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Adaptive Features of Vegetative Organs *Juno hippolyti* (Vved.) Kamelin and *J. narbuti* (O. Fedtsch.) Vved. (Juno Tratt.) in the Conditions of the Kyzylkum Desert

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Abstract

For the first time, the anatomical structure of the vegetative organs of the species *J. hippolyti* and *J. narbuti* was studied in the conditions of Kyzylkum (Uzbekistan, Province Bukhara) and revealed the diagnostic features of these species. A different combination of xeromorphic and mesomorphic features was determined, which ensures adaptation to habitat conditions. In *J. narbuti* xeromorphic features predominate, which indicates a more adaptable and wide distribution in the natural habitat of this species. In *J. hippolyti*—mesomorphic signs that show the rarity of the species in their natural habitat, compared to *J. narbuti*.

Keywords

Anatomy, Vegetative Organs, *J. hippolyti*, *J. narbuti*, Kyzylkum

1. Introduction

The family of Iridaceae includes 75 - 80 genera and about 1800 species common in the tropical and subtropical countries of the Globe. The genus *Iris* L. is the most polymorphic in the homonym family with more than 200 species [1]. In the flora of Uzbekistan, this genus includes more than 30 species. Morphological signs of the inflorescence of representatives of the Iridaceae family of the flora of Uzbekistan are described. It was revealed that the genus *Juno* is characterized by a frontal inflorescence, whereas the species Iris, *Gladiolus italicus* and *Moraea*

sisyrinchium are characterized by the breasts of the inflorescence [2].

We have previously studied the morpho-anatomical structure of the vegetative organs of some species of *Iris* (*Iris sogdiana, Iris korolkowii, I. stolonifera, I. alberti*) and *Juno* (*Juno svetlanae*) to identify the diagnostic features specific to each section (*Limniris* Tausch, *Iris Hexapogon* (Bunge ex Alek.) Baker and *Juno* Tratt [3]-[8].

2. Materials and Methods

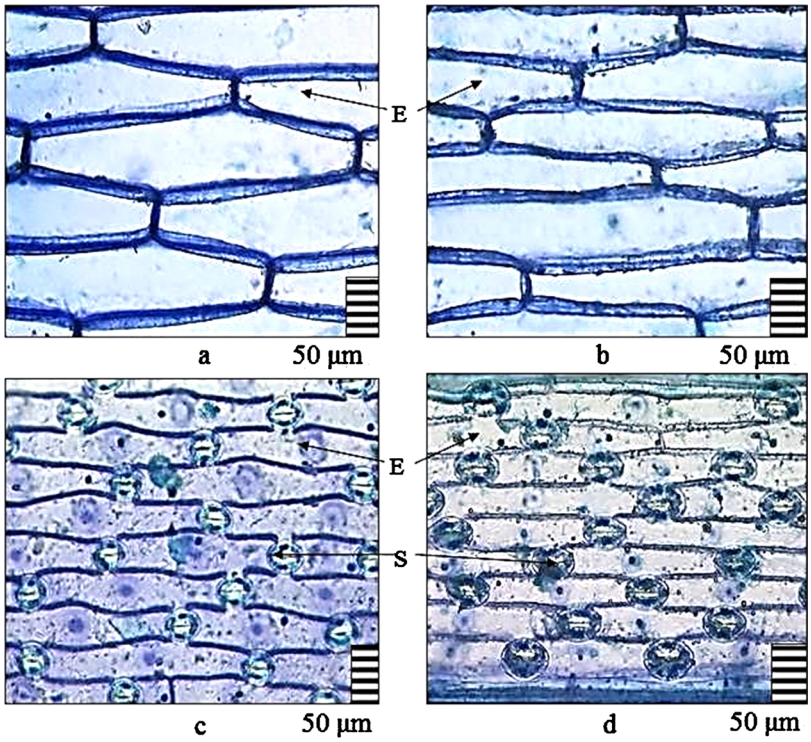
The objects of the study are some species of the genus *Iris* (*Juno*): *Juno hippolyti* (Vved.) Kamelin—Red Book rare narrow local endemic species Kyzylkum status - 1. A perennial, tuberous plant from the family Iridaceae [9]. *J. narbuti* (O. Fedtsch.) Vved.—widespread species. A perennial, tuberous plant from the family Iridaceae.

