Taxonomic revision of *Ornithogalum* subgen. *Cathissa* (Salisb.) Baker (Hyacinthaceae)

by

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Abstract


As a part of a taxonomic revision of the Iberian taxa of *Ornithogalum*, results corresponding to *O*. subgen. *Cathissa* are reported. Quantitative and qualitative characters are studied in detail, and they are evaluated for the taxonomic value of morphological characters of the three considered taxa: *O. concinnum*, *O. broteroi*, and *O. reverchonii*. A complete description is presented for all accepted species, and data on their biology, habitat, and distribution are also included. Moreover, a key is provided to facilitate identification.

Keywords: *Ornithogalum concinnum*, *O. broteroi*, *O. reverchonii*, *Cathissa*, taxonomy, distribution, habitat, western Mediterranean.

Introduction

*Ornithogalum* L. comprises about 120-130 species (Landstrom, 1989), or even 200 according to Obermeyer (1978). However, Müller-Doblies & Müller-Doblies (1996) recognized 123 species only for southern Africa, forty of which were described as new taxa. Therefore, the total number of species in the world could be higher than 200. The genus has a wide distribution, including Europe, Asia (reaching Afghanistan to the East), Africa (excepting the Tropic of Cancer band) and Madagascar (Zahariadi, 1965).

On the basis of floral and reproductive characters, 17 subgenera have been recognized (cf. Baker, 1873; Zahariadi, 1965, 1980; Obermeyer, 1978), many of them based on previously described genera (cf. Gray, 1821; Rafinesque, 1837; Parlatore, 1854; Salisbury, 1866). Among them, *O*. subgen. *Cathissa* includes plants with long and narrow, racemose or spiciform inflorescence; white concolour tepals –without maculae or green bands along its central nerve–, disposed in two whorls of similar morphology; stamens with filament from linear-lanceolate to tapering upwards, without abrupt expansions; ovary fusiform, with style slightly swollen and trigonous capitate stigma, which is well differenced from the style, bearing three decurrent lobes covered with long glands; seeds polygonal, with verruculose or smooth testa, and in the latter case usually formed by sinouse ridge cells, giving a puzzle-like appearance. In this subgenus three species are commonly included –*O. reverchonii* Lange ex Willk., *O. concinnum* Salisb. and *O. broteroi* M. Lainz–, whose distribution is restricted to the Iberian Peninsula (mainly in the western part) and northern Morocco.
Brief history of O. subgen. Cathissa (Salisb.) Baker

Salisbury (1866) reorganized the species previously placed in *Ornithogalum* L. in 13 different genera. One of them, *Cathissa* (Salisb.) Baker, included *Scilla unifolia* L. –basonym of the current *O. broteroi* – and *O. concinnum*, being the only two representatives of this group known by that time.

Later, Baker (1873) considered *Cathissa* as a subgenus of *Ornithogalum*, in which he included 10 species from different origins and with diverse morphological characters. On the one hand, *O. concinnum* Salisb. was regarded as a mere variety in *O. unifolium* (L.) Link (currently *O. broteroi*). That variety had *O. roccense* Link –species described from Cabo da Roca, Portugal (Link, 1799)– as a synonym. On the other hand, Baker extended *O. subgen. Cathissa* to include eight species from the Cape area (South Africa) –today referred to *O. subgen. Aspasia* Oberm. (cf. Obermeyer, 1978)–, and a Caucasian species –currently placed in *O. subgen. Eustachys* (Salisb.) Zahar. (cf. Zahariadi, 1980)–. The infrageneric arrangement of Baker (1873) has been widely accepted by most of authors and European monographs of the XXth century.

In the Iberian Peninsula and after Baker’s proposal, two new taxa related to *O. subgen. Cathissa* were described. First, Rouy (1890) published *O. subcuculla-tum* Rouy & Coincy, which was illustrated by Coincy (1893), and was later considered as a mere synonym of *O. concinnum* (cf. Zahariadi, 1980). Secondly, Willkomm (1891) described *O. reverchonii* from Ronda (Málaga), and attributed its authority to J. Lange. Furthermore, this author pointed out that the new species seemed to be related to taxa of *O. subgen. Cathissa*. *Beryllis*, when considering characters of the inflorescence. However, Maire (1958) transferred *O. reverchonii* to *O. subgen. Cathissa* on the basis of floral features, an opinion accepted by Wittmann (1983), who also apportioned biogeographic data justifying that solution. On the contrary, Zahariadi (1980) placed *O. reverchonii* in *O. subgen. Beryllis*, giving priority to morphology of the inflorescence, but making an explicit reference to the controversy about its taxonomic position. Similarly, Moret & al. (1990) accepted Zahariadi’s option, since ornamentation of seed tests of this species shows clear connections with other taxa in the latter subgenus. As a result of this, the position of *O. reverchonii* still remained uncertain.

Pfosser & Speta (1999) and Speta (2001) revived *Cathissa* following the initial concept of Salisbury (1866), after molecular, morphological and chemotaxonomic data. These authors included four species in that genus: *C. concinna* Salisb., *C. reverchonii* (Lange) Speta, *C. roccensis* (Link) Speta and *C. broteroi* (M. Laínz) Speta. Recently, Manning & al. (2004) presented a very synthetic treatment for the sub-Saharan species based on phylogenetic molecular studies. These authors extended considerably the circumscription of *Ornithogalum*, in which they proposed including most of genera described by Salisbury (l.c.) in “Ornithogaleae”, plus *Albuca* L., *Dipcadi* L., *Galtonia* Decne., *Neopatersonia* Schönland and *Pseudogaltonia* Kuntze.

