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Structural Features of Vegetative Organs *Spiraea hypericifolia* L., Growing in Uzbekistan

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Abstract

The results of a study conducted by light microscopy methods of the anatomical structure of the vegetative organs of *Spiraea hypericifolia* growing in natural habitat in the Bakhmal district in the south of the Jizzakh region of Uzbekistan are presented and the following diagnostic features are identified: **in the leaf**—isolateral-palisade type of mesophyll leaf; thick-walled outer walls of the epidermis; amphystomatic leaves; not submerged stomata; chlorophyll-bearing palisade and spongy parenchyma; open collateral type of vascular bundles and sclerified, due to collenchymal cells; **in the stem and root**—the beam type of structure and more lignified; the stem and root are divided into three topographic zones: the periderm (cork), the secondary cortex and the central cylinder; the periderm is represented by a cork and its cells are dark brown, thick-walled, tightly closed; groups of bast fibers are formed under the cow parenchyma; extensive librimiform; core and radial rays elongated and short; the phloem is extensive, located between the cortex parenchyma and libriform; the narrow core is represented by large and small, round-oval, thin-walled parenchymal cells and they contain hydrocytic cells. Diagnostic signs revealed by us reflect more xeromorphic of this species. All traits were compared, and we concluded that the anatomical traits of the leaf, stem, and root may be useful in providing diagnostic traits for distinguishing the taxa studied.

Keywords

Anatomy, Vegetative Organs, *Spiraea hypericifolia*, Jizzakh Region, Uzbekistan

1. Introduction

The genus *Spiraea* L. (meadowsweet, spiraea) belongs to the family Rosaceae

Juss. the subfamily *Spiroideae* Agardh., which consists of 80 - 100 species [1] [2], of which 5 are found in the flora of Uzbekistan [3]. The genus is divided into 3 [1] [4] - 4 sections [2].

Currently, the most common classification is the division of the genus Spiraea L. into three sections: Sect. I *Chamaedryon* Ser., Sect. II *Calospira* K. Koch. and sect. III *Spiraria* Ser. [5]-[10].

Section *Chamaedryon* Ser. includes shrubs characterized by flowering in spring or early summer. They have white flowers, which develop from the buds of biennial shoots and collected in corymbose and umbellate inflorescences.

Section *Calospira* C. Koch. includes species, compared with the previous ones, blooming later in the beginning and in the middle of summer. Flowers are collected in corymbose panicles having a white or pink color. Inflorescences develop on biennial shoots and are located at the ends of the side shoots or on the shoots of the current year.

Section Spiraea Ser. includes late flowering species of spiraea—bloom in late summer and early fall. Inflorescences are pyramidal panicles that develop at the ends of the shoots of the current year, formed at the base of the bush or on old branches.

Species from the *Chamaedryon* Ser section grow in the flora of Uzbekistan: *Spiraea chamaedryfolia* L., *Spiraea media* Fr. Schmidt, *Spiraea hypericifolia* L., *Spiraea pilosa* Franch. and *Spiraea japonica* L. [3].

In addition, many species of the genus *Spiraea* are honey plants and sources of medicinal raw materials. Ascorbic acid, carotene, alkaloids, flavonoids, saponins, tannins were found in various parts of these plants. *Spiraea* can also be used as soil-strengthening plants [11]-[18].

Many species bloom abundantly and for a long time, are unpretentious and breed easily. They are diverse in height, color of flowers, the form of inflorescences and timing of flowering. Among the spires, you can choose the type and variety for every taste and for a particular planting site, they are considered the best of the bushes for landscaping [19].

Sokolova, A. V. [20] provides a comparative analysis of the structure of the stem and leaf of two closely related species of the Spiraea L. section of the genus Spiraea L., growing in the Amur Region. For the first time the most important diagnostic features that can be used for interspecific diagnostics are identified. It was established that the stems of the species of the Spiraea section can be diagnosed only by the structure of the core, as well as a number of quantitative characters. The leaves of the studied species are well diagnosed by the thickness of the leaf blade in the region of the middle vein and in places remote from the veins, the thickness of the columnar mesophyll, the presence or absence of trichomes.

The anatomical structure of the vegetative organs of *Spiraea hypericifolia* has not been studied in Uzbekistan.

The aim of our study is to study the anatomical structure of the leaf, stem and root of *Spiraea hypericifolia* in order to determine the diagnostic signs and loca-

lization of medicinal substances of the vegetative organs of this studied species.