The material was collected and fixed in the flowering phase in three copies in mid-April 2018 from the south-western desert station of Kyzylkum. The region is characterized by extreme dryness of air and soil, caused by a minimum amount of precipitation (80 - 120 mm per year), high summer and low winter temperatures from max. +40˚C - 45˚C to min −25˚C - 30˚C accompanied by a strong wind [10] [11] [12]. Studies were conducted in the conditions of Kyzylkum (Bukhara region, Kuljuktau). Simultaneously with the morphological description, the vegetative organs of plants (leaf, leaf's vagina, stem) were fixed in 70˚ ethanol for anatomical study. The leaves epidermis was studied on the paradermal and transverse sections. The transverse sections of the leaf are made through the middle, and the vagina of the leaf and stem is the base. Each tissue was described, epidermis according to S.F. Zakharevich [13]. The preparations were stained with methylene blue followed by sealing with glycerin-gelatin [14]. Photomicrographs are made with a computer micro photoset with a digital camera Samsung ES70 and microscope of Motic B1-220A-3. The measurements were performed depending on the organ, tissues and cells in a 30 - 90 short repetition by an ocular-micrometer with the subsequent transfer into microns. Statistical processing of quantitative data was carried out according to generally accepted criteria [15] using a personal computer (MS-*Excel* program).

3. Results and Discussion

***Juno hippolyti* anatomical characteristics.** The leaves are crescent-shaped, 1 - 1.5 cm wide, smooth, edged and sharp at the margin. On the paradermal section, the outlines of epidermal cells are rectilinear, the projection is polygonal, numerous on the abaxial side (79.8 ± 0.64 for 1 mm^2) than on adaxial (41.8 ± 0.32 for 1 mm^2). Adaxial epidermal cells are larger than the adaxial epidermis (**Figure 1(a)**, **Figure 1(c)**; **Table 1**).

The leaves are amphistomatic. The stomata are located transversely to the longitudinal axis of the leaf. The shape of the stomata is rounded, numerous on the abaxial side (72.2 ± 0.69 for 1 mm^2), and on the adaxial side are absent. The



Legend: S—stomata, E—epidermis.

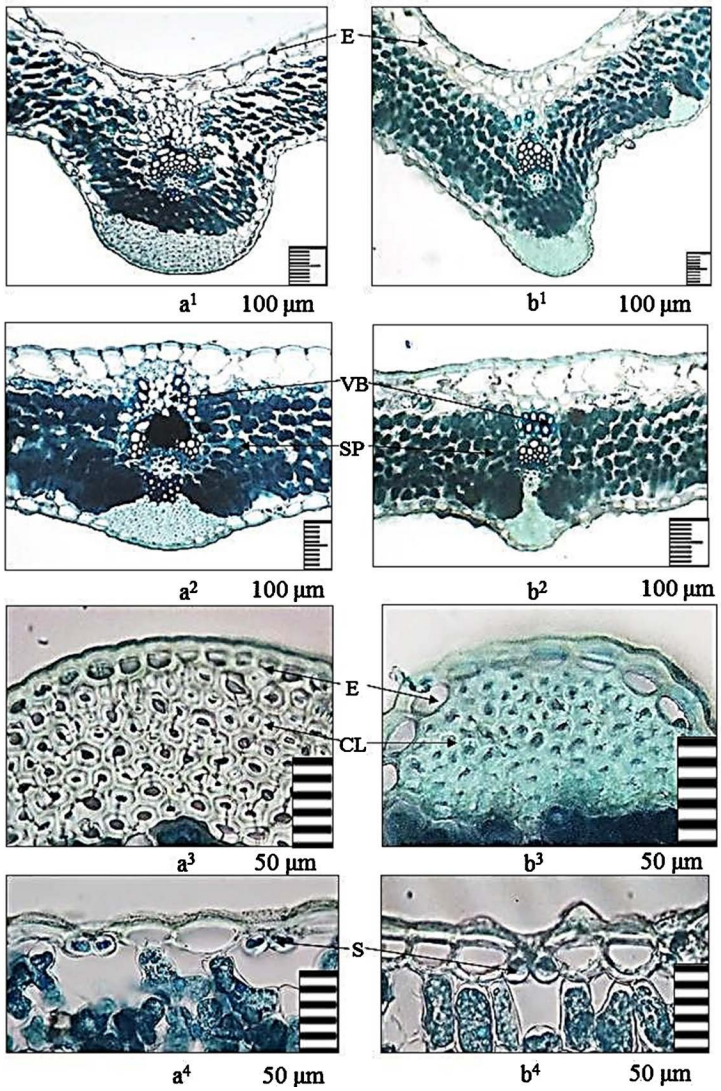
Figure 1. Structure of the epidermis of the leaf of *J. hippolyti* ((a), (c)) and *J. narbuti* ((b), (d)) on the paradermal section: ((a), (c)) adaxial epidermis; ((b), (d)) abaxial epidermis.

