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Rumex kerneri Borbás (Polygonaceae) in the Bulgarian flora – Morphology, Leaf Epidermis, Pollen Morphology, and Karyology

Tsvetanka G. Raycheva[1], Kiril H. Stoyanov[1*], Plamen S. Stoyanov[2]

1 – Agricultural University - Plovdiv, Department of Botany, Mendeleev 12, 4000 Plovdiv, BULGARIA
2 – University of Plovdiv, Faculty of Biology, Department of Botany and Teaching Methods in Biology, 2 Todor Samodumov Str., 4000, Plovdiv, BULGARIA
[*]Corresponding author: nomtax@gmail.com

Abstract. The current study provides detailed information about *Rumex kerneri* Borbás in the flora of Bulgaria. The data about this species in the floristic literature is contradictory and uncompleted. The morphologically closely allied species *R. cristatus* DC. и *R. patientia* L. misleads in the determination of the species. Both species are used as a referent to establish the discrete morphological characters and metrics. The current study provides detailed information about pollen and fruit morphology, leaf epidermis, and karyology of *Rumex kerneri* Borbás in the flora of Bulgaria. The data about this species in the floristic literature is contradictory and uncompleted. The most reliable characters in the differentiation between *R. cristatus* are *R. patientia* the reduced number of flowers in a cluster of *R. kerneri*, the development of only one tubercle in the mature valves, and the abaxial surface of the leaf blade. Also, the pollen morphology (light and scanning electron microscopy) was confirmed in this study. The somatic chromosome number of the species $2n = 80$ is also given. This is the first chromosome number for the taxon from Bulgaria and confirms the earlier reports.

Kew words: chromosome number, *Rumex kerneri*, morphology, leaf epidermis, SEM pollen.

Introduction

Subgenus *Rumex* (*Rumex* L., Polygonaceae Juss.) is taxonomically a very difficult group. This fact is caused by the high range of morphological variability, infraspecific variation, widely presented hybridization, and introgression - typical for the European species from section *Rumex* (Rechinger, 1990). As mentioned by Campderá (1819) and Mosyakin (2005), the species of this genus are forming groups with similar morphological descriptions, hampering their diagnostics. Furthermore, according to Rechinger (1932), the hybrids of*Rumex* too often have been determined and reviewed as single species by many authors. An example: originally, the hybrid between *R. confertus* and *R. obtusifolius* was described under the name *R.* × *kerneri* Błocki (Błocki, 1888). However, the name was corrected when Błocki (1889) found out that the epithet had already been applied to another *Rumex* species by Borbás (1884), namely *R. kerneri* Borbás, to honor of Austrian botanist Anton Joseph Kerner von Marilaun (1831-1898).

Rumex kerneri Borbás (subg. *R.*, subsectio *R.*), reviewed as endemic for the

Balkans (Akeroyd, 1986), have been migrated outside the Balkan Peninsula and is recently known as a neophyte in Austria and Hungary (Rechinger, 1933; 1964), reaches in the east to Southern Ukraine (Eremko, 1997), west to Italy (Prosser, 2000), and in the north to Belgium (Verloove, 2013). From the phytogeographic viewpoint, *R. kerneri* is South-European floristic element with Illyrian-Pannonian areal-diagnosis (Meusel *et al.,* 1965). Due to similar morphological characteristics with *R. cristatus*, many authors include *R. kerneri* as its infraspecific taxon, most often as subspecies (Akeroyd & Webb, 1991).

In Bulgarian flora, before Rechinger (1933), who reported the species for the first time from the Balkan Range, Rila and Rhodopi Mts., the taxon has been not recognized. Probably, this is the reason why in the subsequent floristic editions Stojanov & Stefanov (1948), Stojanov *et al.* (1966) the species is reported for Vitosha Region and Rhodopi Mts. (Western, Central) and is under question for the Balkan Range. Possibly, that is why Delipavlov (2003) treats the species as not confirmed for the flora of Bulgaria. Until recently, no specimens from *R. kerneri* have been deposited in the Bulgarian herbaria (Raycheva, 2009).

The morphology of *R. kerneri* is incompletely described in the Bulgarian literature, and this causes series of wrong determinations. We did not find data about the leaf anatomy and pollen morphology of *R. kerneri.* The data about the chromosome number area few – based on materials from California 2n=80 (Degraeve, 1975; Löve, 1986) and Greece 2n=c. 80 (Löve, 1981). There are no recent studies from other areas of distribution.

In this regard, we undertook a morphological and anatomical study of *R. kerneri,* considering to distinguish it from the related, and most confused in the determination, *R. cristatus,* and *R. patientia*.

