

## COMPARATIVE STEM AND LEAF ANATOMY OF THE GENUS ODONTITES (SCROPHULARIACEAE) IN IRAN

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Following examination by light microscope of the stem and leaf features of species of *Odontites* from Iran; anatomical study revealed that these taxa can be separated on the basis of leaf features. A key distinguishing these taxa is provided. *O. glutinosa* differs from other studied species in having isobilateral cross section.

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تشریح مقایسه‌ای ساقه و برگ جنس *Odontites* از ایران

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ساختار ساقه و برگ ۴ تاکسون از جنس *Odontites* از نظر تشریحی مورد مطالعه قرار گرفت. شرح کامل مشخصات برگ هر تاکسون ارائه می‌شود. کلید شناسایی با استفاده از ویژگیهای تشریحی برگ برای تاکسون‌های مورد بررسی ارائه می‌گردد. گونه *O. glutinosa* با سایر گونه‌ها در داشتن برش عرضی برگ isobilateral با سایر گونه‌های مطالعه شده متفاوت است.

## INTRODUCTION

The genus *Odontites* Ludwig with 20 species is distributed throughout the temperate regions of Europe, Asia and North Africa (Cao Shu, 1988). This genus comprises annual and perennial herbs, with opposite leaves and flowers arranged in racemes. The corolla consists of 2-lipped limb; lower lip spreading 3-lobed; lateral lobes entire; middle lobe emarginate; upper lip slightly arching, obscurely galeate.

The genus *Odontites* was included in the subfamily *Rhinanthoideae* by Rechinger (1981). This genus is composed of 3 species in Iran, i.e. *Odontites aucheri*, *O. glutinosa*, *O. verna* subsp. *verna* and *O. verna* subsp. *serotina*. Among these taxa *O. aucheri* is widely distributed in Iran, while the others have very limited distribution area.

The delimitation of these taxa is somewhat uncertain. In Flora of the USSR (Golubkova, 1955) *O. serotina* was treated as a separate species from *O. verna*, but in Flora Iranica (Rechinger, 1981) and Flora Europe (Webb & Camarasa, 1972) it is reduced to subspecies rank.

Anatomy of *Scrophulariaceae* was discussed in Metcalf & Chalk (1957). Several important features of *Odontites*, such as the presence of glandular hairs were explained there. The foliar anatomy of Turkish *Rhinantheae* tribe including *O. aucheri* has been studied by Kaplan (1999). He explained that the genera in this tribe can be separated from each other based on leaf anatomical characters.

In this paper Anatomy of different taxa of *Odontites* distributing in Iran has been studied to determine the characteristic feature of each taxon and discuss the systematic importance of leaf and glandular hairs among these taxa.

## MATERIAL AND METHODS

Materials were fixed in FAA and transverse sections of leaf and stem prepared by hand cutting. Sections were cleared with sodium

hypochlorite, dehydrated and stained with Iodine green and Kongo red. For the epidermal study with light microscope some fixed leaves were soaked in lactic acid to facilitate the separation of the epidermis. Observations were made with "OLYMPUS BH-2".

The voucher specimens for this study are labeled as follows:

*Odontites glutinosa* (M.B.) Benth.-Azarbaijan: Kaleybar, Nabijan (Arasbaran), 2400m, Yousefy 6818 (Tabriz, Herbarium of Agricultural College).

*Odontites verna* (Bellardi) Dumort. subsp. *serotina* (Dumort.) Corb. -Mazanderan: Noshahr, Alamdeh, Manoucher-cala, 20m, Mozaffarian 10597.

*Odontites verna* (Bellardi) Dumort. subsp. *verna*-Azarbaijan: southern slope of Boz-Goosh mountain, Bloukan village, 2000 m, Mozaffarian & Mohamadi 37451.

*Odontites aucheri* Boiss. -Tehran, Shemshak, Darbandsar, 2500-2800 m, Ghahreman & Mozaffarian 6720.

Materials are preserved in TARI.

