1-бөлім
БОТАНИКА

Раздел 1
БОТАНИКА

Section 1
BOTANY

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Biometric data of anatomical structure of vegetative organs of rare, narrowly endemic species *Oxytropis almaatensis* Bajt. in Trans-Ili Alatau mountains (Kazakhstan)

The article presents the features of the anatomical structure and biometric indicators of vegetative organs ofrare, narrowly endemic species Oxytropis almaatensis Bajt. The first population of O.almaatensis was discovered in the Big Almaty Gorge, coordinates: N 43004.864′, E 076059.604′, altitude 2160 m. The second population was located in the Small Almaty Gorge, coordinates: N 43008.490′, E 077004.198′, altitude 2002 m. The study of anatomical structure of virginal, young and middle-generative O.almaatensis specieswascomparatively carried out in two populations. In the first and second populations of the virginal age period, it was revealed that the cortex thickness is bigger than in the young and middle-generative periods. The study of the stem internal structure of different age periods in different populations showed that all individuals have the bundle structure of the stem that is characteristic of dicotyledonous plants with varying degrees of development of various tissues. By comparing the anatomical structure of the leaf blades from different populations, it was found that for all individuals of different age periodsthe dorsoventral, bilateral mesophyll are characteristic.

Key wods: Oxytropis almaatensis Bajt., narrow endemic, population, conductive bundle, parenchyma, sclerenchyma.

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Іле Алатауы жағдайындағы (Қазақстан) сирек, тар эндем *Oxytropis almaatensis* Bajt. өсімдігінің вегетативтік мүшелерінің анатомиялық құрылысының биометриялық көрсеткіштері

Мақалада сирек кездесетін, тар эндем Oxytropis almaatensis Bajt. өсімдігінің вегетативтік мүшелерінің анатомиялық құрылысы және биометриялық көрсеткіштері келтірілген. Oxytropis almaatensis Bajt. өсімдігінің бірінші популяциясы Үлкен Алматы шатқалынан табылды, GPS координаттары: N 43004.864′, E 076059.604′, теңіз деңгейінен биіктігі 2160 м. Екінші популяция Кіші Алматы шатқалынан анықталды, GPS координаттары: N 43008.490′, E 077004.198′, теңіз деңгейінен биіктігі 2002 м. Виргинильдік, жас және орташа генеративтік дарақтардың анатомиялық құрылысы салыстырмалы түрде екі популяцияда жүргізілді. Бірінші және екінші популяцияның виргинильдік жастық күйінде тамыр қабығы жас және орташа генеративтік жастық кезеңдерімен салыстырғанда, қалың екендігі анықталды. Әртүрлі популяцияда, әртүрлі жастық кезеңдерінде өсімдік сабағының ішкі құрылысын зерттеу барысында,барлық дарақтарда әртүрлі ұлпалардың дамуымен қатар, қос жарнақтылардың сабағына тән шоқты құрылыс байқалды. Екі популяциядағы жапырақ тақтасының анатомиялық құрылысын салыстыру барысында, әртүрлі жастық кезеңіндегі дарақтардың барлығына дорзовентральды, билатеральды мезофилл тән екендігі айқындалды. Жапырақ негізгі фотосинтезге қатысатын өсімдік мүшесі болғандықтан, жапырақ тақтасының ішкі құрылысының ерекшеліктері, әсіресе хлорофиллды ұлпа – мезофиллдің қалыңдығы өсу ортасына, оның ішінде жарыққа тәуелді болуы мүмкін.

Түйін сөздер: Oxytropis almaatensis Bajt.,тар эндем, популяция, өткізгіш шоқ, паренхима, склеренхима.

