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ANATOMICAL STRUCTURE OF ASSIMILATIVE ORGANS IN DOMINANT SPECIES OF THE FAMILY CHENOPODIACEAE (AMARANTHACEAE S.L.)

The Chenopodiaceae family is one of the largest and most ancient families in arid regions of the globe. The representatives of this family, being dominants and edificators of many desert plant communities, play a significant role in forming the vegetation cover, particularly the species of the Salsoloideae subfamily. A characteristic feature of the anatomical structure of Chenopodiaceae species is the presence of Kranz cells. The discovery of a unique pathway of primary carboxylation, known as the C4 dicarboxylic acid cycle, has led to a rapid development of biochemical and anatomical research. It is known that the Chenopodiaceae family has the largest number of species with the C4 photosynthesis type and the greatest diversity in C4 leaf anatomy. This study aimed to identify the anatomical structural features of the dominant species of the Chenopodiaceae family growing in arid regions. The study objects are species of the Chenopodiaceae family growing in arid territories of the Kyzylorda region in Kazakhstan. Cross-sections of samples were made using a "Semi-automatic Rotary Microtome M530" (MEDITE M530). The thickness of the cross-sections was 40 μm. The cross-sections were examined using a Levenhuk Zoom&Joy microscope (China), and images were taken with a Levenhuk D740T 5.1 camera using the LevenhukLite software. The study of the anatomical structure of assimilative organs revealed the following types: Corispermoid-type, Ventro-dorsal type, Kochioid-type, Atriplicoid-type, Salsina-type, Shoberia-type, Salsoloid-type, and Climacoptera-type. The anatomical structure of *Atriplex dimorphostegia* was clarified. *Haloxylon aphyllum* was transferred from the Kranz-ventrodorsal type to the Salsoloid type. For the first time, a detailed anatomical structure of the leaves of *Salsola sogdiana* and *Caroxylon nitrarium* species was described.

Key words: Salsoloideae, Suaedoideae, Chenopodioideae, anatomical structure, kranz cells, arid territories, C4 photosynthesis.

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Chenopodiaceae (Amaranthaceae s.l.) тұқымдасының доминант түрлерінің ассимиляциялық мүшелерінің анатомиялық құрылымы

Chenopodiaceae тұқымдасы – жер шарындағы аридты территориялардың ең үлкен және ежелгі тұқымдастарының бірі. Көптеген шөлді қауымдастықтардың доминанттары мен эдификаторлары болып табылатын тұқымдас өкілдері өсімдік жамылғысының қалыптасуында, әсіресе Salsoloideae тұқымдастармағы түрлері маңызды рөл атқарады. Chenopodiaceae түрлерінің анатомиялық құрылымының ерекшелігі Кранц жасушаларының болуы. Дикарбон қышқылдарының С4 – циклі деп аталатын бастапқы карбоксилденудің арнайы жолының ашылуы биохимиялық және анатомиялық зерттеулердің қарқынды дамуына әкелді. Chenopodiaceae тұқымдасының С4 фотосинтез түрі бар түрлердің ең көп саны, сондай-ақ С4 типті жапырақ анатомиясының ең көп әртүрлілігі бар екені белгілі. Зерттеудің мақсаты-аридты жерлерде өсетін Chenopodiaceae тұқымдасының доминант түрлерінің анатомиялық құрылымының ерекшеліктерін анықтау. Зерттеу нысандары аридты жерлерде өсетін Chenopodiaceae тұқымдасының түрлері болып табылады. Үлгілердің көлденең кесінділері "Айналмалы жартылай автоматты микротам" (MEDITE m530) көмегімен жасалды. Көлденең кесінділердің қалыңдығы 40 мкм болды. Көлденең қималарды қарау Levenhuk Zoom&joy (Қытай) микроскопының көмегімен жүзеге асырылды, көлденең қималардың суреттері LevenhukLite бағдарламасының көмегімен Levenhuk D740T 5.1 камерасына түсірілді. Ассимиляциялық органдардың анатомиялық құрылымын зерттеу олардың келесі түрлерін анықтады: Кориспермоидты (Corispermoid-type); Вентродоральды (Ventro-dorsal type); Кохиоидты (Kochioid-type); Атриплекоидты (Atriplicoid-type); Сальзина (Salsina-type); Шобериа (Shoberia-type); Салсолоид (Salsoloid-type); Климакоптера (Climacoptera-type). *Atriplex dimorphostegia* түрінің анатомиялық құрылымы бойынша нақтылау жасалды. *Haloxylon aphyllum* родорсальды типтен (Kranz-ventrodorsal) Салсолоид типіне ауыстырылды. *Salsola sogdiana* және *Caroxylon nitrarium* түрлері үшін жапырақтың егжей-тегжейлі анатомиялық құрылымы алғаш рет сипатталды.

Түйін сөздер: Salsoloideae, Suaedoideae, Chenopodioideae, анатомиялық құрылым, кранц жасушалар, аридты аумақтар, С4 фотосинтез.

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Анатомическое строение ассимиляционных органов доминантных видов семейства Chenopodiaceae (Amaranthaceae s.l.)

Семейство Chenopodiaceae – одно из самых крупных и древних семейств аридных территорий земного шара. Представители семейства, являются доминантами и эдификаторами многих пустынных сообществ, играют важную роль в формировании растительного покрова, в особенности виды подсемейства Salsoloideae. Особенностью анатомического строения видов Chenopodiaceae является наличие Кранц-клеток. Открытие особого пути первичного карбоксилирования, названного С4 – циклом дикарбоновых кислот, привело к бурному развитию биохимических и анатомических исследований. Известно, что семейство Chenopodiaceae имеет наибольшее число видов с типом фотосинтеза С4, а также наибольшее разнообразие анатомии листьев С4-типа. Целью исследования является выявления особенностей анатомического строения доминантных видов семейства Chenopodiaceae, которые произрастают в аридных территориях. Объектами исследования являются виды семейства Chenopodiaceae, произрастающие в аридных территориях. Поперечные срезы образцов производились с помощью «Ротационного полуавтоматического микротама» (MEDITE M530). Толщина поперечного среза составила 40 мкм. Просмотр поперечных срезов осуществлялся с использованием микроскопа Levenhuk Zoom&Joy (Китай), снимки поперечных срезов осуществлялись на камеру Levenhuk D740T 5.1, с помощью программы LevenhukLite. Изучение анатомического строения ассимиляционных органов выявило следующие их типы: Кориспермоидный тип (Corispermoid-type); Вентро-дорсальный тип (Ventro-dorsal type); Кохиоидный тип (Kochioid-type); Атрипликоидный тип (Atriplicoid-type); Сальзина тип (Salsina-type); Шобериа тип (Shoberia-type); Сальсолоид тип (Salsoloid-type); Климакоптера тип (Climacoptera-type). Сделано уточнение по анатомическому строению вида *Atriplex dimorphostegia*. *Haloxylon aphyllum* перенесен из Кранц-вентродорсального типа (Kranz-ventrodorsal) в Сальсолоид тип. Для видов *Salsola sogdiana* и *Caroxylon nitrarium* впервые описана подробная анатомическая структура листа.

