



# *Galanthus bursanus* (Amaryllidaceae): a new species of snowdrop from the Marmara Sea region, NW Turkey

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**Summary.** *Galanthus bursanus* (Amaryllidaceae), a new snowdrop species endemic to the Marmara Sea region (Bursa Province, NW Turkey), is described and illustrated. Morphological differences between the new species and other possibly related *Galanthus* taxa (*G. plicatus* subsp. *byzantinus*, *G. xvalentinei* nothosubsp. *subplicatus*, and *G. reginae-olgae* subsp. *reginae-olgae*) are discussed. Photographs (habitat and morphology), a distribution map and a preliminary conservation assessment are provided.

**Key Words.** Calciphile, conservation, geophyte, hysternanthous, Turkish flora.

## Introduction

The Marmara Sea region in north-western Turkey (Asian and European parts) is an area of high diversity for *Galanthus*, with five indigenous taxa: *G. gracilis* Čelak., *G. plicatus* M.Bieb. subsp. *plicatus*, *G. plicatus* subsp. *byzantinus* (Baker) D.A.Webb, *G. trojanus* A.P.Davis & Özhatay and *G. xvalentinei* Beck nothosubsp. *subplicatus* (Zeybek) A.P.Davis (Zeybek & Sauer 1995; Davis 1999; Davis 2001; Davis *et al.* 2001; Davis & Özhatay 2001; Taşcı Margož *et al.* 2013). According to the work of Rønsted *et al.* (2013) these taxa belong to three different phylogenetic clades: *Trojanus* (*G. trojanus*), *Nivalis* (*G. plicatus* and *G. xvalentinei* nothosubsp. *subplicatus*) and *Elwesii* (*G. gracilis*). All five taxa are synanthous (the leaves well-developed at the flowering stage (anthesis)) and have a winter – spring flowering period (Dec. – April).

In Nov. 2014, we (Konca & Zubov, pers. obs.) discovered two small populations of *Galanthus* near the city of Bursa (Bursa Province) in the Marmara Sea region of NW Turkey, on the north-western spurs of Korucak Dağı ridge. The plants were either leafless at flowering or leaves less than 3 cm long, mostly hidden under tree leaf litter, and the flowers were highly fragrant. Vegetative clones (clumping plants) were numerous, with many flower stalks in each clump (5 – 24). Both populations were located at an elevation of 500 m, exclusively on rocky, limestone outcrops (but never on cliffs and rock walls), on red clay soil, in the semi-arid xerophytic dry oak forest phytocenosis of the Marmara Transitional region (Atalay *et al.* 2014), in which *Quercus cerris* L. (Turkey oak) acts as an

indicator species (Fig. 2A – C). By their general appearance and period of flowering, the *Galanthus* at these two localities resembled *G. reginae-olgae* subsp. *reginae-olgae*, due to the partial development of leaves at flowering time (hysternanthous) and narrow leaf blades dark green but with a distinct glaucous central stripe, but clearly differed due to the presence of specific vegetative and floral characteristics (see RECOGNITION). Further investigation of the two subpopulations at a single location on Korucak Dağı ridge showed that they possessed a combination of characters not found in any *Galanthus* from the Marmara Sea region, or indeed any other species in the genus. Given the distinct morphological characterisation, we hereby describe these plants as a new species of *Galanthus*: *G. bursanus*.

## Materials and Methods

Field studies for *Galanthus bursanus* were undertaken in Turkey in 2014, 2016 – 2018 (Zubov & Konca, pers. obs.), and seed grown living material in cultivation was examined by us between 2014 and 2018. Herbarium specimens of other *Galanthus* species were examined at the herbaria of K and KWHA (abbreviations after Holmgren *et al.* 1990). Measurements, colours, and other details are based on living material, spirit and herbarium specimens and data derived from field notes. Morphological and anatomical examinations were made using a stereo microscope Stemi 2000 - C and inverted microscope AxioObserver A1 equipped

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with digital camera AxioCamERc 5s and ZEN 2012 software (Carl Zeiss, Germany). Morphological terminology follows Beentje (2010). Distribution maps were plotted using specimens and recorded coordinates, verified using Google Earth Pro (©2017 Google). The distribution map (Map 1) was produced using SimpleMappr (Shorthouse 2010). The preliminary conservation status of *G. bursanus* was informally assessed following the criteria and categories of IUCN's Red List Categories and Criteria (IUCN 2017).