S. hypericifolia L.— *T. hypericum*. Shrub 50 - 150 cm tall, with thin, often long twig-shaped, brown shoots, carrying numerous closely spaced, sedentary flower umbrellas. Leaves are 10 - 25 mm long and 1.5 - 8 mm wide, bare or young, shortly pubescent, oval, oblong-elliptical or lanceolate, with a blunt or sharp tip, wedge-shaped narrowed to short, 1.5 - 5 mm long, petioles, whole at the base of umbrellas, on sterile shoots often with 2 - 5 teeth on top. Umbrellas are sessile, at the base with a rosette of leaves; 4 - 10-flowered, pedicels 6 - 15 mm long, bare or slightly fluffy, with fruits up to 18 mm. Sepals are triangular, erect with fruits, 2 - 3 times shorter than leaflets, corolla 5-8-(9) mm in diameter. Leaflets are naked or fluffy with a column extending from the top from the dorsal side. It flowering in May-June, bears fruit in July-August. It grows along mountain slopes among shrubs, in juniper forests, along the banks of mountain rivers, Tashkent and Samarkand regions. Generally distributed in Central Asia (all mountainous regions and in the steppes of its northern part), Western Siberia, the European part of the USSR, the Caucasus, and Northwest Mongolia [3].

2. Materials and Methods

The objects of study are the perennial shrub *S. hypericifolia* of the genus Spiraea from the family Rosaceae Juss., Growing in the Bakhmal district in the south of the Jizzakh region of Uzbekistan. The material was collected from the natural location of the Bakhmal district of the Jizzakh region of Uzbekistan (**Figure 1**).

The Bakhmal district of the Jizzakh region has a moderately warm climate. Jizzakh has a lot more rainfall in winter than in summer. Throughout the year, there is little rainfall in Jizzakh. The average annual temperature is −15.6˚C. The average rainfall per year is 370 mm.

Simultaneously with the morphological description, the vegetative organs (leaf, stem and root) were fixed in 70˚ ethanol for anatomical study. A manual method was used to prepare slices of the vegetative organs. Cross sections of the leaf, stem and root were prepared manually using a safety razor. Cross sections of the leaf are made through the middle and the stem and root through the base. Sections were stained with methylene blue and safranin, followed by gluing in glycerol-gelatin [21]. Descriptions of the main tissues and cells are given according to C. Esau [22], N. S. Kiseleva [23], the epidermis—according to S.F. Zakharevich [24]. Microphotographs were taken with a Canon A123 digital camera microphotograph with a Motic B1-220A-3 microscope.

3. Results and Discussion

The leaves of *Spiraea hypericifolia* are naked or young in their hair, shortly pubescent, oval, oblong-elliptical or lanceolate, with a blunt or sharp tip.

Our studies have shown that the presence or absence of trichomes can serve as an informative sign. In *S. hypericifolia* trichomes are simple, opaque, awl-pointed, very rarely located along large veins (**Figure 2**). The length of the

Figure 1. General view of *Spiraea hypericifolia*, growing in the Bakhmal district of the Jizzakh region of Uzbekistan.

trichomes on the upper and lower sides of the sheet is different. So, in the upper epidermis, the hairs are longer than the lower ones.

The mesophyll of the leaf on the cross-section of the isolate-palisade type, which is represented by 2 - 3 rows of palisade cells on both sides of the leaf and a spongy layer of different thickness between them. The epidermis is represented by one row of cells with a thick-walled cuticle layer. Adaxial epidermal cells are larger than abaxial.

An assimilation tissue consisting of palisade and spongy cells is located between the adaxial and abaxial epidermis. The palisade parenchyma is chlorophyll-bearing, large and elongated, which consists of 2 - 3 rows of cells and is located between the adaxial and abaxial leaf epidermis. The spongy chlorophyll-bearing parenchyma consists of 3 - 4 rows and is located between the palisade parenchyma. The spongy parenchyma is round, small-cell with small cavities.

Between palisade and spongy cells are lateral vascular bundles. The main vascular bundles protrude on the abaxial side and are located in the central part of the leaf mesophyll. Conducting bundles are sclerified due to the presence of mechanical tissues (collenchyma) in them (**Figure 2**).

Under the abaxial epidermis and above the main vascular bundles there is a 4 - 5 row lamellar collenchyma. Large and small conductive beams alternate with each other. Vascular bundles of open collateral type, numerous, consisting of phloem and xylem (**Figure 2**).