In the present paper, we follow provisionally Baker’s (1873) arrangement, as it is the option fitting better the naturalness of every morphological group. Furthermore, this treatment has been widely followed in most of the Iberian floras. However, our preliminary phylogenetic results on *Ornithogalum* (sensu lato), based on sequencing of plastid (trnL-F and rbcL) and nuclears (ITS) regions, in addition to morphological and anatomical studies, point out to the monophyly of *O. subgen. Cathissa* as a sister group of a clade formed by *O. subgen. Beryllis* plus *O. subgen. Ornithogalum*. Thus, considering *Cathissa* as an independent genus would be perhaps a good future choice, following the initial proposal of Salisbury (1866), and recently corroborated by Speta (2001).

Material and methods

Morphological studies have been usually undertaken on living material from natural populations, and within the few hours after collection. However, they were complemented with data from dried material conserved at the herbaria ABH, BIO, GDA, K, LISU, MA, MACB, OVI, P, RAB, SALA, SANT, SEV, and VAL (Holmgren & al., 1990; Holmgren & Holmgren, 1993).

As some of the herbarium materials are not complete, several morphological characters were not measured. Fragments on vouchers commonly proved to be lower in some cases. Measurements of the bulb. Both measurements were shown in milimetres.

Length and diameter of the bulb: Length was considered as the vertical distance from bulb base to its apex. Diameter was expressed as the maximum width of the bulb. Both measurements were shown in millimetres.

Leaf length and width: Maximum length and width of leaves were measured in each specimen, and expressed in centimetres.
Total number of leaves: Recounts of the total number of basal sheaths were carried out in each specimen. Fragmented or dried leaves were also included in the counts.

Stem length: It corresponded to the length in millimetres from the apex of the bulb up to the first flower (base of the inflorescence).

Inflorescence length and width: The distance from the point where the lowermost floral pedicel starts to the apex of the completely developed inflorescence was considered as the inflorescence length, whilst the maximum horizontal distance between the apexes of the longest pedicels (without considering tepals) was regarded as its width. Both measurements were expressed in millimetres.

Height of the plant: It corresponded to the total length in centimetres of the stem and the inflorescence.

Number of flowers: The total number of flowers was counted, including those at the tip of the immature inflorescence or prior to the anthesis.

Floral pedicels length: Three kind of flowers were distinguished in each inflorescence: lowermost, middle and uppermost. The middle flower was that whose pedicel is on the nearest point to the middle of the inflorescence. Measurements were expressed in millimetres.

Floral and fruiting pedicels insertion angle: Average angles of insertion of the pedicels on the inflorescence axis were measured and expressed in degrees. Floral and fruiting pedicels were annotated separately.

Bract maximum length and width: After identification of the biggest bract of the inflorescence (usually the lowermost), its maximum length and width were measured. Both results were expressed in millimetres.

Flower diameter: Length between the apexes of two opposite tepals was measured, and expressed in millimetres. Only the biggest flower of the inflorescence was considered.

Tepal length and width: Both characters were measured on the biggest flower of the inflorescence, differentiating between outer and inner tepals. All measurements were expressed in millimetres.

Length and width of stamen filaments and ovary at the anthesis: Maximum length and width of stamen filaments and ovary of the biggest flower were measured and expressed in millimetres.

Length of the style and morphology of the stigma: Style length was annotated in millimetres. The aspect of the stigma was described according to its morphology and glandulosity. In all cases, the biggest flower was selected for measuring.

Capsule length and width: Maximum length and width of the biggest capsule were measured and expressed in millimetres.

Number of seeds per capsule: Seeds were counted in 4 to 40 randomly selected capsules from different individuals and/or populations. In some cases, individuals collected in the wild were transferred into pots until capsules ripened. Then, they were cut off and isolated until they opened spontaneously.

Seed length and width: Maximum length and width of seed were measured and expressed in millimetres. Measurements were made on 40 seeds per population, repeating it in different populations when possible. A binocular Leyca® MZ6, with incorporated micrometer was used.

Seed weight: Each seed measured was also weighted with an analytical balance HM-202 (AND®). Results were expressed in milligrams.

**Scanning Electron Microscope (SEM)**

Images of seeds were taken with a SEM JEOL 840. As the material was dried, no special treatment was required prior to observation. Samples were directly glued on metallic stubs. Afterwards, samples were coated with about 30 nm gold. Seed testa classification follows Moret & al. (1990).

**Scanning of fresh plants**

After the morphological study of specimens collected in the wild, scanings were carried out of every living plant and their different vegetative and floral structures. For this purpose, an Epson Perfection 1250 scanner was used. General figures of each species were composed with those images.

**Statistic analyses**

Every morphologic characters studied are accompanied by the rank of the maximum and minimum values. Those data were measured in different specimens from several populations, in order to achieve the maximum morphological variation of each taxon. For *O. broteroi*, 32 specimens from 4 populations were studied; for *O. concinnum*, 36 plants from 3 populations; and for *O. reverchonii*, 13 specimens from 1 population (Table 1).

With regard to the morphologic variables, two Principal Component Analyses (PCA) were conducted. In the first analysis, all morphological characters have been considered for the three species in the subgenus. The number of samples per character varied depending on the availability of fresh material (*O. broteroi*: n = 32; *O. concinnum*: n = 36; *O. reverchonii*: n = 13). In the second analysis, only characters connected to seed (length, width and weight) were included, due to their paramount importance to segre-
gate taxa in that group (see also Martínez-Azorín & al., 2006). In the second analysis, data came from 40 seeds per taxon, mostly from the same populations as in the previous analysis. In both cases, the software SPSS v. 10 was used.

Analysis of characters

Bulb

Bulb size is different in the three considered taxa. *O. reverchonii* presents the biggest one, whilst the smallest corresponds to *O. broteroi*. As regards to *O. concinnum*, it shows intermediate values, much overlapping with *O. broteroi* (Table 2).

Leaves

Number and morphology of leaves show notable differences among the considered species, being therefore important features to separate them. *O. broteroi* presents only one leaf per stem, which is broadly sheathing at the base, and ends in a long cylindrical appendix, almost as long as the blade, which withers soon. The rest of the species have more than one leaf per flowering stem. Those leaves are linear to linear-lanceolate or tapering, lack any cylindrical appendix, and usually wither only at the tips. Furthermore, maximum length and width of leaves are also useful for taxonomy (Table 3).