**Method for estimating AOO.** Area of occupancy was calculated directly at the reference scale of 4 km<sup>2</sup> (2 × 2 km) grid cells by counting the number of occupied cells in a uniform grid that covers the entire range of a considered taxon, and then tallying the total area of all occupied cells: AOO = no. occupied cells × area of an individual cell (IUCN 2017). For *Galanthus bursanus* AOO = 2 × 4 = 8 km<sup>2</sup>.

***Galanthus bursanus* Zubov, Konca & A.P.Davis sp. nov.**  
Type: Turkey, Bursa Province, Marmara Sea region, limestone rocky outcrops near Bursa, c. 500 m, fl., 26 Nov. 2016, Zubov & Konca s.n. (holotype KWH!).

<http://www.ipni.org/urn:lsid:ipni.org:names:60478400-2>

**Bulb** narrowly ovoid to ovoid, 2.2 – 3.5 (– 4.5) × (1.1 –) 1.4 – 2 (– 2.5) cm, bulb scales whitish, bulb fully covered with a light brown to straw brown papery tunic; adventitious roots whitish. **Basal sheath** ± tubular, tubular-conical, circular or oval in cross section, (1.2 –) 3.1 – 6 × 0.3 – 0.7 cm, noticeably veined, slightly inflated, whitish

to greenish (especially the upper part). **Leaves** hysteranthous, applanate (more precisely applanate-narrowly explicate) in vernation, at flowering time (anthesis) either absent or 1.8 – 3.1 cm long, developing in length and width after flowering; leaf blades narrowly linear to linear (strap-shaped), indistinctly canaliculate at early stage, slightly twisted, at maturity (10 –) 21 – 32 × (0.4 –) 0.6 – 0.9 (– 1.4) cm, bearing 2 noticeable longitudinal folds, each 1 – 2 mm from (and parallel to) the margin (leaf margin narrowly explicative), the folds diminishing terminally and then the margin subrevolute to flat; abaxial surface with a prominent keel, dark green base-colour, with glaucous (wax) covering on both surfaces (grey to bluish grey), matt, with greener margins adaxially (i.e. dark green with a broad central glaucous stripe); apex obtuse, flat, with a small white point at tip. **Scape** 2, rarely 1 or 3, (7 –) 10 – 18 (– 25) cm long, 1.7 – 3 mm in diam., light green, dark green in upper part, glaucous. **Pedice**l 1.2 – 4.2 cm long, 1 – 2 mm in diam., light green. **Spathe** papery, slightly arcuate, with 2 thick ribs (up to 1.5 mm in diam.) on margins, 22 – 45 × 4 – 7 mm, ± equal in length to the pedicel at flowering, dark green, glaucous. **Flowers** narrowly ovoid to pyriform when closed (i.e. in outline shape), strongly fragrant; perianth segments 6, separated, in two whorls; outer perianth segments 3, narrowly obovate to obovate, indistinctly ribbed, 26 – 34 × 9 – 13 mm, white, base unguiculate, claw 3 – 7 × 2 – 4 mm; apex acute, slightly cucullate; inner perianth segments 3, ± ½ the size of the outer perianth segments, broadly to narrowly obovoid to obtriangular, white, each segment with an apical sinus (notch) and two green marks, one apical and one basal, or one entire abaxial bold X-shaped mark; on the abaxial surface, the apical mark A-