Materials and Methods

Plant material collected by the authors from naturally growing populations (Table 1) has been used for the morphological, anatomical, and karyological study. Voucher specimens have been deposited in the herbaria SOA (Agricultural University - Plovdiv) and SOM (Institute of Biodiversity and Ecosystem Research).

Mature specimens with well-developed inner tepals – valves, have been carefully collected for reliable identification of *Rumex* species, according to Rechinger (1932) and Snogerup (1991) and confirmed by our observations.

All relevant literature data have been assembled and checked for additional information on the distribution and taxonomy of the species. The herbarium collections of *R. kerneri* W and WU (acronyms according to Thiers, 2020+) have been studied and revised. The metric data for the height of the plants have been taken in vivo (Table 2).

Leaf epidermis. Fresh basal leaves from 20 individuals have been conserved in 75% ethanol for the epidermal observations. The sections have been prepared manually using a razor, in the middle part of the leaf, on both sides of the half-blades. The epidermis was peeled manually from the leaf blade using pincers. The material was mounted in glycerine slides. The observations have been taken on a Carl-Zeiss Amplival microscope with a 5MPix camera mounted to the eyepiece. The measurements in the microscopic slides have done using a mechanical micrometer, attached to the eyepiece of the microscope. Fifty measurements for each observed character were taken randomly. The parameters of the adaxial (ad) and abaxial epidermis (ab) have been compared – shape and disposition of the common epidermal and stomatal cells. The stomatal shape in the studied species has been compared using the proportion length/with. The count of the stomata has given in magnification 16×16. The obtained values have analyzed using basic descriptive statistics.

Pollen observations

Light microscopy. The observations have been done following the methodology of Swietlinska (1960). Dry pollen grains,

slightly heated in a drop of acetocarmine, have been prepared for temporary microscopic slides. The characteristics diameter (μm) and the correlation between fertile and sterile pollen (%) for 1000 pollen grains have been taken 50 times for each evaluated population.

Scanning electron microscopy. Pollen grains collected by the authors have been used for scanning electron microscopy (Table 1). The objects have been observed directly, without any physical or chemical treatment. The pollen has been prepared for observation before scanning, following the methodology of Terziisky & Atanasov (1977) and Terziisky (1983). The observations have been conducted with a JEOL scanning electron microscope, with scanning adaptor JSM-5500.

Karyological studies Root tips of dry nuts (SOA 059243) after germination were pretreated with 0.05% colchicine for 2 hours, fixed in ethanol: glacial acetic acid (3:1) at least for 2 hours at room temperature or 24 h in the refrigerator, and stored in 96% ethanol until required. Hydrolysis has conducted in 1N HCl at 60°C for 9 min. Then the root tips have transferred into HCl:di-ethyl ether (1:1), washed thoroughly in distilled water and stained with hematoxylin after Gomori (Melander & Wingstrand 1953) for 20-25 min at 60°C. Finally, the root tips have squashed in 45% acetic acid and mounted in Canadian balsam. Chromosomes have counted on more than 10 plates to define their numbers. The photos of the best mitotic metaphase cells have been used as a basis for the drawings.

Result and Discussion

Genus *Rumex* L.
Subgenus *Rumex*
Sectio *Rumex*
Subsectio *Rumex*
= Subsect. *Patientiae* Rech. f., Repert. Spec. Nov. Regni Veg. 31 (1933) 230.

R. kerneri Borbás, Fl. Comit. Temesiensis 60 (1884) 34; Rech. f., Repert. Spec. Nov. Regni Veg. 31 (1933) 240 et Fl. Eur. 1 (1964) 86; Prodán, Fl. Reipubl. Popularis Romanicae 1 (1952) 412; Stoj. & Stef., Fl. Bulg. ed. 3 (1948) 346; Stoj., Stef. & Kitan., Fl. Bulg. ed. 4, 1 (1966) 312; Valev, Fl. R. Bulg. 3 (1966) 207; Snogerup & B. Snogerup, Fl. Hellenica 1 (1997) 99; ≡*R. cristatus* subsp. *kerneri* (Borbás) Akeroyd & D.A. Webb, Bot. J. Linn. Soc. 106 (1991) 104; Rech. f. & Akeroyd, Fl. Eur. ed. 2, 1 (1993) 104; =*Rumex confertoides* Bihari, Magyar Bot. Lapok 27 (1829) 73.

Lectotypus: WU-Generale 34260(**!**)**.** Flora comit. Veröcensis Hungariae. Infra cacumen montis Papuk ad pagum Zvecrova, coll. Borbás, 1879.07.14 (orig.: *Rumex patientia*; rev. K.H. Rech. 1936: *Rumex kerneri*).