## RESULTS

*Stem.* In cross section the stem is circular in all studied taxa (Fig. 1). The epidermis has one cell layer with an unrigged cuticle and simple, unbranched, unicellular and multicellular hairs. Below the epidermis there is lamellar collenchyma. Cortex parenchyma is thin-walled, with small intercellular space, just on the tops of vascular bundles. Stem shows a weak secondary growth at basal parts. A complete ring of cambium is formed among all studied taxa but the central pith remains parenchymatous.

*Leaf:* The leaves are dorsiventral except for *O. glutinosa* which is iso-bilateral. The epidermis is one layer thick. Sparse to slightly dense indumentum appears on the surface, made of two types of non-glandular and glandular trichomes except for



Fig.1. Epidermis of leaf in superficial view showing anomocytic stomata (left); stem, transversal section (right) (scale bar=100  $\mu\text{m}$ )

*O. glutinosa* with exclusively glandular hairs. The cuticle is well developed both on abaxial and adaxial surfaces. The leaves are amphistomatic, with stomata slightly raised above the epidermis level and more numerous on the lower side of the leaf.

The mesophyll is differentiated into palisade and spongy parenchyma. The palisade parenchyma consists of 2 (in *O. verna*), 2-3 (in *O. aucheri*) or 6 (in *O. glutinosa*) layers. The radial walls of the palisade cells are slightly smooth. The spongy parenchyma consists of two to three layers of irregular form, relatively compact, with small intercellular spaces. Palisade and spongy tissue ratio is 2 : 1.

Vascular bundles is in one row, mainly in spongy mesophyll.

In superficial view, epidermis layer consists of cells with sinuous anticlinal walls, smooth cuticle and stomata with anomocytic type (Fig.2). Characteristic features of leaf anatomy are given for all studied taxa in table 1.

***Odontites glutinosa* (M. B.) Benth.**(Fig.2 A) Leaf surface (TS). Trichomes present on both surfaces, sparse, with glandular hairs, glandular hairs (52.5–175  $\mu\text{m}$ ) formed a stalk with 1–3 cells and a broadly ovate unicellular head (Fig. 4 A). Subepidermal collenchyma

Table 1. Characteristics of leaf of *Odontites* species in Iran.

	<i>O. glutiosa</i>	<i>O. aucheri</i>	<i>O. verna</i> subsp. <i>serotina</i>	<i>O. verna</i> subsp. <i>verna</i>
Midrib thickness ( $\mu\text{m}$ )	270-300	185-200	320-350	200-220
Length of glandular hairs ( $\mu\text{m}$ )	52.5-175	65-75	30-45	20-22.5
Number of layers of palisade parenchyma	6	2-3	2	2
Number of cells of stalked glandular hair	1-3	1-2	1	1
Spongy parenchyma thickness ( $\mu\text{m}$ )	50-100	17-20	30-70	24-32

one layer. *Mesophyll*: composed of six layers of palisade parenchyma (200–250  $\mu\text{m}$ ) both on upper and lower surfaces, and three layers of spongy parenchyma (50–100  $\mu\text{m}$ ) abaxially. *Midrib*: c. 270–300  $\mu\text{m}$  thick, abaxial surface convex, adaxial surface concave; major veins nonprominent abaxially, with deep groove above major veins, large to small thin-walled parenchyma cells present in ground tissue of midrib.

***Odontites verna* (Bellardi) Dumort. subsp. *serotina* (Dumort.) Corb. (Fig. 2 B)**

*Leaf surface* (TS). Trichomes present on both surfaces, slightly dense, with glandular and eglandular hairs, glandular hairs (30–45  $\mu\text{m}$ ) formed a stalk with one cell and a spherical unicellular head (Fig. 4B). With subepidermal collenchyma in one to two layers. *Mesophyll*. composed of 2 layers of palisade parenchyma (50–200  $\mu\text{m}$ ) on upper surface and two layers of spongy parenchyma (30–70  $\mu\text{m}$ ) abaxially. *Midrib*: c. 320–350  $\mu\text{m}$  thick, abaxial surface slightly convex, adaxial surface concave; major veins nonprominent abaxially, with relatively deep groove above major veins, large to small thin-walled parenchyma cells present in ground tissue of midrib.