Table 1. Quantitative indicators of the leaf some species *Juno* (n = 30).

Index		*J. hippolyti*	*J. narbuti*
Epidermis: thickness outer wall, µm		5.4 ± 0.04	6.8 ± 0.05
height cells, µm	adaxial	70.5 ± 0.63	74.5 ± 0.78
	abaxial	34.5 ± 0.23	30.3 ± 0.22
number on 1 mm^2	adaxial	41.8 ± 0.32	53.2 ± 0.43
	abaxial	79.8 ± 0.64	87.4 ± 0.79
Stomata:			
length, µm		36.3 ± 0.25	41.7 ± 0.34
width, µm		29.6 ± 0.21	33.3 ± 0.28
immersion, µm		7.51 ± 0.06	11.4 ± 0.09
number on 1 mm^2	adaxial	-	-
	abaxial	70.2 ± 0.69	79.6 ± 0.71
Spongy parenchyma:			
diameter of cell, µm		35.5 ± 0.23	30.7 ± 0.25
number of rows		7 - 8	5 - 6
Collenchyma:			
diameter of cell, µm		12.5 ± 0.09	10.7 ± 0.07
number of rows		6 - 7	7 - 8
Vessels vascular bundles:			
diameter of vessels, µm		14.5 ± 0.08	11.6 ± 0.06
number of vessels		16 - 18	14 - 16

closure cells of the stomata on both sides of the leaf are almost the same length. Stoma slightly submerged (7.51 ± 0.06 μm), anomocytic type (**Figure 1(c)**; **Figure 2(a^4)**).

Mesophyll leaf on a cross section of a spongy type, which is represented by spongy cells on both sides of the leaf. The epidermis is represented by one row of cells with a thin-walled cuticle layer (5.4 ± 0.04 μm). Adaxial epidermal cells are large (70.5 ± 0.63 μm), longer than abaxial (34.5 ± 0.23 μm). Spongy parenchyma rounded, large cell (35.5 ± 0.23 μm), consists of 7 - 8 rows. Spongy parenchyma is chlorophylliferous. The main and lateral fibrils are shown on the abaxial side. Under abaxial epidermis and vascular bundles located over 6 - 7 row angled collenchyma diameter 12.5 ± 0.09 μm. The main fibril vascular bundle

