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ADAPTATION OF ASSIMILATING ORANS *CALLIGONUM* L. SPECIES (*POLYGONACEAE* JUSS.) IN KYZYLKUM DESERT

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ABSTRACT: Species of the genus *Calligonum* L. characterized by a high degree of specialization of assimilating organs: cotyledon, leaf, primary cortex, which indicates their high evolutionary position. The adaptation cotyledons and leaves of to arid conditions in the studied species passed through different. In *Calligonum junceum* (Fish. & Mey.) Litv. morphology and anatomical structure has not been substantially altered since the habitat of this species is confined strictly to gamada; in *C. eriopodum* Bunge. and *C. leucocladum* (Schrenk) Bunge. there was a decrease in leaf size and increased its structural signs in connection with the improvement of living environment - vegetation mostly on the sands; in C. microcarpum Borszcz. reduced dimensions of the leaves and its tissues, increased xeromorphic indication to elongation of the growing season.

***Keywords*:** cotyledon, leaf, primary cortex, ecology.

INTRODUCTION

Family *Polygonaceae* Juss. comprises a small number of species, but is widespread in arid area. Its members differ greatly in biomorph: large (about trees) shrubs (*Calligonum* L.), medium shrubs (*Atraphaxis* L.), geoephemerous (*Rumex* L., *Rheum* L.). The morphology of the leaves varies in a wide range: from large (50x50 sm) at *Rheum*, to a very small cylindrical (1-2 sm long, 0.5 sm wide) and falling early in *Calligonum*.

The *Calligonum* comosum structure describes the assimilating cortex and the secondary xylem (Fahn, 1990); in *C. polygonoides* L. - centric structure of the leaf and the initiation of phellogen in pericycle (Metcalfe and Chalk, 1957). All assimilative organs in *C. junceum*, *C.eriopodum, C. microcarpum, C. leucocladum* kept Kranz-cells (Butnik et al., 1991); degreed Kranz-cells sizes (Butnik, Nigmanova, 2012). The special position of *Calligonum* genus in the family *Polygonaceae* noted Halkuziev P. (1990), highlight it in a separate family *Calligonaceae*. There are some facts on the morphology and biology of species of *Calligonum* (Ishchenko, 1969; Zakirov, Parpiyev, 1972; Nechayeva, Vasilewskaya, Antonova, 1973; Saytova, Tagyzov, 1986) and karyotype (Semiotrocheva, 1971). In species of other genera of the family *Polygonaceae* - *Atraphaxis*, *Rheum* and *Rumex* Kranz-structure is absent (Butnik et al., 2001, 2009). All *Calligonum* species contain alkaloids in small amounts (0.07-0.10%). They are pasture plants and can using as ornamental and consolidating sandy soil (Larin et al., 1956; Parpiyev, 1974).

MATERIALS AND METHODS

Material - assimilating organs (cotyledons of seedlings, leaf, vegetative and generative shoots) 4 species of *Calligonum*. 1. *C. junceum* (Fish. & Mey.) Litv. (*Calliphysa* section) - low (35-80 sm), spreading shrub, bark of the old shoots maroon, 5-10 one-year shoots growing from old shoot nodes; cylindrical leaves 7-12 mm long. It is growing at gipsophlious, sand-and-pebble soil. Area: Central Asia, Dzungaria Kashgar, Mongolia, China. 2. *C. eriopodum* Bunge (*Eucalligonum* section) is a tree or shrub up to 2.5 m in height with whitish-gray bark of old shoots and rough green jointed annual shoot. The long cylindrical leaves 8-10 mm, early fall of. Psammofit. Endemic in Central Asia.

3. *C. microcarpum* Borszcz. (*Eucalligonum* section) - a small, 1-1.5 sm shrub with grayish or reddish bark of old shoots and rough green annual shoot; cylindrical leaves 4-5 mm long early fall of. Psammofit, endemic in Central Asia. 4. *C. leucocladum* (Schrenk.) Bunge. (*Pterococcus* section) - shrub 50-70 (120) sm height, with white bark of old shoots, long articulate abbual shoots, opposite leaves 6-10 mm long. Psammofit. Area: Central Asia, Dzungaria (Drobov, 1953) (Figure 1.).