The base of the stem on the cross section is rounded, beam type. The structures of the stems of woody plants are due to many years of active activity of the

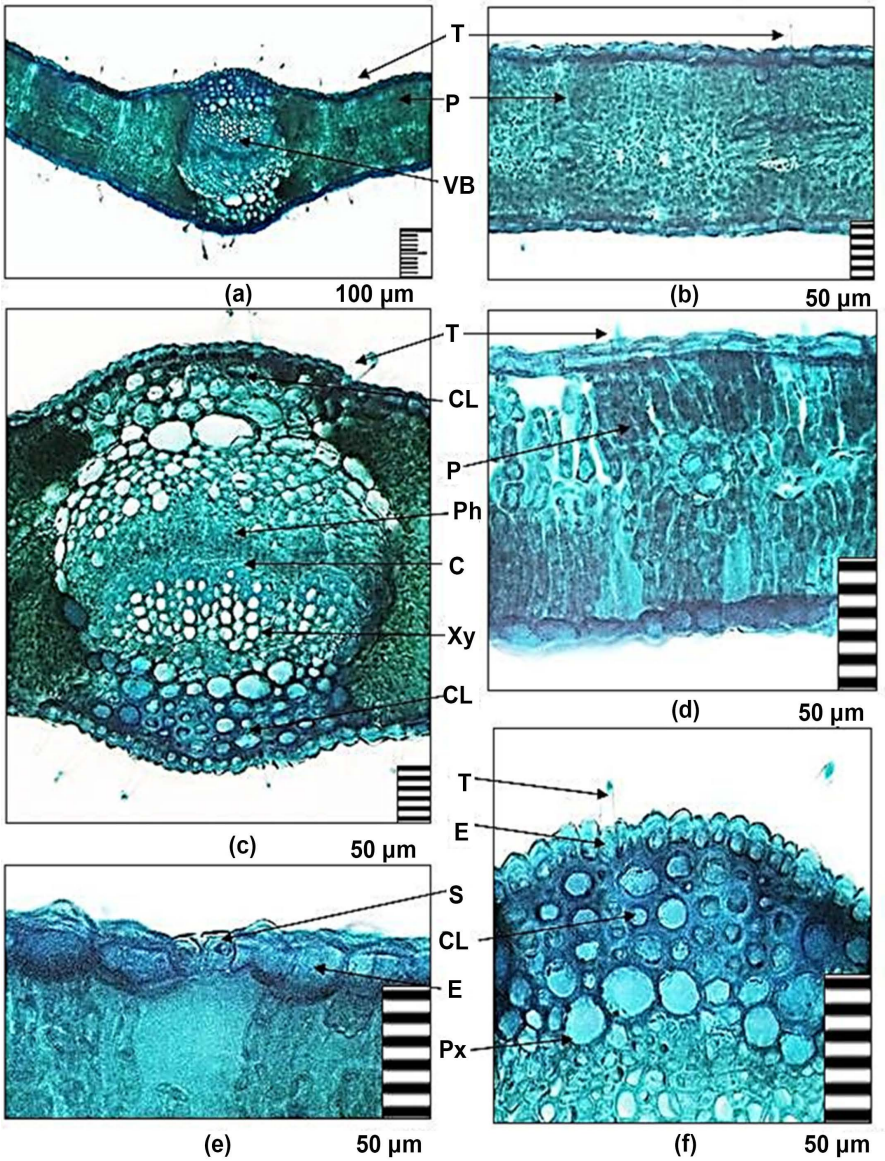

Figure 2. Anatomical structure of the leaf of *Spiraea hypericifolia* in a cross section: (a) General view of the leaf mesophyll; (b)-(d) Detail; (c) Vascular bundles; (e) Not submerged stomata; (f) Epidermis and collenchyma in the main conducting bundles. Legend: CL—collenchyma, C—cambium, E—epidermis, P—palisade parenchyma, Ph—phloem, S—stomata, T—trichome, VB—vascular bundles, Xy—xylem.

apical and lateral meristems. Therefore, the trunk and side branches of these plants are significantly thickened. They are powerful, highly lignified, with the early development of secondary integumentary tissue (**Figure 3**).

The anatomical structure of the stem is divided into three topographic zones: the periderm (cork), the secondary cortex, and the central cylinder (**Figure 3**).

