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MICROSCOPIC AND HISTOCHEMICAL STUDY ON THE PETIOLAR ANATOMY OF SPECIES OF THE GENUS *PARTHENOCISSUS* PLANCH.

Actuality. Species of the genus *Parthenocissus* Planch. are widely distributed as ornamental plants throughout the world, including in Ukraine, where they are common in forests, parks, botanical gardens and on homestead plots, actively growing and capturing new territories.

Considering the availability of raw materials (leaves, fruits, bark), its significant reserves in Ukraine, insufficient study of the chemical composition of biologically active substances (BAS) (in the literature there are only isolated data relating to some groups of BAS), as well as based on the data of our own phytochemical studies, the species *Parthenocissus* Planch. are promising for comprehensive pharmacognostic study and potential further medical application.

The objects of the study were three species of the genus, which are widely introduced in Ukraine: The Asian Japanese creeper *P. tricuspidata* (Sieb. et Zucc.) Planch. and the North American Virginia creeper *P. quinquefolia* (L.) Planch. and thicket creeper *P. inserta* (A. Kerner) Fritsch.

Anatomical studies of the petioles of these species are significant in investigating the species identity of closely related species of *Parthenocissus*, which are difficult to determine only by morphological features. They allow to reliably setting characteristic anatomical specific diagnostic features inherent to a certain species of the genus. Anatomical and histochemical studies of *Parthenocissus* petioles will be taken into account in the development of quality control methods (QCM) to determine diagnostic features of new promising medicinal plant raw materials based on species of the genus *Parthenocissus*.

The aim of the work is *Parthenocissus* species, which can be effectively used for species identification and determination of medicinal plant raw materials, as well as to conduct its histochemical study.

Material and methods. The material for the study are leaf petioles of *P. tricuspidata*, *P. quinquefolia* and *P. inserta*, which were collected during the fruiting of plants in August – September 2024 from the collection plot “Climbing Plants” in the M.M. Gryshko National Botanical Garden of the NAS of Ukraine (Kyiv).

For microscopic analysis, cross-sections of petioles in their proximal, medial and distal parts were used, which were made by hand using a razor. The study was carried out under a light microscope SUNNY XSM-20 6 500; images were taken with a digital camera Sigeta MCMOS 5100 5.1 MP. Anatomical measurements and statistical processing were performed using Image J software. Histochemical reactions were performed for: lipophilic compounds – with Sudan III (Alfa Aesar); phenolic compounds – with ferric chloride 2% (Ukrchemgroup); lignified structures – with 1% solution of phloroglucinol in alcohol and HCl (phloroglucinol/HCl) (Merck); starch – with Lugol solution (Filisit-Diagnostics); mucus – with a solution of methylene blue in alcohol (1:5 000) (Filisit-Diagnostics).

Research results. For the petioles of three *Parthenocissus* species in their proximal, medial and distal parts, microscopic features and anatomometric indicators were determined, namely: the shape of the cross-section; the structure of the epiderma, cortex, fibrovascular bundles and core, as well as the types, shape and localization of crystalline inclusions were investigated. Histochemical studies of the petioles were carried out to determine the presence and localization of lipids, starch, mucilage and phenolic compounds.

As a result of the research, it was found that the most important diagnostic features of the petioles of *P. tricuspidata*, *P. quinquefolia*, *P. inserta*, which have high taxonomic value, are: the shape of the cross-sectional outline of the petiole; the presence or absence of trichomes; the nature of the location of the cortex collenchyma; the degree of development of sclerenchyma; the presence of additional bundles in the cortex; the nature of the location and degree of development of the inter-bundle lignified parenchyma. According to the results of histochemical reactions, waxy substances of the cuticular membrane were detected; lipophilic and/or essential oil secretory cavities in the phloem; lignified sclerenchyma fibers, xylem elements, inter-bundle parenchyma and parenchyma around the xylem; starch; phenolic compounds; mucilage localized in the mucilage-crystalline idioblasts.

Conclusion. Microscopic diagnostic features of the structure of petioles of three *Parthenocissus* species have been studied and established, which can be used as additional ones in determining closely related morphologically similar species of the genus, as well as in identifying medicinal plant raw materials. The obtained data can also be used for developing regulatory documentation for medicinal plant raw materials – leaves of the studied *Parthenocissus* species.

Key words: microscopic analysis, petiolar anatomy, Japanese creeper *Parthenocissus tricuspidata* (Sieb. et Zucc.) Planch., Virginia creeper *P. quinquefolia* (L.) Planch., thicket creeper *P. inserta* (A. Kerner) Fritsch.

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МІКРОСКОПІЧНЕ ТА ГІСТОХІМІЧНЕ ДОСЛІДЖЕННЯ ЧЕРЕШКІВ ВИДІВ РОДУ *PARTHENOCISSUS* PLANCH.

Актуальність. Види роду дівочий виногра́д *Parthenocissus* Planch. широко розповсюджені як декоративні рослини в усьому світі, зокрема в Україні, де вони поширені в лісах, парках, ботанічних садах і на присадибних ділянках, активно розростаються та захоплюють нові території.

Зважаючи на доступність сировини (листя, плоди, кора), її значні запаси в Україні, недостатню вивченість хімічного складу біологічно активних речовин (БАР) (у літературі існують лише окремі розрізнені дані, що стосуються деяких груп БАР), а також виходячи з даних власних фітохімічних досліджень, види *Parthenocissus* Planch. є перспективними для комплексного фармакогностичного вивчення та потенційного подальшого медичного застосування.

Об'єктами дослідження стали три види роду, які широко інтродуковані в Україні, а саме – азійський дівочий виногра́д тригострокінцевий *P. tricuspidata* (Sieb. et Zucc.) Planch., північноамериканські дівочий виногра́д п'ятилистяний *P. quinquefolia* (L.) Planch., дівочий виногра́д прикріплений *P. inserta* (A. Kern.) Fritsch.

Анатомічні дослідження черешків зазначених видів є значущими для встановлення видової ідентичності близькоспоріднених видів *Parthenocissus*, які важко визначити лише за допомогою морфологічних ознак. Вони дозволяють достовірно встановити характерні анатомічні специфічні діагностичні ознаки, властиві кожному виду дівочого виногра́ду. Анатомічні та гістохімічні дослідження черешків *Parthenocissus* будуть враховані під час розроблення МКЯ для встановлення діагностичних ознак нової перспективної лікарської рослинної сировини на основі видів роду дівочий виногра́д.

Мета дослідження – з'ясувати структурні відмінності в анатомії черешків різних видів *Parthenocissus*, які можна ефективно використовувати для видової ідентифікації та визначення лікарської рослинної сировини, а також провести її гістохімічне дослідження.

Матеріал і методи. Матеріалом для дослідження були черешки листків *P. tricuspidata*, *P. quinquefolia*, *P. inserta*, які зібрані під час плодоношення рослин в серпні – вересні 2024 року з колекційної ділянки «Виткі рослини» у Національному ботанічному саду імені М.М. Гришка Національної академії наук України (місто Київ).