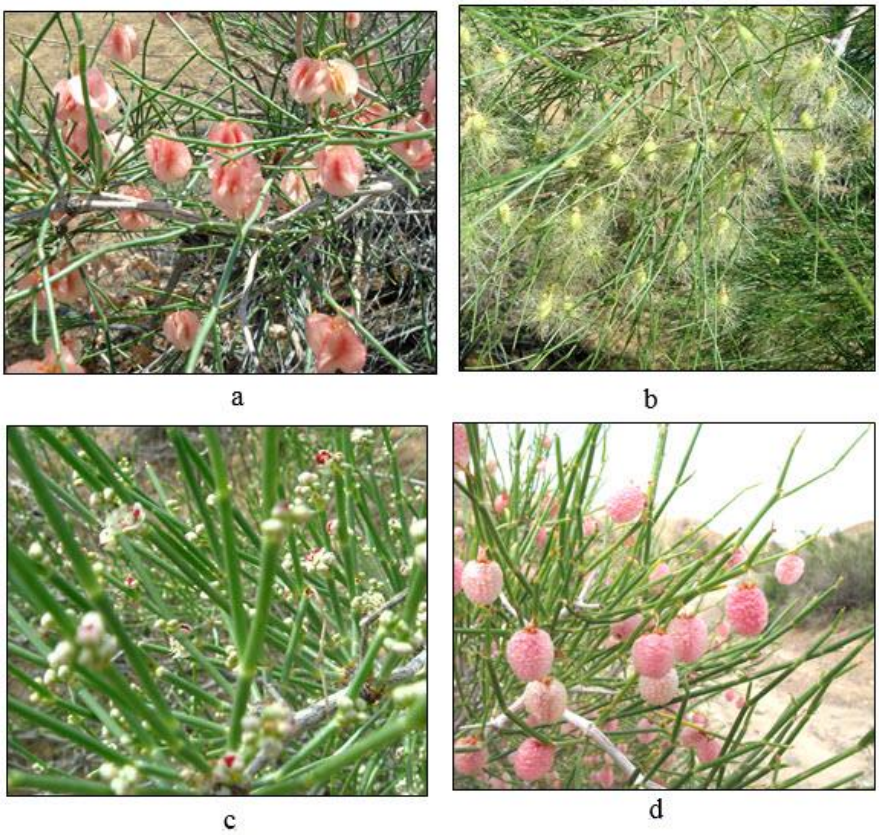

Figure 1. Objects of research at the flowering and fruit, stages formation with assimilates vegetative and generative shoots): a - *C. leucocladum*; b - *C. eriopodum*; c - *C. microcarpum*; d - *C. junceum*.

Ecology of collecting material place. Material for the study collected in the South-western part of the Kyzylkum desert, 150 km from the city of Bukhara (Navoi region, Uzbekistan) in the foothills Kuldzhuktau (Zeravshan-Alai metallogenic zone). The region is characterized by complex xerothermic factors: dry air and soil, the minimum annual rainfall (80-100 mm), high summer (+40-45^{0}C) and low winter (-25-30^{0}C) temperatures, strong winds (Momotov, 1973; Babushkin, 1971; Gorbunov, Kimberg, 1971; Lee et al, 1978). The characteristic features of the composition of the soil: the high content of potassium, rare-earth and rare metal, the presence of arrays of alkaline rocks, the development of tungsten, tin, antimony, mercury and nickel-graphite deposit (Aysanov, Egorov, 1978). The abundance of antimony, copper, arsenic, vanadium, lead, zinc, boron, molybdenum, cadmium, chromium creates near Kuldzhuktau build special mineralogical background, contributing to the formation of the original flora, consisting of 25% of endemics (Granitov, 1964), including species of *Calligonum*.

Species *C. junceum* grows on stony and gravelly substrate, having the features: a small amount of humus; accumulation of moisture in the cracks and its rolling surface; heating the surface xerothermic period, which are forming to specific structural type sclerophyll-plants.

