GEORGIAN BIOMEDICAL NEWS

ISSN (Online): 2720-8796 ISSN (Print): 2720-7994 VOLUME 1. ISSUE 2. APRIL-JUNE 2023

Microstructural Features of Primula woronowii Losinsk., Primula macrocalyx Bunge. and Primula saguramica Gavr. from Georgian Flora

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ABSTRACT

DOI: 10.52340/GBMN.2023.01.01.17

Background: The characterization and study of plants begin with the study of morphological and micro-diagnostic signs. It is essential to determine the common and distinguishing features of the species of the genus Primula to facilitate their identification.

Objectives: The paper presents the macro- and micromorphological characteristics of three species of the genus Primula L.: P. woronowii Losinsk., P. macrocalyx Bunge, and P. saguramica Gavr. In addition, based on the microstructural and anatomical characteristics, the paper distinguishes between two closely related species: P. macrocalyx Bunge and P. saguramica Gavr.

Methods: Microstructural research on experimental samples was carried out using standard laboratory methods adopted in microtechnology. The microtechnical investigation used light microscopes (Carl Zeiss, Jeneval, and Omax). Materials were documented using a digital camera (Canon Digital IXUS 75), and microphotographs were graphically processed in the Adobe Photoshop CS5 program.

Results: Based on the data, the following common and distinguishing microstructural features of P. woronowii, P. macrocalyx, and P. saguramica were established: The basal cells of the epidermis of the leaf of the studied species are non-circular, with a curved and curved-walled structure; The ventilation system is simple, a normocytic structure; the leaf is bifacial Dorsoventra luri, amphistomatous (P. woronowii, P. saguramica), and hypostomatic (P. macrocalyx); Conductive tissue both in the leaf and the aboveground axis organs has an open, collateral, vascular fiber structure; P. macrocalyx and P. saguramica, which are closely related by macro- and micromorphological characteristics, can be separated by the anatomical structure of the mesopetiole zone of the leaf stalk and the structural elements of the wood in the central cylinder of the root.

Conclusions: Common and distinguishing features of all three species were identified: The basal cells of the upper and lower epidermis of the leaves of P. woronowii, P. macrocalyx, and P. saguramica are non-stitched, curvilinear, and curved-walled; also, a chaotically arranged stomata apparatus differentiated into a simple, anomocytic type is typical for all three species, and the presence of a cystolith in the cells of the upper epidermis of P. woronowii leaf is observed. In all three species of petiole xylem, there are large, oval-shaped openings surrounded by mechanical-type cells. Small-caliber spaces in P. woronowii and P. saguramica are arranged longitudinally, while in P. macrocalyx, they are arranged asymmetrically with differentiated spherical lumens. The cross-section of the axial organs of the flower is oval or spherical in outline; the flower stem, but not the stalk, is characterized by the obliteration of medullary cells; P. saguramica collenchyma is of a mixed type, while P. woronowii and P. macrocalyx have lamellar collenchyma. Endodermal cells of P. saguramica have clearly expressed Casparian strips, but in the P. woronowii and P. macrocalyx endoderm, they are less apparent; the central cylinder of P. woronowii and P. macrocalyx is pentarcular, while P. saguramica tends to have a multi-beam xylem structure. In all species, the cells of the central tissue of the crown petals are exceptionally thin-walled, isocytic, and surrounded by dense epidermal tissue; their transitional tissue is incomplete; only the lumens of the conducting vessels of the xylem are visible.

Keywords: Microstructural analyses; Primula L.; Primula macrocalyx; Primula saguramica; Primula woronowii.

BACKGROUND

The Primula family includes 59 genera and up to 697 species,[1] most of which are distributed in the northern countries of the temperate climate zone; In Georgia, this family is represented by 46 species of 7 genera.[2-4] There are 22 species of Primula in Georgia, 12 of which are endemic to the Caucasus, and two, Primula abchasica and Primula saguramica, to Georgia.[2-4] In Georgia, Primulas are distributed from the plains to the subnival belt, but most species grow in alpine meadows and forests.[3] Primula species belong to the cosmopolitans of mesophytic forests and open meadow zones. Like all ephemerides, they can concentrate biologically active compounds. For example, Primula L. species contain saponins, essential oils, glycosides, and vitamins. Accordingly, they treat avitaminosis and infectious and inflammatory diseases of the respiratory tract.[5,6] Special regularities in the organization of the internal structure of a plant are the most important factor determining its nature. Therefore, thoroughly investigating a plant's structural patterns is very important. The study includes three species of Primula of the flora of Georgia - P. woronowii Losinsk. - he P. macrocalyx Bunge, and P. saguramica Gavr. - the study of the relative anatomical structure of aboveground and underground vegetative and generative organs to determine additional

diagnostic signs that allow the identification of these species.

METHODS

Primulas are perennial herbaceous plants with leaves in a rosette at the root collar. The flowers mostly form an umbrella at the tip of the flower stem. P. woronowii is an endemic plant of the Caucasus with slightly wrinkled, sessile leaves covered with often reddish, rather long and dense, split villas.[2-4]

The leaves of P. woronowii are narrowly lobed in a winged stalk, blunt-pointed, unevenly toothed on the edges, and covered with split villas on both sides. The flower stalks are usually longer than the leaves and upright or slightly bowed. The cyst is cylindrical, with a tube 9–10 mm long and lanceolate with acuminate or acuminate, erect teeth 5–6 mm long. The Corolla is bright pink, pink-purple, white, or various shades of purple. There is a small yellow spot in the throat. Crown's contra flexures are quite deeply carved. The fruit capsule is much shorter than the calyx.[3]