***Odontites verna* (Bellardi) Dumort. subsp. *verna* (Fig. 3 A)**

*Leaf surface* (TS). Trichomes present on both surfaces, sparse, with glandular and eglandular

hairs; glandular hairs (20–22.5  $\mu\text{m}$ ) formed a stalk with 1 cell and a spherical unicellular head (Fig. 4C). Subepidermal collenchyma in one layer. *Mesophyll*. composed of 2 layers of palisade parenchyma (70–120  $\mu\text{m}$ ) on upper surface and two layers of spongy parenchyma (24–32  $\mu\text{m}$ ) abaxially. *Midrib*: c. 200–220  $\mu\text{m}$  thick, abaxial surface slightly convex, adaxial surface concave; major veins nonprominent abaxially, with relatively deep groove above major veins and smaller than *Odontites verna* subsp. *serotina*; large thin-walled parenchyma cells present in ground tissue of midrib.

***Odontites aucheri* Boiss. (Fig. 3 B)**

*Leaf surface* (TS). Trichomes present on both surfaces, sparse, with glandular and eglandular hairs, glandular hairs (65–75  $\mu\text{m}$ ) formed a stalk with 1- 2 cells and a spherical unicellular head (Fig. 4 D). Subepidermal collenchyma in one layer. *Mesophyll*. composed of 2-3 layers of palisade parenchyma (70–100  $\mu\text{m}$ ) on upper surface giving the outline its dorsiventral, and two layers of spongy parenchyma (17–20  $\mu\text{m}$ ) abaxially. *Midrib*: c. 185–200  $\mu\text{m}$  thick, abaxial surface slightly convex, adaxial surface concave; major veins nonprominent abaxially, with relatively deep groove above major veins., large thin-walled parenchyma cells present in ground tissue of midrib.

