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A morphological and anatomical study of two Bulgarian *Ornithogalum* species *(Liliaceae)*

Abstract

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As part of a complete morphological study of *Ornithogalum narbonense* and *O. nutans*, based on live and dry Bulgarian material, their anatomical leaf structure was described and illustrated for the first time. The leaves are epistomatic in both. They differ in the dimensions and number of epidermal cells and stomata, in thickness and structure of the epidermal cuticle, and most definitely in the shape and arrangement of mesophyll cells and in the structure of the leaf blade edge.

Introduction

Ornithogalum L. comprises about 150 species, most of which are found in southern Africa. A second diversity centre is in the Mediterranean area, from where several species extend north- and eastwardly to various regions of Eurasia.

In the last 30 years, *Ornithogalum* was the subject of intensive study, e.g. by Zahariadi (1962, 1977, 1980) and Agapova (1977, 1980). Owing to disagreement on the size and delimitation of individual species and lack of knowledge of the taxonomically significant morphological traits, species numbers reported by different authors for Bulgaria vary (see, e.g., Velenovský 1891; Stojanov & Stefanov 1924-1925, 1933, 1948; Stojanov & al. 1966; Radenkova 1964; Zahariadi 1980). *Ornithogalum* species are believed to be in a process of dynamic change and differentiation, which is consistent with the results of cytological analyses (Markova & al. 1974, Agapova 1980, etc.).

Material and methods

The specimens studied were gathered from 6 populations from natural habitats in Bulgaria, as follows: *Ornithogalum narbonense* from Kalofer (38432), Mezek (46413), and near Plovdiv (46400); *O. nutans* from Ostrova near Plovdiv (03954), Novakovo (35021), and Bačkovo Monastery (32542). Voucher specimens have been deposited at the herbarium, Department of Botany, Agricultural University, Plovdiv (SOA).