In the flowering phase, the flower stalk of P. macrocalyx is longer than the leaves and has a multi-flowered umbel. Leaves, flower stalk, peduncle, and calyx are more or less covered with short, split villas that are less dense on the upper than on the lower part of the leaf. The leaves of P. macrocalyx are wrinkled, ovate or oblong-ovate, gradually or more rarely narrowed in a winged stalk. The leaves are heart-shaped at the base and blunt-pointed, round-toothed, or cut-out round-toothed at the edges, characterized by an intense increase in size during fruiting. The calyx of the species is a wide, obovate sepal, gradually greatly expanded from the base to the tip; the calyx teeth are about twice as short as the tube; and they are ovate-triangular in shape, shortly acuminate, or often ending in a short spike. The crown is golden-yellow, its tube length is equal to or slightly longer than the calyx, the corolla lobe is 10–20 mm in diameter, and the lobes are wide. Sepals are lanceolate and shorter than the flower stalk. The flower stalks are 8–20 mm long, and the calyx is almost twice as short.[3]

P. saguramica is an endemic species of Georgia; its floral axis, sepals, flower stalks, and calyx are covered with long, separated split villas.[2-4] The species' leaves are wide elliptic, gradually narrowing in the lower part and turning into a very narrow stalk. The lower side has more villas, is yellow, and is covered with sessile glands. The leaves are blunt-pointed, the edges are unevenly carved, and they have thin, sharp-toothed lips. The flower axis is longer than the leaves, the flower stalks are 8–15 mm long, and the umbel consists of 4–7 flowers. The crown is yellow; its style's length exceeds the tooth calyx, and the diameter of the crown is 12–18 mm, with incised features. Sepals are linear, pointed, of unequal length, lanceolate at the base, and shorter than the flower stalk. The fruit capsule is noticeably shorter than the 8–9 mm long calyx, which is cylindrical, ovate, or broadly triangular-lanceolate, acuminate, and straight after flowering, with 5–6 mm long teeth.[3] P. woronowii and P. macrocalyx were collected in the floristic region of Kartli (Saguramo-Zedazeni meadows of forest-park edges), in the phase of active flowering: P. woronowii N41.88569 0 E044.78534 0, H-891 m, and P. macrocalyx N41.88639 0 E044.78821 0, H-990 m. P. saguramica was taken from Karsani village oak shrub forests on the eastern slope of the Tbilisi ridge, N41.83332 0 E044.71202 0, at H-798 m. Reference specimens are kept in the herbarium of the TSMU Iovel Kutateladze Institute of Pharmacochemistry: P. woronowii (PH-21166), P. macrocalyx (PH-21329), and P. saguramica (PH-21749) (Fig. 1).

FIGURE 1. P. woronowii (A), P. macrocalyx (B) and P. saguramica (C) reference specimens

Microstructural research on experimental samples was conducted using standard laboratory methods adopted in microtechnics.[5] Transverse, longitudinal, and superficial slices were prepared from the central areas of the underground and aboveground vegetative and generative organs of the plants. In the case of P. macrocalyx and P. saguramica, slices were made from dry and subsequently softened material, while P. woronowii preparations were made from live, unfixed material with a sharp razor blade. Slices were stained in a safranin solution for 24 hours and then mounted in glycerine on a glass slide. The microtechnical investigation used light microscopes (Carl Zeiss, Jeneval, and Omax). Materials were documented using a digital camera (Canon Digital IXUS75), and microphotographs were graphically processed in the Adobe Photoshop CS5 program.

