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Overview in representatives of Rumex and Persicaria (Polygonaceae Juss.) in the flora of Bulgaria

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Abstract. The taxonomy of *Rumex* L. and *Persicaria* Mill. has been the subject of revisions for decades. The high morphological similarity between closely related taxa is probably due to a recent divergence and subsequent process of intensive speciation. As a result, complex species aggregates have formed in the genera *Rumex* and *Persicaria*. Hybridization processes, aided by their broad ecological plasticity and adaptation in anthropogenically influenced habitats, are major factors for the dynamic occupation of pioneer sites, with the potential to become aggressive weeds. This requires clarification and knowledge of the species diversity in these groups, which are an important component of the floras of many countries worldwide. As a result of recent studies, new hybrids of the genus *Rumex* have been discovered for our flora. This is an indication that the number of hybrids is greater than indicated in the summarized publications on the Bulgarian flora. Furthermore, the lack of taxonomic studies creates a need to reassess the phylogenetic relationships and status of taxa in the polymorphic, non-monophyletic groups of *Rumex* and *Persicaria* in our country.

Key words: Bulgaria, Polygonaceae, *Rumex*, *Persicaria*.

Introduction

The family Polygonaceae Juss. (Caryophyllales) includes about 1200 species, distributed in about 48 genera. The largest genera are *Eriogonum* Michx. (240 species), *Rumex* L. (200 species), *Persicaria* L. (Mill.) (100 species), and *Calligonum* L. (80 species). The family has a cosmopolitan distribution, but is represented with the greatest species diversity in the northern temperate zone. An exception is the genus *Coccoloba* P.Browne, with about 120 species in the Neotropics. Although considered a monophyletic family, the extent of some subgroups, particularly in the genera *Rumex* and *Persicaria*, as well as related taxa, is controversial. The variability in polymorphic groups is assessed by different authors with different taxonomic weight – the main basis for classification is morphological appearance, often of a modification nature. This is the reason for the existence of a large number of taxonomic schemes in *Rumex* and *Persicaria*, since the criteria for the different taxonomic position of intraspecific taxa are inconsistent (Degraeve, 1975; Tzvelev, 1989; Kubát, 1990; Ciocârlan, 2009). This is why the scope and boundaries, as well as the rank of members of critical groups within the subgenus, are subject to constant revision.

The taxonomic classifications based on morphological characteristics are ambiguous. The molecular studies in this diverse group, as well as

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synapomorphies for the subfamily Polygonoideae and for groups with particularly complex histories such as the tribes Fagopyreae, Persicarieae and Polygoneae, are insufficient. The high morphological similarity between closely related taxa is likely due to recent divergence and subsequent speciation, an adaptive process that results in species complexes (Sanchez et al., 2011). These groups are a taxonomic challenge, and their representatives are an important component of the floras of many countries.

The lack of modern studies on the chorology, morphology, taxonomic structure and ecology of this group of higher flowering plants in our country is the reason for conducting the present study. Along with this, species from the large genera *Rumex* and *Persicaria* in our flora provoke practical interest, since this group contains some of the most widespread invasive (Kowalczyk et al., 2014; Verloove et al., 2021) and weedy therophyte species. The floristic composition and scale of development of ruderal flora and vegetation are important for understanding all the consequences of the increasingly intense processes of global urbanization and high levels of destruction of natural habitats. In addition, there are species in these genera that have potential for pharmaceutical substances.

The modern morphological studies in these two genera are relatively few. Anatomical studies of the stem have been carried out on selected species from Iran (Keshavarzi et al., 2018). In a study of the leaf anatomy of selected species of the genus *Persicaria* in Pakistan, characters of taxonomic value have been elucidated and a key has been proposed (Yasmin et al., 2010a). Key features in floral morphology and the characteristics of the corolla epidermis are indicated (Kong & Hong, 2018a) and a detailed comparative morphological analysis of the fruit structure (Kong & Hong, 2018b) is made in the genus *Persicaria* sect. *Cephalophilon* (Meisner) H. Gross in South Korea. The pollen morphology of selected species in Pakistan has been studied and a key has been proposed (Yasmin et al., 2010b).

Natural hybridization in the genera *Rumex* and *Persicaria*

Unlike representatives of the subgenera *Acetosa* and *Acetosella*, species of the subgenus *Rumex*, section *Rumex* hybridize freely with each other in nature, which causes taxonomic difficulties (Rechinger, 1990). Data on natural hybrids of the subgenus *Rumex* are contained in the works of the first researchers of this group (Rechinger, 1891, 1892; Haussknecht, 1885).