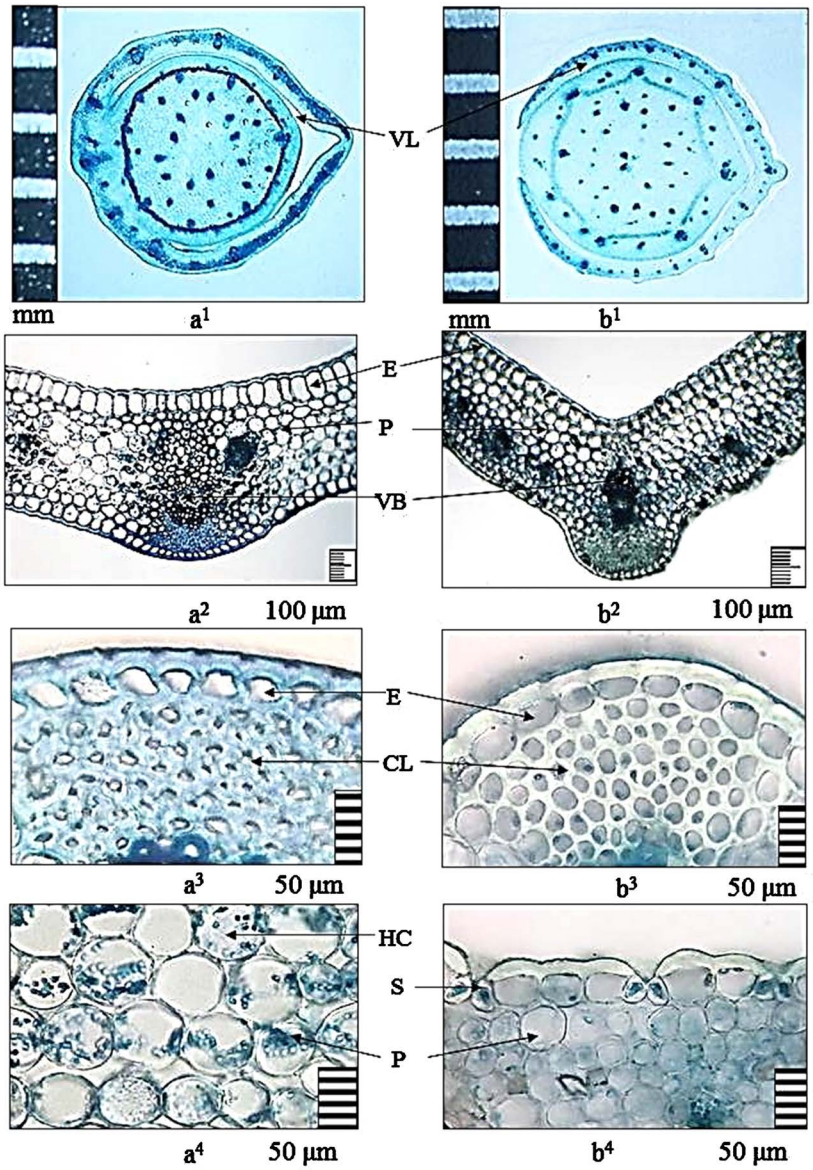


Legend: SP—spongy parenchyma, CL—collenchyma VB—vascular bundles, S—stomata, E—epidermis.

Figure 2. The structure of the mesophyll of the leaf of *J. hippolyti* (a^1)-(a^4) and *J. narbutii* ($б^1$)-($б^4$) on the cross section: (a^1), (a^2), $б^1$, $б^2$—general view and detail of leaf mesophyll, (a^3), $б^3$—epidermis and collenchyma, (a^4), (b^4)—submerged stomata.

includes 1. Vascular bundles are closed, collateral, numerous, consisting of phloem and xylem, with 16 - 18 large and small vessels with a diameter of 14.5 ± 0.08 μm (Figure 2, Table 1).

Vaginal leaf type is closed (with fused margins). In the cross section, the structure of the vagina of a parenchymal-bundle leaf (Figure 3(a^1), Figure 3(a^2)). The epidermis is represented by one row of cells with a thick-walled cuticle layer (8.3 ± 0.07 μm). Adaxial epidermal cells are large (71.4 ± 0.64 μm), longer than the abaxial (42.9 ± 0.30 μm). Over the abaxial epidermis, beneath the



Legend: HC—hydrocite cells, VL—vagina of the leaf, CL—collenchyma, Ph—parenchyma, VB—vascular bundles, U—stomata, E—epidermis.

Figure 3. The structure of the vagina of the leaf *J. hippolyti* (a^1)-(a^4) and *J. narbutii* ($б^1$ - $б^4$) on the cross section: (a^1), ($б^1$—the general view of the vagina of the leaf, (a^2), (b^2) —detail of the vagina of the leaf, (a^3), (b^3)—epidermis and collenchyma, (a^4) —parenchyma, (b^4)—submerged stomata.

large vascular bundles is an angular 4 - 5 row collenchyma with a diameter of 12.5 ± 0.09 μm. Vascular bundles closed, collateral, numerous large and small, consisting of phloem and xylem. Large vascular bundles alternate small bundles composed of phloem and xylem, with 4 - 5 small vessels and large diameter 15.6 ± 0.09 μm. Parenchymal cells are rounded, large and small-celled with a diameter of 53.6 ± 0.48 μm, consisting of 6 - 7 rows, between them there are hydrocitic cells (**Figure 3**, **Table 2**).