RESULTS

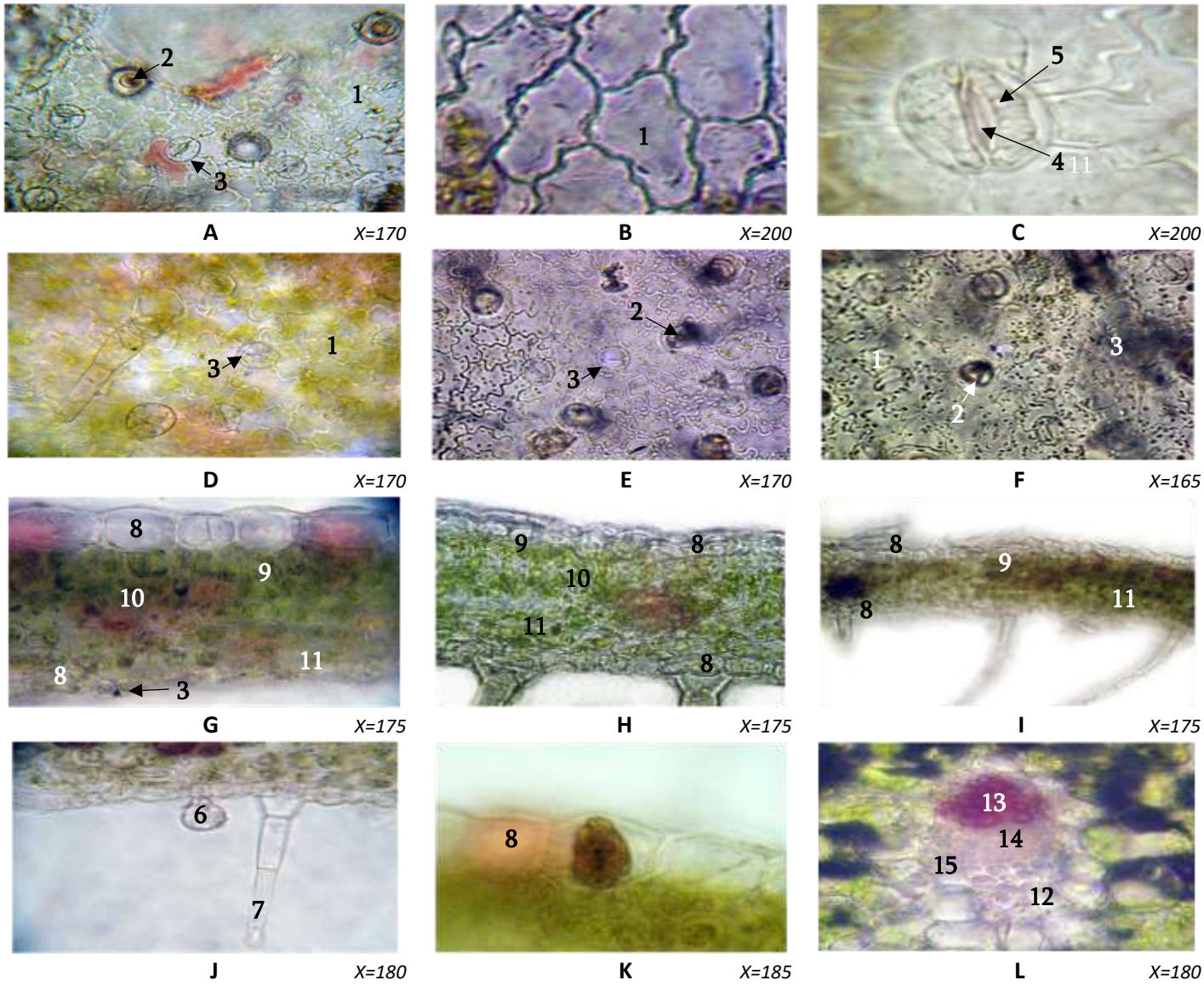
Leaf

The leaf plate of the studied species of Primula is bifacial, with a dorsoventral structure. Regarding stomata distribution, leaves of P. woronowii and P. saguramica have amphistomatic architecture, while P. macrocalyx has hypostomatic architecture. Leaves are abundantly covered with secretory, spherical, single, or multi-celled (3–8) villas.

ISSN (Online): 2720-8796 ISSN (Print): 2720-7994

In the abaxial covering tissue of the leaves of P. macrocalyx and P. saguramica, traces of numerous trichomes are reflected in the form of two contoured arcs. The basal cells of the upper and lower epidermis of taxa are non-stitched, curvilinear, and curved-walled in configuration. Considering the direction of the stomatal pore, a chaotically arranged, simple, anomocytic type of stomata apparatus is differentiated in the abaxial epidermis of the species leaf. The leaves of P. woronowii and P. macrocalyx have spherical stomata, while those of P. saguramica are oval in outline. The thickening of the stoma membrane of P. woronowii is equal, the stomatal pores are finger-shaped, and the chlorophyll in the guard cells is small-grained. P. macrocalyx stomata are significantly smaller; their guard cells are thick and linear; the aperture opening is straight and short; and the chlorophyll in the guard cells is small-grained, like in P. woronowii. The guard cells of P. saguramica are linear, the aperture is fusiform, and the chlorophyll in the guard cells is coarse-grained (Fig. 2).

FIGURE 2. Features of the internal structure of the leaf



Interpretations: **A**. P. woronowii, **B**. P. macrocalyx and **C**. Upper epidermis of P. saguramica; **D**. of P. woronowii, **E**. of P. macrocalyx and **F** lower epidermis of P. saguramica; **G**. P. woronowii, **H**. P. macrocalyx, and **I**. P. saguramica leaf mesophyll; **J**. P. woronowii, B. _ of P. macrocalyx, and C. _ trichomes arranged on the covering tissue of P. saguramica; **K**. _ differentiated cystolith in the epidermal cell of P. woronowii; **L**. of P. woronowi , B. of P. macrocalyx, and C. Collateral-type fibrovascular- conducting bundle located in the pulp of the leaf of P. saguramica. 1. Non-stitched, curvilinear, and curved-walled basal cells of the epidermis; 2. Traces of trichome cutting; 3. Anomocytic stoma; 4. Finger-shaped stomatal aperture; 5. Coarse-grained chlorophyll; 6. Sphere-headed one- and 7. Multi-celled villi; 8. Upper and lower epidermis; 9. Palisade, 10. Atypical palisade and 11. Cloudy parenchyma; 12. Covering fabric; 13. Xylem; 14. Phloem; 15. Mechanical cells.

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ISSN (Online): 2720-8796 ISSN (Print): 2720-7994

The covering tissue of the leaf of the studied species is cutinized, the epidermis is single-layered, and the size of the adaxial epidermal cells is significantly greater than the size of the abaxial epidermal cells. The presence of cystolith was observed in the upper epidermis of the leaf of P. woronowii. In the covering tissue of the leaf of all three species, the stomata arrangement is slightly elevated compared to the epidermal cells. Leaf's palisade is single-layered, as is its arrangement of atypical, messer-like cells. Cells of spongy parenchyma form a dense layer. In the pulp of the leaf of the taxa, open, reverse-collateral, fibrovascular bundles, and anastomoses are present in the surrounding tissue. Spirally thickened conducting vessels are differentiated in the xylem conducting bundles (Fig. 2).

The main vein of the P. woronowii leaf is short and wide, conical in outline; that of P. macrocalyx is spear-shaped; and that of P. saguramica has a wide cone shape. The main vein of the taxa is covered with conical, multicellular (3-5 or more) trichomes with secretory heads. The epidermal cells of P. woronowii and P. macrocalyx leaves are isocytic, while P. saguramica has a heterocytic structure. In the case of taxa, cells of cutinized, narrow, uniform shape or, in the case of P. saguramica, cells of non-uniform size and body are closely interrelated. Lamellar collenchyma borders the integumentary tissue of the central vein of the P. woronowii leaf, whereas, in P. macrocalyx and P. saguramica, collenchyma is a mixed type. In the polygonal parenchyma of the P. woronowii leaf main vein, there is a median, open, collateral, fibrovascular bundle and two pairs of lateral reverse-collateral type conducting bundles adjoined to surrounding tissue. Large-caliber oval-shaped lamps surrounded by mechanical-type cells and small-caliber longitudinally arranged spherical lumens are imprinted in the conductive bundle xylem. The conducting bundles' sheath thickens mostly spirals (Fig. 3).