Specimens of *R. patientia* and *R. cristatus* have found as incorrectly determined as *R. kerneri*. The close characteristics of these species are the reason for the difficulties and mistakes in the determination. That's why we have included *R. patientia* and *R. cristatus* as referent species in the comparison of the morphological and anatomical data.

Revised specimens: W: 00104 - Jugoslavia: Rechinger f. 1956; 01225- Iter Graecum: Rechinger f. 1956; 1935-1643 - Austria: Rechinger 1931; 6333 - Graecia, Phtiotis, in alpestris silvarum et pteridetis jugi Zacharaki circa 36 km ad Macrokomi versus confines Thesaliae, sustr. arenaceo corca 1500 m.: Rechinger f. 1958; 6679 - Iter Aegeum, Creta, Macedonia, Jugoslavia: Rechinger f. 1955; (Originali *R. kerneri*, rev. *R. patientia*, Raycheva 2007): 16111 (Herb. Ernst Vitec 1987); 1997-04628 (Austria: Rechinger 1966); Originali *R. kerneri*, rev. *R obtusifolius*, Raycheva 2007): 05600 - Albania, 1980, Krendl, (Originali *R. kerneri*, rev. *R. patientia*, Raycheva 2007): WU: 1916-32 - Nord Albanien: leg. Dőrfler, det. Rechinger 1916. (Originali *R. kerneri*, rev. *Rumex crispus* L. x *R. patientia* L., Raycheva 2007). Specimens of this hybrid have been determined as *R. kerneri*, because of the similar morphological and metric parameters of the valves and tubercles. The high sterility of the nuts, as well as the different size of the valves and also crumbly

fruits, demonstrate the hybrid origin of the specimens below: W: 1965-7592 - Banatus: Prodán 1914, sub *R. kerneri*; 1956-8091 - Standort: Korb 1926; 1980-04007 - Turcia: Rechinger 1974, sub *R. kerneri*; 2006-21578 - Austria: Barta 2005, sub *R. kerneri*; 2005-15615; 15614; 15613 - Austria: Barta 2003, sub *R. kerneri*; 1974-06916 -Austria: Melzer 1973, sub *R. kerneri*.

Distribution and ecology

General distribution. Native to Southern Europe (Balkan peninsula), sporadic in Austria, Hungary, Italy, South Ukraine, and Belgium. Introduced in за North America (California), from Europe.

Distribution in Bulgaria. At the foothill and mountain meadows, around deciduous forests and populated areas. Rhodopi Mts., between 200 and 1250 m above sea level.

Rumex kerneri differs with a later blooming, according to the inhabited in Bulgaria ecological niches. It is localized mainly at the foothill semi-natural meadow communities, but also represented, by small populations, in anthropophilic localities – around the margins of the villages. According to personal observations on natural populations for 10 years, the Bulgarian populations of this species don't show a tendency of expansion and increasing of the number of individuals. While the *R. kerneri* number of populations in its secondary distributional area, as Italy and other parts of Europe, this species is characterized as aggressive, invasive, with fast expansion (Galasso, 2008).

Rumex cristatus is a lowland species, occurred between 0 and 477 m altitude, with Mediterrano – West Asian origin (Rechinger 1959). In Bulgaria, this species is found mainly in ruderal places, forms dense populations. Similar ecological characteristics shows also *R. patientia,* a Caucasian-Pontico-Poannonian floristic element, with a moderate continental European - West Asian areal-diagnosis (Meusel *et al*., 1965). The primary boundaries of its range are not clear. It is often cultivated as a leafy vegetable, and its high ecological tolerance allows its successful resettlement in ruderal and anthropogenically influenced communities, with a large number of individuals in the populations.

Morphological characteristics

The members of the subgenus *Rumex* are characterized with the shrub-like habit, high and thick stems, branched panicles with dense and close leafless flower clusters, large basal leaves – entire, or wavy to irregularly shallowly serrate margin, valves in the fruit with 1, sometimes 3 non-equally developed tubercles. In the occupied area, the species are polyploids, like hexa- and octoploids (2*n* = 60, 80, further studies for *R. patientia* and *R. cristatus* from Bulgarian populations, Raycheva, 2005).

Table 1. List of accessions studied species of subg. *R.*, subsectio *Rumex*: *R. kerneri, R. cristatus, R. patientia* in Bulgarian origin. Legend: [a] The floristic regions follow the standard accepted in *Flora R Bulgaria*. [b] SEM– scanning electron microscopy of the pollen; K–karyological studies; LA – leaf anatomical studies; M–gross-morphological studies; P – pollen analysis. [c] New chorological data from Bulgaria.