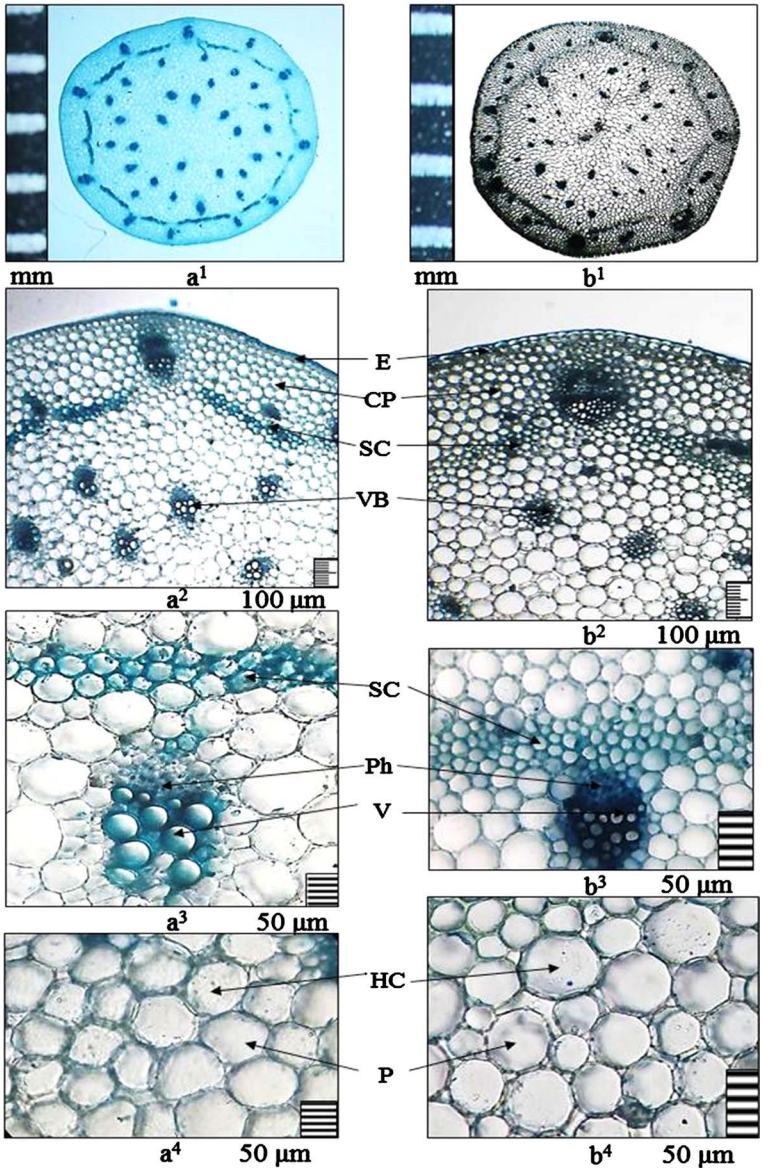
The stem is about 10 cm high, with closely spaced leaves; internodes are invisible. The cross section is rounded, the structure of the parenchymal-bundle type. The epidermis is one row, round-oval, with a thickened outer wall (10.7 ± 0.08 μm). Under the epidermis there is a thin-walled, round-oval, 6-7 row primary cortex parenchyma with a diameter of 55.56 ± 0.48 μm. Primary cervical parenchyma is separated from the central cylinder by a ring of sclerenchyma. The thickness of this ring and the degree of lignification of the cells in some respects reflect the evolutionary advancement of the species. Sclerenchyma thick-walled, annular with a diameter of 24.68 ± 0.16 μm, consists of 1 - 2 rows of cells. The central cylinder is extensive; the parenchymal cells are thin-walled, large and round-oval in diameter 68.8 ± 0.57 μm. Among the thin-walled parenchymal cells of the central cylinder there are numerous vascular bundles that are localized randomly, with 10 - 12 large and small vessels with a diameter of 22.5 ± 0.18 μm. Among the parenchymal cells of the central cylinder there are hydrocitic cells (**Figure 4**, **Table 3**).