The parenchyma of the main vein of P. macrocalyx is represented by large, right-angled, and thick-walled cells, more or less densely arranged. The main vein has an open, collateral, fibrovascular, nal configuration conducting bundle surrounded by mechanical cells. In the wood of the conductive cone, the xylem is libriform, with significantly large-caliber oval lumens and small-caliber asymmetrically arranged spherical lumens. The thickening of the membrane of conducting vessels is mostly spiral. However, stair-step thickened tracheids are also observed (Fig. 3). The tissue of the main vein of P. saguramica is polygonal, large-sized, thick-walled, with a more or less compressed structure, and surrounded by the median, needle-like configuration, and lateral, spherical conductive bundles. Transitional tissue is an open, collateral fibrovascular type. In the wood of the conducting bundle, the libriform, large and small-caliber spherical openings are arranged in groups, and longitudinal rows are imprinted. Conducting vessels have a spiral thickening of the sheath (Fig. 3).

Axial organ of the flower

The Primula flowers are primarily collected in umbels at the tip of the flowering stem, or their flowers are located on stalks emerging from the axils of the root leaves in the form of a rosette. The flower axis of P. woronowii is the stalk, while P. macrocalyx and P. saguramica is the stem. However, the panorama of the epidermal tissue of the floral axis of all three species shows an identical structure: the basal cells are arranged in a row, and the linear cells' periclinal walls are straight or straight obliquely inclined. Traces of trichome cuttings are imprinted by idioblastic cells and two contour arcs (Fig. 4).

The tangential cut of the P. woronowii peduncle is ovate in outline, covered with spherical one- or multi-celled villas. On the cross-section of the axial organ, compared to the area of the central cylinder, the parenchyma zone is significantly larger. The covering tissue of the P. woronowii flower stalk is cutinized. The tight, single-row epidermal tissue of the isocytic structure contains a ventilation system. The covering tissue is bordered by uniformly arranged plate collenchyma cells, followed by irregularly sized polygonal cells of the cortex. In the central cylinder, a 4-6 layered belt of sclerenchyma cells are bounded by a tissue of starch-containing cells. The sheath of the mechanical cells is slightly thickened, and the internal outline of their opening is angular. In the central cylinder of the stalk, five units of collateral-type conducting bundles border each other in the radial direction. Idioblastic cells of the secretory tracts are fixed in the lamina of the conductive bundle. In the wood, 3-4 rectangular openings are differentiated, mainly radially grouped or arranged in longitudinal rows. The thickening of the sheath of conducting vessels is spiral and mesh-like. Large polygonal thin sheathed cells are present in the center of the flower stalk (Fig. 4).

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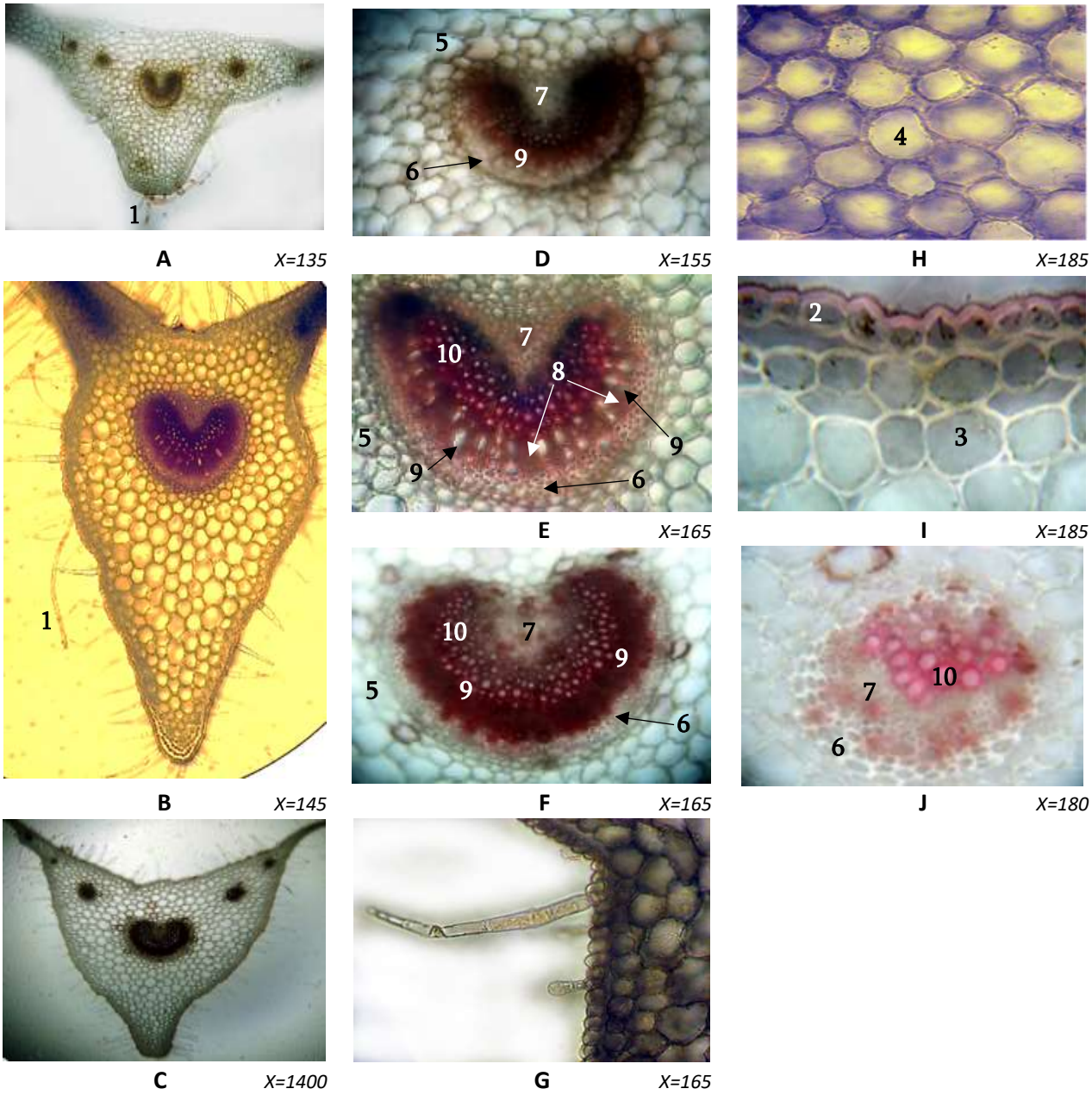
ISSN (Online): 2720-8796 ISSN (Print): 2720-7994