Species *C. microcarpum* grows on clay and gravel soil foothill plain Kuldzhuktau on light-gray slightly saline in the horizon of 0-7 sm of dry loam soil with gravel, below-dense loam with inclusions of gypsum and stony-gravelly sand.

Species *C. eriopodum* and *C. leucocladum* grow on semi-fixed sand ridges Kuldzhuktau. Sand as a substrate has a next of features: low heat capacity and high thermal conductivity. It is very hot and subject to sharp daily fluctuations in temperature. On hot days, the temperature of the sand comes to 70-80^{0}C, which causes heating of the surface air layer. Precipitation quickly seeping down as sand retention capacity is low, and high water permeability. Capillarity sands and low reverse current of groundwater is insignificant. As a result, the root system of

plants is in a meager supply. Sear the sand by the fall comes to a depth of 50-60 sm., but the precipitation form a "suspended" wet horizon at a depth of 1-1.5 m due to which there is a large part of the plant. Sands characterized by intra condensation. Of great importance is the mobility of the substrate, causing the bared of roots (Goryshina, 1979).

Methods. Assimilative organs were fixed in 70% ethanol, cross-sections of the cotyledons of seedlings, leaves and stems of shoots done by hand with a razor in elderberry and enclosed in gelatin-glitserin (Prozina, 1960; Barykina, Chubatova, 2005). Flowers were fixed in Carnoy's (70% ethanol and 30% acetic acid), was treated by the conventional method (Pausheva, 1980). Microtome sections were stained with basic fuchsin for Schiff. Measurements made by the eyepiece micrometer MOV-1.5. Average values of signs were taken from 30-90 measurements. Statistical analysis of quantitative data carried out according to generally accepted criteria (Zaisev, 1991) on a personal computer (MS-Excel program). The picture of sections was performed using a drawing apparatus RA-6, microphotography «Sony» digital camera.

The purpose of research - to identify the relationship of the structure of assimilating organs of 4 species of the genus *Calligonum* ecology and sectional affiliation.

Results and discussion. The cotyledons of seedlings flattened terete, at C. leucocladum and *C. eriopodum* small (2.5-2.7 mm), at *C. microcarpum* and *C. junceum* larger (14-16 mm), the latter are wider (3, 0 mm) than the other (1.3-2 mm). The thickness of the cotyledons is almost the same - 0.7-0.9 mm. Most cotyledons flattened in *C. eriopodum*, terete at *C. microcarpum*. Mesophyll also flattened, Kranz-centric with the hypodermis, one palisade cells row and 7 vascular bundles in the center mesophyll, as well as peripheral, adjacent to the Kranz-cells. Some peripheral beams separated from water bearing cells Kranz-cells. Highest cell hypodermis (53.0 microns), palisade cells (83.0 microns), and Krantz-cells (73.0 mm), almost gigantic in *C. microcarpum*. The remaining species are smaller height hypodermis - 23-36 µm, palisade cells - 36-39 µm, Kranz-cells 22-30 µm (Table 1.) (Figure 2). The ratio height-to-width Kranz-cells is a indicator of their shapes: cube in *C. junceum* (1.1), close to the cubic (1.2-1.3) or at palisade like *C. microcarpum* (3.7) (Figure 2, table 1).

The leafs *Calligonum* species of elongated, terete, leaf *C. microcarpum* small (4.5 mm), almost threadlike (width - 1 mm, equal to the thickness - 0.9 mm). Mesophyll occupies an intermediate position between *Salsoloid* - type (vascular bundles adjacent to Kranz-cells and one main vascular bundle) and *Climacoptera* - type (vascular bundles are separated from Kranz-cells, in the center of the leave are 3 or more vascular bundles). Mesophyll includes hypodermis, at *C. junceum* is the smallest (19.3x15.9). Kranz-cells highest in *C. leucocladum* (46.4x31.4) low, but wide at *C. junceum* (23.2x24.9). In *C. eriopodum* Kranz-cells although lower (33.9 µm) than the *C. leucocladum*, but more palisade like connection of height to width is 2 (y *C. junceum* – 0.9). (Fig 3, Fig. 4, table 1).