Ключевые слова: Salsoloideae, Suaedoideae, Chenopodioideae, анатомическая структура, кранц клетки, аридные территории, фотосинтез С4.

Introduction

The Chenopodiaceae family is one of the largest and oldest families in the arid regions of the world. It holds a leading position among the families of desert flora in Kazakhstan. Several representatives of this family, being dominants and edificators of many desert communities, play a significant role in forming the vegetation cover, particularly species of the Salsoloideae subfamily [1-4].

A distinctive feature of the anatomical structure of Chenopodiaceae species is the presence of Kranz cells. Researchers, having identified these structures in the leaves of Chenopodiaceae, named the cubic-shaped cells “Kranz cells”.

The discovery of a unique pathway for primary carboxylation, known as the C4 dicarboxylic acid cycle, has led to a rapid development in biochemical and anatomical studies. In 2003, G. Kadereit and colleagues [1], analyzing the molecular structure of leaves in the Amaranthaceae and Chenopodiaceae families, identified 7 groups with 17 types of mesophyll. The type of mesophyll refers to the arrangement of assimilative, conducting, spongy, or water-storing tissues in relation to the cross-section of the studied plant organ. The first classification of mesophyll types in the Chenopodiaceae family was made in 1975 by Carolin and coauthors [5], where two groups of types were distinguished:

Non-Kranz types: Axyroid, Corispermum-type, Austrobazidioid (similar to Corispermum-type but containing water-storing tissue), Neokochioid (with peripheral vascular bundles), Simpegmoid (similar to Neokochioid, but with peripheral canals separated from chlorenchyma);

Kranz types: Atriplicoide, Kochioide, Salsoloide, etc., differ by the arrangement of Kranz cells in relation to the vascular bundles [6].

The increase in the number of species with Kranz cells can be considered an indicator of climate aridization in ecological monitoring [6-7].

It is well known that the Chenopodiaceae family has the highest number of species with the C4 photosynthesis type [8-9], as well as the greatest diversity in C4 leaf anatomy, including eight main structural types [10-11] and up to 16 forms, considering all variations [1].

There are two possible arrangements of Kranz cells:

- Around each individual vein;
- Around all the veins of the leaf at once, forming a double concentric layer.

Ten C4 lineages are recognized within the Chenopodiaceae family [8-9].

For studying the evolution of C4 photosynthesis, intermediate C3-C4 products, found in 14 families, are of particular importance: Amaranthaceae, Asteraceae, Boraginaceae, Brassicaceae, Chenopodiaceae, Cleomaceae, Euphorbiaceae, Molluginaceae, Nyctaginaceae, Portulacaceae, Cyperaceae, Hydrocharitaceae, Scrophulariaceae, and Poaceae [9; 12]. Within the Chenopodiaceae family, only one species to date – *Salsola arbusculiformis* from the Salsoloideae subfamily has been structurally and functionally characterized as an intermediate C3-C4 [13]. Based on anatomical features alone, *Sedobassia sedoides* from the Camphorosmoideae subfamily has also been recognized as an intermediate [8].

C4 photosynthesis studies have primarily been conducted on species that form Kranz anatomy with two layers of chlorenchyma surrounding each vein [183]. However, among species with C4 photosynthesis, nine types of Kranz anatomy have two concentric layers of chlorenchyma surrounding all the veins [11; 14]. Among these, the Salsoloid type of anatomy is the most widely represented, and its presence clearly indicates the C4 photosynthesis type characteristic of species in the Salsoloideae subfamily [6; 15].

In modern, widely accepted structural descriptions of the double layer of Kranz cells, the outer layer is referred to as P cells (usually consisting of palisade parenchyma), and the inner layer is referred to as specialized bundle sheath cells (Kc) (referring to a layer of cells in the leaves) [11].

All structural forms of Kranz share the presence of a concentric layer of chlorenchymal cells, in which the outer palisade layer P captures atmospheric CO_2 in the C4 cycle, and the inner layer (Kc) releases CO_2 from the C4 acids [4].

The aim of the study was to identify the anatomical structural features of the dominant species of the Chenopodiaceae family growing in arid territories of Kyzylorda region.

Materials and methods

The study focuses on species of the Chenopodiaceae (Amaranthaceae s.l.) family that grow in the arid regions of the Kyzylorda region in Kazakhstan, where they are predominantly community dominants.

Materials for anatomical analysis were fixed in 70% alcohol. The specimens were frozen for cross-sectioning in histological paraffin, using special forms measuring 15x15 mm. Cross-sections of the samples were made using a " Semi-automatic Rotary Microtome M530" (MEDITE M530). The thickness of the cross-sections was 40 µm. The cross-sections were examined using a Levenhuk Zoom&Joy microscope (China), and images were captured with a Levenhuk D740T 5.1 camera using the LevenhukLite software. Biometric data were also measured using this LevenhukLite software. The mean and standard error of biometric data were calculated using Microsoft Excel's data analysis function. To describe the anatomical structure of the studied samples, more recent literature data on closely related species were used [6-7; 15-26].