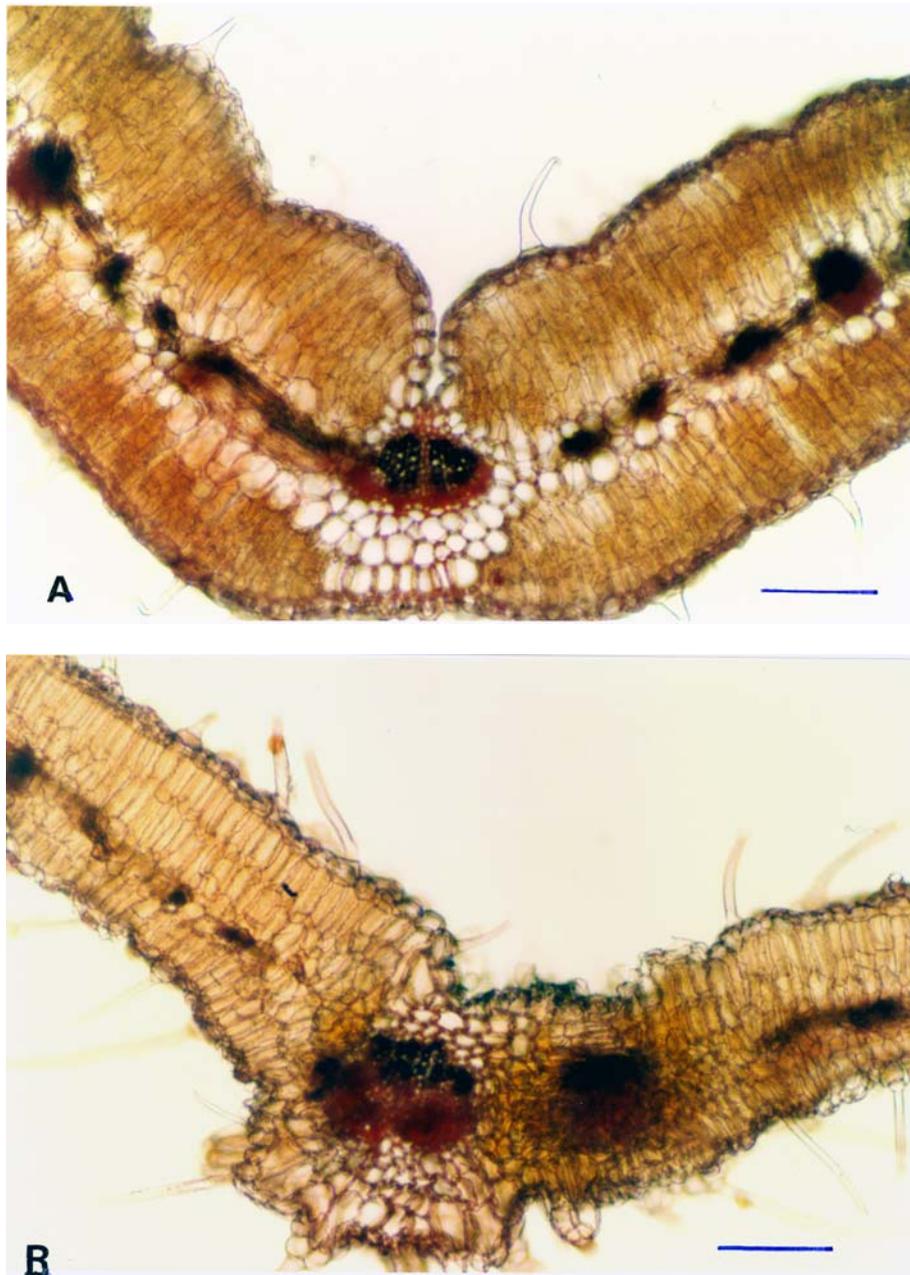


Fig. 2. Transversal sections of leaf lamina of *Odontites* species: A. *O. glutinosa*; B. *O. verna* subsp. *serotina* (Scale bars=100  $\mu$ m).