FIGURE 3. The internal structure of the leaf stalk (mesopetiol)



Interpretations: **A**. P. woronowii , **B**. P. macrocalyx and **C**. P. saguramica panorama of leaf stalk structure; **D**. P. woronowii , **E**. P. macrocalyx, and **F**. P. saguramica - median, open, collateral, fibrovascular bundle; **G**. One- and multi-celled spherical villas on the stalk of the studied species; **H**. P. macrocalyx basic parenchymal tissue; **I**. P. saguramica - differentiated collenchyma structure of the stalk; **J**. Lateral, collateral, fibrovascular conducting bundle. 1. Villas; 2. Cutinized epidermis; 3. Collenchyma of mixed type; 4. Polygonal cells; 5. Surrounding cells; 6. Mechanical tissue; 7. Phloem; 8. Xylem libriform; 9. Large and 10. Small-caliber openings of conducting vessels.

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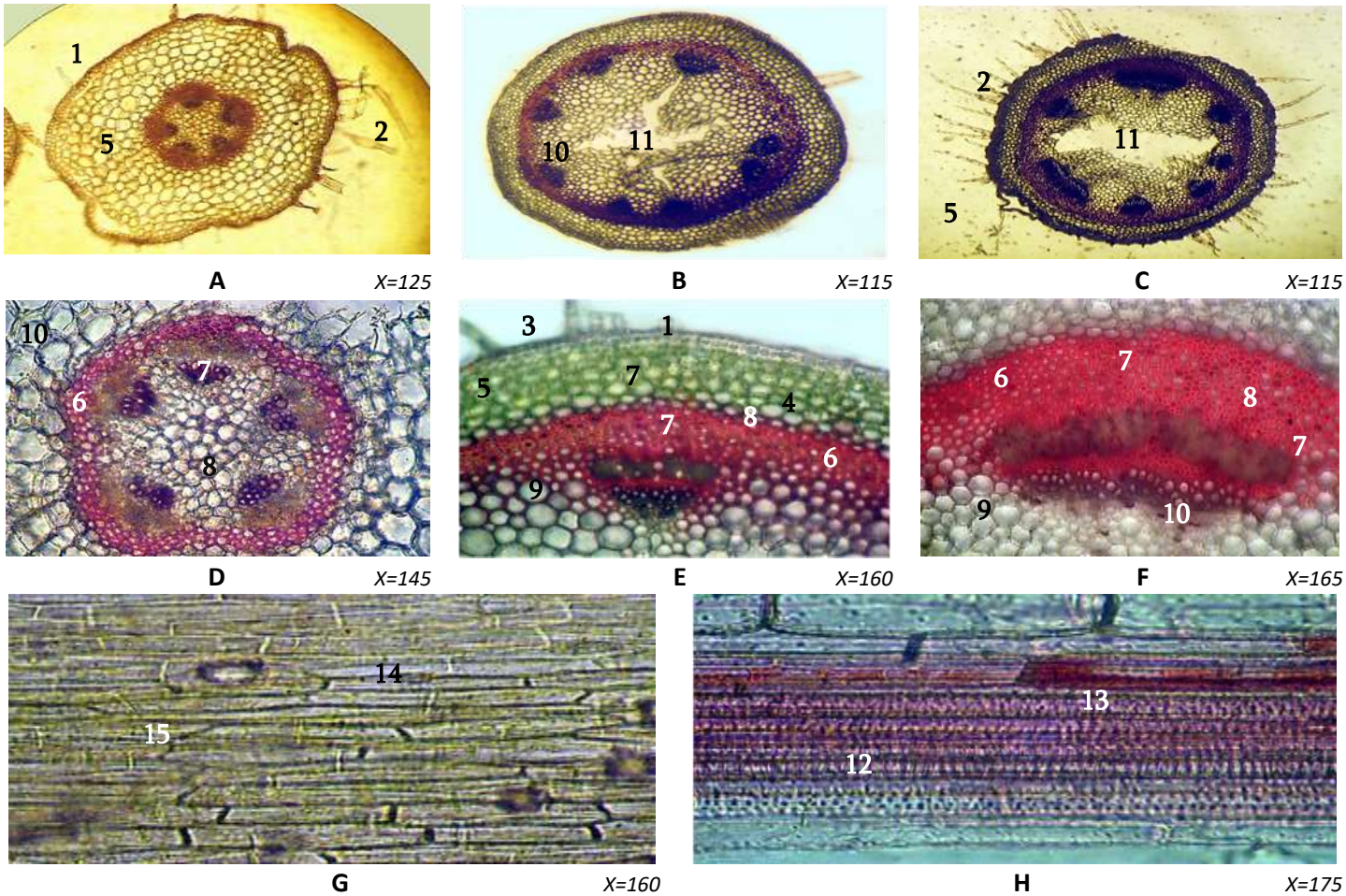
FIGURE 4. The internal structure of the axial organ of the flower



