 2010;34(3):171–178.
- Erol O, Kaya HB, Şik L, et al. The genus *Crocus*, series *Crocus* (Iridaceae) in Turkey and 2 East Aegean islands: a genetic approach. *Turkish Journal of Biology*. 2014;38(1):48–62.
- Coşkun F, Selvi S, Satil F. Phylogenetic relationships of some Turkish *Crocus* (Iridaceae) taxa based on morphological and anatomical characters. *Turkish Journal of Botany*. 2010;34(3):171–178.
- Tawney CH, Penzer NM. *The ocean of story*. London: Priv. print. for subscribers only by CJ Sawyer, Limited; 1924. 13 p.
- Kandemir N. Comparative leaf anatomy of some endemic *Crocus* L. taxa from Turkey. *Bangladesh Journal of Botany*. 2011;40(2):155–162.
- Wani ZA, Kumar A, Sultan P, et al. *Mortierella alpina* CS10E4, an oleaginous fungal endophyte of *Crocus sativus* L. enhances apocarotenoid biosynthesis and stress tolerance in the host plant. *Scientific reports*. 2017;7(1):8598.
- Wani ZA, Ahmad T, Nalli Y, et al. *Porostereum* sp., Associated with Saffron (*Crocus sativus* L.), is a Latent Pathogen Capable of Producing Phytotoxic Chlorinated Aromatic Compounds. *Curr Microbiol*. 2018;75(7):880.
- Candan F, Sik L, Kesercioglu T. Cytotaxonomical studies on some *Crocus* L. taxa in Turkey. *African Journal of Biotechnology*. 2009;8(18).
- K V Peter. *Genesis and Evolution of Horticultural Crops*. UK: Kruger Brent Publishers. Ltd; 2017.
- Alavi-Kia SS, Mohammadi SA, Aharizad S, et al. Analysis of genetic diversity and phylogenetic relationships in *Crocus* genus of Iran using inter-retrotransposon amplified polymorphism. *Biotechnology & Biotechnological Equipment*. 2008;22(3):795–800.
- Kandemir N. Morphology, anatomy and ecology of critically endangered endemic *Crocus pestalozzae* Boiss. (Iridaceae) in North-West Turkey. *Bangladesh Journal of Botany*. 2009;38(2):127–132.
- Petersen G, Seberg O, Thorsøe S, et al. A phylogeny of the genus *Crocus* (Iridaceae) based on sequence data from five plastid regions. *Taxon*. 2008;57(2):487–499.
- Karaismailoğlu MC, Şik L, Çiftçi A, et al. Seed structure of some taxa of the genus *Crocus* L. (Iridaceae) series *Crocus*. *Turkish Journal of Botany*. 2018;42(6):722–731.
- Raca IL, Ljubisavljević I, Jušković M, et al. Comparative anatomical study of the taxa from series *Verni Mathew* (*Crocus* L.) in Serbia. *Biologica Nyssana*. 2017;8(1).
- The country of crocuses.
- Yüzbaşıoğlu S, Aslan S, Özhatay N. *Crocus thracicus* (Iridaceae), a new species from north-western Turkey. *Phytotaxa*. 2015;197(3):207–214.
- Peter KV. *Genetic Resources and Crop Evolution (New edition) Volume I: Saffron Evolution*. UK: Kruger Brent; 2017:325–340. ISSN: 1573-5109.
- Yüzbaşıoğlu S. *Crocus tuna-ekimii* (Iridaceae), a new species from Turkey. *Phytotaxa*. 2017;314(1):110–116.
- Erol O, Can L, Şik L. *Crocus demirizianus* sp. nov. from northwestern Turkey. *Nordic Journal of Botany*. 2012;30(6):665–667.
- Addam K, Bou-Hamdan M, Alameh MY, et al. *Orchis Troodi* (Renz) P. Delforge, *Orchis Sitiaca* (Renz) P. Delforge and *Orchis Anatolica* Subsp. *Albiflora* Subsp. *Novo* K. Addam & M. Bou-Hamdan, three rare orchids joined the Lebanese Flora. *International Journal of Botany Studies*. 2017;2(6):221–228.
- Addam K, Al-Zein MS, Bou-Hamdan M, et al. A new record: *cyclamen persicum* mill. var. *autumnale* grey-wilson was added to the native Lebanese Flora. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*. 2016;26(4):186–194.
- Jaradi G, Khater C. Fourth National report of Lebanon to the convention on biological diversity. Beirut: United Nations Development Program (UNDP); 2009:10–19.
- Tohmé G, Tohmé H. *Illustrated Flora of Lebanon*. Beirut: CNRS Publication; 2014.
- Mouterde P. *New flora of Lebanon and Syria*. Beirut: Texte. Dar El-Machreq Sarl; 1983.
- Post GE. *Flora of Syria, Palestine, and Sinai*. Ripol Klassik; 1932:583–586.
- Addam K, Sabbagh N, Bou-Hamdan M, et al. Phytogeography, population, habitat, ecology, threat and conservation action of *Orchis anatolica* Boiss. in Lebanon. *International Journal of Applied Research*, 2018;4:34–46.
- <https://www.ancient.eu/Baalbek/>
- <http://www.localiban.org/rubrique536.html>
- Kerndorff HE, Pasche ER, Harpke DÖ. The genus *Crocus* (Liliiflorae, Iridaceae): life-cycle, morphology, phenotypic characteristics, and taxonomical relevant parameters. *Stapfia*. 2015;103:27–65.



31. Mathew B. The Crocus: a revision of the genus *Crocus* (Iridaceae). Timber Pr; 1983:220–222. ISBN: 0917304233.
32. Addam K, Sabbagh N. *Ophrys holoserica* (Burm. f.) Greuter subsp. *Shoufensis* subsp. novo K. Addam & M. Bou-Hamdan (ORCHIDACEAE), A new world record from Lebanon. *International Journal of Botany Studies*. 2018;3(6):25–32.
33. Addam K, Bou-Hamdan M, Ibrahim S, et al. *Ophrys Omegaifera* Subsp. *Gharifensis* (Orchidaceae), a new subspecies from Lebanon. *Journal of Botanical Research*. 2013;4(1):25–27.