***Juno narbuti* anatomical characteristics.** The leaves are dark green, sickle-shaped, gradually narrowed toward the apex, broadly bordered along the margin, smooth, rarely roughened; the bottom is 0.5 - 2.5 cm wide. On the paradermal section the outlines of epidermal cells are rectilinear, the projection is polygonal, numerous on the abaxial side (87.4 ± 0.79 for 1 mm^2) than on adaxial (53.2 ± 0.43 for 1 mm^2). Adaxial epidermal cells are larger than the adaxial epidermis (**Figure 1(b)**, **Figure 1(d)**; **Table 1**).

The leaves are amphystomatic. The stomata are located transversely to the longitudinal axis of the leaf. The stomata of the stomata are oval, numerous on the abaxial side (79.6 ± 0.71 mm for 1 mm^2), on the adaxial—are absent. The closure cells of the stomata on both sides of the leaf are almost the same length. Stomata more submerged (11.4 ± 0.09 μm), anomocytic type (**Figure 1(d)**, **Figure 2(b^4)**).

Mesophyll leaf on a cross section of a spongy type, which is represented by spongy cells on both sides of the leaf. The epidermis is represented by one row of cells with a thick-walled cuticle layer (6.8 ± 0.05 μm). Adaxial epidermal cells are large (74.5 ± 0.78 μm), elongated than abaxial (30.3 ± 0.22). Spongy parenchyma is rounded, small-celled (30.7 ± 0.25 μm), consists of 5 - 6 rows. Spongy parenchyma is chlorophylliferous. The main and lateral fibrils are shown on the abaxial side.

Under abaxial epidermis and vascular bundles located over 7 - 8 row angled



Legend: HD—hydrocite cells, CP—cortex parenchyma, Ph—parenchyma, VB—vascular bundles, V—vessels, SC—sclerenchyma, Ph—phloem, E—epidermis.

Figure 4. The structure of the stem of *J. hippolyti* (a^1)-(a^4) and *J. narbutii* (b^1)-(b^4) in cross sections: (a^1), (b^1)—general view of the stem, (a^2), (b^2)—detail, (a^3), (b^3)—sclerenchyma and vascular bundles, (a^4), (b^4)—parenchyma.

collenchyma diameter 10.7 ± 0.07 µm. The main fibril vascular bundle includes 1. Vascular bundles are closed, collateral, numerous, consisting of phloem and xylem, with 14 - 16 large and small vessels with a diameter of 11.6 ± 0.06 µm (**Figure 2**, **Table 1**).

Vaginal leaf type is not closed (open). In the cross section, the structure of the vagina of a parenchymal-bundle leaf (**Figure 3(b^1)**, **Figure 3(b^2)**). The epidermis is represented by one row of cells with a thin-walled cuticle layer (7.69 ± 0.05 µm). Adaxial epidermal cells are large (42.3 ± 0.34 µm), elongated than abaxial (19.2 ± 0.12 µm). The main and lateral fibrils are shown on the abaxial side. Un-

der abaxial epidermis and vascular bundles located over 5 - 6 row angled collenchyma diameter 13.8 ± 0.09 μm. Vascular bundles closed, collateral, numerous large and small, consisting of phloem and xylem. Large vascular bundles alternate small bundles composed of phloem and xylem, with 5 - 6 small vessels and large diameter 17.4 ± 0.09 μm. Parenchymal cells are rounded, small-celled with a diameter of 30.8 ± 0.25 μm, consisting of 7 - 8 rows, between them there are hydrocitic cells (Figure 3, Table 2).