Plant height and inflorescence

In *O.* subgen. *Cathissa*, height of plants usually can help to discriminate between *O. reverchonii* and both *O. broteroi* and *O. concinnum*. The former species includes the highest individuals in the subgenus, (26)40-70(80) cm, whilst both latter others the smallest. Individuals of *O. broteroi* are similar in height to those of *O. concinnum*, though commonly they are slightly smaller. *O. concinnum* is very variable in size and can overlap some specimens of *O. broteroi* or even *O. reverchonii*.

Similarly, inflorescence length is a diagnostic character for identification of the species in the subgenus. In *O. broteroi*, they are spiciform and usually short and thin, with subsessile or briefly pedicellate flowers (pedicel: 0.1-5 mm long). Inflorescences of *O. concinnum* show a similar appearance, but they are usually bigger, many-flowered, and the floral pedicels are slightly longer (1-8 mm). On the contrary, inflorescences of *O. reverchonii* are racemose, being the longest in the group and having long pedicellate flowers (pedicel: 6-25 mm long). Insertion angle of floral pedicels on the inflorescence axis allows easy differentiation of both *O. concinnum* and *O. broteroi* from *O. reverchonii* (Table 4). However, fruiting pedicels are always appressed to the inflorescence axis in all three taxa. The different pattern of inflorescences led some authors (Willkomm, 1891; Zahariadi, 1980; Wittmann, 1985) to place *O. reverchonii* in *O.* subgen. *Beryllis*.

Perianth

Tepal size allows easy separation of *O. reverchonii* from the rest of species (*O. concinnum* and *O. broteroi*) (Table 5). In all cases, *O. reverchonii* shows the highest length and width values, being the diameter of the flower around 35-40 mm. Contrarily,
O. broteroi and O. concinnum produce smaller tepals, which are very similar in size. As a result, flower diameter is similar in both taxa, and reaches around 25-30 mm. For that reason, differentiation between O. concinnum and O. broteroi is usually difficult regarding only to floral characters.

**Androecium**

Stamen filaments of both whorls show valuable characters to identify the three taxa, though not in an absolute way. In O. broteroi, they are constantly shorter –(5)6-8 mm–, whilst they are longer in O. reverchonii –(8)9-10(11) mm–, and present medium, slightly overlapping values in O. concinnum –(6)8-9(10) mm–. However, shape and width of filament show notable differences between taxa. In O. reverchonii, filaments of both whorls are broad, about 2-3 mm wide in all their length. In both O. broteroi and O. concinnum, they are narrower (1-1.3 mm width), though the inners are slightly broader than the outers, and all of them taper progressive and notably to a point in the upper third.

**Gynoecium**

Size and morphology of gynoecium also allow separation among all three taxa. The biggest ovary appears in O. reverchonii, being oblong-ovoid and obtuse at the apex. The medium values correspond to O. concinnum, which produces a narrowly ovoid-fusiform or lanceolate ovary with an attenuate apex. Finally, O. broteroi shows the smallest ovary, which is obovoid and rounded to truncate at the apex (cf. Franco & Rocha Afonso, 1994). Considering the style, it is long and narrow in all three taxa, being slightly longer in O. reverchonii (Table 6). Generally, the stigma is usually slightly capitate and trigonous, always bearing three decurrent rows of glands.

**Fruit and seeds**

Size of capsule and seeds allow a clear differentiation, being one of the best discriminating characters among species in the subgenus (Table 7). The biggest capsule is found in O. reverchonii, which has an ellipsoid to ovoid outline and a blunt apex. In O. concinnum, it has medium size and is ovoid-elliptic in outline with acute or slightly apiculate apex. In O. broteroi, the capsule is smaller and narrower, with lanceolate-elliptic outline and with acute and slightly apiculate apex.

Seeds of taxa in O. subgen. Cathissa are blackish and more or less polygonal or subglobose. They are often pointed in a short beck around the funicular end, and are usually somewhat flattened and angulate, with more or less winged edges, and with irregularly rugose or slightly crested surface. Size, weight and shape of seeds, as well as testa ornamentation are characteristics with a very high diagnostic value (Martínez-Azorín & al., 2006) (Table 8). Regarding the seed testa features, Moret & al. (1990) described three morphological types for the North African species of Ornithogalum. Within O. subgen. Cathissa,

### Table 4. Characters of the inflorescence.

<table>
<thead>
<tr>
<th></th>
<th>Length (cm)</th>
<th>Width (cm)</th>
<th>Number of flowers</th>
<th>Insertion angle of pedicels</th>
</tr>
</thead>
<tbody>
<tr>
<td>O. broteroi</td>
<td>(1.5)-3-8(11)</td>
<td>0.3-0.4(0.6)</td>
<td>3-7</td>
<td>10º-20º</td>
</tr>
<tr>
<td>O. concinnum</td>
<td>(2)3-12(16)</td>
<td>(0.3)0.4-0.6(0.7)</td>
<td>(4)7-20(33)</td>
<td>10º-20º</td>
</tr>
<tr>
<td>O. reverchonii</td>
<td>(6)10-20(25)</td>
<td>(1)1.5-2.5(3.5)</td>
<td>(9)10-15(18)</td>
<td>40º-70º</td>
</tr>
</tbody>
</table>

### Table 5. Characters of tepals.

<table>
<thead>
<tr>
<th></th>
<th>Length inner tepal (mm)</th>
<th>Length outer tepal (mm)</th>
<th>Width inner tepal (mm)</th>
<th>Width outer tepal (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O. broteroi</td>
<td>(11)13-18(19)</td>
<td>(11)13-18(19)</td>
<td>(3)3.5-5.5</td>
<td>(3)3.5-5</td>
</tr>
<tr>
<td>O. concinnum</td>
<td>(12)13-16(18)</td>
<td>13-16(18)</td>
<td>(4.5)5-6</td>
<td>(3.5)4-5-6</td>
</tr>
<tr>
<td>O. reverchonii</td>
<td>(18)20-23(25)</td>
<td>(17)21-24(26)</td>
<td>(7)8-10</td>
<td>(7)8-10(11)</td>
</tr>
</tbody>
</table>