Species, voucher number	**Floristic region, locality, UTM, voucher number**	**Applied methods** [b]
R. kerneri Borbás		
SOA 059605	Rhodopi Mts. (central). 35TLG03, 700 m, Meadows above village of Hvoyna, 22.07.2005, coll. Ts. Raycheva	M, K, LA, P
SOA 56414	Rhodopi Mts. (central) 35TLG13, 780 м, Grass places around the village of Jougovo, 10.07.2003 coll. Ts. Raycheva	M, LA, P
SOA 059243	Rhodopi Mts. (eastern), 35TMF28, 200 m, Between the villages	M, K,

	of Siv Kladenets and Mandritsa, 18.06.2008, coll. Ts. Raycheva.	SEM
SOA 56414	Rhodopi Mts. (western)[c] – Near the village of Youndola, on the road to Belmeken Dam Lake, 34TGM36, 1250 m, 15.07.2016, coll. Ts. Raycheva, K. Stoyanov	M, LA
R. cristatus DC.		
SOA 056842	Rhodopi Mts. (eastern), 35TLF99, 272 m, The village of Rogach, Krumovgrad district, 14.07.2005, coll. Ts. Raycheva	M, LA, P
SOA 56939	Black Sea Coast (northern), 35TNJ90, 10 m, Near city of Varna, between Albena and town of Balchik, 18.06.2004, coll. Ts. Raycheva	M, SEM
SOA 057065	Black Sea Coast (south), 35TNJ76, 20 m, The town of Tsarevo, 3.07.2014.	P
SOA 059247	Strandja Mt., 35TNJ75, 56 m, Grass places, near the village of Brodilovo, 23.06.2007, coll. Ts. Raycheva	M, LA
SOA 056941	Pirin Mt. (south), 34TGL19, 477 m, In the village of Gorno Spanchevo, 18.06.2011, coll. Ts. Raycheva	P
R. patientia L.		
SOM 163984	Znepole region, 34TFN43, 916 м, Near to the village of Paramoun, 05.07.2006, coll. Ts. Raycheva	LA, M, SEM
SOA 059477	Balkan Range (central) 35TKH63, 710 м, Near to village of Anton (town of Pirdop), 03.07.2005, coll. Ts. Raycheva	M, LA, P
SOA 059235	Sredna Gora Mts. (western), 35TKH60, 530 m, Near to town of Panagjuriste, 03.07.2005, coll. Ts. Raycheva	M, LA, P
SOA 059478	Rhodopi Mts. (central), 35TLG03, 695 m, Grasslands near to village of Hvoyna. 18.07.2016, coll. Ts. Raycheva, K. Stoyanov	P

Fig. 1. *Rumex kerneri* Borbás: A – flower clusters; B – mature fruits.

Table 2. Comparative morphological parameters of *R. kerneri, R. patientia,* and *R. cristatus.*

Character	Values x±Sx (min-max)		
	***R. kerneri* Borbás**	***R. cristatus* DC.**	***R patientia* L. subsp. *patientia***
Stem height, cm	(75) 90-120 (160)	(125)135-180 (200)	(80) 165-190(210)
Valve length, mm	**5.86**±0.05 (5.2-6.5)	**6.57**±0.05 (5.3-7.8)	**7.98**±0.1 (6.8-10)
Valve width, mm	**5.46**±0.04 (4.9-6)	**6.18**±0.05 (5-7.6)	**7.48**±0.08 (5.9-9.6)
Tubercle length, mm	**2.06**±0.02 (1,9-2,3)	**2.78**±0.03 (1-3,4)	**1.53**±0.,02 (1.1-1.9)
Tubercle width, mm	**1.48**±0.02 **(**1,1-1,8)	**2**±0.02 (1.4-2.8)	**0.95**±0.01 (0.5-1.3)
Nut length, mm	**2.66**±0.04(2.1-3.1)	**2.92**±0.02 (2.3-3.4)	**3.24**±0.03 (2.8-4)
Nut width, mm	**1.54**±0.02 (1.4-1.8)	**1.82**±0.02 (1.5-2.2)	**1.91**±0.02 (1.5-2.3)
Fruit stalk, mm	**7.63**±0. (6.4-9.1)	**8.09**±0.17 (5.8-11.3)	**10.28**±0.21 (7-14.2)
Number of flowers in a cluster	(12)**15–20**(26)	(21)**30-60**(68)	(17)**20-50**(55)