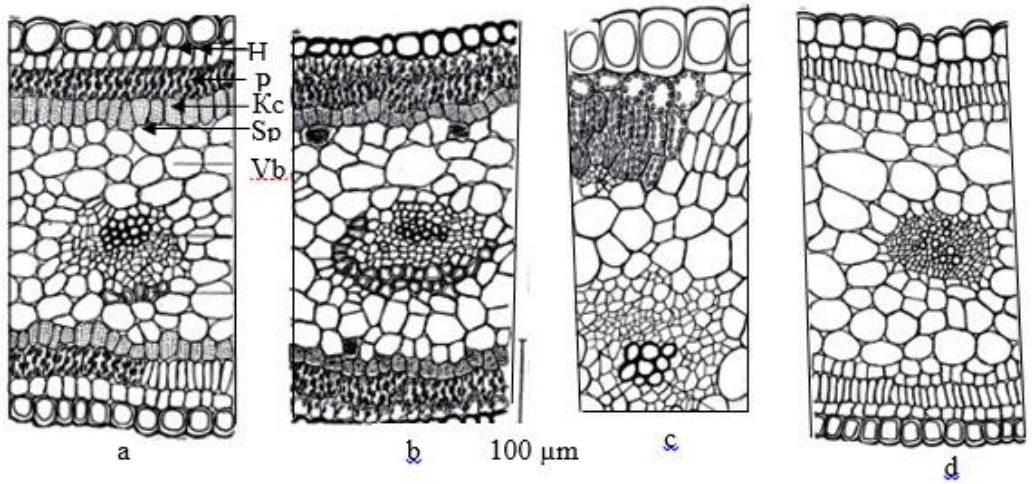

Figure 2. Structure of the cotyledons of seedlings species of the genus *Calligonum*: a - *C. leucocladum*; b - *C. eriopodum*; c - *C. microcarpum*; d - *C. junceum*. Legend: H – hypodermis, Kc - Krantz-cells, P - palisade parenchyma, Sp - spongy parenchyma, Vb- vascular bundle

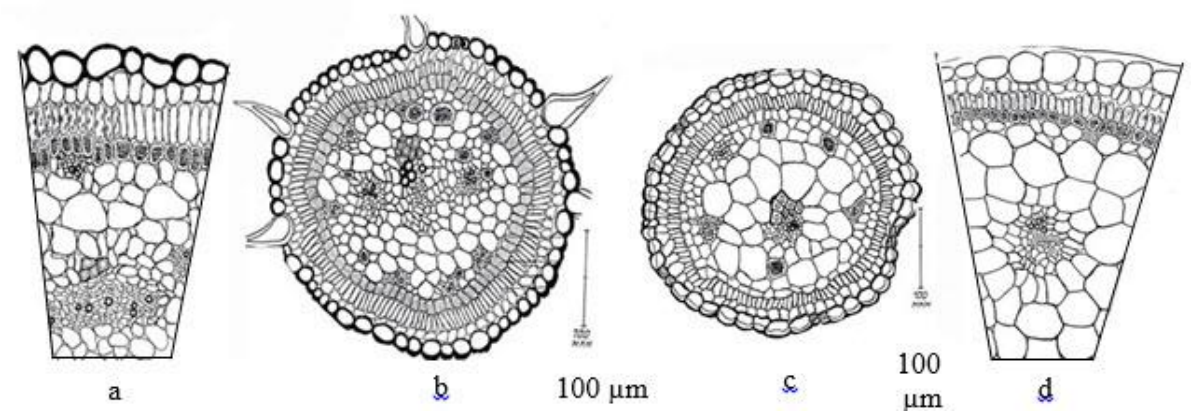

Figure 3. The structure of the leaf of the genus *Calligonum*: a – *C. leucocladum;* b – *C. eriopodum;* c – *C. microcarpum;* d – *C. junceum.*