Stem is short, 5 - 10 cm high, with closely intertwined leaves; internodes sometimes only with fruits are noticeable. The cross section is rounded, the structure of the parenchymal-bundle type. The epidermis is single-row, round-oval, with a thickened outer wall (10.7 ± 0.08 μm). Under the epidermis there is a thin-walled, small-celled, oval, 7 - 8 in-line primary cortex parenchyma with a diameter of 26.83 ± 0.21 μm. Primary cervical parenchyma is separated from the central cylinder by a ring of sclerenchyma. Sclerenchyma thick-walled, numerous, annular in diameter 13.28 ± 0.08 μm, consists of 3 - 4 rows of cells. The central cylinder is extensive, the parenchymal cells are thin-walled, small-celled, round-oval in diameter 42.5 ± 0.34 μm. Among the thin-walled parenchymal cells of the central cylinder are numerous vascular bundles that are localized randomly, consisting of phloem and xylem, with 12 - 14 large and small vessels 18.28 ± 0.09 μm in diameter. Among the parenchymal cells of the central cylinder there are hydrocitic cells (Figure 4, Table 3).

Based on the biometric analysis of the quantitative indices of the vegetative organs of some species of the genus Juno, the following predominant features are characteristic of this genus (Tables 1-3).

In the leaf—large, numerous epidermal cells with thickened outer walls were noted in *J. narbuti*, small, few, thin-walled in *J. hippolyti*; the most submerged stomata in *J. narbuti*, slightly submerged in *J. hippolyti*, all species prevails

Table 2. Quantitative indicators of the vaginal leaf of some species *Juno* (n = 30).

Index		*J. hippolyti*	*J. narbuti*
Epidermis: thickness outer wall, μm		8.33 ± 0.07	7.69 ± 0.05
height cells, μm	adaxial	71.4 ± 0.64	42.3 ± 0.34
	abaxial	42.9 ± 0.30	19.2 ± 0.12
Immersion of stomata, μm		7.14 ± 0.05	16.7 ± 0.21
Parenchyma: diameter of cell, μm		53.6 ± 0.48	30.8 ± 0.25
number of rows		6 - 7	7 - 8
Collenchyma: diameter of cell, μm		12.5 ± 0.09	13.8 ± 0.09
number of rows		4 - 5	5 - 6
Vessels vascular bundles: diameter of vessels, μm		15.6 ± 0.09	17.4 ± 0.09
number of vessels		4 - 5	5 - 6

Table 3. Quantitative indicators of the stem of some species *Juno* (n = 30).

Index	*J. hippolyti*	*J. narbuti*
Epidermis: thickness		
outer wall, μm	10.7 ± 0.08	8.56 ± 0.05
height of cells, μm	42.86 ± 0.33	28.89 ± 0.24
Cortex parenchyma:		
diameter of cell, μm	55.56 ± 0.48	26.83 ± 0.21
number of rows	5 - 6	7 - 8
Sclerenchyma:		
diameter of cell, μm	24.68 ± 0.16	13.28 ± 0.08
number of rows	1 - 2	3 - 4
Diameter of parenchymal cells, μm	68.8 ± 0.57	42.5 ± 0.34
Vessels vascular bundles:		
diameter of vessels, μm	22.5 ± 0.18	18.28 ± 0.09
number of vessels	10 - 12	12 - 14

anomotsitny type of stomata; in the studied species of this genus, there was a lack of stomata on the adaxial side and the presence of numerous stomata on the abaxial side in *J. narbuti*, a few in *J. hippolyti*; a large, multi-row spongy parenchyma was noted by *J. hippolyti*, small, small-rowed in *J. narbuti*; large, slightly row cells of the collenchyma were noted in *J. hippolyti*, small, multi-row cells in *J. narbuti*; Large, numerous vessels in the vascular bundles were noted in *J. hippolyti*, small, few in *J. narbuti*; **in the vagina leaf**—large, thick-walled epidermal cells were noted in J. hippolyti; small, thin-walled in *J. narbuti*; immersed stomata in *J. narbuti*, slightly submerged in *J. hippolyti*; large and small-row parenchymal cells in *J. hippolyti*, small and many-rowed in *J. narbuti*; large, multi-row cells of the collenchyma were noted in *J. narbuti*, small, small-row cells in *J. hippolyti*; large, numerous vessels in the vascular bundles of *J. narbuti*, small, few in *J. hippolyti*; **in the stem**—large epidermal cells with thickened outer walls were noted in *J. hippolyti*, small and thin-walled in *J. narbuti*; a large-cell and a few-rowed parenchyma in *J. hippolyti*; small-cell and multi-row in *J. narbuti*; the cells of the intermediate sclerenchyma are large, not numerous, noted in *J. hippolyti*, small, multi-row in *J. narbuti*; large, few vessels in the vascular bundles of *J. hippolyti*, small, multi-row in *J. narbuti*.