Для мікроскопічного аналізу використовували поперечні зрізи черешків в їхній проксимальній, медіальній і дистальній частинах, які робили від руки, за допомогою бритви. Дослідження проводили під світловим мікроскопом “SUNNY XSM-20 6 500”; знімки зроблені цифровою камерою “Sigeta CMOS 5100 5.1 MP”. Анатомічні вимірювання та статистичну обробку проводили за допомогою програмного забезпечення “Image J”. Були проведені гістохімічні реакції на: ліпофільні сполуки – із Суданом III (Sudan III) (Alfa Aesar); фенольні сполуки – із хлоридом заліза (III) 2% (ferric chloride 2%) (Ukrchemgroup); лігніфіковані структури – з 1% розчином флороглюцину у спирті та HCl (phloroglucinol/HCl) (Merck); крохмаль – з розчином Люголя (Lugol solution) (Філісіт-діагностика); слиз – з розчином метиленового синього у спирті (1:5 000) (Філісіт-діагностика).

Результати дослідження. Для черешків трьох видів *Parthenocissus* у їхніх проксимальній, медіальній і дистальній частинах з’ясовані мікроскопічні особливості й анатометричні показники, а саме: форма поперечного перерізу; будова епідерми, кори, волокнисто-провідних пучків і серцевини, а також досліджені типи, форма та локалізація кристалічних включень. Проведені гістохімічні дослідження черешків для з’ясування наявності та локалізації ліпідів, крохмалю, слизу та фенольних сполук.

У результаті досліджень встановлено, що найбільш вагомими діагностичними ознаками черешків *P. tricuspidata*, *P. quinquefolia*, *P. inserta*, що мають високу таксономічну цінність, є: форма обрисів поперечного перерізу черешка; наявність чи відсутність трихом; характер розташування коленхіми кори; ступінь розвитку склеренхіми; наявність додаткових пучків у корі; характер розташування та ступінь розвитку міжпучкової лігніфікованої паренхіми. За результатами гістохімічних реакцій виявлені воскоподібні речовини кутикулярної мембрани; ліпофільні чи/та ефіроолійні вмістича у складі флоєми; лігніфіковані склеренхімні волокна, елементи ксилеми, міжпучкова паренхіма та паренхіма навколо ксилеми; крохмаль; фенольні сполуки; слиз, що локалізований у слизово-кристалічних ідіобластах.

Висновок. Вивчені та встановлені мікроскопічні діагностичні ознаки будови черешків трьох видів *Parthenocissus*, які можна використовувати як додаткові під час визначення близькоспоріднених морфологічно подібних видів роду, а також в ідентифікації лікарської рослинної сировини. Отримані дані також можуть бути використані для розроблення нормативної документації на лікарську рослину сировину – листя досліджених видів *Parthenocissus*.

Ключові слова: мікроскопічний аналіз, петіолярна анатомія, дівочий виногра́д тригострокінцевий *Parthenocissus tricuspidata* (Sieb. et Zucc.) Planch., дівочий виногра́д п’ятилистяний *P. quinquefolia* (L.) Planch., дівочий виногра́д прикріплений *P. inserta* (A. Kern.) Fritsch.

Introduction. Actuality. According to phylogenetic studies, five tribes are distinguished in the family Vitaceae Juss., corresponding to five main clades: *Ampelopsidae* J. Wen et Z. L. Nie, *Cisseae* Rchb., *Cayratieae* J. Wen et L.M. Lu, *Parthenocisseae* J. Wen et Z. D. Chen, *Viteae* Dumort.; the tribe *Parthenocisseae* includes two genera: *Parthenocissus* Planch. (in different sources from 12 to 15 species) and *Yua* C. L. Li (2 species) (Ren et al., 2011; Wen et al., 2018). The tribe *Parthenocisseae* unites vines that climb with the help of tendrils; tendrils 2- or 3-12-branched, with or without sticky discs; leaves are usually palmately compound, sometimes simple, without domatia (Wen et al., 2018).

Species of the genus *Yua* are distributed in China, Vietnam, Nepal and North India; the genus was separated from *Parthenocissus* on the basis of two-branched tendrils without adhesive discs at the tip and an inflorescence in the form of a compact compound cyme with a few dichasia opposite to leaves (Li, 1998; Wen et al., 2018).

The genus *Parthenocissus* is disjunctively distributed in the temperate zone of the Northern Hemisphere between Asia and North America; most species originate from Temperate Asia (including *P. tricuspidata* (Sieb. et Zucc.) Planch. and *P. henryana* (Hemsl.) Graebn. ex Diels et Gilg, introduced in Ukraine), and only three from North America: *P. quinquefolia* (L.) Planch., *P. inserta* (A. Kern.) Fritsch (syn. *P. vitaceae* (Knerr) A. Hitchc.)

(both species introduced in Ukraine) and *P. heptaphylla* (Planch.) Britton (Gerrath et al., 2015; Wen et al., 2018).

Representatives of the genus *Parthenocissus* are primarily of great decorative importance, due to their rapid growth they are often used for landscaping facades of buildings, fences and slopes, as well as for protecting soils from erosion; their plantings in urban areas also provide significant dust absorption, reduce air pollution and improve its quality. For this purpose, mainly three species of *Parthenocissus* (as well as their forms and cultivars) are widely grown in Ukraine: Japanese creeper *P. tricuspidata*, Virginia creeper *P. quinquefolia*, thicket creeper *P. inserta*; other species – Chinese Virginia creeper *P. henryana* is given only for Crimea (Vakhnovska et al., 2004; Gotsiy et al., 2023).

In Ukraine, *P. tricuspidata* occurs only in culture; *P. quinquefolia* and *P. inserta* belong to anthropophytes – adventitious species that spread in anthropogenic ecosystems; by the degree of naturalization, *P. quinquefolia* is a colonophyte (capable of forming primary populations or colonies and spreads through diaspores in anthropogenic ecotopes); *P. inserta* is an agro-epicophyte (stable in anthropogenic ecosystems and capable of taking root in disturbed natural coenoses) (Fedoronchuk et al., 2020).

Species of the genus *Parthenocissus* are of interest for pharmacognostic studies, since a wide range of BAS of different groups, such as saponins, polyphenolic compounds (flavonoids, anthraquinones, tannins),

cardiac glycosides, polysaccharides, organic acids, etc., have been found in their leaves, shoots, bark, and roots (Zhang, et al., 2016; Liang et al., 2018; Faisal et al., 2018). However, the literature data on the composition of BAS of species of the genus *Parthenocissus* are not systematic and are scattered. According to our previous studies, in the leaves, shoots, and fruits of *P. quinquefolia*, nine phenolic compounds were identified: rutin, quercetin, quercetin-3- β -glycoside, naringin, epicatechin, catechin, halocatechin, and epicatechin gallate (Konovalova et al., 2023b). In the course of further studies of various types of raw materials of *P. quinquefolia*, we determined the presence of a wide range of BAS of different chemical nature. In particular, the fatty acid composition of the leaves and shoots of Virginia creeper was studied by chromatography-mass spectrometry, the highest content among unsaturated fatty acids is oleic, linoleic, and laurooleic acids, among saturated ones – palmitic, behenic, and stearic acids (Konovalova et al., 2021c). Analysis of *P. quinquefolia* fruits by gas-liquid chromatography-mass spectrometry (GC-MS) showed the presence of free mono- and disaccharides, in particular, galacturonic acid, glucose, fructose, sucrose, mannose, galactose, fucose predominate (Konovalova et al., 2021a). Also, in the leaves and shoots of *P. quinquefolia*, the quantitative content of 19 amino acids was identified by GC-MS, 8 of which (valine, leucine, isoleucine, threonine, methionine, lysine, phenylalanine, tryptophan) are essential; and the composition of phytosterols, including β -sitosterol, urs-12-ene, stigmast-4-en-3-one, and cycloartenol-3-acetate, was investigated (Konovalova et al., 2022). For medical purposes, *Parthenocissus* species are used due to their antioxidant, tonic, expectorant, antirheumatic, antitussive, diuretic, and astringent properties (Faisal et al., 2018; King, Henson 2021).