Results and discussion

We analyzed the anatomical structure of the assimilative organs of 22 species: *Anabasis aphylla*, *Haloxylon aphyllum*, *Halothamnus subaphyllus*, *Salsola tragus*, *S. sogdiana*, *Xylosalsola arbuscular*, *Caroxylon orientale* (=*Salsola orientalis*), *C. nitrarium* (=*S. nitraria*), *Petrosimonia sibirica*, *Climacoptera lanata*, *Suaeda microphylla*, *S. acuminata*, *Bassia prostrata*, *Kalidium capsicum*, *K. foliatum*, *Halocnemum strobilaceum*, *Halostachys belangeriana*, *Salicornia europea*, *Ceratocarpus utriculatus*, *Atriplex dimorphostegia*, *Krascheninnikovia ceratoides*, and *Agriohyllum pungens*. For six of these species (*Anabasis aphylla*, *Haloxylon aphyllum*, *Kalidium capsicum*, *Halocnemum strobilaceum*, *Halostachys belangeriana*, and *Salicornia europea*), cross-section of young shoots were made, as their leaves are reduced or poorly developed.

Transverse anatomical sections of the assimilative organs are provided for all studied species, showing their structure (Figures 1, 2, 3, 4, 5). Measurements of the thickness of each layer for all species are also presented in Table 1.

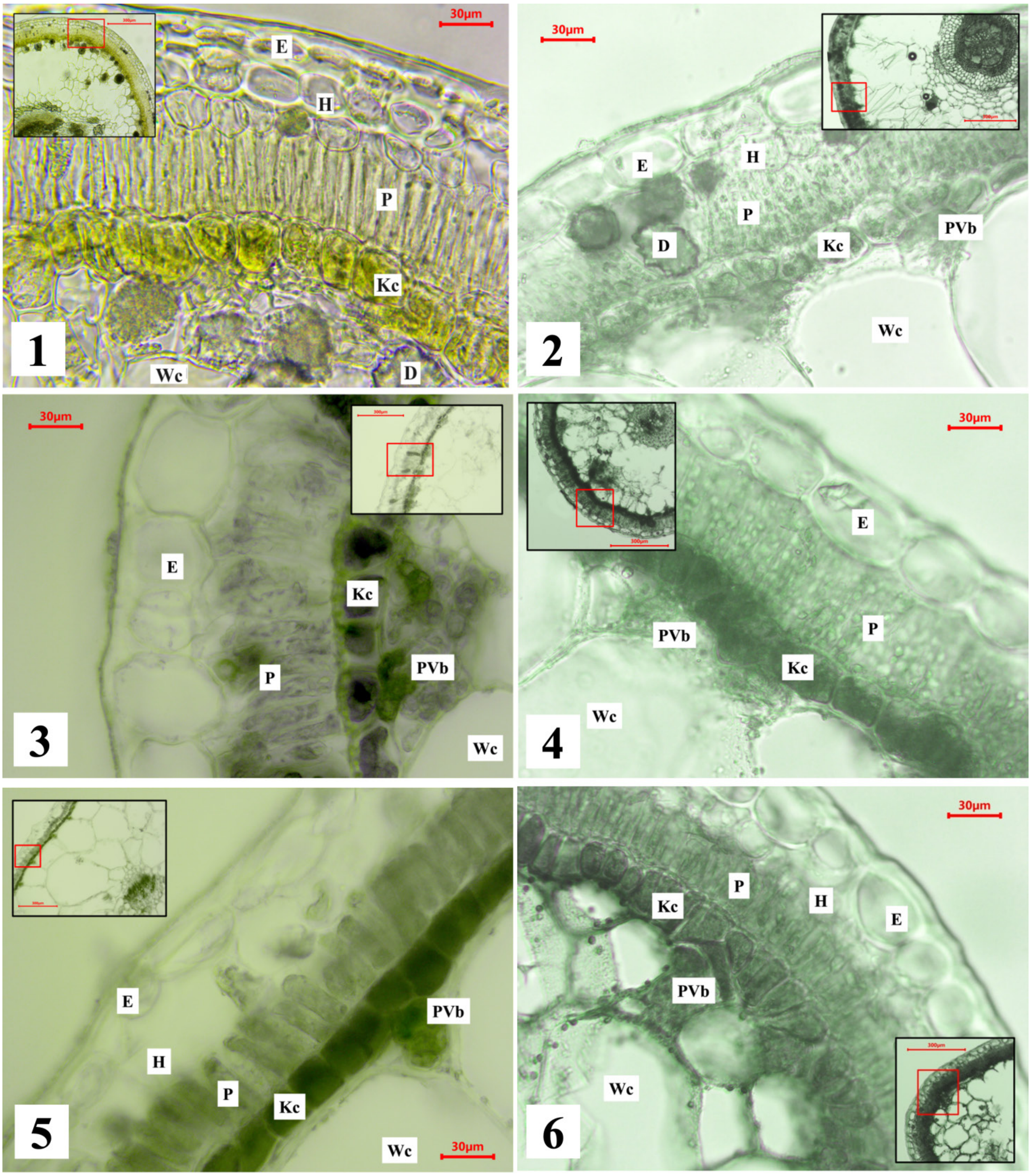

Figure 1 – Species of the tribe Salsolae in the Subfamily Salsoloideae
1 – Anabasis aphylla, 2 – Haloxylon aphylla, 3 – Halothamnus subaphyllus,
4 – Salsola tragus, 5 – Salsola sogdiana, 6 – Xylosalsola arbuscular
E – epidermis; H – hypodermis; P – palisade mesophyll (chlorenchyma); Kc – Kranz cell;
PVb – peripheral vascular bundle; Wc – water- bearing cell; D – druse