In the vegetative organs of all species of the genus *Juno*, xeromorphic and mesomorphic features are observed, manifested in a different combination. The thickened outer wall of the epidermis, small, numerous epidermal, spongy, parenchymal cells, small, numerous, submerged stomata, thick-walled sclerenchymal cells, multicellular collenchyma cells, small and numerous vessels in the conducting beams predominate in *J. narbuti*, and this indicates a greater xeromorphism of this species (Figure 5).

Thin-walled, large, few epidermal, spongy, parenchymal cells, large, fewer intermediate sclerenchymal cells, large and few vessels in the conducting bundles predominate in *J. hippolyti*, indicating greater mesomorphicity of this species (Figure 5).

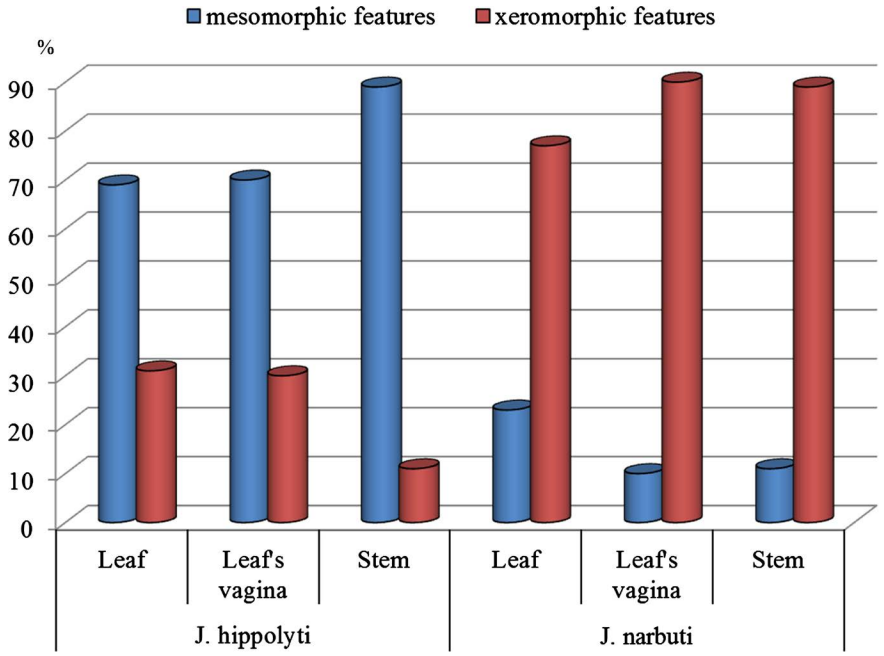


Figure 5. The ratio of adaptive mesomorphic and xeromorphic features (n = 32) in the vegetative organs species of *Juno*.

4. Conclusion

Thus, based on the results obtained for a comparative study of the anatomical structure of the vegetative organs of *J. hippolyti* and *J. narbuti* species of the genus *Juno* and a different combination of xeromorphic and mesomorphic features is determined, which provides adaptation to habitat conditions, which is achieved by accumulation of moisture in leaf tissues, specializing not only as protective, but also as water-preserving tissues that reduce evaporation. The primary cortex of the stem is preserved until the end of vegetation, which is associated with an earlier completion of the life cycle. In *J. narbuti* dominated xeromorphic signs that indicate more fitness and widespread in the natural habitat of this species. In *J. hippolyti*—mesomorphic signs that show the rarity of the species in their natural habitat, compared to *J. narbuti*.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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