Given the economic and ecological importance of *Parthenocissus*, along with the underdeveloped and controversial intrageneric taxonomy, contradictions in the interpretation of individual species, and difficult diagnosis using only morphological characters, especially of closely related North American species (Gerrath et al., 2015; Wen, et al., 2018; Gotsiy, 2023), further taxonomic and anatomical and morphological studies of the genus are promising.

Anatomical features are more stable in evolution than morphological ones; therefore, they are important for determining the relationships between species within the family, as well as individual genera and families. Elucidation of the anatomical features of *Parthenocissus* will provide important information for distinguishing closely related species, and will also allow determining diagnostic features of medicinal plant raw materials

for the further development of the corresponding quality control methods (QCM).

A promising method for diagnosis and confirmation of species specificity is petiolar anatomy. While the anatomical structure of the main plant organs – root, stem and leaves – is relatively constant and typical for dicotyledonous plants, the structure of the leaf petiole is characterized by a wide variety of diagnostic features (Konovalova et al., 2023a). Also, the anatomical structure of the petiole is quite stable within the genus, which is useful for determining the taxonomic position of controversial genera.

For the family Vitaceae, the structure of the petioles can also be used as an important diagnostic feature (Najmaddin, 2014). However, the anatomical features of *Parthenocissus* leaves and their petioles remain poorly understood (Najmaddin, 2014; Lubna et al., 2019; Filar-tiga et al., 2022; Makhynia, Yemelianova, 2023).

The most important diagnostic features of the structure of petioles are the shape of the cross-section, the presence and number of additional vascular bundles, the structure of the vascular system, the peculiarities of the location of the collenchyma, etc. The taxonomic significance is also shown and some general regularities of the structure of the vascular tissues of the phloem and xylem (mainly in the stem) of representatives of Vitaceae are highlighted (Metcalf, Chalk, 1950; Davis, Evert, 1970; Angeles, Leon-Gomez, 1997; Takhtajan, 2009).

The study of diagnostic features of the structure of leaf petioles of representatives of the genus *Parthenocissus* is of both theoretical interest for the purposes of systematics and practical interest – from the point of view of determining diagnostic features of medicinal plant raw materials for their further standardization and development of the QCM.

The aim of the study is to identify structural differences in the anatomy of petioles of different *Parthenocissus* species, which can be effectively used for species identification and determination of medicinal plant raw materials, to take into account the development of QCM for raw materials, and to conduct appropriate histochemical studies.

Materials and research methods. 1. Collection of plant material. Latin plant names are given by International Plant Names Index (IPNI) (<https://www.ipni.org/>). The studied species: *P. tricuspidata*, *P. quinquefolia*, *P. inserta* cultivated in the collection plot “Climbing Plants” in the M.M. Gryshko National Botanical Garden of the NAS of Ukraine (Kyiv); the identification of species was carried out by V.V. Makovskiy, the curator of this plot.

Leaf samples of all studied species were collected during fruiting in August–September 2024. Mature, maximally developed leaves were selected from the middle

part of the annual growth of shoots. For each species, five to ten leaves were collected from no less than five fruiting shoots. For anatomical studies, petioles of selected leaves were used, which were fixed in 70% alcohol.

2. Microscopic studies. For microscopic analysis, cross-sections of petioles at their basal, middle and apical parts were used, which were made by hand using a razor. Sections were stained using 0,1% aqueous safranin solution (Filisit-Diagnostics) for 1 min, washed with 70% ethanol, then stained with 1% aqueous Astra Blue solution (Morphisto) for 2 min and washed with distilled water (Kraus et al., 1998).

To study the epiderma of petioles, segments up to 1–2 cm long were cut from their middle part, which were boiled in a mixture of 50% lactic acid and 30% nitric acid; after lightening, the segments of the petioles were washed with water. Then a few leaves were boiled in 70% lactic acid and 30% nitric acid till the leaves become transparent. After maceration, the epiderma was separated with a needle and stained using a 1% aqueous solution of Astra Blue for 2 min and washed with distilled water. In the epiderma samples of the petioles prepared in this way, the shape and size of the cells were examined using a light microscope, and the presence of stomata and pubescence were noted.

The study was conducted using a SUNNY XSM-20 6 500 light microscope; images were taken with a Sigeta MCMOS 5100 5,1 MP digital camera.

Anatomical measurements and statistical processing were performed using Image J software (NIH, Wayne Rasband; <http://rsbweb.nih.gov/ij/>); arithmetic mean (M) and standard deviation (\pm SD) were calculated, the number of observations was 25–50 for each quantitative trait.

3. Histochemical studies. Histochemical reactions were performed on: lipophilic compounds – with Sudan III (Alfa Aesar); phenolic compounds – with ferric chloride 2% (Ukrchemgroup); lignified structures – with 1% solution of phloroglucinol in alcohol and HCl (phloroglucinol/HCl) (Merck); starch – with Lugol solution (Filisit-Diagnostics); mucilage – with a solution of methylene blue in alcohol (1:5 000) (Filisit-Diagnostics) (Solodovnychenko et al., 2014).

Research results and their discussion. 1. The outline shape of petiole cross-section.

The shape of the petiole cross-sections in the genus *Parthenocissus* has taxonomic significance (Najmaddin, 2014).

Середні значення розраховували для 25–50 спостережень для кожної кількісної ознаки. Cross-sections of petioles of the studied *Parthenocissus* species are shown in fig. 1. The study showed that the shape of the

Table

Anatomometric parameters of *P. tricuspidata*, *P. quinquefolia* and *P. inserta* petioles