### Table 6. Characters of the gynoecium.

<table>
<thead>
<tr>
<th></th>
<th>Length of the ovary (mm)</th>
<th>Width of the ovary (mm)</th>
<th>Lenght of the style (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O. broteroi</td>
<td>3-3.5(4)</td>
<td>2-3</td>
<td>4-5</td>
</tr>
<tr>
<td>O. concinnum</td>
<td>4-5(6)</td>
<td>2</td>
<td>4-5</td>
</tr>
<tr>
<td>O. reverchonii</td>
<td>6-7</td>
<td>2.5-3</td>
<td>(4)5-6</td>
</tr>
</tbody>
</table>

### Table 7. Characters of the capsule.

<table>
<thead>
<tr>
<th></th>
<th>Lenght of the capsule (mm)</th>
<th>Width of the capsule (mm)</th>
<th>Number of seeds (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O. broteroi</td>
<td>(6)7-9(11)</td>
<td>3-4(5)</td>
<td>(3)12-25(28)</td>
</tr>
<tr>
<td>O. concinnum</td>
<td>(9)11-14(16)</td>
<td>5-6-9(10)</td>
<td>(6)15-40(43)</td>
</tr>
<tr>
<td>O. reverchonii</td>
<td>20-25</td>
<td>12-13</td>
<td>15-25</td>
</tr>
</tbody>
</table>
only two of those types have been identified. First, *O. reverchonii* produces very big and notably heavy seeds, dull coloured, markedly flattened and angulose, with slightly winged edges, and with a granulate testa (Type 2), which is similar to some species of *O*. subgen. *Beryllis* (Fig. 1). Secondly, seeds of *O. concinnum* are medium sized, lighter and dull coloured, flattened and angulose, with winged edges and ruminate or puzzle-like testa (Type 3), in which cells are flat with almost smooth or slightly rugulose surface and delimited by deep furrows (Fig. 1). Finally, in *O. broteroi* seeds are small, much lighter and with a metallic shine, subglobose, somewhat apiculate, with blunt edges, not winged, and a ruminate or puzzle-like testa (Type 3), in which cells are flat and sunk, delimited by small, rounded and sinuate ridges (Fig. 1).

Though seed types could be thought to characterize different subgenera of *Ornithogalum*, a direct relationship has not been demonstrated, as shown by Coskuncelbı & al. (2000) and Moret & al. (1990), who found more than one seed type in various Eurasian sections of the genus. Preliminary results of the phylogenetic studies we are carrying out, based on sequences of plastid and nuclear DNA regions (Martínez-Azorín & al., inéd.), place all three studied species in a monophyletic clade clearly apart from other Mediterranean subgenera, such as *Beryllis* or *Ornithogalum* (= *Heliocharmos*). This supports the fact that testa ornamentation can be used as an absolute diagnostic character among species but not for higher taxonomic levels.

### Principal Component Analyses (PCAs)

In the PCA of all studied morphological characters (Fig. 2), all three taxa in the subgenus appear rather clearly separated. Five principal components have been obtained, which explain together 81.5% of the variance, though the first two components explain 67.3% of the variance (59.7% and 7.5%, respectively). The first one allows *O. reverchonii* to be separated easily from *O. broteroi* and *O. concinnum*. This fact is mainly based on certain characters, such as the inflorescence length, the insertion angle of floral pedicels, the tepal size, the leaf dimensions, or fruit and seed features, among others (Table 9). In that analysis, *O. broteroi* and *O. concinnum* show a weak overlap, since both species are similar in the overall morphology. The second principal component was not effective to distinguish taxa. In fact, the obtained values and percentages of variance explained were very low in all cases.

Regarding the PCA conducted with only seed characters (Fig. 3), it was crucial to differentiate among all three species, namely between *O. concinnum* and *O. broteroi*. Two principal components were obtained, which explained together 97% of the variance (91.9% and 5.2%, respectively). The first one was the most effective to separate taxa. Every morphological character considered in the analysis presents a high importance for

### Table 8. Seed characteristics.

<table>
<thead>
<tr>
<th>Species</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>O. broteroi</em></td>
<td>1.6-1.9</td>
<td>0.9-1.2</td>
<td>0.4-0.7</td>
</tr>
<tr>
<td><em>O. concinnum</em></td>
<td>2.8-3.9</td>
<td>1.7-2.3</td>
<td>1.8-4.9</td>
</tr>
<tr>
<td><em>O. reverchonii</em></td>
<td>4.5-4.9</td>
<td>2.5-2.9</td>
<td>6-11</td>
</tr>
</tbody>
</table>

### Table 9. Studied morphological characters and values obtained in the Principal Component Analysis (PCA) of all morphological characters.