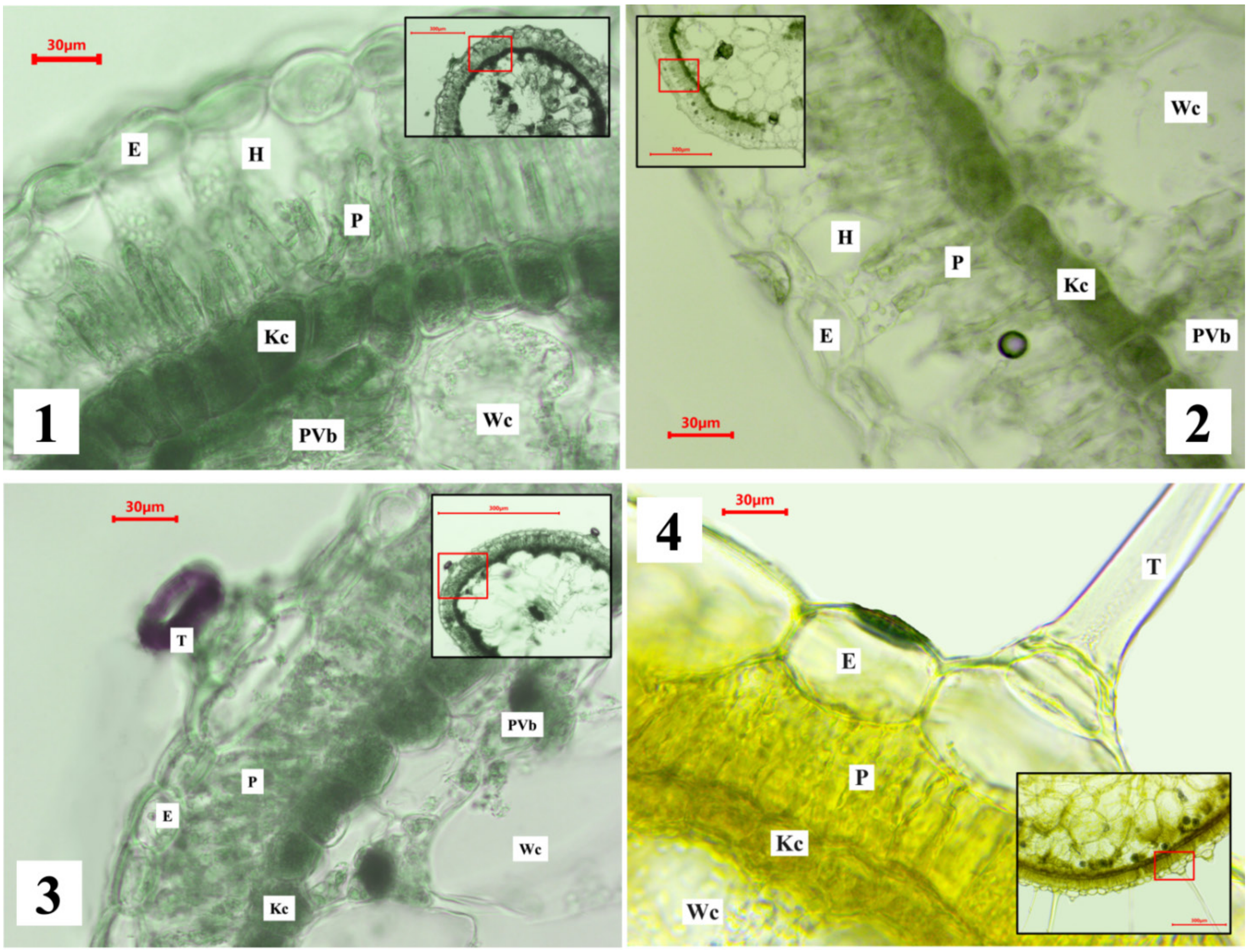

Figure 2 – Species of the tribe Caroxyloneae of the subfamily Salsoloideae
1 – *Caroxylon orientale (Salsola orientalis),* **2 –** *C. nitrarium (S. nitraria,*
3 – *Petrosimonia sibirica,* **4 –** *Climacoptera lanata*
T – trichome; E – epidermis; H – hypodermis; P – palisade mesophyll (chlorenchyma);
Kc – kranz cell; PVb – peripheral vascular bundle; Wc – water-bearing cell