Parameters	Proximal part of petiole			Medial part of petiole			Distal part of petiole			
	<i>P. tricuspidata</i>	<i>P. quinquefolia</i>	<i>P. inserta</i>	<i>P. tricuspidata</i>	<i>P. quinquefolia</i>	<i>P. inserta</i>	<i>P. tricuspidata</i>	<i>P. quinquefolia</i>	<i>P. inserta</i>	
Epidermal cells	height without cuticle, μ m	8.10 \pm 1.17 5.44-11.06	16.50 \pm 7.60 8.70-28.97	12.23 \pm 1.94 7.95-16.25	10.33 \pm 2.01 7.03-13.19	15.96 \pm 5.46 7.11-24.84	12.22 \pm 1.50 7.05-15.83	11.47 \pm 2.14 8.05-15.65	15.68 \pm 3.74 8.05-25.33	12.35 \pm 1.29 7.70-16.87
	width, μ m	11.85 \pm 3.31 7.05-18.45	29.65 \pm 3.53 24.61-39.86	18.54 \pm 3.13 13.59-28.61	17.17 \pm 3.81 10.83-24.26	24.68 \pm 3.80 18.52-33.74	17.88 \pm 3.38 9.17-24.75	16.14 \pm 3.35 11.31-22.70	20.92 \pm 3.56 12.87-24.84	17.85 \pm 3.43 10.80-24.73
The thickness of the outer cell wall of the epiderma with the cuticle, μ m		4.36 \pm 1.04 3.82-5.31	8.57 \pm 1.05 6.02-11.91	8.49 \pm 0.90 5.86-9.801	4.32 \pm 0.72 3.64-6.13	8.43 \pm 1.14 6.11-11.39	8.10 \pm 1.01 4.82-8.67	3.90 \pm 1.07 3.44-6.42	8.58 \pm 1.11 6.11-11.63	11.88 \pm 1.62 8.99-15.87
The thickness of the outer cell wall of the epiderma with the cuticle, μ m	on the adaxial side	1279.63 \pm 201.67 787.44-1462.76	744.35 \pm 114.38 563.11-1012.48	675.42 \pm 60.42 569.01-818.48	1134.07 \pm 230.01 770.04-1390.25	519.35 \pm 94.99 159.71-673.53	435.47 \pm 74.02 194.05-570.20	1069.88 \pm 141.80 846.50-1225.55	529.72 \pm 90.80 390.88-674.80	555.43 \pm 117.69 402.26-818.08
	on the abaxial side	723.01 \pm 88.54 568.18-889.46	618.87 \pm 106.34 469.91-846.64	558.75 \pm 63.13 467.66-693.24	590.51 \pm 136.22 331.70-896.91	461.65 \pm 77.50 151.45-574.19	391.55 \pm 68.61 194.58-497.48	519.47 \pm 82.54 170.42-662.32	404.71 \pm 86.61 289.82-562.65	487.38 \pm 76.54 265.67-693.74
The thickness of the cortex collenchyma layer, μ m		273.63 \pm 92.33 143.66-438.55	399.70 \pm 53.18 295.33-507.96	257.81 \pm 56.98 156.88-406.76	173.14 \pm 28.60 83.89-236.48	196.82 \pm 44.13 109.58-326.73	176.28 \pm 57.50 95.14-336.89	155.57 \pm 23.91 80.05-268.78	184.72 \pm 39.09 83.43-279.917	156.00 \pm 26.27 83.12-223.24
Collenchyma cell wall thickness, μ m		9.91 \pm 2.20 5.39-15.69	12.31 \pm 3.29 7.55-21.06	9.19 \pm 1.35 4.80-9.92	9.56 \pm 1.32 4.71-15.37	9.20 \pm 2.05 5.69-14.05	9.30 \pm 2.03 4.49-15.59	9.67 \pm 1.73 6.78-13.92	9.06 \pm 1.74 5.61-14.16	10.94 \pm 1.78 4.98-16.21
Diameter of collenchyma cells, μ m		21.70 \pm 5.48 9.93-33.92	41.90 \pm 7.69 20.96-53.73	19.92 \pm 3.81 13.80-25.69	19.78 \pm 5.87 9.76-31.29	24.27 \pm 5.81 13.03-35.82	13.55 \pm 2.06 8.99-18.05	17.85 \pm 5.41 8.44 \pm 31.60	21.51 \pm 4.40 10.44-32.48	13.36 \pm 3.62 10.24-17.27
Diameter of cortex parenchymal cells, μ m		83.06 \pm 20.17 29.05-117.64	65.41 \pm 17.87 34.87-119.15	51.79 \pm 14.59 28.49-106.48	75.67 \pm 20.53 33.42-136.48	47.27 \pm 13.74 16.21-77.18	45.72 \pm 5.94 25.51-89.12	79.98 \pm 22.62 28.96-120.07	42.82 \pm 9.98 15.59-70.49	42.96 \pm 13.04 25.68-80.90
The thickness of the sclerenchyma sheath, μ m		37.88 \pm 13.05 21.03-63.94	-	-	57.71 \pm 18.17 32.54-87.15	44.24 \pm 9.64 22.93-62.53	48.86 \pm 12.81 27.59-86.15	51.32 \pm 16.12 22.45-69.16	35.81 \pm 8.83 19.00-52.80	33.97 \pm 9.94 10.30-52.03
Diameter of sclerenchymal fibers, μ m		15.51 \pm 4.67 7.28-30.36	-	-	25.94 \pm 4.93 16.11-38.26	20.71 \pm 4.33 13.03-28.52	9.04 \pm 1.96 4.65-12.37	23.43 \pm 5.26 13.78-35.36	18.22 \pm 3.43 9.94-25.62	8.71 \pm 3.19 4.38-16.68
The thickness of the walls of sclerenchyma sheath cells, μ m		3.41 \pm 0.85 2.09-5.66	-	-	3.84 \pm 0.80 2.04-5.96	5.58 \pm 1.07 3.98-7.48	4.10 \pm 0.65 2.74-5.51	3.75 \pm 0.83 2.07-5.67	5.17 \pm 1.05 2.81-6.74	4.33 \pm 1.20 2.10-6.73
Phloem thickness, μ m		102.53 \pm 29.65 50.75 \pm 197.65	179.30 \pm 33.19 111.13-233.16	171.49 \pm 42.20 80.09-247.67	104.68 \pm 26.14 46.59-162.40	115.72 \pm 31.06 42.16-195.37	80.41 \pm 13.42 50.91-103.66	89.08 \pm 25.46 51.72-147.91	129.32 \pm 38.91 55.79-220.79	124.47 \pm 37.19 60.94-205.70
Xylem thickness, μ m		289.08 \pm 85.81 125.32-414.40	224.21 \pm 37.24 74.52-264.45	196.56 \pm 36.26 99.81-253.43	265.04 \pm 66.59 105.76-374.29	211.73 \pm 48.79 107.26-306.51	157.10 \pm 32.66 80.78-233.23	195.17 \pm 48.29 97.87-306.49	190.92 \pm 50.82 89.19-281.56	146.09 \pm 30.24 79.21-223.15
Vessel diameter, μ m		31.63 \pm 4.80 21.02-41.50	34.84 \pm 10.26 15.16-53.63	27.33 \pm 5.29 16.44-35.89	30.61 \pm 9.51 16.37-47.03	35.00 \pm 8.48 20.98-53.05	30.37 \pm 7.81 12.76-45.85	29.27 \pm 6.85 11.18-41.05	30.68 \pm 6.20 17.82-46.94	27.95 \pm 6.54 12.09-42.24
Diameter of pith parenchymal cells, μ m		128.04 \pm 34.89 51.68-220.46	134.89 \pm 39.55 56.80-224.16	83.87 \pm 24.28 40.46-150.53	117.69 \pm 22.73 47.59-215.89	94.07 \pm 19.37 38.76-131.31	60.72 \pm 8.56 46.19-83.48	100.27 \pm 37.49 38.6-205.23	92.12 \pm 14.23 27.85-115.11	56.66 \pm 14.21 38.23-105.72

Note. Average values were calculated for 25–50 observations for each quantitative feature..

petiole cross-sections in the proximal, medial, and distal parts varies in different species.

In the cross-section, the proximal (basal) part of the petiole of *P. tricuspidata* is oval; in *P. quinquefolia* it is cordate; in *P. inserta* it is more or less circular; on the adaxial side in *P. quinquefolia* it is almost flat, in *P. tricuspidata* and *P. inserta* it is convex (fig. 1.1.A – 1.1.C). The dimensions of the petioles in the proximal part in *P. tricuspidata* are larger in the dorsoventral direction (in height) (HxW) ($4\ 668,96 \pm 244,18 \times 3\ 972,3 \pm 259,15$); in *P. quinquefolia* it is, on the contrary, larger in the tangential direction (in width) ($4\ 936,22 \pm 282,07 \times 5\ 255,21 \pm 298,17$); in *P. inserta* – approximately the same in height and width ($3\ 871,94 \pm 232,36 \times 3\ 702,04 \pm 252,18$).