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Биометрические показатели анатомической структуры вегетативных органов редкого, узкоэндемичного вида *Oxytropis almaatensis* Bajt. в условиях Заилийского Алатау (Казахстан)

В статье приводятся особенности анатомической структуры и биометрические показатели вегетативных органов редкого, узкоэндемичного вида Oxytropis almaatensis Bajt. Первая популяция была обнаружена в Большом Алматинском ущелье, координаты: N 43004.864′, E 076059.604′, высота над ур. моря – 2160 м. Вторая популяция располагалась в Малом Алматинском ущелье, координаты: N 43008.490′, E 077004.198′, высота над ур. моря – 2002 м. Исследование анатомического строения виргинильных, молодых и средних генеративных особей растений O.almaatensis сравнительно проводилось в двух популяциях. В первой и второй популяциях в виргинильном возрастном периоде было выявлено, что толщина коры больше по сравнению с молодым и средним генеративными периодами. Изучение внутренней структуры стебля растений различных возрастных периодов в разных популяциях показало, что все особи имеют пучковое строение стебля, характерное для стеблей двудольных растений с различной степенью развитости тех или иных тканей. При сравнении анатомического строения листовых пластинок растений различных популяций было установлено, что для всех особей разных возрастных периодов характерны дорзовентральность, билатеральный мезофилл.

Ключевые слова: Oxytropis almaatensis Bajt., узкоэндемичный, популяция, проводящий пучок, паренхима, склеренхима.

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BIOMETRIC DATA OF ANATOMICAL STRUCTURE OF VEGETATIVE ORGANS OF RARE, NARROWLY ENDEMIC SPECIES *OXYTROPIS ALMAATENSIS* BAJT. IN TRANS-ILI ALATAU MOUNTAINS (Kazakhstan)

Introduction

Family *Fabaceae*, comprising 750 genera and over 18,000 species, is one of the largest family of dicotyledonous with the high economic value [1]. *Oxytropis* is an important genus of the family *Fabaceae*. *Oxytropis* DC. representscomprehensive taxonomic genera, which includes about 450 species, with the greatest diversity in the mountains of Asia [2]. In Kazakhstan, the genus is represented by 126 species, 39 of which are endemic [3], and 10 are listed as endangered [4].

Endemic species are often characterized by narrow specialization, adaptation to a strictly defined existence conditions, and as a result, an intermittent spread even within the main range. These endemic species make up the most vulnerable part of regional floras. Changing the biotopes under human influence leads to a further reduction of their natural habitat [5]. Endemic and rare plants are integral components of the local flora and vegetation, and the disappearance of these species could lead to the biodiversity decrease. Some researchers noted that the threat to the gene pool of rare, endemic species at the current stage is primarily in the anthropogenic transformation of environment and habitat fragmentation, causing a decrease in the volume and size of the population, their isolation [6-8]. More and more attention of researchers is given to the number and biodiversity, morphological and anatomical features of endemic species [9-12].

Mountainous regions maintain high productivity of plant diversity and endemism, but are vulnerable to the climate changes. Rare plant species can be particularly vulnerable to climate changes, because of their limited distribution and abundance [13].

There were analyzed anatomical features of leaf blades of rare, endemic species *Ferula iliensis*from different ages in three different populations growing in the eastern part of the Trans-Ili Alatau mountains (Big Bogutu Mountains, Kazakhstan). Among all the studied populations of plants there was determined one type with the formation of the leaf blade and xero mesomorphic structure.The planarpolarity of the blade showed multilayer of palisade mesophyll, a characteristic for all plants. Most of the covering hairs onthe pubescent leaves are located on the lower side of the blades. The leaf

type in general is xero mesomorphic. Thedifferences are mainly of quantitative character and are related to the environmental conditions of the plants. The leafstructure reflects the result of plant adaptation to various environmental factors, so the information on the leaf structurecomplements the environmental characteristics of the plants and improves the idea of its range of plasticity [14].

Many researchers refer to the list as the main indicator when studying the sustainability and adaptability of plants, due to its basic functions – photosynthesis and transpiration [15-17]. The leaves have a variety of morphological and anatomical features mostly under the influence of climatic, soil and biotic factors. Leaves are organs of plants responsible for obtaining solar energy and for gas exchange as well as photosynthesis. Their anatomical variations can be interpreted as a strategy to adapt to different environmental conditions, where plants are found [18]. The effect on the leaf anatomical structure of environmental factors, such as low temperatures, drought, light, and the height, response of leaf structure to the environment have been recognized for long periods, and environmental trends have generalization. Knowledge of the leaves anatomy of meadow plants is crucial to the understanding of how these plants adapt to their environment [19].