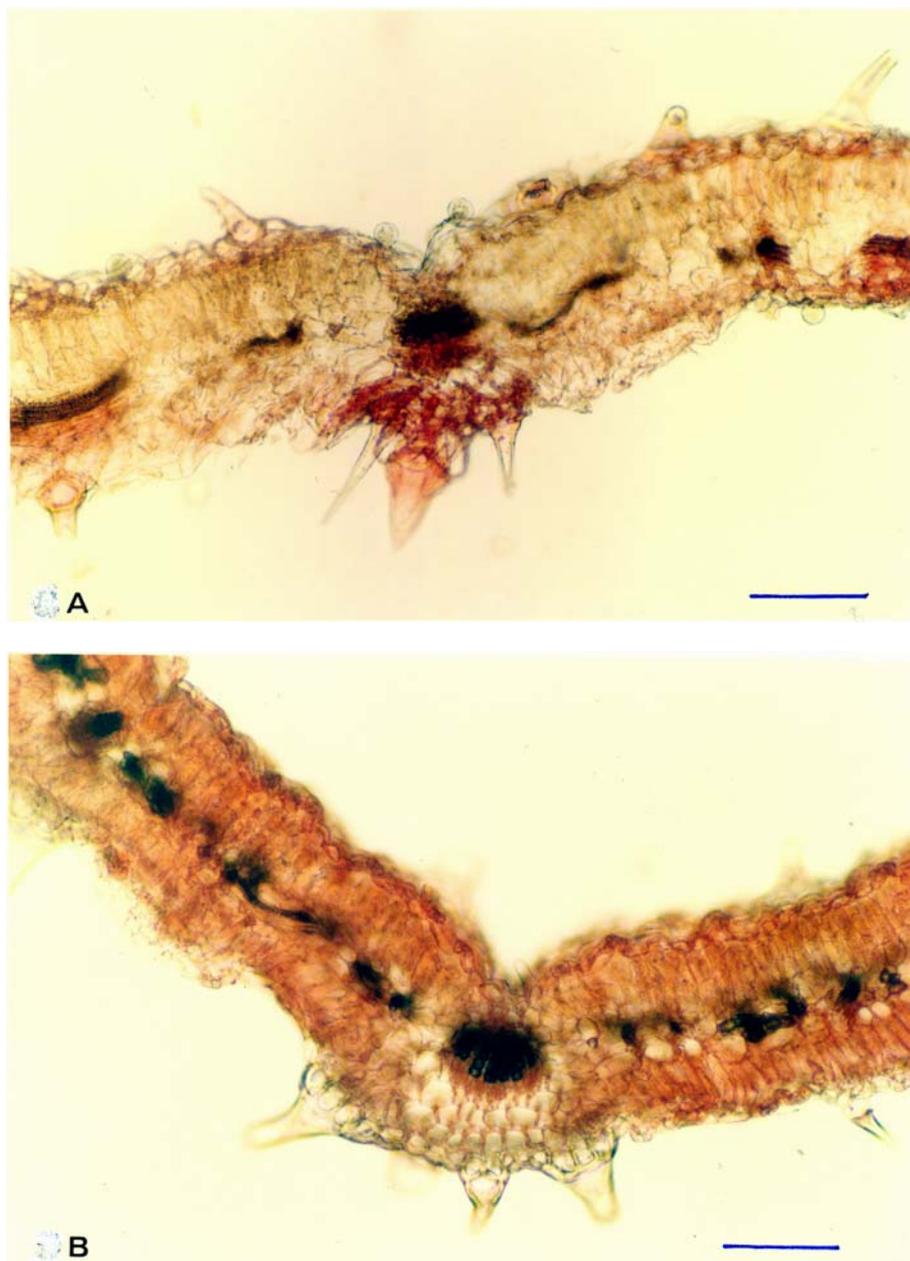


Fig. 3. A. *O. verna* subsp. *verna*; B. *O. aucheri* (scale bars= 100  $\mu$ m).