<table>
<thead>
<tr>
<th>Character</th>
<th>Component 1</th>
<th>Component 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the stem</td>
<td>0.886</td>
<td>-0.044</td>
</tr>
<tr>
<td>Number of flowers</td>
<td>0.427</td>
<td>-0.450</td>
</tr>
<tr>
<td>Length of the inflorescence</td>
<td>0.748</td>
<td>-0.230</td>
</tr>
<tr>
<td>Width of the inflorescence</td>
<td>0.868</td>
<td>-0.104</td>
</tr>
<tr>
<td>Length of the bract</td>
<td>0.724</td>
<td>-0.042</td>
</tr>
<tr>
<td>Width of the bract</td>
<td>0.432</td>
<td>-0.158</td>
</tr>
<tr>
<td>Length of the lowermost floral pedicel</td>
<td>0.866</td>
<td>-0.204</td>
</tr>
<tr>
<td>Length of the middle floral pedicel</td>
<td>0.888</td>
<td>-0.173</td>
</tr>
<tr>
<td>Length of the uppermost floral pedicel</td>
<td>0.769</td>
<td>-0.174</td>
</tr>
<tr>
<td>Insertion angle of the floral pedicels</td>
<td>0.926</td>
<td>0.028</td>
</tr>
<tr>
<td>Insertion angle of the fruiting pedicels</td>
<td>-0.152</td>
<td>0.549</td>
</tr>
<tr>
<td>Length of the outer tepal</td>
<td>0.867</td>
<td>0.311</td>
</tr>
<tr>
<td>Length of the inner tepal</td>
<td>0.880</td>
<td>0.296</td>
</tr>
<tr>
<td>Width of the outer tepal</td>
<td>0.874</td>
<td>0.278</td>
</tr>
<tr>
<td>Width of the inner tepal</td>
<td>0.868</td>
<td>0.204</td>
</tr>
<tr>
<td>Length of the outer filament</td>
<td>0.748</td>
<td>0.314</td>
</tr>
<tr>
<td>Length of the inner filament</td>
<td>0.751</td>
<td>0.334</td>
</tr>
<tr>
<td>Width of the outer filament</td>
<td>0.823</td>
<td>0.380</td>
</tr>
<tr>
<td>Width of the inner filament</td>
<td>0.750</td>
<td>0.356</td>
</tr>
<tr>
<td>Length of the ovary</td>
<td>0.838</td>
<td>0.206</td>
</tr>
<tr>
<td>Width of the ovary</td>
<td>0.701</td>
<td>0.415</td>
</tr>
<tr>
<td>Length of the style</td>
<td>0.529</td>
<td>0.397</td>
</tr>
<tr>
<td>Width of the capsule</td>
<td>0.688</td>
<td>-0.341</td>
</tr>
<tr>
<td>Length of the capsule</td>
<td>0.715</td>
<td>-0.265</td>
</tr>
<tr>
<td>Number of leaves</td>
<td>0.923</td>
<td>-0.221</td>
</tr>
<tr>
<td>Maximum length of leaves</td>
<td>0.846</td>
<td>-0.009</td>
</tr>
<tr>
<td>Maximum width of leaves</td>
<td>0.862</td>
<td>-0.180</td>
</tr>
<tr>
<td>Diameter of bulb</td>
<td>0.559</td>
<td>-0.356</td>
</tr>
<tr>
<td>Length of bulb</td>
<td>0.585</td>
<td>-0.242</td>
</tr>
<tr>
<td>Length of seed</td>
<td>0.873</td>
<td>-0.217</td>
</tr>
<tr>
<td>Width of seed</td>
<td>0.864</td>
<td>-0.199</td>
</tr>
<tr>
<td>Weight of seed</td>
<td>0.887</td>
<td>-0.094</td>
</tr>
</tbody>
</table>

### Table 10. Seed morphological characters studied and values obtained in the Principal Component Analysis in *O*. subgenus *Cathissa*.

<table>
<thead>
<tr>
<th>Character</th>
<th>Component 1</th>
<th>Component 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>0.967</td>
<td>-0.122</td>
</tr>
<tr>
<td>Width</td>
<td>0.962</td>
<td>-0.195</td>
</tr>
<tr>
<td>Weight</td>
<td>0.946</td>
<td>0.322</td>
</tr>
</tbody>
</table>
Fig. 1. Seeds of the species of Ornithogalum subgen. Cathissa: a, b, O. broteroi [A. Rodríguez s.n. (MA 21869)]; c, d, O. concinnum [M. Martínez-Azorín, M.B. Crespo & C. Pena s.n. (ABH 51026)]; e, f, O. concinnum [M. Martínez-Azorín s.n. (ABH 47141)]; g, h, O. reverchonii [M. Martínez-Azorín s.n. (ABH 47138)]. Scale: a, c, e, g = 1 mm; b, d, f, h = 100 µm.
distinguishing among taxa (Table 10). The second principal component did not give resolution enough to segregate all three taxa, due to the low variance it explained. Only the seed weight could allow a weak segregation between *O. broteroi* and *O. concinnum*, though both taxa were not clearly separated from *O. reverchonii*, a species that shows a high variability in this character.

**Taxonomic treatment**

**KEY TO ORNITHOGALUM SUBGEN. CATHISSA SPECIES**

1. Plant (9.5)12-32(42) cm. Tepals (11)13-18(19) mm long. Capsule (6)7-14(16) mm long. Seed 1.6-3.9 mm long. Testa puzzle-like (with smooth or weakly granulate surface) ............. 2

2. Flowering stem 1-leaved. Ovary 3-3.5(4) mm long. Capsule (6)7-9(11) mm long. Seed 1.6-1.9 mm long .. 1. *O. broteroi*

2. Flowering stem 2 or more leaves. Ovary 4-5(6) mm long. Capsule (9)11-14(16) mm long. Seed 2.8-3.9 mm long .............

---

**Description of the species**


*Scilla unifolia* L., Sp. Pl.: 309. 1753 [basion.].

*O. unifolium* (L.) Link in J. Bot. (Schrader) 1(2): 320. 1799, nom. illeg. [non Retz., Obs. 2: 17. 1781].

*Cathissa unifolia* (L.) Salisb., Gen. Pl.: 34. 1866.


*Ind. loc.:* “Común en las Colinas del Paraiso [sic] y del valle de Viso” [Galicia, Spain]. TYPE: not extant at BCN [synonym from description].