In the understanding of the evolutionary tendencies of plant anatomy is a major, although recent evo-devo concepts based on molecular genetics, classical structural information is useful as ever [20]. Phylogenetic investigations are based on morphological and anatomical features. Identification of the anatomical features of the plants is not always useful as morphological. Anatomical characteristics can be used to distinguish between closely related species [21]. Anatomical characteristics are also very important for the identification of medicinal parts of the plants [22].

Since, *O. almaatensis* on the status of rare, narrowly endemic species with a threatened area of distribution, we first studied the anatomical structure of vegetative organs of this species in the comparative aspect in two natural populations. The aim of the work was to study the anatomical structure of vegetative organs of rare, narrowly endemic species *Oxytropis almaatensis* Bajt. in conditions of Trans-Ili Alatau mountains (Kazakhstan).

Materials and Methods

During the expeditions in Almaty region two populations of *Oxytropis almatensis* in the Trans-Ili Alatau mountains were found. The populationswere previously studied.The first population of *Oxytropis almaatensis* was discovered in the Big Almaty Gorge, coordinates: N 43004.864', E 076059.604', altitude 2160 m. The second population was located in the Small Almaty Gorge, coordinates: N 43008.490', E 077004.198', altitude 2002 m. The study of coenopopulations was conducted by Y. Zlobin et al. [23] and A.S. Kashin et al. [24].

Each population was collected and fixed vegetative organs of *O. almaatensis* individuals of different ages. Plant conservation was carried out according to the method of Strasburger-Flemming. Persevering liquid was a mixture of: alcohol-glycerol-water in a ratio of 1: 1:1. Fixation was preserved in 96% ethanol. Aboveground organ and underground vegetative organs of studied plant species have been fixed.

While studying the anatomical features of plant organs generally accepted methods of R.G.Barykina were used [25]. Static processing of biometric data was conducted according to the procedures F.G. Lakin [26] and N.L. Udolskaya [27], as well as using Microsoft Office Excel 2003. The photomicrographs of anatomical blades were made on the MC 300 microscope («Micros» Austria) with a video camera CAM V400 / 1.3M («Micros» Austria).

Results and discussion

Root anatomy (Population №1). In cross section of the root it can be seen that the root is surrounded by periderm, which contains suberic cellswith clearly distinguished lenticels. Under the peridermcortex is located. The cortex consists of various parenchyma and sclerenchyma cells. It is possible to clearly distinguish the central cylinder, where medullary raysare clearly visible. Also, in the central part the xylemis located andxylem is surrounded byphloem.

In the first oxytropis population in virginal age state, it was identified that the thickness of the cortex is bigger than in the young and middle-generative periods (Fig. 1). In the central cylinder of conductive elements, including xylem rays increased with age, as well as increased periderm.

Root anatomy (Population №2). In the virginal state of *Oxytropis almaatensis* Bajt. root, may notice a thick layer of periderm, cortex covers a large part of the root, central cylinder is in the center that composed of xylem and phloem (Fig. 2, A). At the young generative state central cylinder covers most of the part of the root (Fig. 2, B). In the cross section of the middle generative state central cylinder almost completely covers the root. The size of xylem vessels increased (Fig. 2, C).