The integumentary tissue—the cork consists of several rows of radially located cells with thick cork-covered membranes. The integumentary tissue is represented by a cork. Its cells are dark brown in color, thick-walled, densely closed. Outwardly, upon division by tangential septa, the cells of the phellogen

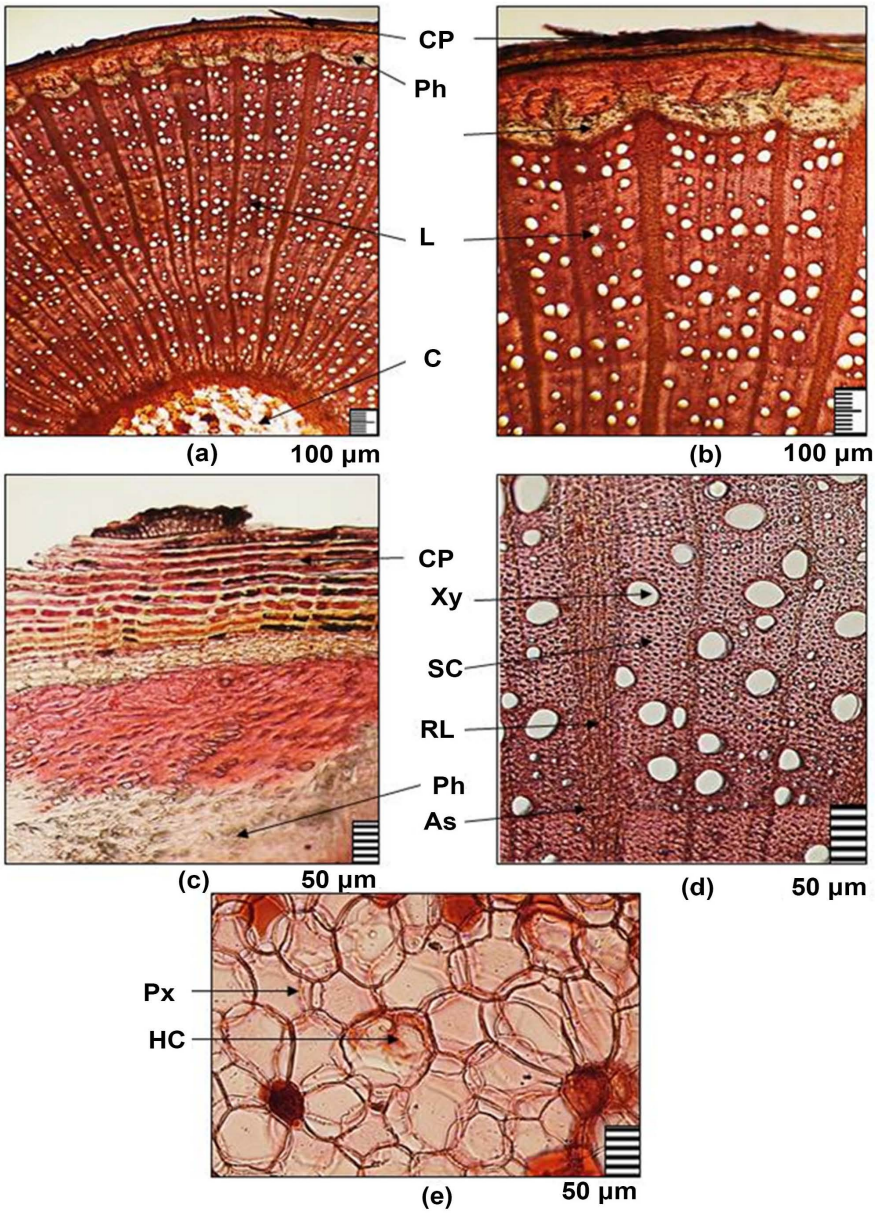

Figure 3. Anatomical structure of the stem of *Spiraea hypericifolia* in a cross section: (a) General view of the stem; (b) Detail; (c) Cow parenchyma; (d) Secondary vascular bundles; (e) The core. Legend: C—core, CP—cortex parenchyma, As—annual shoot, HC—hydrocytic cells, L—libriform, Ph—phloem, Px—parenchyma, RL—radial rays, SC—sclerenchyma, Xy—xylem.

are formed by the cells of the tube, and inside—the cells of the phelloderm. The complex of the phellogen, phellem and phelloderm makes up the periderm.

Under the periderm is a round-oval secondary cortical parenchyma, which consists of 5 - 6 rows and remains throughout. Under the parenchyma of the cow, groups of bast fibers form. The phloem is extensive, located between the cow parenchyma and librimiform.