Interpretations: **A.** panorama of the structure of the flower stalk of P. woronowii; **B**. P. macrocalyx and **C.** - P. saguramica A view of the microstructure of the flower stem; **D.** P. woronowii , **E.** P. macrocalyx, and **F.** P. saguramica - fragments of the axial organ; **G.** panorama of the epidermal tissue of the axial organ of P. macrocalyx; **H.** longitudinal section of P. saguramica axial organ xylem vessels. 1. Epidermis with cuticle; 2. Villas; 3. Collenchyma; 4. Chlorenchyma; 5. Bark parenchyma; 6. Sclerenchymal tissue; 7. Mechanical cells; 8. Phloem; 9. Openings of conductive vessels; 10. Perimedullary tissue; 11. Medulla; 12. Spiral and 13. Stair-step conductive bundles; 14. Stitched rectilinear underlying cells; 15. Trace of trichomes cuts.

The cross-section of the flower stems of P. macrocalyx and P. saguramica is spherical with densely packed multicellular (3-5), cone-shaped, secretory-headed trichomes. The cross-sectional panorama of the stem of the studied species shows a small volume of the cortex, massive central cylinder structural elements, and a medulla prone to obliteration. The covering tissue of the flowering stem of taxa is cutinized, and the single-layer epidermal tissue is equipped with a stomatal apparatus. First, mixed-type collenchyma, then chlorenchyma, and finally, structural elements of bark parenchyma are separated from the covering tissue of the flower stem. The parenchymal cells of the bark of P. macrocalyx are primarily large, vary in shape, are predominantly obtuse-angled, and have a loose structure. In contrast, those of P. saguramica have a tight polygonal structure (Fig.4).

In the central cylinder of the flower stems of P. macrocalyx and P. saguramica, a belt of massive sclerenchyma tissue is differentiated; the structural elements of the mechanical tissue are distinguished by the non-uniform thickening of the inner sheet and the outline of the openings. The sclerenchyma tissue is bounded by complex, open, collateral-type conductive bundles arranged uniformly in the radial direction. In the wood of the conducting bundles of P. macrocalyx and P. saguramica flower stalks, oval and round conducting vessels are arranged chaotically or longitudinally—Small-caliber lumens, as well as woody fibers and unevenly thickened cells. The unity of floema tissue is often broken by the openings of large-caliber conducting vessels. Spirally and stair-step-thickened conducting vessels of the wood are located along the length of the flower stem (Fig. 4).