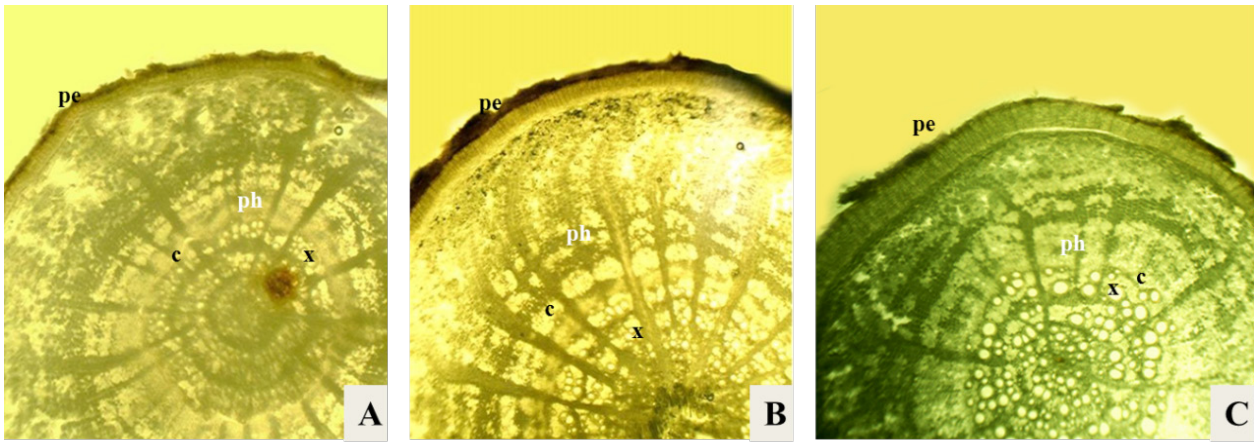

Figure 1 – Cross section of the root of Oxytropis almaatensis Bajt., population 1 (A-virginal plant, B-young generative plant, C-average generative plant). pe: peridermis, ph: phloem,c: cambium, x: xylem (10x4)

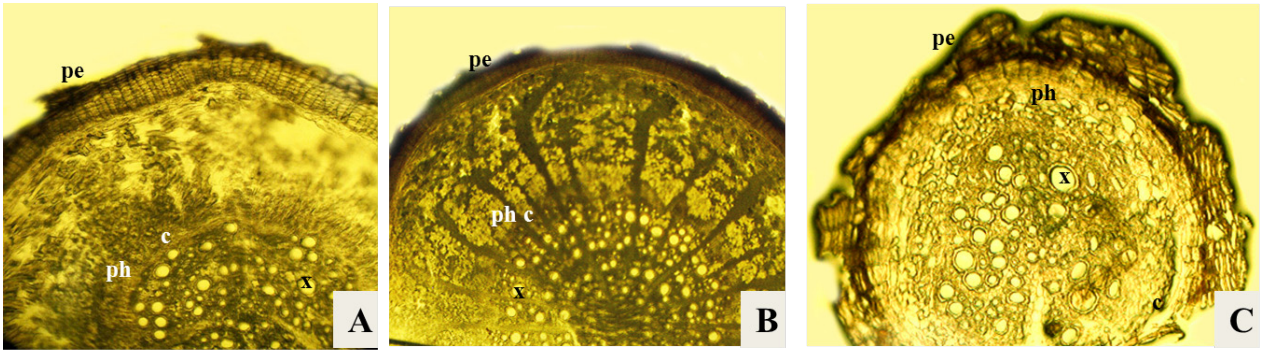

Figure 2 – Cross section of the root of Oxytropis almaatensis Bajt., population 2 (A-virginal plant, B-young generative plant, C-average generative plant). pe: peridermis, ph: phloem,c: cambium, x: xylem(10x4)

Table 1 – Biometric indicators Oxytropis almaatensis Bajt.root,μm

Anatomical features	Samples of *Oxytropis almaatensis* Bajt.					
	Population №1			Population №2		
	Virginal	Young generative	Middle generative	Virginal	Young generative	Middle generative
Diameter of the root	489,69±14,25	788,23±18, 67	484,72±10,92	392,92±8,72	542,54±7,63	353,77±8,78
Thickness of the periderm	26,55±1,67	35,38±2,36	32,53±1,25	57,13±5,42	22,77±1,59	39,6±3,28
Thickness of the primary cortex	87,85±5,47	75,58±6,11	60,66±3,66	149,57±8,04	59,96±4,34	21,26±0,98
Diameter of the central cylinder	286,72±11,89	541,2±9,61	318,45±12,12	357,31±3,45	285,14±9,3	376,63±5,43
Diameter of the xylem vessels	7,49±0,53	8,57±1,23	9,7±1,01	11,42±1,35	9,49±1,67	12,73±1,11

With the plant age-related growth the diameter of xylem vessels increases. Primary cortex thickness on the contrary decreases with growth, for example, in the first population in virginal state the thickness of primary cortex is 87,85±5,47 microns, in middle generative these data decreased in 60,66±3,66 microns.In the second population there is also noticeably sharply reduction of thickness of the primary cortex in virginal from 149,57 ± 8,04 microns to 21,26 ± 0,98 microns on middle generative state(Table1).