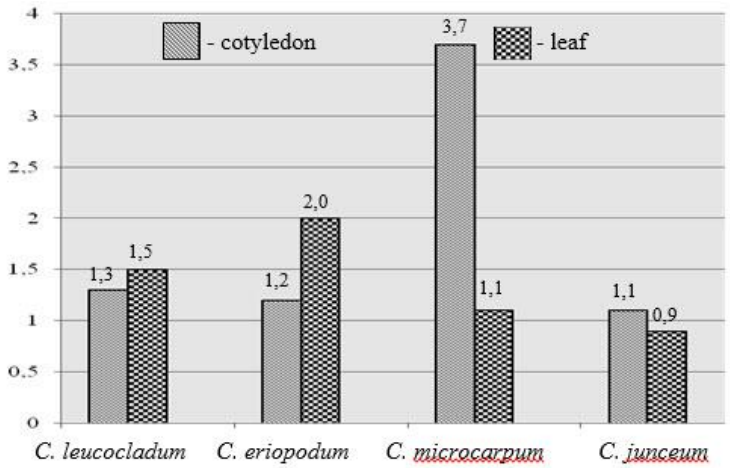

Figure 4. The height of Kranz cells in the cotyledon and leaf species Calligonum. Numeral on the figure is ratio height-to-width of Kranz-cells

Table 1. Signs of the cotyledon and leaf mesophyll structure at species Calligonum

Evidence	*C. leucocladum*		*C. eriopodum*		*C. microcarpum*		*C. junceum*	
	cotyledon	leaf	cotyledon	leaf	cotyledon	leaf	cotyledon	leaf
Cotyledons, mm:	25±2,0	11,0±1,9	27±2,3	8,5±0,7	14,0±1,3	4,5±0,3	16,0±1,03,0±0,2	11,5±1,0
length	2,0±0,19	1,8±0,8	1,5±0,13	2,0±0,1	1,3±0,11	1,0±0,09	0,8±0,07	2,0±0,18
width	0,9±0,07	0,9±0,06	0,7±0,06	1,0±0,09	0,7±0,06	0,9±0,09		0,6±0,05
thickness								
Hypodermis, µm	26,8±1,9	35,6±3,1	23,3±1,8	39,2±3,7	53,0±4,6	26,5±2,3	36,9±2,3	19,3±1,7
height	20,2±1,9	21,8±1,8	21,1±1,8	24,5±1,9	22,0±1,9	22,3±2,0	21,7±1,7	15,9±1,4
width								
Palisade cell, µm	36,8±3,1	46,7±3,9	38,4±3,3	51,8±4,8	83,0±7,9	39,9±3,6	39,9±3,2	38,7±3,6
height	7,8±0,6	11,6±1,0	18,8±0,9	15,4±1,3	26,0±1,9	18,0±1,4	15,9±1,4	11,2±1,0
width	4,7	4,7	2,0	3,3	8,5	2,2	2,6	3,4
index (h/w)								
Kranz-cells, µm	28,8±2,3	46,4±4,1	22,4±1,9	33,9±2,9	73,0±6,4	29,3±2,2	30,2±2,7	23,2±2,1
height	21,4±2,0	31,4±2,7	18,6±1,7	16,9±1,4	19,9±1,8	27,3±2,4	29,2±2,3	24,9±1,9
width	1,3	1,5	1,2	2,0	3,7	1,1	1,1	0,9
index (h/w)								

Comparison of cotyledon and leaf structure signs by species revealed the following legals (regularity). The cotyledons of *C. junceum* small (16.0 mm), but larger sheet (11.5 mm). The height of the hypodermis cells, palisades and Krantz-cells in the cotyledons are close in index (36.9 µm, 39.9 µm, 30.2 µm), but more than in the sheet (19.3 µm, 38.7 µm, 23.2 µm). The connection of height to width Kranz-cells in the cotyledons and leaves of the same (1.1-0.9). In cotyledons *C. leucocladum* they in at four times longer than in the leaf, however, the same width and thickness. Hypodermis and palisade cells sheet to slightly higher. Kranz-cells higher and wider in the cotyledons.