The medial (middle) part of *P. tricuspidata* petiole in cross-section remains oval and compressed in the tangential direction ($3\ 726,32 \pm 298,22 \times 2\ 947,04 \pm 223,64$), with a U-shaped notch on the adaxial side ($3\ 726,32 \pm 298,22 \times 2\ 947,04 \pm 223,64$) (fig. 1.2.A); in *P. quinquefolia* it becomes more rounded ($3\ 498,36 \pm 251,37 \times 3\ 665,73 \pm 270,44$), with a V-shaped protrusion on the adaxial side (fig. 1.2.B); in *P. inserta* – oval, somewhat elongated in the dorsoventral direction ($2\ 638,33 \pm 199,55 \times 2\ 455,95 \pm 172,38$), with a small U-shaped notch on the adaxial side (fig. 1.2.C). Rib traces become noticeable in the form of small rounded protrusions, which are most pronounced in *P. quinquefolia* (fig. 3.3.B, 3.4), least pronounced in *P. inserta*.

In the distal (apical) part, the cross-sections of the petioles of all species approach rounded in shape; in *P. tricuspidata* and *P. inserta* it is with a U-shaped notch on the adaxial side (fig. 1.3.A, 1.3.C), and in *P. quinquefolia* a V-shaped protrusion remains (fig. 1.3.B); the lateral ribs are most pronounced in *P. quinquefolia*, in *P. tricuspidata* and *P. inserta* they are almost invisible (fig. 1.3.A – 1.3.C). The cross-sections of the petioles have a slightly greater height than width in *P. tricuspidata* ($3\ 213,56 \pm 222,63 \times 3\ 197,08 \pm 297,23$) and in *P. inserta* ($2\ 571,07 \pm 195,61 \times 2\ 411,17 \pm 185,28$); in *P. quinquefolia*, on the contrary, the width is slightly greater than the height ($3\ 180,65 \pm 294,33 \times 3\ 345,53 \pm 263,17$).

On microscope slides with the surface view of the petioles, the epiderma of *P. inserta* and *P. quinquefolia* consists of cells of predominantly quadrate, less often triangular or irregular shape; in *P. tricuspidata*, the cells are predominantly rectangular, and quadrate or irregular ones are also found; the anticlinal walls of the cells of all species are more or less straight (fig. 2.1.A, 3.1.A, 4.1.A). In terms of size (HxW), the epidermal cells are the largest in *P. quinquefolia*, the smallest in *P. tricuspidata*, and intermediate in size in *P. inserta*. On the

surface of the *P. tricuspidata* petiole, simple unicellular trichomes (fig. 2.4), which are characteristic of Vitaceae (Metcalfe, Chalk, 1950), are occasionally found; all species also occasionally have stomata surrounded by four to five subsidiary cells and lenticels (fig. 2.1.A, 2.3).

2. Epiderma.

In cross-section, epidermal cells are round or oval in shape, with thickened membranes; the outer cell walls are covered with a cuticular membrane (fig. 5.2.A, 5.2.B), which in *P. inserta* has prominent papillae (fig. 4.2, 4.5, 5.2.C). The cuticular membrane is the thinnest in *P. tricuspidata* ($1,52 \pm 0,45$ (0,89–2,85)), thicker in *P. quinquefolia* ($3,709 \pm 0,74$ (2,23–5,10)) and *P. inserta* ($2,64 \pm 0,58$ (2,10–5,91)).

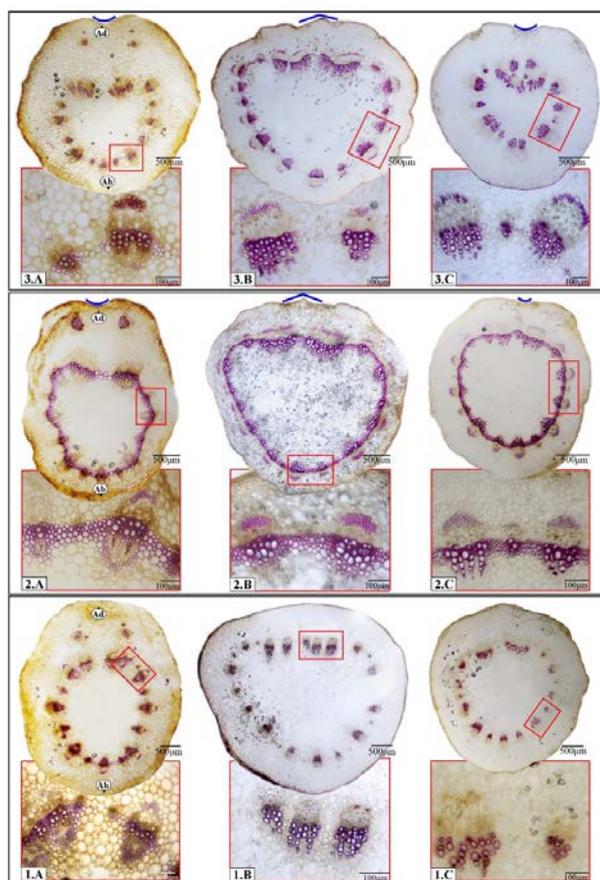


Fig. 1. Anatomical structure of the petiole of A. *Parthenocissus tricuspidata*, B. *P. quinquefolia*, C. *P. inserta*.

Cross-section: 1. Proximal (basal), 2. Medial (middle), 3. Distal (apical). Staining Phloroglucinol/HCl. Ad – adaxial side, Ab – abaxial side

3. Cortex.

The cortex in all species is most developed on the adaxial side, especially in the petioles of *P. tricuspidata*; it consists of collenchyma and cortex parenchyma. The collenchyma is adjacent to the epiderma in *P. tricuspidata*.

idata (fig. 2.2), or separated by a single-layered hypodermis in *P. quinquefolia* and *P. inserta* (fig. 3.2, 4.2). The collenchyma ring in *P. tricuspidata* is continuous in all parts of the petiole (fig. 1.3); in *P. quinquefolia* and *P. inserta* in the proximal part of the petiole the collenchyma is continuous, and in the medial and distal parts it is located in small isolated islands in the ribs of the petiole and is interrupted by chlorenchyma (fig. 3.3.B, 4.3.B, 4.5). Collenchyma with 4–6-angular cells, the membranes of which are thickened at the corners, is more developed in the proximal part of the petioles, where it reaches the greatest thickness in *P. quinquefolia* (fig. 3.3.B, 3.4, 3.5). The thickness of the collenchyma cell walls does not differ significantly in different species; their sizes are the largest in *P. quinquefolia*, the smallest in *P. inserta*. In the collenchyma of all species, cells with druses and raphides occur (fig. 2.6, 4.2).