Since the leaf is the main photosynthetic organ, especially the internal structure of the leaf blade, particularly the thickness of the chlorophyll tissue – mesophyll, may depend on the place of growth conditions, including the lighting conditions.

Stem anatomy (Population №1). A cross section of the *Oxytropis almaatensis* Bajt.stem covered by one layer of epidermal cells of different sizes, in the epidermisglandular trachoma are found. Under the epidermis the primary cortex of 3-5 layers of parenchymaand collenchyma cells are located.In the central cylinder located in a circle of collateral open vascular bundles. In the conducting bundles between the xylem and phloem there iscambium, above the phloem there isthe linerof sclerenchyma bundles that consist of 3-4 layers of cells. In the part of pithcavity isformed. At the virginal plantstate the number of vascular bundles is 5-9(Fig. 3, A).In the young generative plant the stem covered with the glandular trachoma, under the epidermis,there are several layers of parenchyma cells, there was alsofound collenchyma continuous layer above the conductive bundles. Liner of bundles made a continuous layer of sclerenchyma cells.The sclerenchyma observed between bundles, in particular at the periphery of xylem vessels. Between the large bundlesthe xylem bundles with a single ray are developing. In one conductive bundle there are 5 xylem rays. In one ray- 5-7 vessels. In the central part of the stemcavity of the pith is formed (Fig. 3, B).Above the epidermis in the primary cortex unidentified black substance is found. There was an increase of the central cylinder, also continuous layer of sclerenchyma, the thickness of which is increased in comparison with the young generative. Between the large bundlesthere are developing xylem bundles with a single ray.In one large vascular bundle the xylem rays reach up to 7, vessels in one xylem ray are biggerthan 7. The parenchyma of the central cylinder is up to 9 rows. The size of the pith cavity is increased (Fig. 3, C).

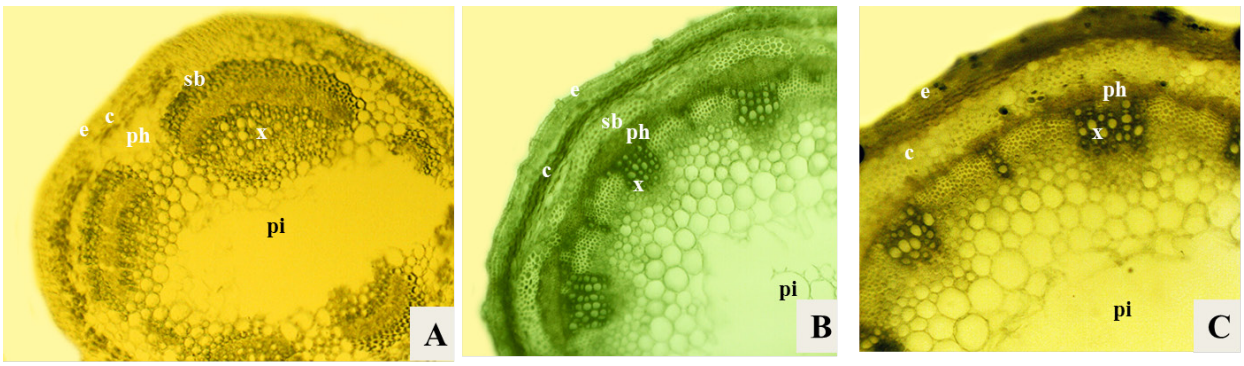

Figure 3 – Cross section of the stem of Oxytropis almaatensis Bajt., population 1 (A-virginal plant, B-young generative plant, C-average generative plant). e: epidermis, c: cortex, sb: sclerenchyma bundle, ph: phloem, x: xylem, pi: pith (10x10)

Stem anatomy (Population №2). In the second population *O.almaatensis*stem in virginal age state has large glandular trachoma. Above the epidermis primary cortex consists of parenchyma and collenchyma. The central cylinder of vascular bundles collateral open, i.e. between the xylem and phloem there is a row of cambium.Above the phloem there are well developed bast fibers. In the virginal state the stem has in average 9 bundles of various sizes. The largest bundle's xylem vessels constitute 10-11 rays, 5-6 vessels in each ray. In the central cylinder parenchymal cells composed of 6-7rows.In the center of the parenchyma cells started to break down and there was a very small cavity (Fig. 4, A). In the cross-section of the young generative stem, there were observed about 13-15 vascular bundles, 3 of which are large. The xylem rays are about 15, and ratio of xylem to the phloem of one to three.