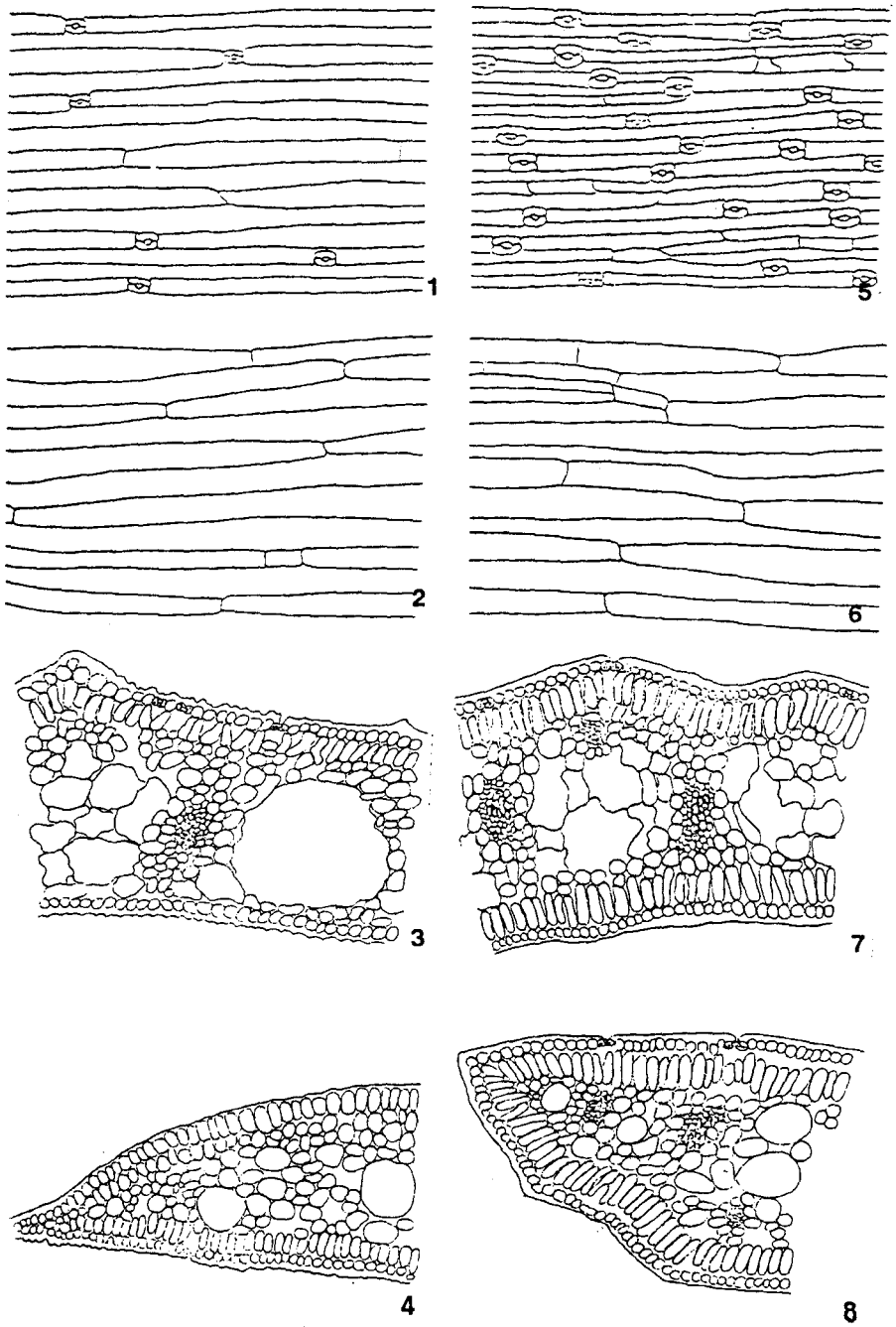

Fig. 1-8. Leaf anatomical details of *Ornithogalum narbonense* (1-4) and *O. nutans* (5-8). – 1, 5, adaxial epidermis; 2, 6 abaxial epidermis; 3, 7, cross section of central portion; and 4, 8, of edge.

Table 1. Biometrical data on the morphology and leaf anatomy of *Ornithogalum narbonense* and *O. nutans*. – All measurements are given as (minimum-) mean (-maximum) ± standard deviation.

Character (unit)	*O. narbonense*	*O. nutans*
Stem height (cm)	(58-)81.798(-102) ± 0.948	(42-)47.199(-54) ± 0.205
Bulb length (cm)	(3.5-)5.048(-6.5) ± 0.259	(2.0-)2.590(-3.0) ± 0.043
Bulb width(cm)	(1.4-)2.896(-4.0) ± 0.216	(1.5-)1.558(-1.8) ± 0.013
Leaf length(cm)	(17-)36.199(-59) ± 0.198	(15-)30.298(-50) ± 0.303
Leaf width (cm)	(6-)9.299(-16) ± 0.247	(10-)6.599(-17) ± 0.033
Flowers per raceme	(55-)88.199(-109) ± 2.037	(8-)13.498(-19) ± 0.460
Pedicel length before flowering (mm)	(12-)1.188(-17) ± 0.047	(5.5-)6.446(-8) ± 0.092
Pedicel length after flowering (mm)	(12-)1.058(-50) ± 0.486	(5.5-)8.620(-12) ± 0.044
Bract length (mm)	(4-)8.247(-13) ± 0.014	(18-)19.599(-21) ± 0.165
Perigon segment length (mm)	(6-)0.670(-12) ± 0.045	(15-)16.796(-18) ± 0.053
Perigon segment width (mm)	(2.5-)3.596(-4.5) ± 0.014	(4.5-)4.795(-5.0) ± 0.019
Ovary length(mm)	(2-)2.696(-3.5) ± 0.009	(2-)2.661(-3.5) ± 0.001
Ovary width (mm)	(2-)2.316(-2.7) ± 0.006	(2.4-)2.770(-3.0) ± 0.019
Style length (mm)	(1.5-)2.397(-3.0) ± 0.020	(4.0-)4.287(-4.8) ± 0.030
Thickness of leaf blade (μm)	(392.85-)492.28(-594.61) ± 6.46	(305.55-)428.00(-549.02) ± 6.80
Thickness of spongy mesophyll (μm)	(109.99-)309.05(-438.72) ± 12.21	(204.60-)317.74(-414.18) ± 1.89
Thickness of adaxial epidermis (μm)	(23.03-)30.99(-40.89) ± 0.29	(24.44-)30.01(-35.72) ± 0.30
Thickness of abaxial epidermis (μm)	(16.45-)24.11(-33.30) ± 0.60	(23.50-)28.20(-34.78) ± 0.22
Thickness of adaxial cuticle (μm)	(5.64-)9.65(-16.45) ± 0.26	(4.70-)6.22(-9.40) ± 0.18
Thickness of abaxial cuticle (μm)	(9.40-)12.78(-16.45) ± 0.09	(4.70-)6.58(-9.40) ± 0.12
Cells of adaxial epidermis (mm^{-2})	(165-)197(-255) ± 1.79	(280-)353 (-420) ± 0.49
Stomata of adaxial epidermis (mm^{-2})	(15-)37.33(-255) ± 2.06	(35-)68.83(-100) ± 0.98