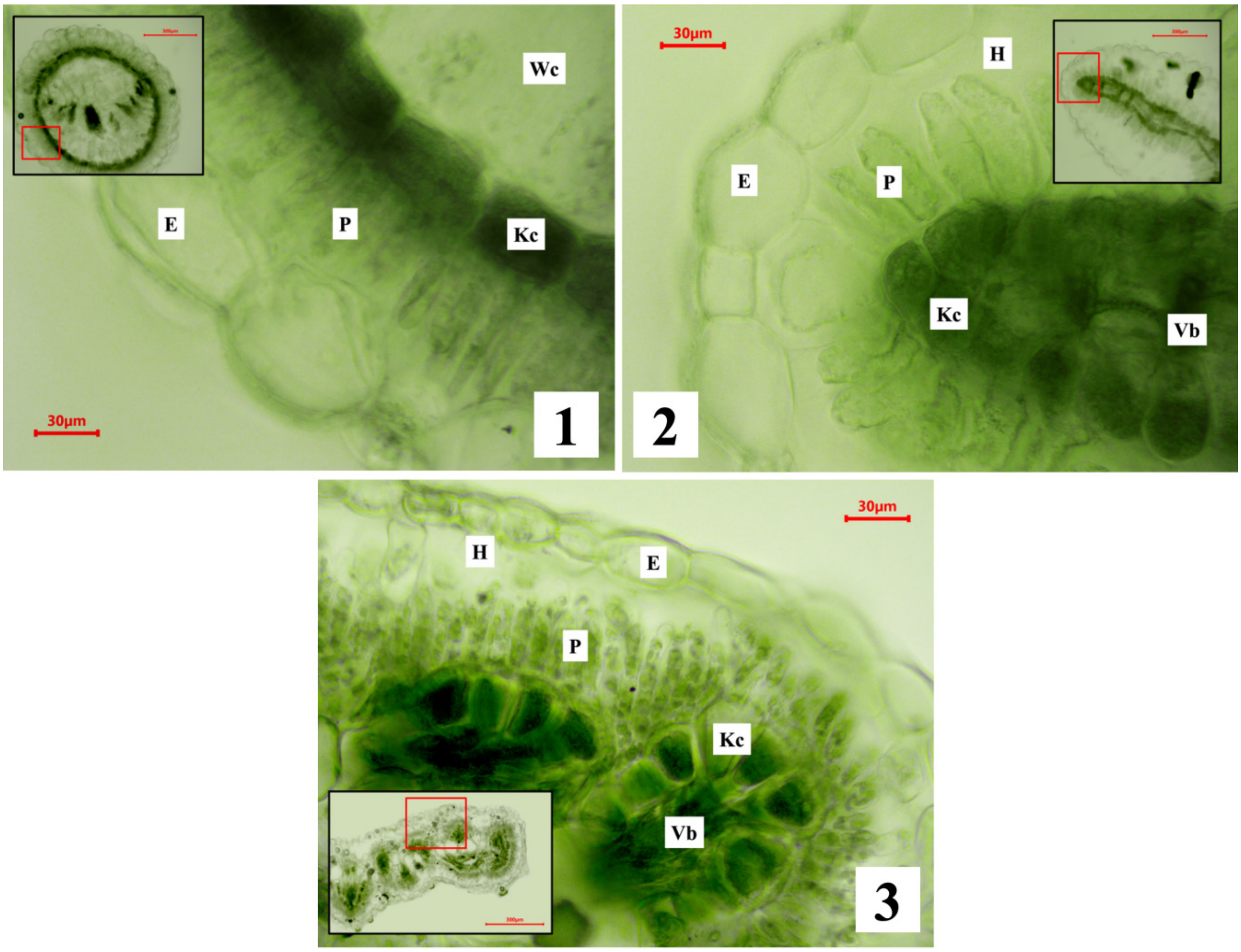

Figure 3 – Species of the tribe Suaedeae of the subfamily Suaedoideae and species of the tribe Camphorosmeae of the subfamily Camphorosmoideae
1 – *Suaeda microphylla*, **2 –** *S. acuminate*, **3 –** *Bassia prostrata*
E – epidermis; H – hypodermis; P – palisade mesophyll (chlorenchyma);
Kc – kranz cell; Wc – water-bearing cell; Vb – vascular bundle

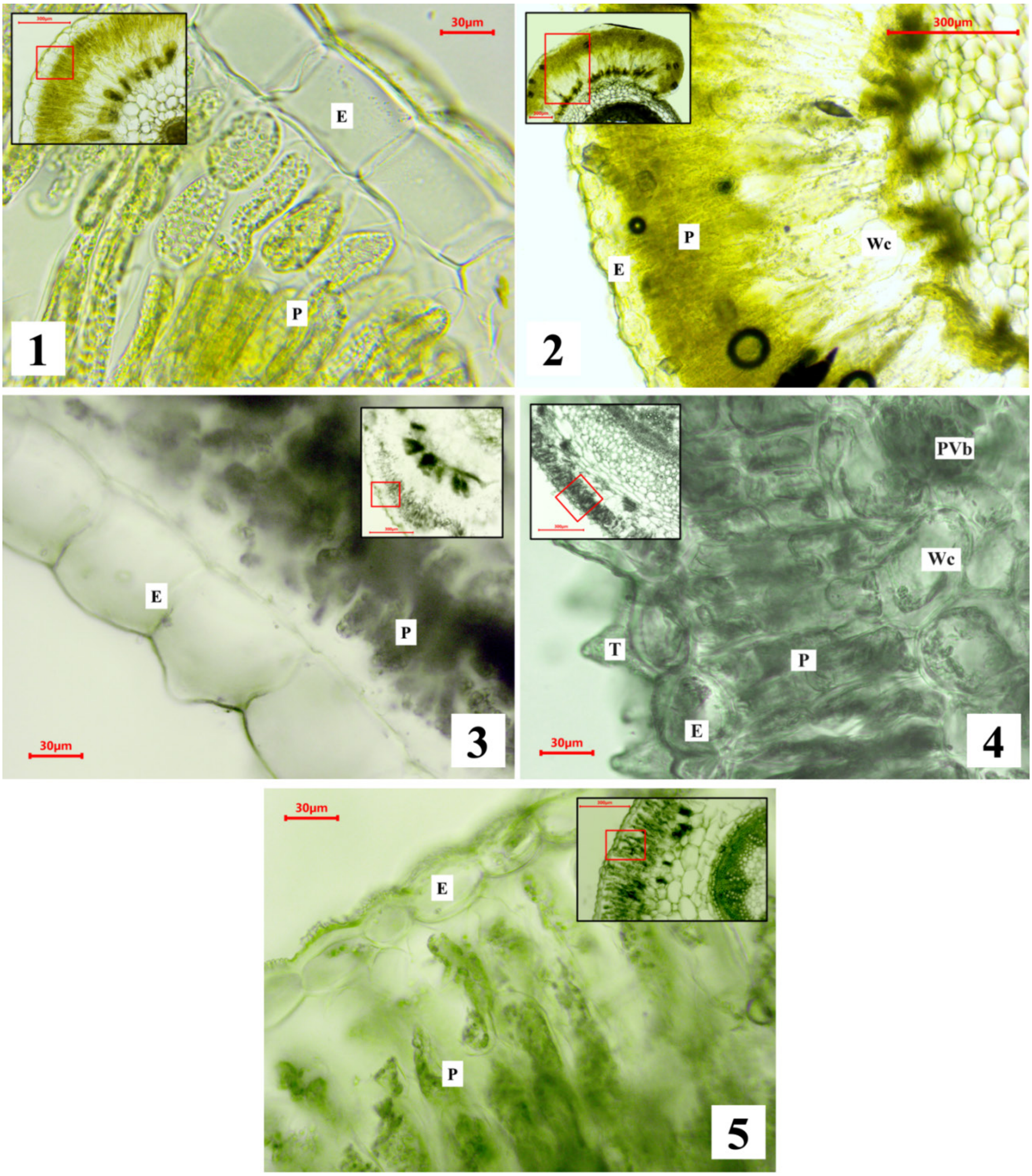

Figure 4 – Species of the tribe Salicornieae in the subfamily Salicornioideae
1 – *Kalidium capsicum*, **2 –** *K. foliatum*, **3 –** *Halocnemum strobilaceum*, **4 –** *Halostachys belangeriana*, **5 –** *Salicornia europaea*
T – trichome; E – epidermis; P – palisade mesophyll (chlorenchyma);
PVb – peripheral vascular bundle; Wc – water-bearing cell; Vb – vascular bundle