Wood occupies a continuous cylinder surrounding the core, which is located centrally in the stem. The outer cells of the core are called the perimetric zone. It

is represented by smaller, thick-walled cells densely closed with each other.

Primary conductive tissues are preserved in the stem, and then the secondary ones immediately form a continuous cylinder, which in the cross section looks like an almost continuous ring. With age, the emerging cambium changes the anatomical structure of the stem. It annually produces secondary xylem (wood). Towards the xylem, the cambium works more vigorously, pushing the primary xylem to the core.

Continuous and rhythmic activity of cambium causes the "layering" of wood. In it, the boundaries between annual growths (annual rings) are clearly distinguishable. This is due to differences in the composition and structure of histological elements formed from cambium at different times of the year. By the number of tree rings, you can determine the age of the plant. The secondary xylem, which occupies a large part of the section, is easy to determine, since its cells are stained red-brown (**Figure 3**).

It is represented by tracheid's located in radial rows and multi-row, elongated and short core rays. The core is not wide, it is represented by large and small round-oval, thin-walled parenchymal cells and they contain hydrocytic cells (**Figure 3**).

The root is the axial organ of a plant that has radial symmetry, has unlimited long growth, has root hairs and a cap and does not form any other organs on itself. The main functions of the root are the absorption of water and minerals dissolved in it from the soil, the attachment of the plant organism to the substrate and the synthesis of organic substances (amino acids, nucleotides, hormones, enzymes and alkaloids). In addition, he performs other functions: the supply of nutrients, respiration, vegetative propagation, communication with soil microorganisms.

The base of the root on the cross section is round, bundled type, more lignified. In the anatomical structure of the roots of the studied species, three main zones can be distinguished: the periderm, the secondary cortex, and the central cylinder. Primary cortex with secondary thickening of the root is usually broken and dies. The integumentary tissue is a cork; at large roots, the cork replaces the cork. Perennial root with a multilayer crust, including large numerous groups of bast fibers and periderm (**Figure 4**).

The periderm is three-layered, consists of the phellogen, phellem, and phelloderm. Phellogencells are rectangular flattened in the radial direction and passing from the outside to the phellem cells, inside the cell of the phelloderm, the latter is clearly distinguished from the cells of the inner cortex by a larger size and rectangular flattened in the radial direction. Under the periderm is a round-oval secondary cortex parenchyma, which consists of 4 - 5 rows and remains throughout (**Figure 4**).

Under the parenchyma of the cow, groups of bast fibers form. The phloem is extensive, located between the cortex parenchyma and libriform (**Figure 4**).

Wood occupies a continuous central root cylinder. The root retains the primary conductive tissues, and then the secondary ones immediately form a