**Map 1.** Distribution of *Galanthus bursanus* based on collection localities.

shaped, often narrower above the sinus, mostly looking like two fused (rarely non fused) commas; the margins near sinus curled upwards (flared); the basal mark mostly trapezoidal and indistinctly notched in upper and lower areas, rarely obovoid or like two fused narrowly obovoid or oblong strips, bold near the base, or separated from the receptacle by a 2–3 mm white gap and covering up to slightly more than half of the segment, 9–15 × 5–9 mm; adaxial surface with 3–4 coaxial green lines, forming blurred apical and basal marks, and interspaced with a central white groove and 3–4 white coaxial grooves at the margins; stamens 6, in two whorls; anthers basifixed, ± sagittate, orange, connective c. 2.5 × 0.6 mm, anther sacs 4 per anther, c. 6 mm long and c. 1.2 mm in diam., latrorse in the middle part and introrse to the apex; anther apex sharply acute with multiple villi; filaments c. 2 mm long, white; pollen orange, microsporangia ± oval, with lipid drops in exine, c. 35 × 25 µm. *Gynoeceium* (ovary and receptacle) syncarpous, tricarpellate; ovary superior, globose, or ellipsoid to narrowly ellipsoid, indistinctly triangular in cross section, bright green, 4–12 mm long, 3–8 mm in diam.; placentation axile, ovules 12–18 per locule; pistil filiform, style 7–10 mm long and 0.3 mm in diam., greenish, with numerous villi (c. 0.4 mm long) in the upper ½–⅓; stigma capitate, trilobed, c. 0.3 mm in diam. *Fruit* (capsule) at maturity indistinctly triangular in cross section, globose to ellipsoid, or narrowly ellipsoid, at maturity 0.9–1.7 (–2.3) × 0.6–1.5 cm, bright to light green; seeds ± orbicular to ovoid, 3–4.5 × 2–3 mm, with shiny light to dark brown reticulate seed coat and ± developed whitish elaiosome (myrmecochory), 1–3.5 mm long. Figs 1, 2 and 3.

**RECOGNITION.** Possibly related to *Galanthus plicatus* subsp. *byzantinus* and *G. xvalentinei* nothosubsp. *subplicatus* but differs by having hysteranthous leaves (vs synanthous in *G. plicatus* subsp. *byzantinus* and *G. xvalentinei* nothosubsp. *subplicatus*); and Oct. – Jan. flowering period (vs Dec. – April). Related possibly to *G. reginae-olgae* subsp. *reginae-olgae* but differs by the inner perianth segment carrying an apical and a basal mark, which infrequently merge into a single, bold, X-shaped mark (vs inner perianth segment only has one apical mark in *G. reginae-olgae* subsp. *reginae-olgae*). (see NOTES).

**DISTRIBUTION.** Asia Minor: Turkey, Marmara Transitional region (north-western spurs of Korucak Dağı ridge); a narrow local endemic of the Marmara Sea region. Map 1.

**SPECIMENS EXAMINED. TURKEY.** Bursa Province, Marmara Sea region, limestone rocky outcrops near Bursa, c. 500 m, fl., 26 Nov. 2016, Zubov & Konca (holotype KWH!); *ibid.*, cult. (specimens grown from seeds in UK), fl., 6 Oct. 2017, Zubov & Konca s.n. (K!). The exact localities of *Galanthus bursanus* have not been documented here for fear of unlawful plant collecting.

**HABITAT.** Described from *Quercus cerris* forest at c. 500 m elevation; growing in red clay soils on limestone

rocky outcrops around the city of Bursa. Mesophyte, calciphile. Phytocenosis indicators observed in the understory included the woody species *Q. coccifera* L., *Crataegus monogyna* Jacq., *Acer monspessulanum* L., *Phillyrea latifolia* L. and *Ruscus aculeatus* L.; and the herbaceous species *Paeonia peregrina* Mill., *Fritillaria pontica* Wahlenb., and *Helleborus orientalis* Lam.