**Illustrations:** Ker Gawl. in Bot. Mag. 24: 935. 1806; Willk., Ill. Fl. Hispan. 2(17) tab. CLIII. 1890; Fig. 4.

Geophyte, (9.5)12-24(30) cm high; bulb (1.3)1.5-2.1 × (1)1.1-1.5(1.6) cm, ovoid-spherical, with contractile roots, usually without or with few (2-3) offsets; outer tunics pale brown to pale orange. Leaf synanthous, solitary or rarely 2 (in this case, each one on a flowering stem), (6)13-35(40) × (0.3)0.4-0.9(1.2) cm, linear-lanceolate, flat, widely sheathing at the base, glaucous-green, glabrous, erect-patent, ending in a cylindrical appendix almost as long as the blade, that withers soon and falls down. Floral stem (8)9-16(19) × 0.2-0.3 cm, shorter than leaf, erect, glaucous-green, smooth and glabrous. Inflorescence racemose-spiciform, dense, (1.5)3-8(11) × 0.3-0.4(0.6) cm (excluding flowers but not their pedicels), with (2-3)×7(9) flowers; bracts (7)8-20(25) × (3)4-8(9) mm, longer than the accompanying pedicel, triangular, membranous, whitish-hyaline with setose acuminate greenish apex, pale brown when dry, sometimes toothed at the basal part; floral pedicels erect or slightly patent, lower ones 1-4(5) mm, middle ones 1-2(3) mm, and upper ones 0.1-1 mm; fruiting pedicels 2-5 mm, erect and
Fig. 4. Ornithogalum broteroi (Spain, Huelva, La Nava, Martínez-Azorín & al. s.n. (ABH 50131)): a, flower; b, bract; c, inner stamen (left) and outer (right); d, gynoecium; e, sections of the mature capsule; f, capsules before dehiscence; g, inflorescence and leaf; h, bulb. Scale = 1 cm.
appressed to stem. Flowers 25-30 mm in diameter, slightly fragrant; tepals white, rarely with a small and weak dorsal greenish band at the apex, lanceolate-elliptic, patent or erect-patent, with papillate-glandlose acute apex; outers (11)13-18(19) × (3)3.5-5 mm; inners (11)13-18(19) × (3)3.5-5.5 mm, being somewhat wider than the outers. Stamens 6, ½ to 2/3 of the tepal length; filaments white, lanceolate, progressively tapering in a point in the upper third, (5)6-8 × 1-1.3 mm; inners (11)13-18(19) × (3)3.5-5.5 mm, being somewhat wider than the outers. Ovary 3-3.5(4) × 2-3 mm, pale green, obovoid, rounded at the apex, trigonous, with three obtuse ridges, bearing nectariferous sepals; style whitish, filiform, 4-5 mm; stigma capitate, trigonous, with decurrent glandlose ridges. Capsule (6)7-9(11) × 3-4(5) mm, lanceolate-elliptic, acute, slightly apiculate, trigonous, pale brown, with late trivalvar dehiscence, usually only through the upper third. Seeds (3)12-25(28) per capsule (n = 16), 0.4-0.7 mg, 1.6-1.9 × 0.9-1.2 mm, blackish with metallic shine, subglobose, with blunt edges, not winged, usually apiculate at the apex; testa ruminate or puzzle-like (Type 3), with cells flat and sunk, delimited by small rounded sinuate ridges.


Biology: This species flowers from the end of February to June (exceptionally to August). It usually does not produce offsets, though usually splits up into two equal parts, each of them generating a contiguous mature plant. Therefore, sometimes individuals of this species seem to generate more than one leaf, though indeed each floral stem bears only one leaf. The reproduction of this species is mainly by seeds. Dehiscence of capsules occurs late (several weeks after the complete drying), and it takes place through the apical third.

Habitat: Open forests, scrubbs and grasses, usually on siliceous soil, mainly on littoral areas. It seems to avoid the excessive continentality. It grows between 0 to 1300 m altitude.

Distribution: Western half of the Iberian Peninsula and northwestern Africa (Fig. 5). Maire (1958) placed near to Marrakech the southern distribution limit of this species, though we have confirmed its presence only until the surroundings of Casablanca. According to Merino (1909), this species would spread north to Vivero (Lugo), though we could not study any collections from that area.

Observations: Living materials of *O. broteroi* are easy to distinguish from *O. concinnum* by the number of leaves, usually shorter and few-flowered inflorescences, and the truncate apex of the ovary as well as the fruit features. Sometimes herbarium materials of *O. broteroi* lacking leaves have been misidentified as *O. concinnum*. However, the much smaller seeds and capsules are diagnostic for an unequivocal identification. *O. broteroi* is abundant in the sites it grows, therefore it is not endangered nowadays, though its predilection for littoral areas could place this taxon in an uncertain future position. UICN (2001) category: LR lc.

Selected material

s.n. (K). Badajoz: Puebla de Obando, subida al puente del Zán- 
Cáceres: Valencia de Alcántara, 19-V-1987, 29PD3471, M. 
Ladero & A. Anor s.n. (SALA 76589); ibid., Sierra Fría, 1-VI-1984, 
E. Rico s.n. (MA 560845, SALA 57193, SALA 58364).
Cádiz: Pizar del Rey, prop. San Roque, IV-1984, G.C. Churchill 
644 (K). Tarifa, Sierra de Salavaciones, cortijo de Salavaciona, 
Huelva: La Nava, sierra de las Herrumbres, Pto. de los 
Aurrumiados, 23-2004, 29PSC906, I. Pérez Núñez, M. 
Martínez-Azorín, M.B. Crespo & C. Penas s.n. (ABH 50131).
Málaga: Cortes de la Frontera, Cortijos la Alegrias, 30-IV-1983, 
TF8495; A. Aparicio & S. Silvestre s.n. (SEV). Cortes de la Frontera, 
cerro del Rubio, 3-1990, TF8556, Aparicio & Silvestre s.n. (SEV).
Ourense: Coto de Novelle, Castredal de Miño (Barral), 19-VII-1935, 
material con cápsulas, A. Rodríguez s.n. (MA 21869). Sierra del 
Pontevedra: Canegas, Vilanova, prop. Área Brava, 27-IV-2006, 29TNG1283, 
A. Juan s.n. (ABH 51024); Bealim, 8-V-1955, F. Bellot & B. 
Casaseca s.n. (MA 183184). Bueu, entre Donón y Cabo de 
Home, 9-IV-1986, 29TNG1178, M.J. Toimil s.n. (GDA 24549, MA 
40662, MACB 26843, SALA 44463, SALA 80601, SANT 17358). Coveo, 
Lamora, 24-1998, 29TNG3575, Amigo, Orti, Louzan, Quinantilla 
& San León s.n. (SANT 39777). Dozón, Maceiras, 15-IV-1982, 
29TNG711, M. Horjales & N. Redondo s.n. (MA 432863). Entre 
Carril y Cañón, 8-V-1953, Bellot & Casaseca s.n. (GDA 37612).
Entre Puenteecueses y Cataias, 5-1977, F. Bellot & B. Casaseca 
s.n. (SANT 09497). Isla de la Toja, 10-V-1954, A. Rodríguez s.n. 
(K). Marrubol, VI, A. Segura Zubizarreta s.n. 
(K).
Anales del Jardín Botánico de Madrid 64(1): 7-25, enero-junio 2007. ISSN: 0211-1322
Localities selected from the bibliography