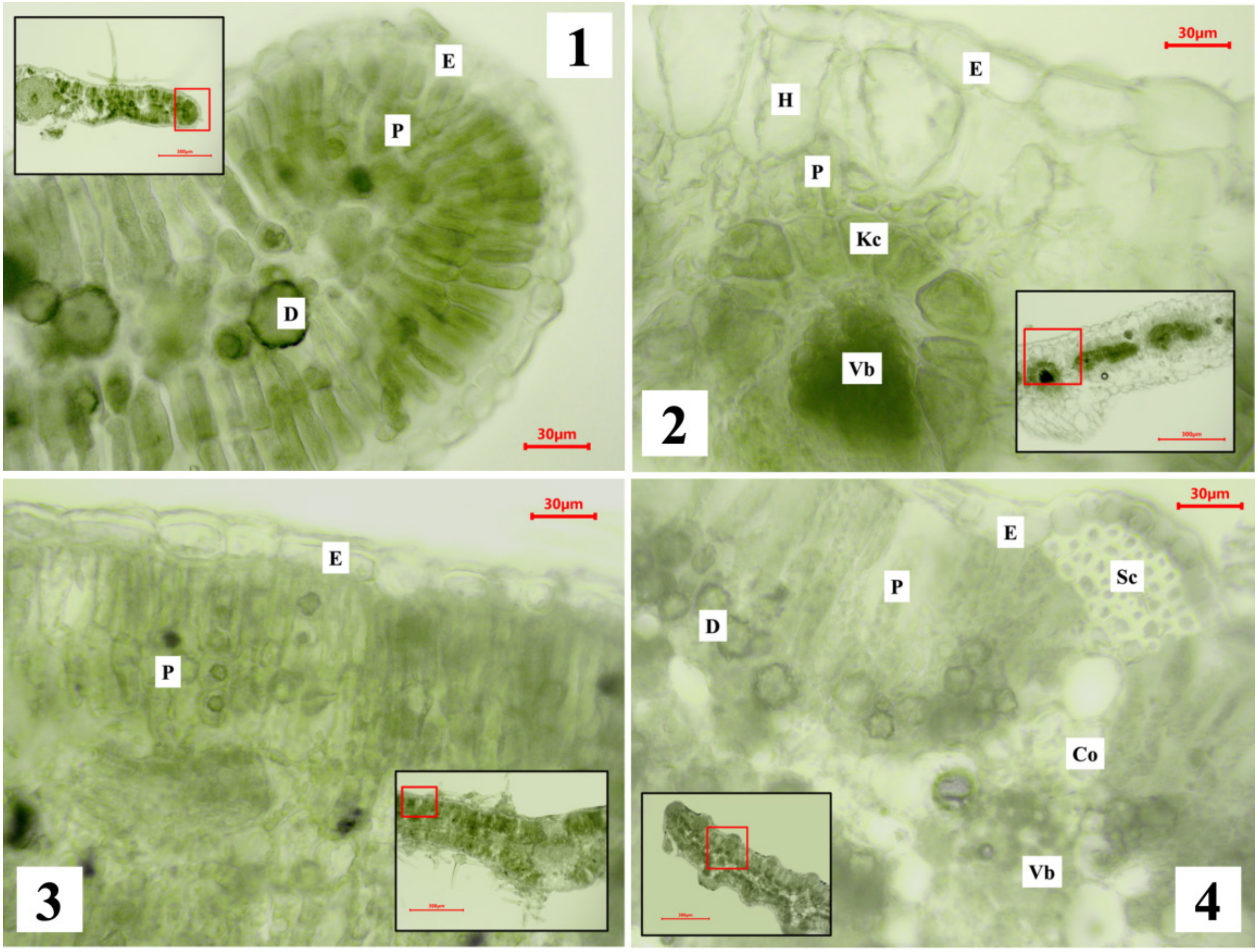

Figure 5 – Species of the subfamily Chenopodioideae
1 – *Ceratocarpus utriculosus*, **2 –** *Atriplex dimorphostegia*, **3 –** *Krascheninnikovia ceratoides*, **4 –** *Agriophyllum pungens*
T – trichome; E – epidermis; H – hypodermis; P – palisade mesophyll (chlorenchyma); Kc – kranz cell;
PVb – peripheral vascular bundle; Wc – water-bearing cell; Vb – vascular bundle;
Sc – sclerenchyma; Co – collenchyma; D – druse

Table 1 – Average biometric measurements of cross-sections of assimilative organs in species of the Chenopodiaceae

Species	Epidermis, μm	Hypodermis, μm	Palisade mesophyll, μm	Kranz cell, μm
Anabasis aphylla	19,91±0,58	31,37±1,24	50,28±2,13	29,87±0,65
Haloxylon aphyllum	25,84±0,85	16,97±0,62	40,55±0,92	17,84±0,81
Halothamnus subaphyllus	57,36±1,85	-	74,75±1,10	25,19±0,88
Salsola tragus	35,99±0,95	-	56,81±1,34	25,29±0,85
Salsola sogdiana	22,79±0,68	30,15±1,09	38,17±0,52	22,70±0,70
Xylosalsola arbuscula	35,03±0,85	16,31±0,63	33,67±0,77	21,55±1,10
Caroxylon orientale (Salsola orientalis)	27,16±1,25	28,78±1,44	53,35±1,05	34,99±0,84
Caroxylon nitrarium (Salsola nitraria)	25,05±1,18	24,57±1,50	48,23±1,39	23,73±0,75
Climacoptera lanata	48,17±2,49	-	59,67±1,46	23,92±0,47
Petrosimonia sibirica	20,58±0,73	-	45,11±0,74	25,44±0,85
Suaeda microphylla	57,24±1,89	-	53,43±1,35	31,95±1,10
S. acuminata	40,87±2,10	117,01±13,67	64,18±3,46	29,06±1,13

Continuation of the table

Species	Epidermis, µm	Hypodermis, µm	Palisade mesophyll, µm	Kranz cell, µm
Bassia prostrata	17,88±0,61	20,58±1,27	36,68±2,01	22,98±1,26
Kalidium caspicum	54,27±0,90	-	196,66±5,78	-
K. foliatum	49,08±1,74	-	268,31±4,58	-
Halocnemum strobilaceum	63,45±1,24	-	148,72±6,45	-
Halostachys caspica	37,40±2,01	-	111,83±1,38	-
Salicornia europaea	23,64±0,64	-	203,29±3,55	-
Ceratocarpus utriculosus	13,14±0,47	-	59,65±1,18	-
Atriplex dimorphostegia	22,45±1,43	47,22±2,15	31,28±1,36	34,15±0,86
Krascheninnikovia ewersmanniana	15,54±0,54	-	84,49±1,43	-
Agriophyllum pungens	19,79±0,65	-	97,41±1,46	-

The presence and size ratios of their various layers are shown in Figure 6 to facilitate the understanding of the anatomical structure of the studied species.