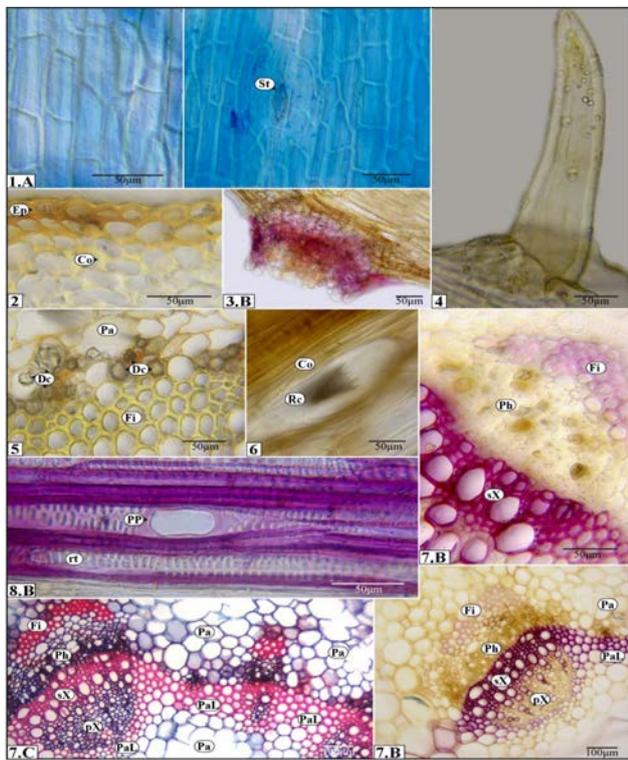


Fig. 2. Anatomical structure of the petiole of *Parthenocissus tricuspidata* (medial part)

Staining: A. Astra Blue; B. Phloroglucinol/HCl; C. Safranin/Astra Blue.

1. Epiderma (in surface view); 2. Epiderma and collenchyma in cross-section; 3. Lenticels; 4. Simple unicellular trichomes; 5. Druses in the cortex parenchyma; 6. Raphides in the collenchyma; 7. Fibro-vascular bundles; 8. Xylem elements.

St – stomata, Ep – epiderma, Co – collenchyma, Pa – parenchyma; PaL – lignified parenchyma; Fi – bundle-sheath of sclerenchyma fibres, Ph – phloem, sX – secondary xylem, pX – primary xylem, PP – perforation plates, Ra – raphide crystals, Dc – druse crystals: type of lignification of the cell wall of xylem elements: rt – reticulate

The cortex parenchyma, which is located inward from the collenchyma, is of the same type in the studied species; it is the most developed on the adaxial side, and consists of large thin-walled cells, which are round in cross-section and rectangular in tangential sections. The size of the cortex parenchyma cells is the largest in *P. tricuspidata*; in *P. quinquefolia* and *P. inserta* they do not differ significantly. Cells with druses and raphides are often found in the cortex parenchyma (fig. 2.5, 4.4).

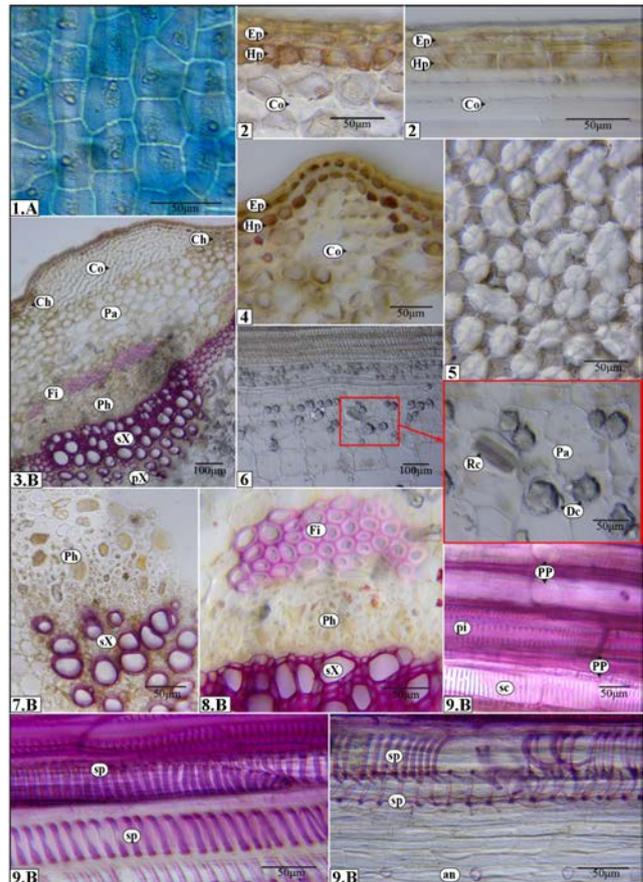


Fig. 3. Anatomical structure of the petiole of *Parthenocissus quinquefolia* (medial part)

Staining: A. Astra Blue; B. Phloroglucinol/HCl. 1. Epiderma (in surface view); 2. Epiderma and collenchyma cross and tangential sections; 3. Cortex and vascular bundles; 4. Ribs; 5. Collenchyma; 6. Druses and raphides in the pith; 7. Fibro-vascular in the proximal part; 8. Fibro-vascular bundles in the medial part of the petioles; 9. Xylem elements.

Hp – hypoderma, Ch – chlorenchyma; types of lignification of the cell wall of xylem elements: an – annular, sp – spiral, sc – scaliforme, pi – pitted, the other components of the legend are same as in fig. 2

4. Fibro-vascular bundle.

The structural features of vascular bundles are of taxonomic importance, especially their number and structure of the xylem (Coutinho et al., 2016). Accord-

ing to literature data, the xylem of Vitaceae, in particular *Parthenocissus*, is characterized by large vessels (30–50 μm); perforation plates simple; tyloses; fibers occur in narrow bands or patches separated by more abundant thin-walled parenchyma; fibers non-septate, very thick-walled, very long; vasicentric tracheids with scalariform thickening and sometimes with delicate spiral thickening; raphides in parenchyma and rays (Metcalf, Chalk, 1950). Vitaceae are also characterized by a petiole with a complete cylinder of vascular tissue, or with a ring of vascular bundles connected by parenchyma or by more or less lignified fibers; or vascular bundles are isolated (Takhtajan, 2009). It has been shown that the petioles of representatives of Vitaceae are characterized by secondary xylem.

Diagnostic features of the structure of the vascular system of *Parthenocissus* are: the number of central (main) conductive bundles (ranging from 10 to 30 or more); the degree of their isolation (completely isolated from each other, or forming a closed false ring, or a false ring open in the adaxial part); the presence of peripheral additional vascular bundles.

Common features of the structure of the vascular system of the studied species are the isolation of the central vascular bundles regardless of the location of the cross-section of the petiole. The vascular bundles are of different sizes (larger and smaller bundles alternate), they are clearly separated from each other and are not densely located (fig. 1, 2.7.C, 3.3.B, 4.7.B). The xylem and phloem are located collaterally, their structure is the same type.

The phloem reaches its maximum thickness in the proximal and distal parts of the petioles of *P. quinquefolia* and *P. inserta*, where the sclerenchyma fibers above the phloem do not develop or develop weakly (fig. 1, 3.7.B, 4.6.B). The strengthening function in such bundles is performed by peripheral collenchymatous parenchymal cells of the primary phloem (fiber rudiments), which do not stain or stain weakly with phloroglucinol/HCl (fig.). The deposition of callose in the protophloem is accompanied by the death of sieve elements, companion cells and partial destruction of their common walls (Davis, Evert, 1970).