In *C. eriopodum* cotyledons the length at 3 times more of the leaf, the same width, but thicker. Hypodermis, palisade parenchyma and palisade index leaf is higher than in cotyledons. Kranz-cells above but narrow, in this connection ratio the height to width larger (Table. 1).
The *C. microcarpum* cotyledons at 3 times longer than the leaf, indicators of the width and likely thickness. Hypodermis cells and palisade parenchyma in the cotyledons is 2-2.5 times higher than in the sheet. However, the cell width is almost the same, as a result of the index at the cotyledon palisade high (8.5). The same tame Kranz-cells of cotyledons tall and narrow (73.0x19.9), the ratio of height to width highest (3.7). These indicators are similar in leaf to other species.
Thus, the most ancient species *C. junceum* cotyledons and leaves are small and small cell; indicators hypodermis, palisade parenchyma and Kranz-cells in the cotyledons are nearly identical, but larger than a leaf; palisade index similar. In *C. leucocladum* cotyledons longer leaf palisade parenchyma and Kranz-cells larger palisade same index. In cotyledons *C. eriopodum* all signs smaller than in leaf except length and size Kranz-cells. Xeromorphic and specialization cotyledons very high in *C. microcarpum*. All cotyledons signs greater than the leaf including palisade index, i.e. reduction and increased xeromorphic leaf.

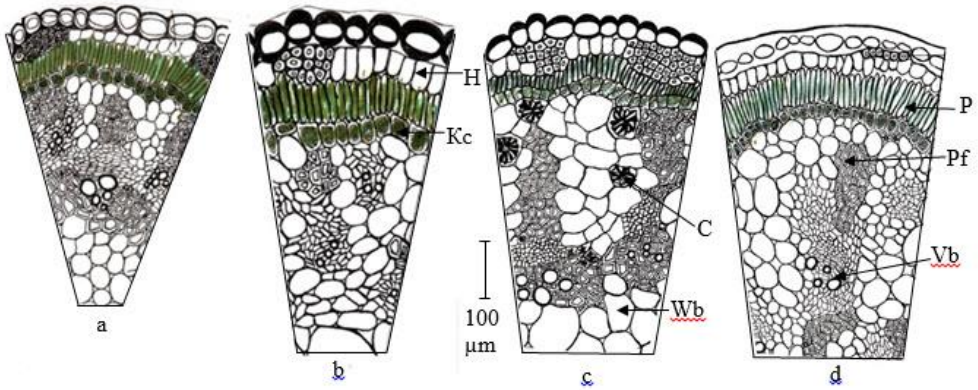

Fig. 5. The structure of the primary cortex annual shoots *Calligonum* species: a - *C. eriopodum;* b - *C. leucocladum;* c - *C. microcarpum;* d - *C. junceum*. Legend: Wb - water-bearing parenchyma, C - crystal, Pf - pericyclic fiber, another legend on the fig. 2