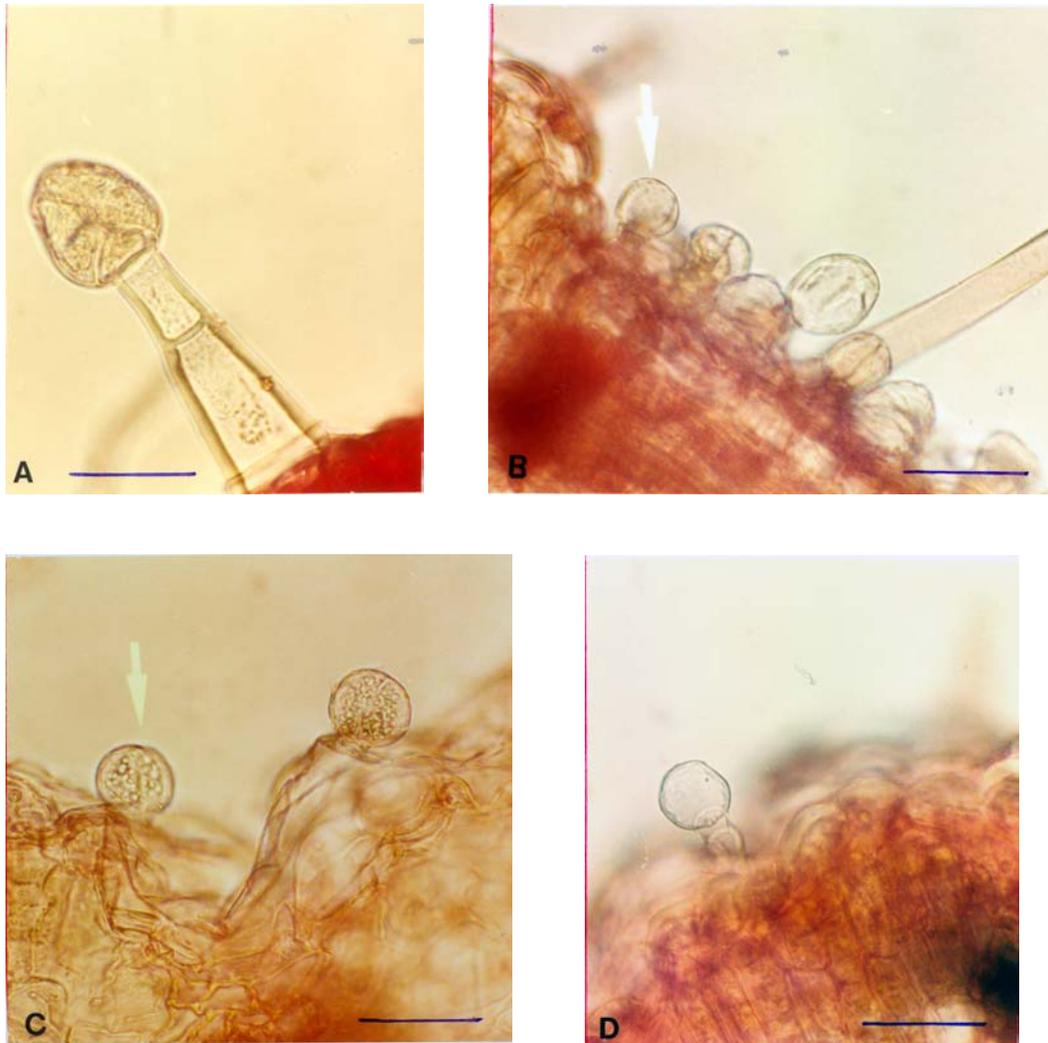


Fig. 4. Glandular hairs of *Odontites* species. A. *O. glutinosa*; B. *O. verna* subsp. *serotina*; C. *O. verna* subsp. *verna*; D. *O. aucheri* (scale bars= 400  $\mu$ m).

### Key to the species

1- Cross section isobilateral, glandular hairs with broadly ovate head, mesophyll with six layers of palisade parenchyma

*Odontites glutinosa*

- Cross section dorsiventral, glandular hairs with spherical head, mesophyll with 2-3 layers of palisade parenchyma 2

2- Glandular hairs > 60 µm long

*Odontites aucheri*

- Glandular hairs < 60 µm long 3

3- Midrib with more than 230 µm thick, Glandular hairs > 25 µm long.

*Odontites verna* subsp. *serotina*

- Midrib with less than 230 µm thick, Glandular hairs < 25 µm long.

*Odontites verna* subsp. *verna*

### DISCUSSION

The importance of leaf anatomical characters in identification of species has been reported for 11 genera of the Turkish *Rhinantheae* (Kaplan, 1999). It was established that leaf anatomy can provide additional characteristic features for separating different genera in this tribe.

No significant difference in stem anatomy has been observed among the *Odontites* species distributed in Iran. There are only minor variation in regarding the shape and size, influenced by ecological conditions.

The result of this study shows that some characters such as length of glandular hairs and the thickness of midrib are important for determination at specific level. For example, *Odontites glutinosa* is easily distinguishable by presence of large glandular hairs, a deep groove above the major veins and six layers of palisade parenchyma. Also the head of glandular hairs of *O. glutinosa* is broadly ovate; whereas three other taxa have spherical head.

*Odontites verna* subsp. *serotina* and *O. verna* subsp. *verna* are similar in general aspects of leaf anatomy, but they can be

distinguished by some features like the thickness of midrib and spongy parenchyma or by length of glandular hairs of leaf. These taxa were considered as two separated species in Flora of the USSR (Golubkova, 1955), but the results presented here do not support this treatment.

*O. aucheri* differs from the other species in less midrib thickness (185–200 µm). Thus, the studied taxa show interspecific variation due to the presence of glandular hairs and midrib thickness.

In conclusion, clear differences exist between the species studied, which makes their identification through a key possible.

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