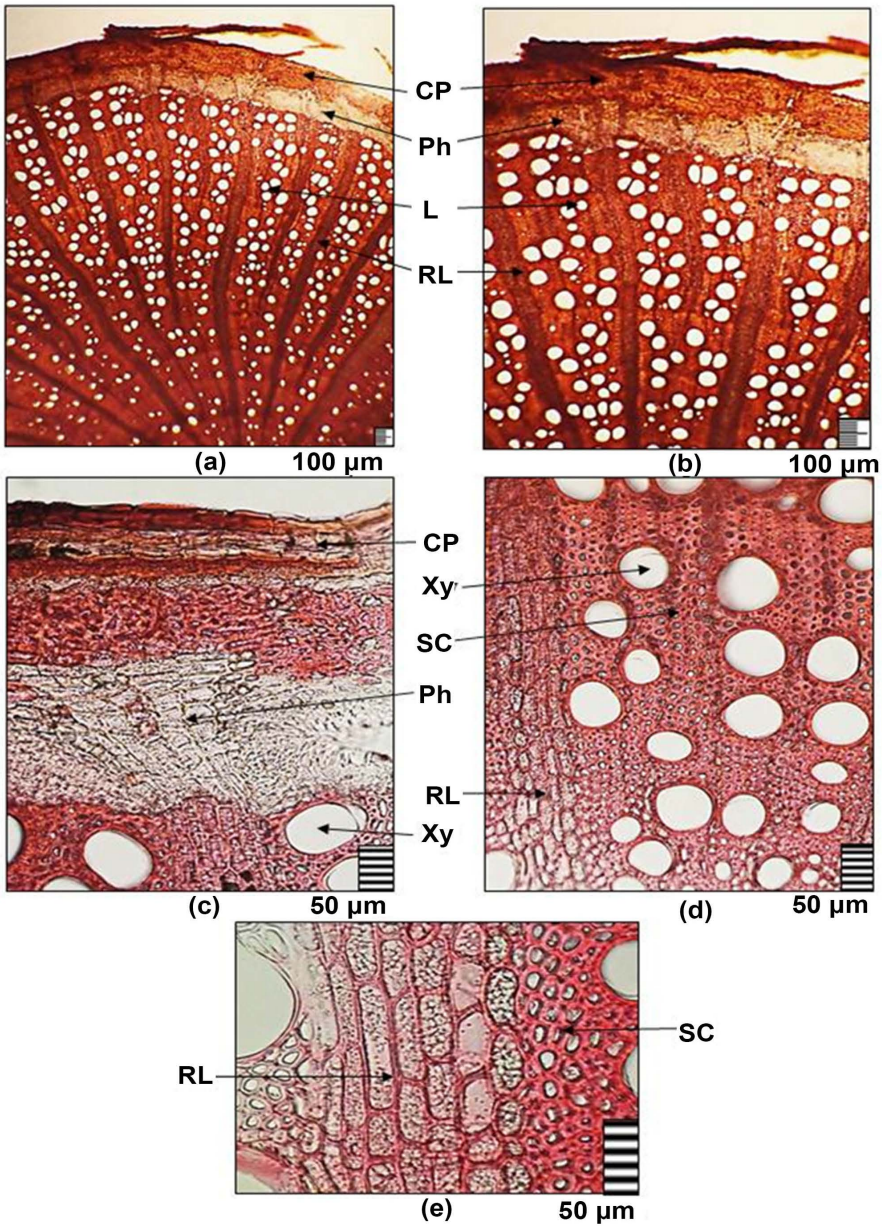

Figure 4. Anatomical structure of the root of *Spiraea hypericifolia* in a cross section: (a) General view of the stem; (b) Detail; (c) Cow parenchyma and phloem; (d) Secondary vascular bundles; (e) Radial rays. Legend: CP—cortex parenchyma, L—libriform, Ph—phloem, RL—radial rays, SC—sclerenchyma, Xy—xylem.

continuous cylinder, which in the cross section looks like an almost continuous ring. Libriform fibers are often thick-walled, with 3 - 5-angled or rounded gaps.

The secondary xylem, which occupies most of the section, is easy to determine, since its cells are stained red-brown. The vessels in the secondary xylem are larger, with thickened walls. It is represented by tracheid's located in radial rows and radial rays. Radial rays are 10 - 13 in row; their cells are elongated, filled with tannins (Figure 4).

Thus, the anatomical structure of the vegetative organs of *Spiraea hypericifo-*

lia was studied and diagnostic signs were determined. In the leaf there is an isolated-palisade type of mesophyll leaf; thick-walled outer walls of the epidermis; amphystomatic leaves; unloaded stomata; chlorophyll-bearing palisade and spongy parenchyma; open collateral type of conducting bundles and sclerified, due to collenchymal cells. In the stem and root—the beam type of structure and more lignified; the stem and root are divided into three topographic zones: the periderm (cork), the secondary cortex and the central cylinder; the periderm is represented by a cork and its cells are dark brown, thick-walled, tightly closed; groups of bast fibers are formed under the cow parenchyma; extensive libriform; core and radial rays elongated and short; the phloem is extensive, located between the cortical parenchyma and librimiform; the narrow core is represented by large and small, round-oval, thin-walled parenchymal cells and they contain hydrocytic cells. Diagnostic signs revealed by us reflect more xeromorphic of this species. All characters were compared, and we concluded that the anatomical features of the leaf, stem, and root may be useful in providing diagnostic features to distinguish between studied taxa. Diagnostic signs that we have identified reflect xeromorphic, which shows the widespread prevalence of these species in natural habitat and is also considered the best of shrubs for landscaping in ornamental horticulture and forestry. An anatomical study of the vegetative organs revealed the presence of drugs (ascorbic acid, carotene, alkaloids, flavonoids, saponins), and tannins in the leaf mesophyll, stems of the secondary cortical parenchyma and parenchymal core cells, and their localization was confirmed on the basis of anatomical images. Detected diagnostic signs are used in pharmaceuticals in the process of identifying raw materials.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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