**CONSERVATION STATUS.** *Galanthus bursanus* is endemic to northwestern Turkey, and is restricted to the Bursa Province. Its area of occupancy (AOO) is provisionally estimated to be less than 10 km<sup>2</sup>, and there are two known severely fragmented subpopulations. The habitat could decline rapidly due to deforestation and agricultural conversion of suitable habitat to crop land, although the rocky limestone outcrops where this species occurs offer some protection; marble mining occurs in the area and would influence subpopulations in sites corresponding to this species habitat; there is also the threat of small-scale collection of bulbs by illegal collectors, and this could cause a slow, long-term decline. This species is also deemed to be climate change sensitive. Due to the limited AOO, severely fragmented subpopulations and the range of threats, this species is assessed as Critically Endangered (CR) under IUCN Red List Categories and Criteria (IUCN 2017). CR B2ab(ii,iii): B2 – Geographic coverage in the form of AOO estimated to be less than 10 km<sup>2</sup> threshold (AOO for *G. bursanus* is estimated to be 8 km<sup>2</sup>) and – a. Severely fragmented or known to exist at only a single location (*G. bursanus* is known from only two severely fragmented subpopulations (based on two geolocated data points) at a single location); and – b. Continued decline observed (Map 1).

**PHENOLOGY.** Flowering: Oct. – Jan. (Feb.) in the wild; late Sept. – Dec. in cultivation; fruiting (wild and cultivated): April. In February, plants observed *in situ* were in the early fruiting stage and with considerably developed fruit, although about one-sixth of the population was at the very end of flowering. The northern spurs of Korucak Dağı normally have significant snow cover from Dec. to early Feb.

**ETYMOLOGY.** Named after the Marmara Sea region Turkish Province – Bursa.

**NOTES.** Three *Galanthus* taxa from the *Nivalis* clade (Rønsted *et al.* 2013) have morphological affinities with *G. bursanus*: the broadly sympatric *G. plicatus* subsp. *byzantinus* (Davis 1999; Davis 2001) and *G. xvalentinei* Beck nothosubsp. *subplicatus* (Davis *et al.* 2001; Taşcı Margoz *et al.* 2013); and allopatric *G. reginae-olgae* subsp. *reginae-olgae* (Davis 1999; Davis 2001).

*Galanthus plicatus* subsp. *byzantinus* is broadly sympatric with *G. bursanus* (e.g. in Bursa and neighboring Yalova Provinces) and both taxa have an apical and basal, or sometimes large, bold, X-shaped mark on each inner perianth segment (Fig. 2D). However, unlike *G. bursanus*, *G. plicatus* subsp. *byzantinus* (and *G. plicatus* subsp. *plicatus*) are winter flowering, with



