Anatomical structure of leaves, stems and roots of hemiparasitic plants Thesium ebracteatum Hayne (Santalacea R. Br.) from the Urals

Olga Kiseleva[1,*], and *Ludmila* Trofimova[2]

[1]Russian Academy of Sciences, Ural Branch: Institute Botanic Garden, 620144, Ekaterinburg, Russia
[2] Ural Federal University, Ekaterinburg, 620000, Russia

Abstract. The paper presents the results of structure researches of *Thesium ebracteatum* Hayne. plants from the Ural populations. The anatomic description includes the characteristic of leaves and roots, the stems structure in its top, middle and lower part. Some stomatografic parameters of leaves are calculated. This is the fist anatomical report on the important diagnostics signs of *Thesium ebracteatum* Hayne plants.

1 Introduction

Detailed anatomical studies of *Thesium ebracteatum* Hayne plants from the Urals were not carried out. This species is known from sites in central Europe, European part of Russia, Western Siberia and in the Urals. It is a native herb of forest lawns and thickets of bushes. It is perennial hemiparasitic herb with a subterranean rhizome and numerous storage lateral root with haustorial connections. The aerial shoots annual, erect or ascending at the top, 10-30 cm tall, usually unbranched, glabrous, rarely leafy. At the top of the shoots presents bracts devoid of flowers; leaves linear, glabrous. Inflorescence is a simple, unbranched brush; flower on short stalk with one bract, bracts like the leaves but decreasing in size, perianth tubular, upward strongly wrapped. Capsule on the stalk is elliptical, with longitudinal branching veins, three times larger than the remaining part of the perianth. The paper presents the studies of anatomical structure of the leaf, stem and roots of *Thesium ebracteatum* plants from the Urals populations.

2 Materials and Methods

The plants were collected from the mountainous areas of Middle Ural (Sverdlovsk region) in two populations nearby Nizhnyaya Irga, Ust'-Bayak. Specimens for morphological study were dried according to standard herbarium techniques and stored in the Herbarium of Institute of Plant and Animal Ecology, Ural Branch of the Russian Academy of Sciences (SVER)**.** The materials for anatomical study were preserved in 70% alcohol in the field. Anatomical observations were performed on transverse sections of root and stem (in its top,

* Corresponding author: kiselevaolga@inbox.ru

average and lower part) cut by rotary microtome Microm HM (Carl Zeiss, Germany), and surface sections of leaves cut by hand. All slides were observed by light microscopes Micros (Austria) and Zeiss Axioscopus (Carl Zeiss, Germany). Well-staining sections were photographed. Stomatal index (SI) has been calculated according to Salisbury (1927) [1]. All measurements and observations were made ten times on different slides. All microscopic measurements were made with the aid of an occular micrometer.

3 Results and Discussion

Leaf features of the species are shown in Figure 1. In surface preparations, the epidermal cells are covered by a thick cuticular layer. The leaf is amphystomatic with oval paracytic stomata. Epidermal cell walls are not undulate. The cells of the epidermis are isodiametric and polygonal with straight walls except in the coastal regions where they are narrow, elongated parallel to the veins. Upper epidermal cells have the same size as the lower ones; trichomes are absent, leaf margin with sharp papillae. Stomata orientation was random. Guard cells are elliptical, pores are elongated. Average size of guard cells in microns is 31 in lengths (varies from 16 to 38), 23 in widths (varies from 14, to 35). SI adaxial epidermis 12,8 and abaxial epidermis 11,3. The presens of stomata in adaxial and abaxial epidermis in equal parts may be the adaptive advantages to hemiparasitic nutrition. Lamina is dorsiventral. Mesophyll consists of 1 layer of elongated palisade cells and 2 or 3 layers of isodiametric, spongy parenchymatic cells have small intercellular cavities.

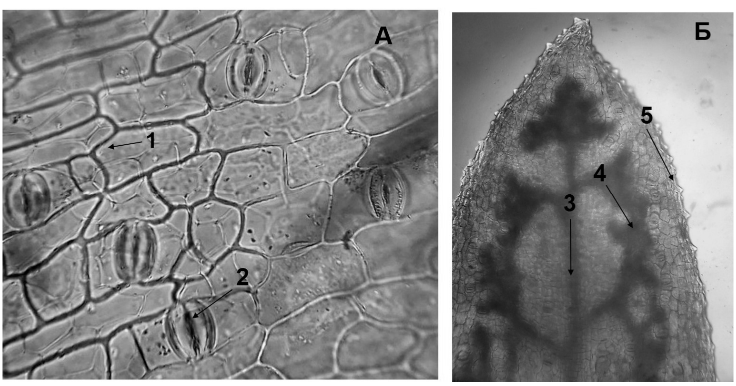

Fig. 1. Anatomical features of *Thesium ebracteatum* leaves. A Lower epidermis X400, Б Surface section of leaf X80. 1 – epidermis cell; 2 – stoma; 3 – Midrib; 4 – vascular bundle; 5 – leaf margin with sharp papillae.

A transverse section taken from the top, middle and lower part of the stem was observed (Fig. 2, 3A). The epidermal cells are covered by cuticular layer, trichomes are absent. Stem cortex consists of 2-5 layers of usually oval cells. Some cortex cells contain secretes at the top and middle part of the stem. The sclerenchimatic sheath is upper the vascular bundles. Cambium is distinguishable. Secondary thickening develops from a conventional cambial ring. In the lower part of the stem secondary thickening tissues predominate. Vascular bundls consists of secondary phloem and xylem. Xylem has vessels. Vessel end-walls are simple. Vessels have not vestured pits. Pith cells are large and spherical. Cavity arises in the middle and lower part of the stem.