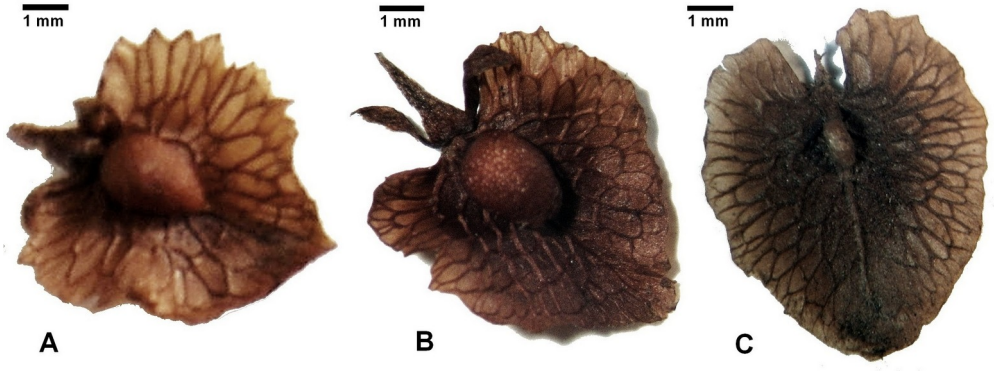

Fig. 2. Valves of A – *Rumex kerneri*; B – *R. cristatus*; C – *R. patientia.* Scale bar: 1 mm.

A character with a diagnostic value for the determination of *R. kerneri* is the presence of sparse hairs on both surfaces of the basal (cataphylls) leaves, and their absence in *R. patientia* and *R. cristatus*. The stems of *R. kerneri* a shorter approximately 90-120 cm, and the number of the flowers in a cluster is the lowest – about 20 (Fig. 1). The stems of the other two related species reach a height between 135 and 200 cm and have densely clustered flowers– between 30 and 60 flowers in a cluster. The metric values of the fruiting stalk are definitive too – shorter in *R. kerneri*, as well as the sizes of the mature valves and tubercles (Table 2). The mature fruits of *R. kerneri* (Fig. 2A) and *R. patientia* (Fig. 2C) have one smaller tubercle (about 2×1.5 mm). The tubercles of the other two valves lack, or are reduced to nodes. Compared to them, *R. cristatus* has three unequally developed (by size) tubercles, the biggest one about 2.8 × 2 mm, i.e. has the larger sizes as compared to the remaining two species (Fig. 2B). The nut's sizes correspond to those of the valves, and the longest are those of *R. patientia* (3.2 mm) and respectively the smallest are those of *R. kerneri* (2.7 mm).

Karyology

Karyology of *R. kerneri* in Bulgaria has shown stable chromosome numbers 2n = 8x = 80 (Fig. 3). The our study confirmed the octopoid number 2n = 80 (Degraeve, 1975; Löve, 1986) и 2n = c. 80 (Löve 1981). Karyologically, the species is studied for the first time in Bulgarian specimens.

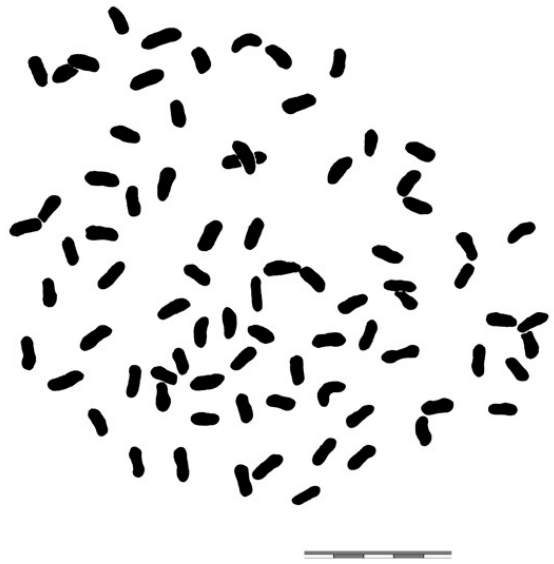

Fig. 3. Drawing of mitotic metaphase plate of *Rumex kerneri*, 2n=80. Scale bar = 5 μm.

Leaf epidermis

The leaf has a dorsoventral type in cross-section. The palisade parenchyma in the studied species has 2 rows. The spongy parenchyma has 4-5(6) rows. The geodes of calcium oxalate, reported by Metcalfe & Chalk (1950) were found in all three studied species.

The epidermal complex of the evaluated taxa contains 4 types of cells: common epidermal cells, stomatal guard cells, subsidiary cells, and trichomes. The leaves are amphistomatic – with stomata on both of the surfaces. The density of the stomata is regularly higher on the abaxial surface of the leaf. The stomata on both surfaces are messily oriented.