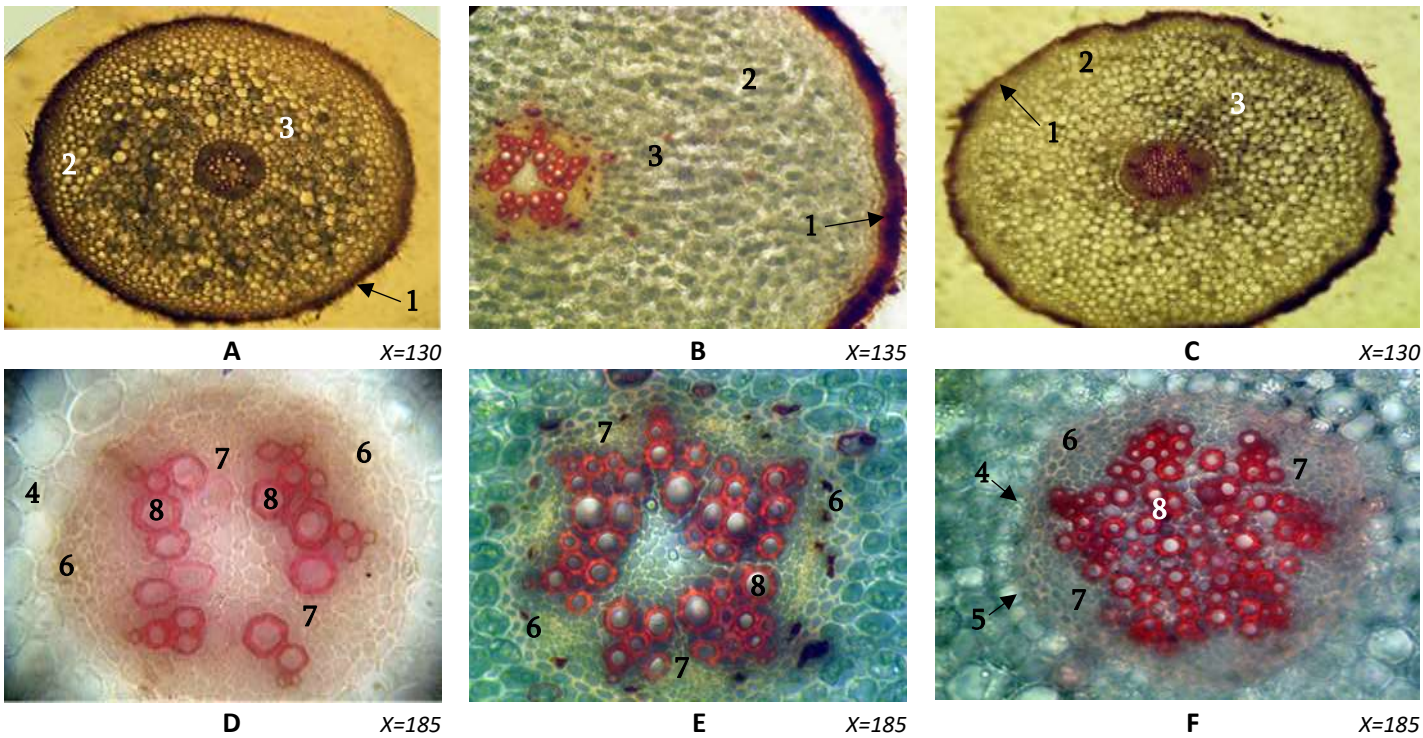
Root

The horizontal cut of the P. woronowii root is oval, and P. macrocalyx and P. saguramica are spherical. The covering tissue of roots is represented by epiblem and epiblemous fibers. The covering tissue of the root is separated from the

ISSN (Online): 2720-8796 ISSN (Print): 2720-7994

massive area of the exoderm and then the mesoderm. The exodermal cells are characterized by a closely spaced, thickened, polygonal habitus. Mesodermal parenchymatic cells have a heterogeneous structure from the periphery to the center, differing in shape and size. Based on the visual evaluation, it can be noted that their dimension index first increases from the periphery to the center, becomes a compressed structure, and then decreases again. The density between the cells is also observed. The presence of a significant number of starch grains in the structure of the mesoderm is observed. Mesoderm cells separate from the endoderm belt. The central cylinder of the studied species is characteristic of P. woronowii and P. macrocalyx and consists of five xylem beams, while P. saguramica tends to have a multi-beam xylem structure. Casparian stripes are more or less pronounced in the root endoderm of P. woronowii and P. macrocalyx, while in P. saguramica, they are distinct. In the wood of the conductive tissue of the taxa, the conducting vessels with thickening of the spiral and mesh sheath, arranged in groups of different calibers, predominantly spherical and slightly inclined towards the internal sheath, are reflected (Fig. 5).

FIGURE 5. The internal structure of the root



Interpretations: **A.** P. woronowii, **B**. P. macrocalyx, and **C.** P. saguramica - panorama of root structure; **D**. P. woronowii, **E**. P. macrocalyx and **F**. P. saguramica - central cylinder of the root. 1. Epiblema with villis; 2. Exoderm; 3. Structural elements of mesoderm filled with starch grains; 4. Endoderm; 5. Casparian stripes; 6. Pericycle; 7. Phloem; 8. Openings of xylem conductive vessels.

Flower

The basal cells of the petals of the calyx of the studied species of Primula are stitched in a row, the curvilinear and curved-walled cells are located at the base of the petals, and the traces of the cuts of the villas are observed as two contour arcs. The petal of the species' flower is five-lobed and abundantly covered with spherical, multi-celled villas on both sides. Concentric conductive bundles are differentiated in the sepal area, and the main tissue cells of the isocytic structure on the sides are filled with chloroplasts. The mesophyll of the leaf is surrounded by two-sided, single-layered epidermal tissue. Concentric conductive bundles bounded by the surrounding tissue are differentiated in the main sepal tissue (Fig. 6).

On the cross-section of the sepal, the main tissue of an isocytic structure with a distinctively thin sheath and an irregular structure, surrounded by pitted epidermal tissue, is imprinted. Sepals contain incomplete conducting bundles and spirally thickened vessels surrounding the wood (Fig. 6).

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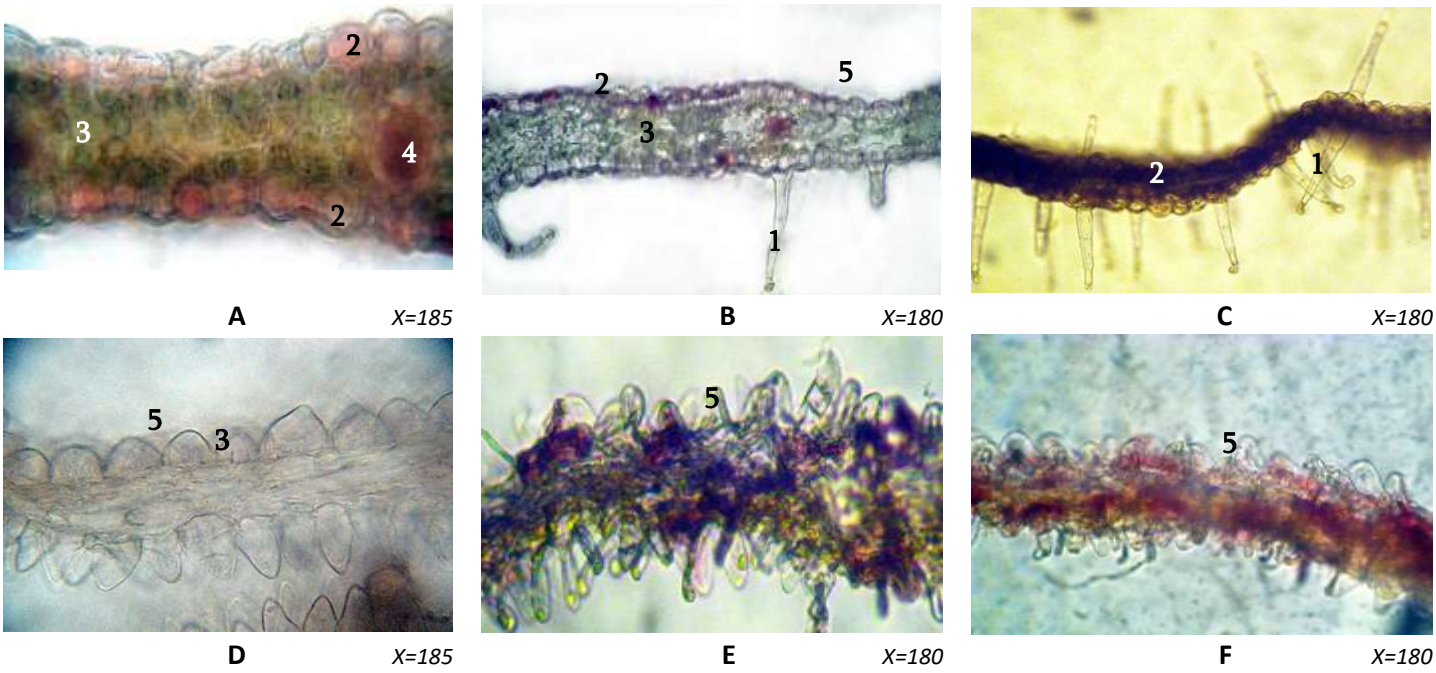
FIGURE 6. The internal structure of P. woronowii flower