The anatomical studies were conducted by conventional methods (Metcalfe & Chalk 1950). Biometrical measurements were statistically treated by the method of "Student-Fisher" (Sokal & Rohle 1981).

Results

Detailed comparative morphological studies on live plants and herbarium specimens resulted in new, complete descriptions of the two investigated species studied: *Ornithogalum narbonense* L. and *O. nutans* L. From these descriptions (not reported here in full) some quantitative characters have been extracted and are tabulated in full (Table 1): bulb size, scape height (with the raceme), leaf length and width, flower number, pre- and post-anthesis pedicel length, bract length, dimensions of perigon segments and of the ovary, and style length.

Descriptions of leaf anatomical features are given below, with the numerical values of quantitative characters similarly included in Table 1.

Ornithogalum narbonense (Fig. 1-4). – The leaf blade is epistomatic. The normal epidermal cells are elongate, thin-walled, narrowed at both ends (Fig. 1-2). The number of normal cells and stomata on the upper (adaxial) leaf surface is 197 and 37.33 per mm^2, respectively (fewer than in *O. nutans,* due to their larger size). The wide range of variation of its stomata is typical for the species. The cuticle is strongly plicate. Thickness of t he adaxial cuticle ranges from 5.64 μm to 16.45 μm, that of the abaxial cuticle from 9. 4 to 16.45 μm.

Thickness of the leaf blade varies between 392.85 μm and 594.61 μm. The mesophyll consists of two types of cells. Elongate palisade cells, perpendicular to the leaf surface, form a single subepidermal tier, varying in length from 20.3 μm to 102.8 μm adaxially, and from 48.5 μm to 100.8 μm abaxially. The spongy parenchyma, located in the central part of mesophyll, is built of cells of irregular shape and with very large intercellular spaces in-between (Fig. 3). The mean thickness of the adaxial and abaxial epidermis is 30.99 μm and 24.11 μm, respectively. The edge of leaf blade is sharp, the upper and lower epidermis becoming contiguous marginally, which is a typical feature of the species (Fig. 4).

Ornithogalum nutans (Fig. 5-8).– The stomata are also confined to the upper surface of the leaf blade (Fig. 5-6), their number varying from 35 to 100 per mm^2. The normal epidermal cells are thin-walled, elongate, slightly narrowed at the ends. Their mean number on the adaxial side is 353 per mm^2. The mean cuticle thickness of the adaxial and abaxial epidermis is 6.22 μm and 6.58 μm, respectively.

Thickness of the leaf blade ranges from 305.55 μm to 549.02 μm. The mesophyll consists of three cell types: elongate, rounded and irregularly shaped. The elongate palisade cells form a single subepidermal tier, they are perpendicular to it, and tightly packed. Their length varies from 46.56 μm to 85.36 μm in the adaxial, and from 41.1 to 73.72 μm in the abaxial tier. The rounded cells are located underneath the palisade tissue, while the central mesophyll layer is built of larger, irregularly formed cells separated by large intercellular spaces (Fig. 7). The mean thickness of the mesophyll (including the palisade tiers) is 398.74 μm. In contrast to *Ornithogalum narbonense,* the leaf blade edge of *O. nutans* is blunt, the cells of the adaxial and abaxial epidermis remaining clearly separated by palisade tissue to the very edge (Fig. 8).

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