Above the epidermis there are continuous layer of collenchyma cells. Above the bundles there are well developed bast fibers. The thickness of the bast fibers is 2 times greater than phloem. Between and above the bundlesthere are clearly visible parenchymal cells of various sizes. The central cavity formed in the cylinder center (Fig. 4, B).The middle age state has epidermis with trachoma, also has 9 large bundles, which are composed of xylem, phloem and cambium. The number of xylem rays is 9, xylem is much bigger than the phloem. In the center of the stem cavity size increased (Fig. 4, C).

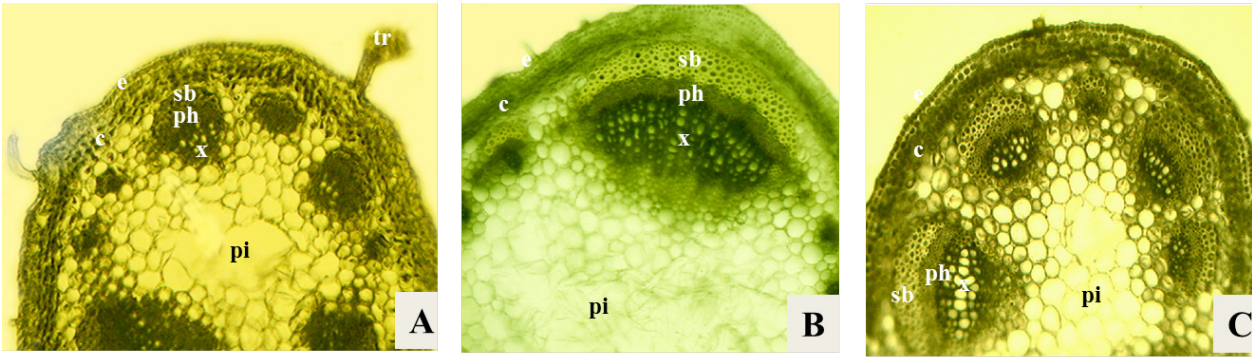

Figure 4 – Cross section of the stem of Oxytropis almaatensis Bajt., population 2 (A-virginal plant, B-young generative plant, C-average generative plant). e: epidermis, c: cortex, sb: sclerenchyma bundle, ph: phloem, x: xylem, pi: pith, tr: trachoma (10x10)

Table 2 – Biometric indicators Oxytropis almaatensis Bajt. stem, µm

Anatomical features	Samples of *Oxytropis almaatensis* Bajt.					
	Population №1			Population №2		
	Virginal	Young generative	Middle generative	Virginal	Young generative	Middle generative
Diameter of the stem	419,07±11,2	785,1±13,21	917,4±14,69	379,67±5,12	569,02±1,72	461,9±4,53
Thickness of the primary cortex	31,88±0,54	42,15±1,13	49,09±0,48	43,99±1,02	49,19±1,08	36,31±1,06
Diameter of the central cylinder	340,54±7,61	710,94±12,74	826,13±9,94	330,5±4,17	483,28±2,59	371,94±3,03
Length of the conductive bundle	100,87±5,43	105,94±5,47	114,69±2,36	79,70±2,99	105,81±2,27	98,76±2,17
Width of the vascular bundle	152,28±3,83	66,68±54,19	67,195±2,14	106,09±1,85	139,48±3,39	98,98±2,74
Thickness of the bast fibers	19,43±1,46	24,69±1,35	26,61±0,97	27,17±0,68	39,72±1,04	29,97±0,88
Length of the xylem rays	43,92±2,18	48,41±1,67	52,89±2,41	31,0±0,98	67,40±1,24	40,31±1,21
Thickness of the phloem	24,04±0,48	23,02±0,23	29,2±0,96	17,03±0,66	23,98±0,6	12,77±0,53
Diameter of the xylem vessels	8,28±0,09	9,90±0,60	11,23±0,88	7,11±1,02	10,28±0,3	8,06±0,15

In the first population anatomical indicators increased with the growth of plants. But in the second population of all biometric indicators in the young generative age state were much more than the virginal and middle-generative. For example, the diameter of the stem in a young generative 569,02 ± 1,72, in virginal 379,67 ± 5,12 and 461,9 ± 4,53 in the middle generative age state (Table 2).