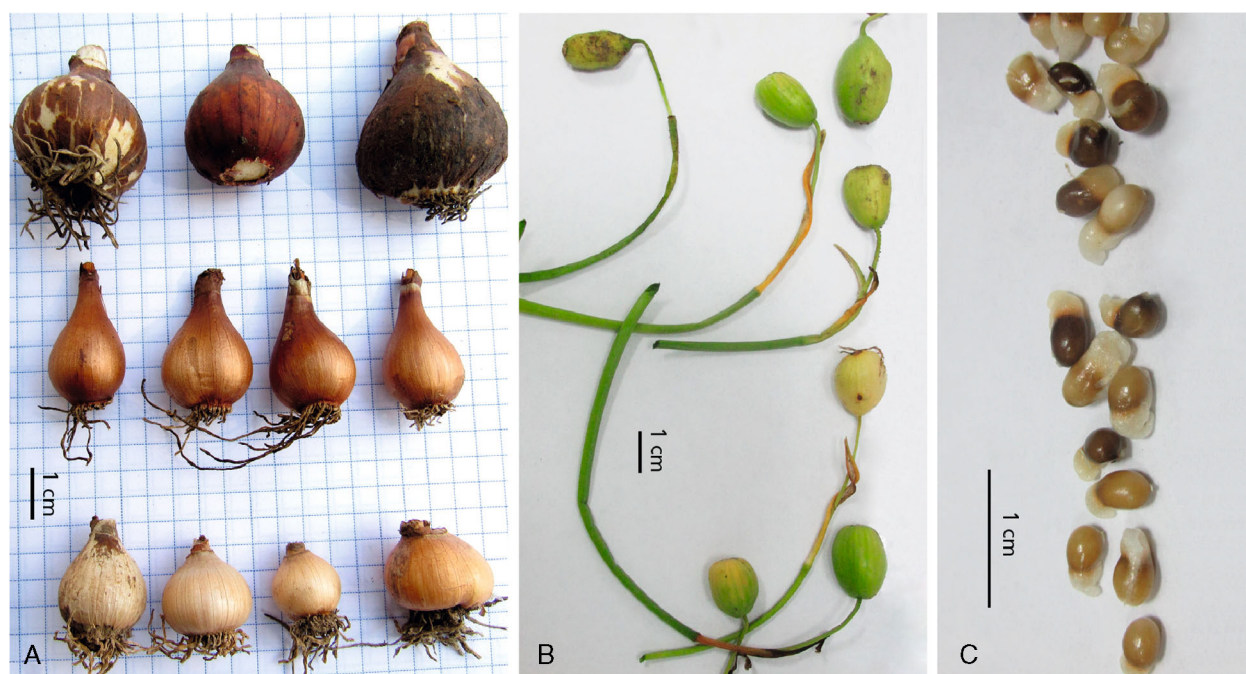
**Fig. 1.** *Galanthus bursanus*. A habit; B leaf (adaxial view (left) and adaxial view (right)), as cut from basal sheath; C flower with segments removed; D flower with segments removed in L.S.; E outer perianth segment (abaxial view (left) and adaxial view (right)); F inner perianth segment (abaxial view (left) and adaxial view (right)); G inner perianth segment (abaxial view), showing X-shaped marked variant; H anthers, showing side, abaxial and adaxial views (from lower to upper); J fruit (capsule) (including ovary); K seed. Scale bar: A = 2 cm; B, C = 7 mm; D – G = 8 mm; H = 4 mm; J, K = 1 cm. All from Zubov & Konca s.n. DRAWN BY LUCY T. SMITH.





**Fig. 2.** Images of *Galanthus bursanus* in situ. A habitat, at red soil pockets developed in limestone outcrops under *Quercus cerris* forest; B, C habitat at *locus classicus*; D flowers; E leaves at fruiting stage. All photos taken at the *locus classicus* (A, B 26 Nov. 2016; C, D 25 Nov. 2018; E 11 Feb. 2017). PHOTOS: A, C – E D. ZUBOV AND B Y. KONCA.





**Fig. 3.** Morphological features of *Galanthus bursanus*. **A** dormant bulbs (seed grown) — top row *G. plicatus* subsp. *plicatus* (Chatyrdag, Crimea, Ukraine), middle row *G. bursanus*, *ex locus classicus*, bottom row *G. plicatus* subsp. *byzantinus* (Polonezköy Ormani forest, Istanbul (Asian part), Turkey); **B** mature seed pods of *G. bursanus*; **C** mature seeds of *G. bursanus*. PHOTOS: D. ZUBOV.