Based on the above results of the anatomical structure of the assimilation organs, we classify the studied species into the following types:

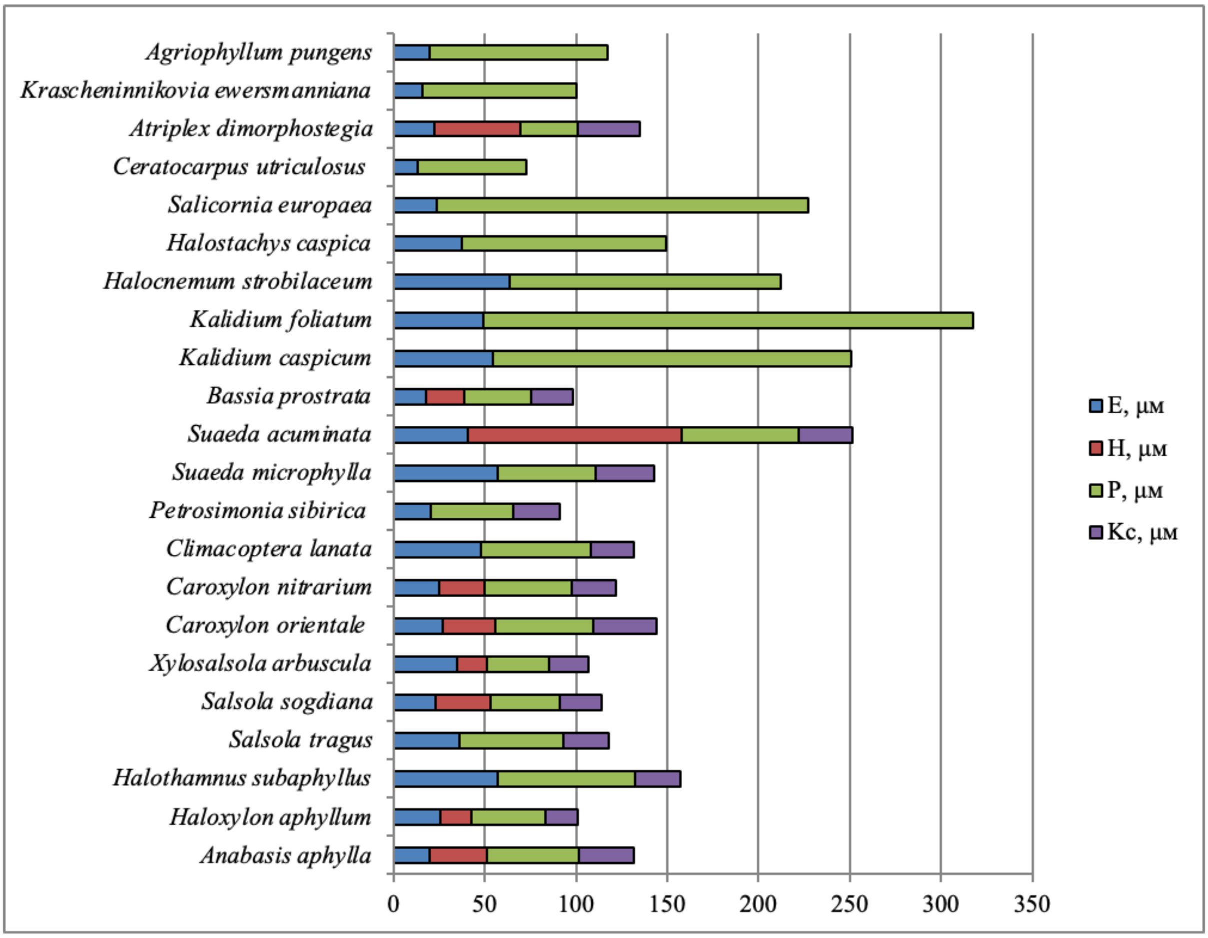

Figure 6 – Schematic representation of the presence or absence of layers and their comparative thickness

Non-Kranz types: Corispermoid type with palisade parenchyma on both sides of the leaf and spongy parenchyma in the middle part. This type is found in the leaves of *Krascheninnikovia ewersmanniana, Agriophyllum pungens, Ceratocarpus utriculosus*.

Ventro-dorsal type. Reduced leaves represent the apex of the reduction of the assimilation apparatus in the species of the non-Kranz group. The palisade parenchyma is 2-3 rows; on one side, it is in contact with the vascular bundles or separated by the aquiferous parenchyma. It should be noted that there are no clear boundaries, on the other side with the epidermis (*Salicornia europea, Halostachys caspica, Halocnemum strobilaceum, Kalidium caspicum, K. foliatum*).

Kranz types. A distinctive feature of the Kranz type is the presence of the Kranz chlorophyll sheath, located between the palisade cells and vascular bundles. Kranz cells are capable of rapidly accumulating starch and are often devoid of granules. In C4 photosynthesis, the mesophyll and bundle sheath chloroplasts function jointly. Mitochondrial activity in Kranz cells is 10 times higher than in mesophyll cells. Their location and structure allow for rapid movement of photosynthesis products, protection of the photosynthetic cell, and provision of their moisture during the critical xerothermic period.

Kochioid type. One row of palisade parenchyma and Kranz cells are located on both sides of the peripheral vascular bundles in a flat leaf, which are also located on both sides of the leaf. In the center of the leaf are located the aquiferous tissue and the central vascular bundle (*Bassia prostrata*).

Atriplicoid type. One row of palisade and Kranz cells surrounds the vascular bundles in one central plane. There is a hypoderm (*Atriplex dimorphostegia*); earlier, it was believed that this type does not have a hypoderm; it should be taken into account that for this type, the hypoderm is not considered the main component. There are several aquiferous cells with calcium oxalate druses between the chlorenchyma and vascular bundles. The Salsina type is characterized by the arrangement of palisade parenchyma and Kranz cells throughout the leaf circle. The main and lateral vascular bundles are located in one plane in the center of the aquiferous tissue (*Suaeda microphylla*).

A large-celled epidermis characterizes the Shoberia type. Palisade parenchyma and Kranz cells are located on both sides of the leaf, are adjacent to the vascular bundles (Suaeda acuminata), and have a hypodermis. However, in our case, the epidermal cells of *Suaeda acuminata* (40.87±2.10 μm) were smaller than those of *Suaeda microphylla* (57.24±1.89 μm), perhaps due to the peculiarity of the sampling time.