Leaf anatomy (Population №1). Leaf is covered with the upper and lower epidermis, among them the bilateral mesophyll is located. Trachoma are present on the both part of epidermis, but are dominated in the lower epidermis. Under the upper epidermis cells are located 1-2 layers of palisade mesophyll cells located under them the spongy mesophyll. The boundary between the palisadeand spongy mesophyll is expressed clearly. In spongy mesophyll there are many intercellular spaces. In veins closed collateral vascular bundles are located, that consist of phloem towards to the lower epidermis and the xylem towards to the upper epidermis (Fig. 5, A). In the young generative state there are clearly expressed liner bundles (Fig. 5, B). In the middle generative age state, in the mid veinunder the vascular bundles there is the bulge, under the phloem located parenchyma cells to the lower epidermis (Fig. 5 C).

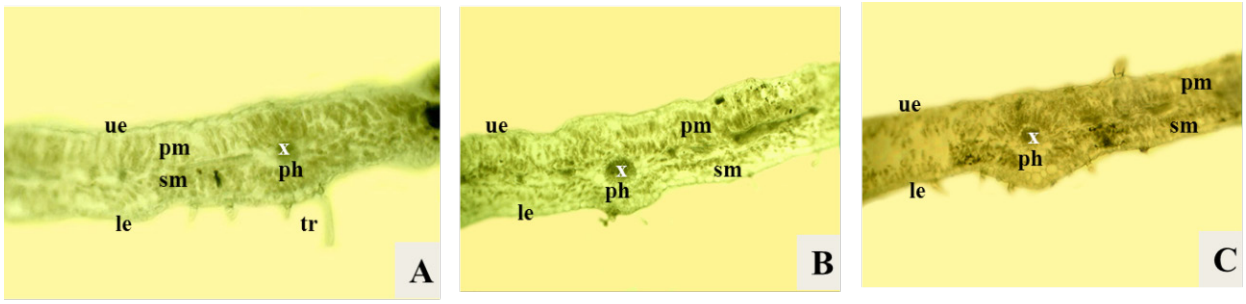

Figure 5 – Cross section of the leaf of Oxytropis almaatensis Bajt., population 1
(A-virginal plant, B-young generative plant, C-average generative plant). ue: upperepidermis,
pm: palisade mesophyll, sm: spongy mesophyll, x: xylem, ph: phloem, le: lower epidermis, tr: trachoma (10x10).

Leaf anatomy (Population №2). In the second population in the virginal age state in the anatomical structure of the oxytropis leaf as in the first population trachoma dominate in the lower epidermis (Fig. 6, A). In the young generative age state boundary between the palisade and spongy mesophyll is expressed clearly. There are well developed liner bundles cells (Fig. 6 B). Under the upper epidermis there are 2 layers cells of palisade mesophyll,the spongy mesophyll cells are under them. There are parenchymal cells under the phloem to the lower epidermis (Fig. 6 C).