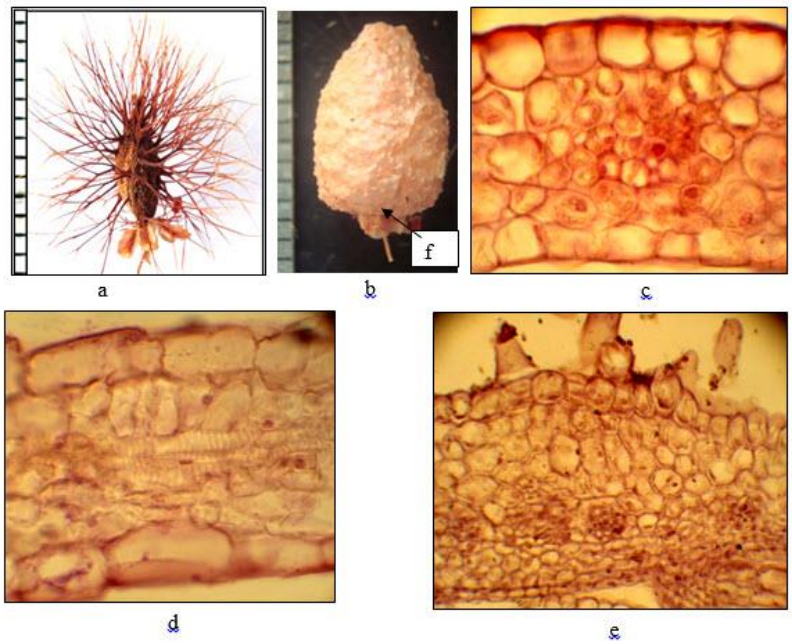

Fig. 6. Structure tepals *Calligonum* species: a - the fruit with the remaining tepals *C. eriopodum*, b - *C. junceum*; crosscut; c - *C. leucocladum*; d - *C. eriopodum*; e - *C. junceum*. f – remainder of tepals at fruit.

The representatives of the family *Chenopodiaceae* Kranz-cells predominantly cubic. The middle size of cells in family: height - 27.2 m, width - 27.3 m (Butnik, Yusupova, 2012). Kranz-cells of the genus *Calligonum* palisade like: height - 31,9, width - 22.6 (Butnik, Nigmanova 2012). That is types of *Calligonum* kept the original, origin palisade Kranz-cells. The form and size of Kranz-cells in species of *Calligonum* are close to the species *Salsola richteri* (Moq.) Karel ex Litv. and *S. paletzkiana* Litv. (*Chenopodiaceae*). This is probably due to the general ecology of these species (psammophytes) and life form (shrubs).

In species *Calligonum* the leaves annual shoot early (April - May) are falling off and pass of over's performs assimilation function of the primary cortex, which is represented by single row epidermis, palisade parenchyma and Kranz-cells, which forming a continuous layer. Hypodermis sometimes interrupted collenchyma cell groups consisting of 1-4 laer. Collenchyma most extensive and is more common in the cross-cut the stem at *C. microcarpum*. Hypodermis cells the highest, at palisade like in *C. leucocladum* leaf. Palisade cells of all species (except C*. microcarpum*) with a high index of palisade. Kranz-cells highest are in *C. leucocladum*, which corresponds to this signs in leaf. The small periferic vascular bundles deposited near Kranz-cells. In *C. microcarpum* at Kranz-cells abundant idioblast with calcium oxalate crystals (Figure 5). Generative shoots all species are sclerophyllos less than assimilating and more succulent, that apparently necessary fore more abundant water supply to the generative organs.

The role of the tepals desert plants is difference. In many species of the family. *Chenopodiaceae* tepals served a protective function and changing, form varying complexity a fruit coat. In species of the genus *Calligonum* pericarp it is the main protection of the fruits, forming nutlike structure with numerous bristles of different shapes (Butnik, 1981). In this regard, the protective role of the tepals is unimportant. Structure tepals parenchymal, represented by the single-row epidermis and 4-7 rows of spongy parenchyma cells (Fig. 6). In all species studied after pollination and fertilization at preserved fruit dried perianth with nectary at the base of the ovary and staminate thread.

Species of the genus *Calligonum* are characterized by a high degree of specialization of assimilating organs (cotyledons, leaf, primary cortex), which indicates their high evolutionary position. The adaptive evolutionary processes in cotyledons and leaves were different: in *C. junceum* quantitative signs of the cotyledon and leaf are similar because, connection with the preservation of the habitat (pestrotsvety). The sign in leaf size of *C. eriopodum* and *C. leucocladum* a decrease, but an increase is the structural signs due to the more favorable (fixed sands) habitat. Reduction in the size of the leaf and its tissues marked in *C. microcarpum*, possibly due to the lengthening of the growing season and habitats on gypsum soil. The signs of Calligonum cotyledon and leafs likely with *Salsola richteri* Kar. et Kir. and *S. paletzkiana* Litv., behind to the similarity of environmental habitats. Preserving nectary at the base of the perianth of fruits is indicates a part of the synthesized nectary in the development of the embryo.

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