The subterranean rhizome structure is similar to those of the stem. A transverse section taken from the lateral roots was observed (Fig. 3Б). The features of the primary structure are retained. The typical primary root is bounded by an exodermis. The centre of the root made up entirely of many-layered cortex, what have cavities and cells with starch. The inner side is an endodermis. Next follows the pericycle, and then the vascular system is in the middle. Vessel wall pittings and thickenings are similar to those of the stem.

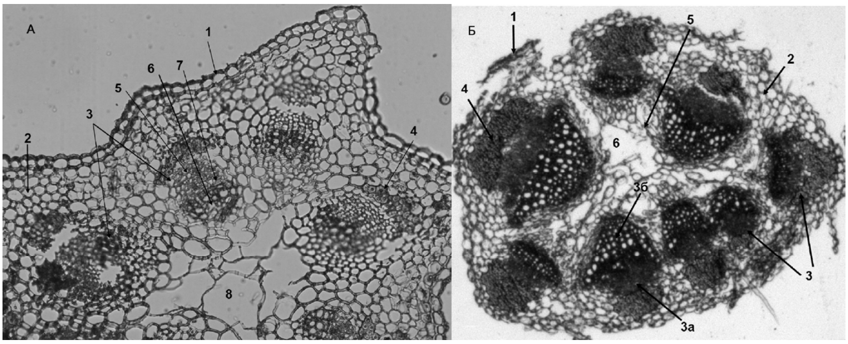

Fig. 2 *Thesium ebracteatum* transverse section of stem A Top part X200 1 – epidermis; 2 – cortex; 3 – vascular bundle; 4 – sclerenchyma; 5 – phloem; 6 – xylem; 7 – cambium; 8 – pith; Б Middle part X100. 1 – epidermis; 2 – cortex; 3 – vascular bundle; 3a – phloem; 3b – xylem; 4 – sclerenchyma; 5 – pith; 6 - cavity.

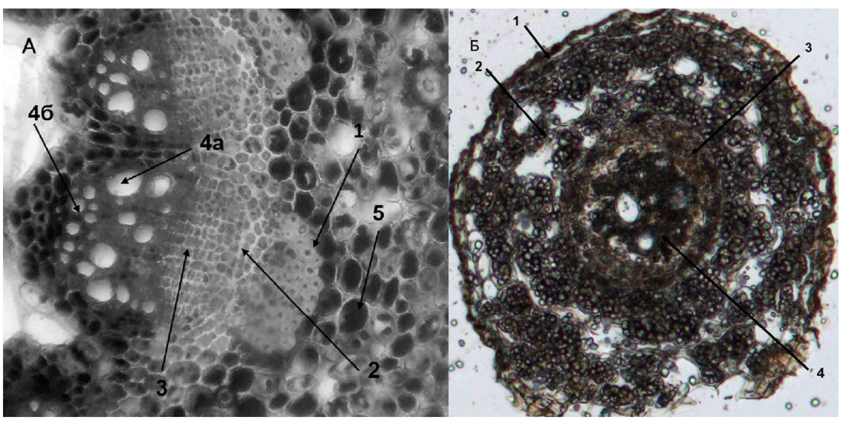

Fig. 3. *Thesium ebracteatum* transverse section of A Stem in the lower part X400. 1 – sclerenchyma; 2 – phloem; 3 – cambium; 4a – secondary xylem; 4б – primary xylem; 5 – starch grains. Б Lateral root X400. 1 – exodermis; 2 – cortex with starch grains; 3 – phloem and pericycle; 4 – xylem.

4 Discussion

Thesium L. with ca. 330 species counts the highest number of species of any genus in *Santalales* [2]. The *Santalaceae* family (*Santalaceae* R.Br.) is represented in Russia by 12 species, 3 species are found in the Urals. All of them are hemiparasitic herbs from the genus *Thesium* L. Several studies demonstrate geographical distribution of *Thesium* species [3-4], biochemical features [5], physiology of host plant-parasitic plant interaction in comparison with others parasitic plants [6], host range and selectivity [7], active ingredients of medicinal material of *Thesium* [8]. This reflects the general trends in the study of the biology of hemiparasitic plants. The analysis of functional features of adaptation to parasitism in plants is considered as importance [9, 11, 14]. The anatomical studies of *Thesium* species in the Urals have never been done before. We performed analysis of available data on the structure of root-hemiparasitic *Scrophs* such as *Rhinanthus*, *Melampyrum*, *Odontites* species and others [10-14] in comparison with *Thesium ebracteatum*. Root-hemiparasitic *Scrophs* have leaves with hydathodes and trichomes [11-13], stems and roots with ring cambium [11, 14] that produce additional xylem tissue embedded lignified xylem parenchyma and deficiently secondary phloem [10]. All roots hemiparasitic plants had haustorial connections, but we noticed that hemiparasitic Scrophs had significant differences from *Thesium* in leaves, roots and stems structure. It is confirmed that not only the parasitic way of life affects the nature of the vegetative organs adaptations. An anatomical structure of leaves, roots and stems reflects primarily belonging to the taxonomic group of hemiparasitic plants.

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