flowers from Feb. – April (Davis 1999; Davis 2001), or sometimes earlier (Dec. or Jan.); have leaves that are well developed at flowering (synanthous), and leaf blades lanceolate to broadly lanceolate, with a prominent longitudinal fold 2 – 7 mm from each margin (explicative [‘plicate’] vernation). *Galanthus bursanus* is autumn to early winter flowering, with flowers from Oct. – Jan.; has leaves that are either absent or poorly developed at flowering (hysteranthous), and leaf blades narrowly linear to linear, with a rather sharp longitudinal fold 1 – 2 mm from each margin (applanate, or more precisely applanate-subrevolute, weakly explicative) (Fig. 2E). Distinctly synanthous (flowering) representatives of *G. plicatus* subsp. *byzantinus* were discovered by us (Zubov & Konca, pers. obs.) in Feb. 2017, in the river canyon to the north-east of Bursa (southern spurs of Katırlı Dağları ridge). In this locality these populations were found in small *Pinus brutia* Ten. woodlands, the plants growing in small numbers on a limestone scree (in brown forest soil) and on a flat, north-west facing cliff along the bottom of the narrow canyon. In the neighboring Yalova Province (visited by us in Nov. 2018, Zubov & Konca, pers. obs.) synanthous *G. plicatus* subsp. *byzantinus* is exclusively confined to the *Fagus orientalis* Lipsky forests at c. 600 m, within the northern spurs of Samanlı Dağları ridge and flower there early Dec. – Feb. All of the plants in these populations possessed leaves typical of the species.

*Galanthus* *×valentinei* nothosubsp. *subplicatus* is a hybrid taxon believed to be the result of introgression

between *G. nivalis* L. and *G. plicatus* subsp. *byzantinus* (Davis *et al.* 2001; Rønsted *et al.* 2013). This taxon is not narrowly sympatric with *G. bursanus* but it does occur in the Marmara Sea region, including the part of Turkey in Istanbul (in Europe), Kırkareli and Edirne Provinces and it shares some characteristics with the new species. Like *G. bursanus*, *G. ×valentinei* nothosubsp. *subplicatus* has linear leaf blades, and the leaves can be weakly explicative (on the same leaf, same plant, or plants may differ; some leaves with flat-subrevolute margins), and although there is usually only one mark on each inner perianth segment it may sometimes have one or two small, faint marks at the base of the segment (*i.e.* approaching a basal mark) (Davis *et al.* 2001). *Galanthus* *×valentinei* nothosubsp. *subplicatus* differs further from *G. bursanus* by its flowering period (Jan. – March vs Oct. to Jan.), synanthous leaves (vs hysteranthous) and by leaf colour, which is glaucescent (green with a slight glaucous bloom) to almost glaucous on the adaxial surface and green-glaucous to glaucescent on the abaxial surface (Davis *et al.* 2001) (vs dark green with a central, broad glaucous stripe (Fig. 2E)).

The leaf folding in *Galanthus bursanus*, which is applanate-narrowly explicative in vernation (*i.e.* the position of the leaves in bud, as viewed in transverse section (T.S.), with narrowly explicative leaf margins (folded sharply towards the abaxial surface) at maturity, is similar, although more pronounced than the hybrid *G. ×valentinei* nothosubsp. *subplicatus*. Morphological investigations suggest that the parentage of *G. ×valentinei* nothosubsp. *subplicatus* involves

*G. plicatus* subsp. *byzantinus* and *G. nivalis* (Davis *et al.* 2001). Molecular data (Rønsted *et al.* 2013; Taşcı Margoş *et al.* 2013) support the assumption of hybrid origin for *G. xvalentinei* nothosubsp. *subplicatus* (Davis *et al.* 2001), although the exact parentage is not yet known; the most detailed molecular study so far (Rønsted *et al.* 2013) infers introgression between *G. plicatus* s.l. and a member of the *Nivalis* clade. On this basis, it is possible that *G. bursanus* could be a species of hybrid origin, most likely involving *G. plicatus* subsp. *byzantinus*. Molecular data would be required to elucidate a possible hybrid origin.