The indumentum of the leaf and stem of *R. kerneri* is represented by unicellular papillae on the abaxial surface on the abaxial leaf surface, finely distributed on the stem base. The leaves and the stems of the other referent species have not simple trichomes. All three taxa showed the presence of unicellular and multicellular vesicular glands, similar to the papillae but differing by their spheric shape, without basis, containing 1 to 4-5 cells, and formed by swelling of the apical part of the epidermal cells. According to Metcalfe & Chalk (1950), the glands are typical for genus *Rumex*.

According to Aneli (1975), the variability of the shape and the degree of curvature of the anticlinal walls in the common cells have defined limits. The shape of the cells varies from isodiametric to oblong-amoebic. The anticlinal cells of the adaxial epidermis are straight in *R. patientia* (Fig. 4E) and *R. cristatus* (Fig. 4C), while in *R. kerneri* (Fig. 4A) they are moderately curved (Fig. 4A). This feature is less differentiated on the abaxial epidermis – the studied taxa have more or less curved walls (Fig. 4E, 4D, 4F).

Stomatal type. All three species frequently showed the presence of anisocytic type of stomata, which is typical for order *Polygonales* (Inamdar, 1969). Single stomata are surrounded by symmetrically arranged subsidiary cells, directed along the long and short axes of the guard cells, which is a sign of an actinocytic type (according to the classification of Metcalfe & Chalk, 1950). Actinocytic stomata with radially oriented periosteal cells, which are difficult to distinguish from the common epidermal cells, are also observed. Besides, tetracytic stomata are found. All these types occur within the same species. Although the studied species from the *Rumex* subsection show a wide range of stomata types, the main anisocyte type for the family is dominant in all three studied species (Fig. 3).

Shape, size, and count of the stomata. On the adaxial epidermis, the stomatal index is between 1,38-1,45 (*R. cristatus*) and 1,51-

1,61 (*R. kerneri*) and describes the stomata as oval-elliptical. The metrics of the stomatal guard cells have a low amplitude of variation (Table 2). The sizes (length and width) are higher on the abaxial side. The number of the stomata is also variating parameter, correlating to the irregular distribution of the stomata and their sizes. In the investigated Bulgarian populations, the number of stomata on the adaxial is about 32 to 52 for mm^2, and on the abaxial side– between 52 and 73 per mm^2 (Table 3). Lower values of variations are found in *R. cristatus* and *R. kerneri.* However, no significant difference is recorded in the widths of the stomata in all the three investigated species. Their lengths are adequately related to the level of the ploidy. The stomata of the octoploids *R. cristatus* and *R. kerneri* are longer than those of the hexaploid *R. patientia*.

Pollen analysis. The microscopic analysis of the pollen fertility is a good indication for the non-hybrid origin of the investigated samples of species (Table 4). We consider this indicator to be an important feature when working with species from this group, due to widespread hybridization and the existence of introgressive populations. Between the species of the typical subsection were not found discrete differences of the pollen size, but, according to the high levels of ploidy in the group (6*x* to 8*x*), the sizes correspond to the classification of Erdtman (1952). *Rumex patientia* and *R. cristatus* fall into the group with medium (31-37.5 µm), while *R. kerneri* has large pollen grains (38-41 µm).

The performed scanning electron microscopy analysis of *R. kerneri* (Fig. 4A), together with the related *R. patientia* (Fig. 4B) and *R. cristatus* (Fig. 4C) pollen grains displayed uniform structural organization of the submicroscopic surface of the exine. The observation confirms the results in previous studies (Romanova, 1993; Zhou et al., 2000). The sculpture of the exine is perforate-microechinate, without differences in the observed taxa. The pollen grains have 3(4)-colpate apertures, with shallow ends of the furrows, and as result – with difficult to measure exact sizes. The submicroscopic structure of the sporoderm in the investigated species did not show discrete differences and could be valued as a feature with a low taxonomic value.

Table 3. Metric characteristics of the epidermal stomata – mean ± standard deviation.