Interpretations: **A.** P. woronowii, **B**. P. macrocalyx and **C**. P. saguramica pulp fragments of sepals; **D**. P. woronowii, **E**. P. macrocalyx and **F**. P. saguramica fragments of petal's structure. 1. multicellular trichomes; 2. epidermis; 3. monochromatic pulp parenchyma; 4. conductive bundle of concentric type; 5. epidermal pitted cells.

DISCUSSION

The diagnostic characteristics of the internal structure of the underground and aboveground vegetative and generative organs of three species of the genus Primula—P. woronowii, P. macrocalyx, and P. saguramica—in Georgian flora have been studied. The peculiarities of their anatomical structure were established as a result of the research with the camera methods adopted in microtechnics. Diagnostic characteristics of the internal structure of two species, P. macrocalyx and P. saguramica, with identical macro- and micromorphological characteristics, have been determined based on the distinction of microstructural features and anatomical data: The basal cells of the upper and lower epidermis of the leaves of P. woronowii, P. macrocalyx, and P. saguramica are non-stitched, curvilinear, and curved-walled; A chaotically arranged stomata apparatus differentiated into a simple, anomocytic type is typical for all three species. The covering tissue of the leaves of P. woronowii and P. macrocalyx is spherical, but in the leaf of P. saguramica it is ovate; the P. woronowii and P. saguramica stomatal apertures are finger-shaped, while in P. macrocalyx they are straight and short; the chlorophyll present in the guard cells is fine-grained in P. woronowii and P. macrocalyx, and coarse-grained in P. saguramica; the leaves of the studied species are bifacial, with a dorsoventral structure, amphistomatic in P. Woronowii and P. saguramica, and hypostomatic in P. macrocalyx. They are characterized by stomata slightly raised above the epidermal cell. Vegetative and reproductive aboveground organs of taxa are densely covered with secretory spheroidal single- or multi-celled villas; The presence of a cystolith in the cells of the upper epidermis of P. woronowii leaf is observed. In the leaf pulp of the studied species, reverse-collateral conductive bundles and spiral anastomose xylem are present; The P. woronowii leaf is elongated and short-conical in outline; the one of P. macrocalyx is lanceolate; and the Saguramica leaf is conical in configuration. P. woronowii leaf stalks are lamellar, while P. macrocalyx and P. saguramica are characterized by a mixed type of collenchyma. In the main parenchyma of the petiole of the studied species, the median, open, lateral, and fibrovascular bundles and two pairs of lateral vascular bundles of the collateral type are differentiated. The location of the lateral vascular bundles of the P. macrocalyx leaf petiole differs in that they penetrate deep into the region of the petiole wings. In all three species of the petiole xylem, there are large-caliber oval-shaped openings surrounded by mechanical-type cells. Small-caliber spaces in P. woronowii and P. saguramica are arranged longitudinally, while in P. macrocalyx, they are arranged asymmetrically with differentiated spherical lumens; the thickening of the sheath of conductive xylem vessels of the transitional tissue of the petiole is spiral, except in P. macrocalyx, where the stair-step thickenings are fixed as well; The basal cells of the epidermis of the axial organ of the flower of the taxon are arranged in a row, and the periclinal walls of the linear cells are straight or obliquely inclined; The cross-section of the

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ISSN (Online): 2720-8796 ISSN (Print): 2720-7994

axial organs of the flower is oval or spherical in outline; the flower stem, but not the stalk, is characterized by the obliteration of medullary cells; P. saguramica collenchyma is of a mixed type, while P. woronowii and P. macrocalyx have lamellar collenchyma; In the flower axis organ of all three species, the central cylinder is surrounded by a belt of sclerenchyma cells. The transitory system of the species is conical, complex, and open; collateral-type conducting bundles are reflected; the thickening of the sheath of the conducting vessels is predominantly spiral, rarely stair-step; Endodermal cells of P. saguramica have clearly expressed Casparian strips, but in P. woronowii and P. macrocalyx endoderms, they are less apparent. The central cylinder of P. woronowii and P. macrocalyx is pentarcular, while P. saguramica tends to have a multi-beam xylem structure. In the roots of the studied species, xylem tissues contain angled internal openings with spiral and mesh-type thickening of the sheath; The basal cells of the epidermal tissue of the flower petals of the studied species have a curved structure. The calyx of the studied species is five-lobed; The main tissue of all studied taxa leaves is isocytic, containing concentric-type conductive bundles; In all species, the cells of the main tissue crown petals are exceptionally thin-walled, isocytic, and surrounded by dense epidermal tissue. Their transitional tissue is incomplete, and only the lumens of the conducting vessels of the xylem are visible.

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ISSN (Online): 2720-8796 ISSN (Print): 2720-7994