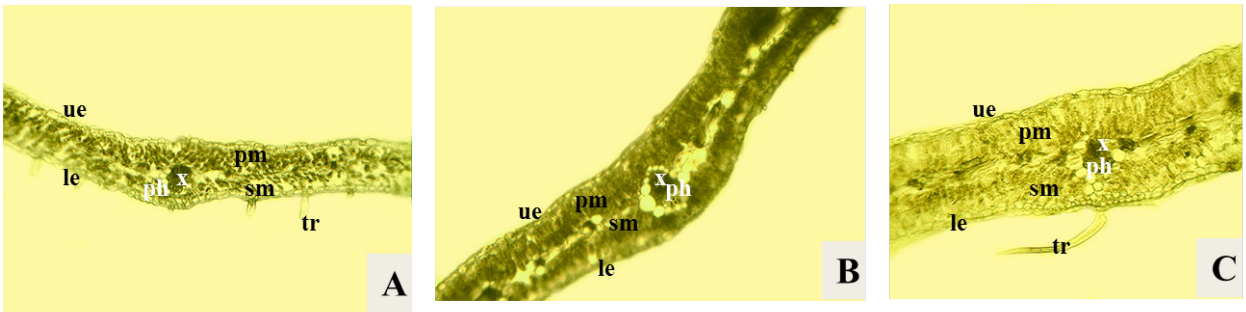

Figure 6 – Cross section of the leaf of Oxytropis almaatensis Bajt., population 2
(A-virginal plant, B-young generative plant, C-average generative plant). ue: upperepidermis,
pm: palisade mesophyll, sm: spongy mesophyll, x: xylem, ph: phloem, le: lower epidermis, tr: trachoma (10x10)

Table 3 – Biometric indicators Oxytropis almaatensis Bajt. leaf, μm

Anatomical features	Samples of *Oxytropis almaatensis* Bajt.					
	Population №1			Population №2		
	Virginal	Young generative	Middle generative	Virginal	Young generative	Middle generative
Thickness of the middle leaf rib	101,08±1,06	124,48±2,38	144,79±1,85	90,01±0,22	106,75±3,98	150,9±1,16
Thickness of the upper epidermis	7,29±0,09	12,81±0,4	7,81±0,91	10,02±0,74	10,33±0,03	9,37±0,04
Thickness of the lower epidermis	6,71±0,98	12,95±0,3	10,2±0,22	8,54±0,49	9,6±0,81	8,21±0,94
Thickness of the palisade mesophyll	40,57±1,07	52,56±2,1	51,92±1,08	36,5±0,64	42,75±1,01	54,5±2,4
Thickness of the spongy mesophyll	30,59±0,78	35,31±0,85	37,71±1,03	32,43±1,05	30,7±1,04	50,11±1,16
Diameter of the vascular bundle	25,95±0,77	27,1±0,92	32,98±0,65	44,88±1,66	45,1±1,71	46,04±1,07

In both populations, there is increase in thickness of the middle vein, accordingly to the age of the plants. In the first population in virginal age state there was observed that the thickness of the epidermis is less than thickness of the lower epidermis, and on the contrary, in the other phases, the thickness of lower epidermis dominates than the upper epidermis. In the second population the thickness of lower epidermis in the young and middle generative age state is less than the upper epidermis.In both populations, it was revealed that palisade mesophyll indicators are higher than the spongy mesophyll. Also, the diameter of the conductingbundle increases with the plants growth, like the diameter of the conductive bundle in the first population increased from 25.95 ± 0.77 to 32.98 ± 0.65 micron (Table 3).

Conclusions

Thus, in the process of study, we first identified biometrics of anatomical structure of vegetative organs of rare, narrowly endemic species *Oxytropis almaatensis* Bajt.. The following conclusions can be drawn on the basis of the obtained data:

1. In the first and second populations in the virginal age period it was revealed that the thickness of the cortex is bigger than in the young and middle-generative periods. In the central cylinder of the root there is a positive correlation between the diameter of the conducting elements, the xylem vessels and periderm increase accordingly of plants age.

2. The study of the internal structure of the plant stem different age periods in the two populations showed their great similarity. The study of the internal structure of the plant stem different age periods in different populations showed that all individuals have the bundle structure of the stem that is characteristic of the stems of dicotyledonous plants with varying degrees of development of various tissues. The main part of the stem occupies the central cylinder.

3. By comparing the anatomical structure of the leaf blades of plants of different populations, it was found that for all individuals of different age periods the dorsoventral, bilateral mesophyll, i.e. differentiation of mesophyll to palisade and spongy, are characteristic. Since the leaf is the main photosynthetic organ, especially the internal structure of the leaf blade, particularly the thickness of the chlorophyll tissue – mesophyll, may depend on the place of growth conditions, including the lighting conditions.

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