O. unifolium var. concinnum (Salisb.) Ker Gawl. in Bot. Mag. 24: 953. 1806. Cathissa concinna (Salisb.) Salisb., Gen. Pl.: 34. 1866. Ind. loc.: “Juxta Gibralter sponte nasci fertur, unde habuit Fothergill anno 1780” [probably erroneous, since this species does not grow in that area]. TYPE: ESP, Zamora: Torregamones, sobre un asomo, pale brown. Leaves synanthous, 2-3(5), in a basal rosette, (9)15-30(45) × (0.4)0.6-1.5(2) cm, linear or linear-lanceolate, slightly canaliculate, somewhat glaucous green, glabrous, suberect, usually withering at tips. Floral stem (8)10-20(26) × 0.3-0.4 cm, equal to shorter than leaves, erect, glaucous-green, smooth and glabrous. Inflorescence racemose-spiciform, dense, (2)3-12(16) × (0.3)0.4-0.6(0.7) cm, (excluding the flowers but not their pedicels), with (4)7-20(33) flowers; bracts (8)9-16(19) × (4)5-8 mm, much longer than the accompanying pedicel, ovate-lanceolate to triangular, membranous, whitish-hyaline with setose acuminate greenish to brownish apex, sometimes toothed at the basal part; floral pedicels erect or slightly patent, lower ones 2-8 mm, middles ones 1-4(5) mm, and upper ones 1-2(3) mm; fruiting pedicels 4-8 mm, erect and pressed to stem. Flowers 25-30 mm in diameter, slightly fragrant; tepals white, lanceolate to linear-lanceolate, erect or erect-patent, with dense papillate-glandulose apex; outers 13-16(18) × (3.5)4-5(6) mm; inners (12)13-16(18) × 4.5-5(6) mm, being somewhat wider (0.5-1 mm) than the outers. Stamens 6, ½ to ⅔ of the tepal length; filaments white, linear-lanceolate, progressively tapering in a point in the upper third, (6)8-9(10) × 1-1.3 mm, inners somewhat wider; anthers dorsifixed, pale yellow to whitish, 2 × 1 mm. Ovary 4-5(6) × 2 mm, pale green, narrowly ovoid-fusiform to lanceolate, attenuated at the apex, trigonous with three obtuse ridges, bearing nectariferous sepalts; style whitish, filiform, 4-5 mm; stigma capitate, trigonous, with deeply glandulose ridges. Capsule (9)11-14(16) × (5)6-9(10) mm, ovate-elliptic, acute, slightly apiculate, trigonous, pale brown, with trivalvar dehiscence through the upper half. Seeds (6)15-40(43) per capsule (n = 23), 1.8-4.9 mg, 2.8-3.9 × 1.7-2.3 mm, dull black, flattened, angular, with winged edges, testa ruminate or puzzle-like (Type 3), with cells flat with smooth to slightly rugulose surface, delimited by deep sinuate furrows.


Biology: This species flowers from March to July, exceptionally to November (Quiroga, Lugo). It usually does not bear offsets or they are in low number, though usually the bulb splits up into two or three equal parts, each of them producing a contiguous mature plant. The reproduction of this species is mainly by seeds. Dehiscence of capsules occurs immediately after ripening, and more rapidly than in O. broteroi. Habitat: Open forest and scrubs, mainly on siliceous soil and in continental areas. It grows between 200 and 2000 m altitude.
Fig. 6. Ornithogalum concinnum (a-g) Ávila, Hoyocasero, Spain: Martínez-Azorín & al. s.n. (ABH 47141); h) Zamora, Torregamones, Spain: Martinez-Azorín s.n. (ABH 47140) (corresponding to the neotype designated by Martínez-Azorín & al., 2006): a, flower; b, bract; c, inner stamen (left) and outer (right); d, gynoecium; e, sections of the immature capsule; f, capsule after dehiscence; g, inflorescence; h, general view. Scale = 1 cm.
Distribution: Endemic to the northwestern Iberian Peninsula (Fig. 7). It covers a quite continuous continental area of the northwestern quadrant, except for a couple of locations in the coastal areas of Portugal, near Cabo da Roca (Estremadura) and the surroundings of Alcácer do Sal (Baixo Alentejo), both apart over 200 km from the main distribution nucleus. Intermediate populations between both areas would be expected, though all studied collections from there belong undoubtedly to O. broteroi.

Observations: Living individuals of O. concinnum usually produce two or more leaves per stem, usually longer and many-flowered inflorescences, and the ovary with a fusiform outline. As said before, herbarium materials of O. concinnum lacking leaves have been misidentified as O. broteroi. However, the much bigger seeds and capsules warrant a correct identification. This species is abundant in the sites where it grows. It does not seem to face serious threats. UICN (2001) category: LR lc.