Voucher specimen (see Table 1)	**Stomata**					
	Adaxial epidermis			**Abaxial epidermis**		
	Length, µm	**Width, µm**	**Count, mm²**	**Length, µm**	**Width, µm**	**Count, mm²**
R. kerneri Borbás						
SOA 056414	52.8±0.47	32.67±0.44	42±1.75	48.53±0.67	28.05±0.18	56±1.77
SOA 059243	52.07±0.9	34.34±0.64	42±2.27	50.16±0.58	32±2.27	54±2.35
R. cristatus DC						
SOA 056939	48.24±1.78	33.21±0.93	49.1±2.28	46.98±0.67	34.56±2.12	53.21±1.8
SOA 059247	50.12±2	36.1±2.18	47±2.22	48.5±1.26	32.02±1.94	52.5±2.92
R. patientia L.						
SOA 059235	42.67±2.43	32.4±2.73	52±2.46	42.06±4.31	31.85±2.27	73.33±2.4
SOA 059477	46.51±3.16	30.21±1.63	32.33±2.28	46.03±2.21	34.9±2.64	50±1.86
SOA 163984	37.99±2.87	34.81±2.86	48.3±2.6	33.93±1.66	29.34±1.34	67.3±1.9

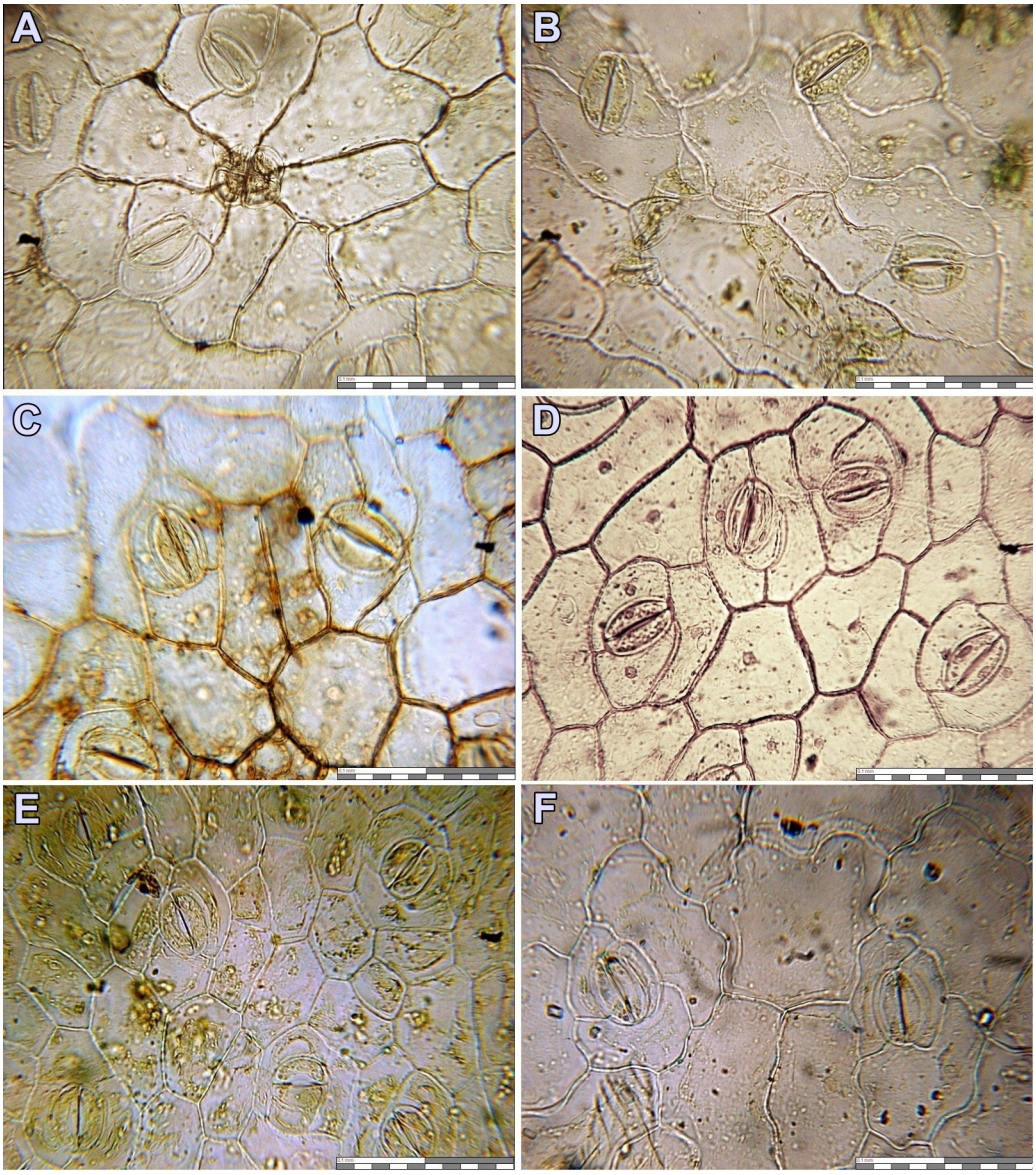

Fig. 4. -Leaf epidermis in frontal view: *Rumex kerneri* – adaxial epidermis with 4-celled peltate trichome in the middle (A) and abaxial epidermis (B); *R. cristatus* – adaxial (C) and abaxial (D) epidermis; *R. patientia* – abaxial (E) and adaxial (F) epidermis. Scale bars A-F = 100 µm.