The most common is the Salsoloid-type. Single-row palisade parenchyma and Kranz cells are located along the entire circumference of the leaf. Peripheral vascular bundles are adjacent to Kranz cells. The main vascular bundle is located in the center of the leaf among the water-bearing cells. Hypodermis is present or absent (*Anabasis aphylla, Haloxylon aphyllum, Halothamnus subaphyllus, Salsola tragus, Salsola sogdiana, Xylosalsola arbuscula, Caroxylon orientale, Caroxylon nitrarium, Petrosimonia sibirica*). This type is noted in succulent and scleromorphic modifications (*Halothamnus subaphyllus*).

Climacoptera type. Differs from the Salsoloid type in that the peripheral vascular bundles are separated from the Kranz cells by water-bearing cells (*Climacoptera lanata*).

Based on the above data, we will first consider the species with Kranz cell anatomy. These include *Bassia prostrata*, *Atriplex dimorphostegia*, *Suaeda microphylla*, *S. acuminata*, *Anabasis aphylla*, *Haloxylon aphyllum*, *Halothamnus subaphyllus*, *Salsola tragus*, *Salsola sogdiana*, *Xylosalsola arbuscula*, *Caroxylon orientale*, *Caroxylon nitrarium*, *Climacoptera lanata*, and *Petrosimonia sibirica*. As mentioned earlier, *Bassia prostrata* and *Atriplex dimorphostegia* have a distinctive arrangement of Kranz cells located directly around the vascular bundles, and the leaves of these species are lamellar. The anatomical structure of *Bassia prostrata* described in the literature fully aligns with our data. However, for *Atriplex dimorphostegia*, our findings include a small addition of hypodermis (47.22±2.15 μm), which was previously thought to be absent in this species.

The next group of species under consideration is characterized by the Kranz cells being located around all the vascular bundles and water-bearing tissue, spreading along the entire periphery of the leaf. First, we will consider species of the genus *Suaeda* (*Suaeda microphylla, S. acuminata*). These species belong to different anatomical types and prefer loamy soil. However, as previously mentioned, *Suaeda acuminata* is characterized by large epidermal cells, which is notable in comparison to *Suaeda microphylla*. It is important to note that the samples of *Suaeda microphylla* were collected in the spring, while those of *S. acuminata* were collected in the fall, which may be a key factor influencing these results. Additionally, *S. acuminata* exhibits a hypodermis in its anatomical structure, which is also quite large (117.01 ± 13.67 μm).

Considering the obtained results for species of the Salsoloideae subfamily (*Anabasis aphylla, Haloxylon aphyllum, Halothamnus subaphyllus, Salsola tragus, Salsola sogdiana, Xylosalsola arbuscula, Caroxylon orientale, Caroxylon nitrarium, Climacoptera lanata, Petrosimonia sibirica*), we can conclude that the presence of a hypodermis is unimportant, as it functions primarily for water collection. Additionally, all the studied species differ in their substrate preferences. While it was previously believed that *Haloxylon aphyllum* belonged to the Kranz-ventrodorsal type, our data suggests that this species should be classified as a Salsoloid type, likely a modified version, since this species lacks leaves, and assimilation occurs in young shoots.

For the species *Salsola sogdiana* and *Caroxylon nitrarium*, the anatomical structure of the leaf was described for the first time, and the sizes of the layers are given. In other cases, the addition is that the sizes of the layers are given for all species, which was not previously given.

Species lacking Kranz cells. First, we will consider species with lamellar leaves, specifically *Krascheninnikovia ewersmanniana, Agriophyllum pungens,* and *Ceratocarpus utriculosus*. These species are primarily found in sandy areas, with *Ceratocarpus utriculosus* also occurring in clayey regions. All three species belong to the Corispermoid type. While they share similar features, each species also has distinctive characteristics. *Agriophyllum pungens*, in particular, exhibits a unique anatomical structure, where the leaf blade is modified by sclerenchyma under the epidermis, forming stripes along the leaf blade that visually resemble veins.

The most interesting group without Kranz cells is the species of the Salicornieae tribe of the Salicornioideae subfamily (*Salicornia europea, Halostachys caspica, Halocnemum strobilaceum, Kalidium caspicum, K. foliatum*). In the process of evolution, these species, have developed an anatomical structure in which they need and prefer a salt environment with a high concentration. Considering the thickness of the layers, we can say that this group is characterized by very long cells of the polysade mesophyll (Table 1; Figure 6).

Both groups of types (non-Kranz and Kranz) complete the reduction of the leaf (aphyllous) and form the assimilative primary bark of the non-Kranz type in the subfamily Chenopodiaceae and the Kranz type in the subfamily Salsoloideae. The presence of non-Kranz and Kranz types in aphylloids is a significant version of its ancient and convergent origin in different structural groups. Aphyllous is a phenomenon of a progressive replacement organ, the result of replacing the photosynthetic functions of some organs (leaves) with others (shoots with assimilating bark), better adapted to arid conditions.

The predominance of the succulent species is associated with the general saline background of the deserts of Kazakhstan. Despite the relatively high level of study of Kranz cells, we have not encountered data on their other quantitative parameters and changes within one plant during its development under different growing conditions and during the growing season, which is a relevant topic for further research in this area.

Conclusion

As a result of the study of the anatomical structure of assimilative organs, frequently found in dominant species of the Chenopodiaceae family of the Syr Darya River valley flora, the following types of the anatomical structure of leaves and other assimilation organs were determined: Corispermoid-type – *Krascheninnikovia ewersmanniana, Agriophyllum pungens, Ceratocarpus utriculosus*; Ventro-dorsal type – *Salicornia europea, Halostachys caspica, Halocnemum strobilaceum, Kalidium caspicum, K. foliatum*; Kochioid-type – *Bassia prostrata*; Atriplicoid-type – *Atriplex dimorphostegia*; Salsina-type – *Suaeda microphylla*; Shoberia-type – *Suaeda acuminata*; Salsoloid-type – *Anabasis aphylla, Haloxylon aphyllum, Halothamnus subaphyllus, Salsola tragus, S. sogdiana, Xylosalsola arbuscula, Caroxylon orientale, C. nitrarium, Petrosimonia sibirica*; Climacoptera-type – *Climacoptera lanata.* The sizes of the layers with the average value are given. The anatomical structure of the species *Atriplex dimorphostegia* has been clarified. *Haloxylon aphyllum* was transferred from the Kranz-ventrodorsal type to the Salsoid type. For the species *Salsola sogdiana* and *Caroxylon nitrarium*, a detailed anatomical structure of the leaf was described for the first time.

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