Selected material


Fig. 7. Distribution of Ornithogalum concinnum.
Taxonomic revision of Ornithogalum subgen. Cathissa


Ind. loc.: “Hab. in regno Granatensi occidentali, ubi in fissuris rupium calcarearum regionis montanae crescit (in faicibus Tajo de Ronda dictis prope oppidum Ronda ad altit. circ. 200 m., Reverchon!). Floret Junio, Julio”. TYPE: Willk., Ill. Fl. Hisp. 2(18): tab. CLVIII, atque explic. tabulae in p. 118. 1891 (lectotype = iconotype, designated by Martinez-Azorin & al., 2006).


Illustrations: Willk., Ill. Fl. Hispan. 2(18): tab. CLVIII. 1891. Fig. 8.

Geophyte, (26)40-70(80) cm high; bulb 5.6 × 2.5-4 cm, ovoid, with contractile roots, usually without or with few (2-3) offsets; outer tunics pale brown, membranous. Leaves synanthous, 4-6, in a basal rosette, with few (2-3) offsets; outer tunics pale brown, membranous. Leaves synanthous, 4-6, in a basal rosette, with few (2-3) offsets; outer tunics pale brown, membranous.
Fig. 8. Ornithogalum reverchonii [Spain, Cádiz, Grazalema, Tajo de los Pajaritos, M. Martínez-Azorín s.n. (ABH 47138)]; a, flower; b, bract; c, inner stamen (left) and outer (right); d, gynoecium; e, capsule after dehiscence; f, bulb and leaves; g, inflorescence. Scale = 1 cm.
Taxonomic revision of *Ornithogalum* subgen. *Cathissa*

with (9)10-15(18) flowers; bracts (18)20-30(32) × 5(6)-8(10) mm, usually longer than the accompanying pedicel, oblong-lanceolate, early withering, brownish with long acuminate apex, with about 8 marked nerves; floral pedicels erect-patent, lower ones (7)-9-18(25) mm, middle ones (6)-8-15(18) mm and upper ones (2)-3-8(10) mm; fruiting pedicels 15-20(25) mm, erect and appressed to stem. Flowers (25)35-40 mm in diameter, slightly fragrant, tepals white, rarely with a small and weak dorsal greenish band at the apex, widely elliptic to ovate-elliptic, subacute to obtuse or slightly truncate densely papillate-glandulose apex; outers (17)21-24(26) × (7)8-10(11) mm; inners (18)20-23(25) × (7)8-10 mm. Stamens 6, 3/4 to 1/2 of the tepal length; filaments white, broadly oblong-lanceolate, 2-3 mm wide in all their length; outers (8)-9-10 × 2-3 mm, inners (8)-9-10(11) × 2-3 mm; anthers dorsifixed, sagittate, pale yellow to whitish, 6-8 mm prior to dehiscence and 4.5 × 1-1.2 mm after dehiscence. Ovary 6-7 × 2.5-3 mm, pale green, oblong-ovoid, rounded at the apex, trigonous, with three obtuse ridges bearing nectariferous septals; style whitish, filiform, (4)-5-6 mm; stigma capitata, trigonous, with recurrent glandulose ridges. Capsule 20-25 × 12-13 mm, elliptic-ovoid, rounded at the apex, pale brown, with trivalvar dehiscence through the upper half. Seeds 15-25 per capsule (n = 19), 6-11 mg, 4.5-4.9 × 2.5-2.9 mm, dull blackish, markedly flattened and angulose, with slightly winged edges, testa irregularly granulate (Type 2).

**Number of chromosomes:** 2n = 32 (own count). 2n = 32 (Fernández & al., 1985; Pastor & Diosdado, 1994). 2n = 32 + 4B (Fernández Casas & García Guardia, 1977).

**Biology:** The vegetative period is from January to the end of July. It flows from the beginning of March to June, exceptionally to July (Sierra de Almijara). Fructification begins in May and finishes at the end of July. The reproduction of this species is mainly by seeds, though some offsets can be produced (cf. Parra & al., 2000).

**Habitat:** In Cádiz and Málaga provinces, it grows in vertical limestone shady cliffs, facing north or northeast. It usually participates in perennial grasslands, growing in rock crevices or ledges in peaty soils. In Sierra de Almijara (Granada), it is found in open forests with understorey of *Cistus* sp., and in Sierra de las Villas (J) it grows in grasslands on loamy soils. In El Hajeb (Morocco), it was collected in open scrubs and on edges of cultivated grounds on clayey soils. This species is found between 600 and 1300 m altitude.

**Distribution:** Southern Iberian Peninsula and northwestern Morocco. In Andalucía it grows in Se-
Acknowledgements

We thank the curators of the herbaria cited in the text for the loan of vouchers. Ignacio Pérez Núñez took us to populations of O. reverchonii de Andalucía brought us permissions and field help for collecting O. reverchonii of some taxa. Antonio Rivas Rangel and Junta de Andalucía (Sociedad Broteriana) brought us important chorological information on the Anhaltria plantarum hispanicarum. Francisco Bejarano and Faustino Castroviejo, S. 1969. Catálogo de Ons y Onza inédito. In: Blanca, G., Cabezudo, B., Heredia, C.M., Herrera, C.M., Muñoz, J. & Valdés, B. (eds.) Boletim da Sociedade Broteriana ser. 2, 24: 335-347.

Acknowledgements

We thank the curators of the herbaria cited in the text for the loan of vouchers. Ignacio Pérez Núñez took us to populations of O. reverchonii de Andalucía brought us permissions and field help for collecting O. reverchonii in P.N. de Sierra de Grazalema (Cádiz-Malaga).

References


(eds.), *Libro rojo de la flora silvestre amenazada de Andalucía, 2 (Especies vulnerables)*: 256-258. Junta de Andalucía, Sevilla.


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