Table 4. Metric features and fertility of the pollen grains of Bulgarian representatives of subsectio *Rumex*.

Taxon	**Voucher specimen**	**Diameter, µm mean ± standard deviation**	**Fertility, %**
R. kerneri Borbàs	SOA 056414	38.55±2.28	96
	SOA 059605	40.03±1.59	92
R. cristatus DC	SOA 056939	36.47±2.24	90.7
	SOA 057065	37.45±1.57	96
	SOA 056941	36.99±1.98	93
R. patientia L.	SOA 059478	36.97±1.94	95.3
	SOA 059477	33.75±1.84	97.6
	SOA 059235	37.03±1.87	94

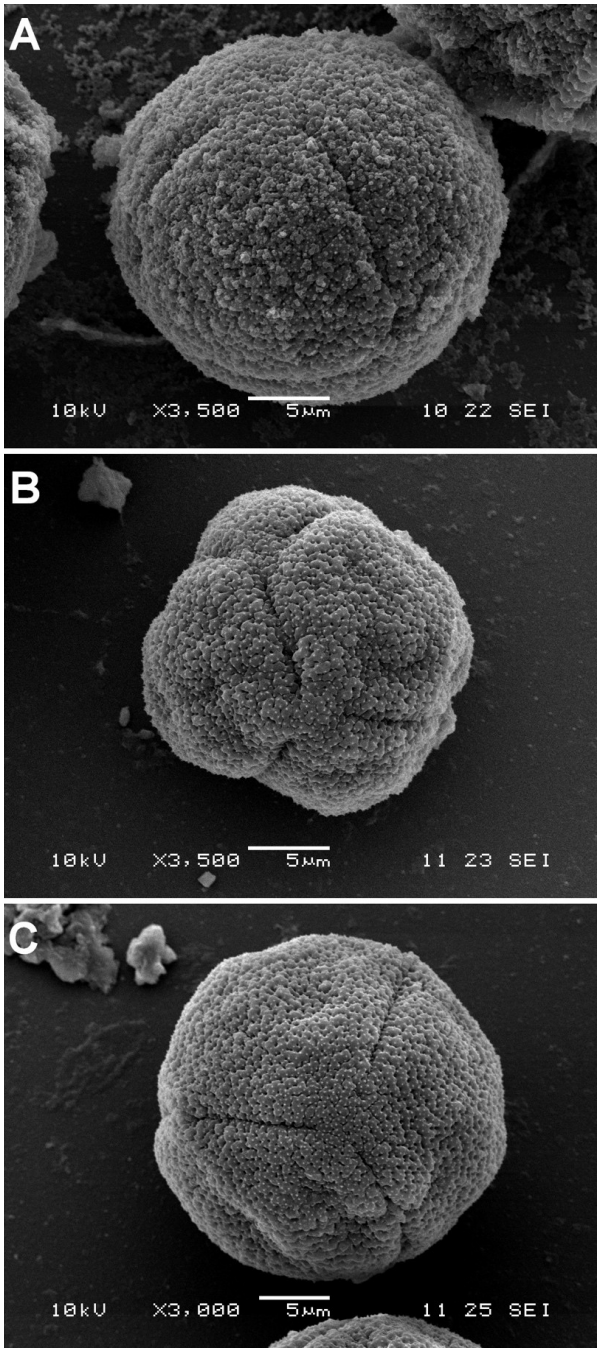

Fig. 5. Scanning electron microphotographs of the pollen grains from:
A – *R. kerneri*, B- *R. cristatus*; C – *R. patientia*.

Conclusion

Our observations showed that most of the taxonomically reliable morphological features for *Rumex*, sect. *Rumex*, subsect. *Rumex* can be found in the valves of mature plants. The evaluated morphological differences are stable and reliable in the distinction of *R. kerneri* from both compared species from the typical subsection. The differentiation of *R. kerneri* is expressed in a reduction of the flower count in a cluster, as well as the one developed tubercle, presence of indumentum on the stem base and the abaxial surface of the leaf blades, and the sporadic distribution on the mountain foothill belt. The leaf epidermis is not decisive for the closely related species of subsect. *Rumex*, but some of the qualitative parameters, as the shape of the common cells and the stomatal index, are useful for the delimitation of the species. The pollen grains of the studied species have a similar type of apertures and sculpture surface of the exine, but they tend to size increase related to the ploidy level.

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