In the medial and optionally distal parts of the petioles of *P. quinquefolia* and *P. inserta*, as well as in all parts of the petiole of *P. tricuspidata*, sclerenchyma fibers (pericyclic fibers or protophloem fibers) are located on the periphery of the primary phloem (fig. 1, 2.7.B, 2.7.C, 3.8.B, 4.7.B). In all species, the sclerenchyma caps above the primary phloem is bean-shaped, consisting of 3 to 7 layers of weakly lignified fibers. The thickness of the sclerenchyma sheath and the diameter of its fibers are somewhat higher in *P. tricuspidata*, and their walls are thicker in *P. quinquefolia* and *P. inserta*.

The presence or absence, as well as the nature of “pericycle” sclerenchyma has taxonomic value (Metcalf, Chalk, 1950). Also, weak development or absence of sclerenchyma is a characteristic feature of long, flexible stems of climbing plants.

In the vascular bundles of the studied species, primary and secondary xylem are found (fig. 1, 2.7.B, 2.7.C, 3.3.B, 4.7.B). In the primary xylem (protoxylem and metaxylem), the vascular elements have annular (in rings), spiral or scalariform lignification of the secondary cell walls (fig. 3.9.B, 4.8.B). In the protoxylem closer to the pith, the vascular elements are destroyed and obliterated by the surrounding parenchymal cells. The parenchyma of the primary xylem is not lignified, the fibers are not visible (fig. 3.9.B, 4.8.B). Secondary xylem consists of vessels, tracheids, libriform fibers and parenchyma cells. All elements of the secondary xylem are lignified, stained with phloroglucin and safranin (fig. 2.7.B, 2.7.C, 4.8.B). The vessels of the secondary xylem are wider, by the nature of the thickenings porous pitted or reticulate (fig. 2.8.B, 3.9.B). The libriform fibers are non-septate, pitted, elongated and thickened (fig. 4.8.B). Also, around the vascular bundles from the side of the cortex and pith, crystalline sheath of parenchymal cells are formed containing druses and raphids (fig. 2.5, 3.6).

Differences in the structure of the vascular system of the petiole depend on the species studied and the location of the cross-section. The number of vascular bundles in the proximal and medial parts of the petioles is the smallest in *P. tricuspidata* 14–21, somewhat larger in *P. inserta* 15–22 and *P. quinquefolia* 17–23; in the distal part the number of vascular bundles is somewhat reduced in all species due to the fusion of 2–3 bundles in the adaxial part of the petioles (fig. 1). The diameter of the vessels and the thickness of the xylem are the largest in the high climbing lianas *P. tricuspidata* and *P. quinquefolia* and have slightly smaller values in *P. inserta*.

An important diagnostic feature of the vascular system of *P. tricuspidata* petioles is the additional bundles located in their adaxial part, as well as the presence of a false ring in which individual vascular bundles are connected by layers of lignified interfascicular parenchyma. These features are preserved in all parts of the *P. tricuspidata* petiole (fig. 1). Also, only in petioles of *P. tricuspidata* have a layer of lignified parenchyma forms a sheath of bundle around the xylem (fig. 2.7.C, 2.7.B). Petioles of *P. inserta* and *P. quinquefolia* do not have additional adaxial vascular bundles; also in both species, interfascicular lignified parenchyma is noted on cross-sections only in the medial and optionally in the distal parts of the petioles and is completely absent in the proximal parts (fig. 1, 3.3.B, 4.7.B). On cross-sections in the medial part of the petioles of all species, the false ring of vascular bundles is closed (fig. 1).

In Vitaceae, the recognized primitive type of the structure of the vascular system is a closed true ring of vascular bundles formed by their fusion; the intermediate type is a false ring; and the most evolutionarily advanced type is discrete bundles. According to this characteristic, the studied *Parthenocissus* species have an intermediate type of the structure of the vascular system.

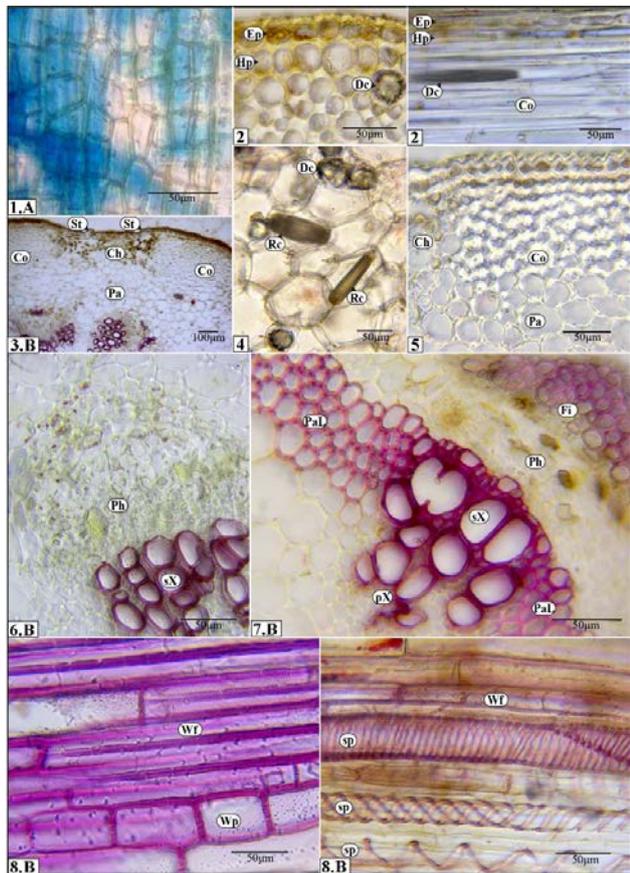


Fig. 4. Anatomical structure of the petiole of *Parthenocissus inserta* (medial part)

Staining: A. Astra Blue; B. Phloroglucinol/HCl. 1. Epiderma (in surface view); 2. Epiderma and collenchyma cross and tangential sections; 3. Cortex and vascular bundles; 4. Cortex parenchyma; 5. Collenchyma; 6. Fibro-vascular in the proximal part of the petiole; 7. Fibro-vascular bundles in the medial part of the petioles; 8. Xylem elements.

Wf – wood fiber, Wp – wood parenchyma, the other components of the legend are same as in fig. 2, 3

5. Pith.

The pith does not differ significantly in structure in the studied species and is of the same type in different parts of the petiole. It consists of thin-walled large parenchyma cells, between which intercellular spaces occur; on the periphery of the pith the cells are smaller. The largest diameter of the pith cells is reached in the petioles of *P. tricuspidata* and *P. quinquefolia*, the small-

est in *P. inserta*. In the parenchyma there are cells with druses and raphids, especially in cells adjacent to vascular bundles and interfascicular rays (fig. 3.6).

6. Crystalline inclusions.

Vitaceae is characterized by the presence of druses, as well as needle-like crystals – single styloids and clustered raphides, which are contained in mucilage idioblasts (Metcalf, Chalk, 1950). Prismatic single crystals are indicated for old tissues of *P. tricuspidata* (Calmes, Carles, 1970). It is noted in the literature that the juice of *P. quinquefolia*, due to the high content of oxalate crystals, can cause skin irritation and allergic reactions (King, Henson, 2021).

Crystalline inclusions, which occur as intravacuolar deposits, play an important role in the deposition of excess calcium and the regulation of its homeostasis, protection against herbivores, detoxification of heavy metals and as a source of CO₂ during photosynthesis (Paiva, 2019). Raphids are considered to be reserve substances that dissolve when needed, remobilizing the bound calcium used for plant growth and development; druses are the end product of metabolism and are partially excreted with fallen leaves (Calmes, Carles, 1970; Nakata, 2012).