The leaves of both *Galanthus reginae-olgae* subsp. *reginae-olgae* and *G. bursanus* are hysteroanthous, i.e. they are either absent or only partially developed (e.g. only a few cms long) at flowering time (anthesis), and both taxa flower in the autumn (Sept. – Dec. for the former, and Oct. – Jan. for the latter). The other subspecies of *Galanthus reginae-olgae* subsp. *vernalis*, has synanthous leaves, i.e. fully developed, or more less so, at flowering time, and flowers in the spring (Jan. – March) (Davis 1999, 2001). The leaf blades of *G. reginae-olgae* subsp. *reginae-olgae* (and subsp. *vernalis*) are narrow (narrowly linear to linear (strap-shaped)), and dark green with a glaucous covering (mostly confined to the centre of the leaf and thus often described as a central stripe). Despite sharing characters, there are clear differences between these taxa: the leaves of *G. reginae-olgae* are never longitudinally folded (see below) but are flat (not

folded) with either flat or subrevolute margins, and each inner perianth segment only has one apical mark. In *G. bursanus* the leaf blades have longitudinal folds either side of the midrib and each inner perianth segment carries an apical and a basal mark, which infrequently merge into a single, bold, X-shaped mark (Fig. 2D, E). The present-day distributions of *G. bursanus* and *G. reginae-olgae* are separated by a considerable distance, the latter occurring in southern Italy, Sicily, western and southern Greece, Albania and possibly Montenegro (Davis 1999, 2001).

Sympatric *Galanthus gracilis* intersects mosaically with *G. bursanus* on the northern spurs of Korucak Dağı, and this region also inhabits the southeastern shore of Ulubat Gölü lake. The valley of the Nilüfer Çayı river (which flows latitudinally, enters Susurluk Çayı river and descends to the Marmara Sea) can be considered to form a natural watershed between the populations of *G. plicatus* subsp. *byzantinus* in the north and the populations of *G. gracilis* and *G. bursanus* in the south. *Galanthus gracilis* does not share obvious morphological affinities with *G. bursanus*.

The recently described *Galanthus samothracicus* Kit Tan & Biel (Biel & Tan 2013; Tan *et al.* 2014) from the island of Samothraki (N Aegean, NE Greece) does not have any conspicuous morphological affinities with allopatric *G. bursanus*, having synanthous leaves, dull green leaves, with flat-subrevolute margins and a single green, apical mark on each inner perianth segment.

### Key to the identification of *G. bursanus*, *G. plicatus*, *G. reginae-olgae* and *G. xvalentinei* nothosubsp. *subplicatus*

1. Leaves absent or < 3 cm long at flowering time (hysteroanthous); flowering Sept. – Jan. . . . . 2
1. Leaves present and well developed at flowering time (synanthous); flowering Dec. – March . . . . . 3
2. Leaf blade margins each with 2 sharp longitudinal folds 1 – 2 mm from the leaf margin (margins narrowly explicative-subrevolute); each inner perianth segment with two distinct green marks, one at the apex and one at the base, or one large, more or less X-shaped green mark; flowering Oct. – Jan.; NW Turkey . . . . . ***G. bursanus***
2. Leaf blades margin flat to subrevolute; each inner perianth segment with a single, green apical mark; flowering Sept. – Dec.; Italy, Sicily, Greece, and possibly Albania . . . . . ***G. reginae-olgae* subsp. *reginae-olgae***
3. Leaf blade margin distinctly folded longitudinally (explicative). . . . . 4
3. Leaf blade margin flat to subrevolute, or narrowly explicative-subrevolute. . . . . 5
4. Inner perianth segments with one green mark at the apex. . . . . ***G. plicatus* subsp. *plicatus***
4. Inner perianth segments with one green mark at the apex and one distinct green mark at the base . . . . . ***G. plicatus* subsp. *byzantinus***
5. Leaf margins flat to subrevolute; inner perianth segments with one green mark at the apex. . . . . ***G. reginae-olgae* subsp. *vernalis***
5. Leaf margins weakly to conspicuously explicative-subrevolute; inner perianth segments with one green mark at the apex and often one sometimes with two faint marks at the base . . . . . ***G. xvalentinei* nothosubsp. *subplicatus***

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