The mucilage that accumulates in mucilage and crystalline idioblasts is important for water retention in plants (Angeles, Leon-Gomez, 1997).

For the studied species, no specific features in the type, shape, or localization of crystalline inclusions in the petiole were found, although the literature indicates that the signs of the presence or absence of crystals, their types, and chemical composition have taxonomic value (Nakata, 2012; Najmaddin 2014). Raphids, unlike druses, have more limited distribution and, therefore, are of greater taxonomic interest (Metcalf, Chalk, 1950).

In the studied species, raphides and druses are observed in the pith and cortex parenchyma closer to the vascular bundles, in the interfascicular parenchyma and collenchyma; less often, druses occur in the parenchyma of the phloem and protoxylem, in the collenchymatous parenchymal cells of the protophloem. The sizes of druses in the studied species do not differ significantly and on average are $30,78 \pm 8,09$ (8,57–65,00). Raphides also do not differ significantly in size in investigated species; their average dimensional indicators: length – $64,68 \pm 3,80$ (40,37–122,01), width – $30,05 \pm 9,20$ (16,40–52,26); The width of the cells of the mucilage and crystalline idioblasts is $60,82 \pm 7,20$ (46,46–73,98), their length is $85,36 \pm 11,97$ (51,41–136,47).

7. Results of histochemical studies.

In the histochemical reaction with phloroglucin/HCl, lignified caps of sclerenchyma fibers above the protophloem, elements of the primary and secondary xylem, interbundle parenchyma and parenchyma around the xylem acquired a raspberry-red color

(Fig. 1, 2.7.B, 3.8.B, 4.7.B). In all cross-sections, the collenchyma of the primary cortex, as well as the collenchymatous parenchyma of the protophloem only in the proximal and optionally in the distal part of the petioles of *P. inserta* and *P. quinquefolia*, did not show lignification in the reaction with phloroglucin/HCl (Fig. 3.7.B, 4.6.B).

Amyloplasts were detected by reaction with Lugol's solution in the parenchyma between the vascular bundles, in the xylem parenchyma, in the epiderma and hypoderma, in the cortex parenchyma around the vascular bundles, and in individual cells of the primary cortex parenchyma (Fig. 5.1.A – 5.1.C).

The cuticular membrane is diagnosed by its orange-brown color when treated with Sudan III solution (Fig. 5.2.A – 5.2.C). The phloem contains cavities with a yellow secretion that turns orange under the influence of Sudan III solution (fig. 5.2.A).

Phenolic compounds were detected by histochemical reaction with iron (III) chloride in the parenchyma of the xylem and phloem of the petiole, epiderma, and hypoderma (fig. 5.3.B).

Mucilage and crystalline idioblasts stained with a solution of methylene blue in alcohol in a deep blue color were found in the parenchyma of the cortex and pith, in the phloem, sclerenchyma, and collenchyma (fig. 5.4.B, 5.4.C).

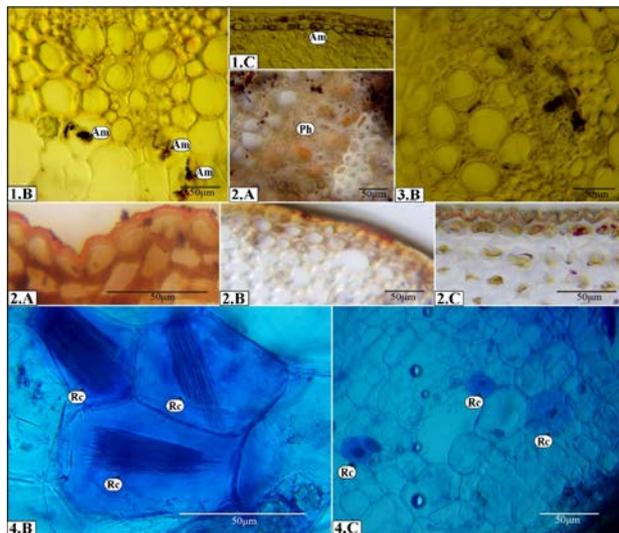


Fig. 5. Results of histochemical investigations of A. *Parthenocissus tricuspidata*, B. *P. quinquefolia*, C. *P. inserta*

1. Reaction with Lugol's solution – dark blue color of amyloplasts; 2. Reaction with Sudan III – orange-red color of the cuticle and secretory cavities of the phloem; 3. Reaction with iron (III) chloride – black color of phenolic compounds; 4. Reaction with a solution of methylene blue in alcohol – blue color of mucilage and crystalline idioblasts.

Am – Amyloplast

Conclusions. Comparative anatomical and histochemical studies of the structural features of the petioles of three *Parthenocissus* species, which are widespread in Ukraine and are promising for use in pharmaceutical production, were conducted. As a result of the studies, structural and anatomometric differences in the structure of the petioles of *P. tricuspidata*, *P. quinquefolia*, and *P. inserta* were determined.

The most significant diagnostic features of the petioles of the studied species, which have high taxonomic value, are:

1. The shape of the cross-section outline of the petiole, which changes from the basal to the medial part in *P. quinquefolia* from cordate to more rounded with a V-shaped protrusion on the adaxial side; in *P. inserta* – from rounded to oval with a U-shaped notch on the adaxial side; in *P. tricuspidata* – does not change fundamentally and remains oval, with a U-shaped notch on the adaxial side. In the distal part, the cross-sections of the petioles of all species approach rounded in shape, differ in the shape of the adaxial side and the degree of development of the lateral ribs.

2. The presence of simple unicellular trichomes in *P. tricuspidata*, and the absence of pubescence in *P. quinquefolia* and *P. inserta*.

3. The nature of the arrangement of the cortex collenchyma, which in *P. tricuspidata* mostly forms a continuous subepidermal layer; in *P. quinquefolia* and *P. inserta* – in the medial and distal parts it is located as small islands in the protruding ribs of the petiole and is interrupted by chlorenchyma.

4. In the proximal and optionally distal parts of the petioles of *P. quinquefolia* and *P. inserta*, sclerenchyma above the phloem is not expressed, instead, the collenchymatous parenchyma of the non-vascular part of the primary phloem is developed, which has a mechanical function. In *P. tricuspidata*, sclerenchyma caps above the phloem are present in all parts of the petiole.

5. Additional vascular bundles in the adaxial part of the petioles are noted only in *P. tricuspidata*.

6. Interfascicular lignified parenchyma in *P. quinquefolia* and *P. inserta* is noted on cross-sections only in the medial and optionally in the distal parts of the petioles and is completely absent in the proximal parts; whereas in *P. tricuspidata* a layer of lignified parenchyma is noted in all parts of the petiole and also forms a sheath of the bundles around the xylem.

For the studied species, the structural features of the epiderma, parenchyma of the cortex and pith, xylem, as well as the type, shape or localization of

crystalline inclusions in the petiole have low taxonomic value. Most of the dimensional parameters of the petioles also did not show significant taxonomic value.

According to the results of histochemical reactions, waxy substances of the cuticular membrane

were detected; lipophilic and/or essential oil cavities in the phloem; lignified sclerenchyma fibers, xylem elements, interbundle parenchyma and parenchyma around the xylem; starch; phenolic compounds; mucilage localized in mucilage and crystalline idoblasts.

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