The expansion of the range of taxa with broad ecological specialization correlates with the expansion of the range of hybrids between them (Kitchener, 2002). All this shows that natural hybridization is a normal process in this group of higher flowering plants, which occurs with high frequency.

Polyploidy, following hybridization (allopolyploidy) is known to play an important role in plant evolution (Comai, 2005). Reproductive isolation from parental lines, with subsequent polyploidization, provides the ability to maintain a new genetic composition (Rieseberg & Willis, 2007). In the evolution of angiosperms, the frequency of polyploid events is significant (Otto & Whitton, 2000). Allopolyploid speciation appears to be quite common in some plant groups through chromosome doubling following hybridization of diploid parents, or for the emergence of new tetraploids (de Wet, 1980). If allopolyploids are characterized by broadly adaptive phenotypic plasticity, they are likely to be ecological dominants and therefore potentially invasive (Sultan, 2004; Richards et al., 2006). Hybridization creates new gene combinations that can expand the range of phenotypic expression and therefore environmental tolerance beyond that of the parental taxa, leading to greater plasticity (Wares et al., 2005). Although polyploidy alone is not always associated with wider ecological amplitude (Bretagnolle & Thompson, 2001), the combined effects of hybridization and genome doubling can in some cases lead to highly plastic new taxa capable of rapid colonization in different habitats.

Allopolyploidy vs. autopolyploidy - in contrast to the many assumptions about cases of allopolyploidy, we find little evidence for autopolyploidy in the genus *Persicaria*. This finding is consistent with the long-standing view that allopolyploidy predominates in polyploid speciation (Soltis et al., 2004), although the role of autopolyploidy may have been underestimated in the past. The molecular studies of *Persicaria longiseta* (Bruijn) Kitagawa and *P. bicornis* (Raf.) Nieuwl. suggest an autopolyploid origin of *P. puritanorum* (Fernald) Soják (Kim et al., 2008). Hybridization processes, aided by anthropochory, are major factors in the emergence of new species that have the potential to become aggressive weeds.

Rumex acetosa is a dioecious plant with a chromosome system XY1Y2 (Cuñado et al., 2007; Steflova et al., 2013). Studies on the evolution of sex chromosomes in *R. acetosa* and the newly described *R. suffruticosus* J.Gay ex Meisn. by Southern-blot hybridization of satellite DNA, fluorescence microscopy of in situ hybridization with satellite DNA and rDNA, and electron microscopy of the synaptonemal complex. Early stage of genetic differentiation between sex chromosomes has been discovered (Cunãdo et al., 2007). Evolutionary processes in sex chromosomes have been studied by phylogeny of retrotransposons and transposons, and their localization and mapping in sex chromosomes (Steflova et al., 2013).

Molecular investigations

DNA barcoding is widely applied in systematics and taxonomy to distinguish species, differentiate related taxa, and reveal hidden variability. Furthermore, it is widely used for biodiversity assessment and in a number of ecological studies (Hebert et al., 2003; Kress et al., 2005; Chase et al., 2007; Valentini et al., 2009; Chen et al., 2010; China Plant BOL Group et al., 2011; Hollingsworth, 2011; Ziqiang et al., 2020). DNA barcoding results help develop rules for collecting species from their natural habitats (Kress & Erickson, 2007), as well as determining the degree of ecological specialization of plants (Jurado-Rivera et al., 2009). They are also important in selecting the most genetically heterogeneous parts of a species' population, which is key to adaptation and provides a more justified need for protection. Four regions are used as standard for barcoding plant species: rbcL, matK, trnH-psbA, and ITS (Xu et al., 2015; Howard et al., 2020). However, the often-imposed resolution of these regions does not allow for effective discrimination of close taxonomic units, and barcoding sometimes conflicts with other molecular biological and biochemical methods, such as alloenzyme analyses. Therefore, it is advisable to combine it with other molecular approaches.

The use of ITS barcoding allows the successful elucidation of the phylogeny of the genus *Polygonum* s.l. and the study of intraspecific variation in its populations (Choudhary et al., 2011, 2012). By combining the trnL-F and ITS markers, the presence of the neophyte *Persicaria hydropiperoides* (Michaux) Smal in the Canary Islands has been proven (Verloove et al., 2021). Recent genotyping studies reveal the existence of phylogenetically distinct populations of *P. amphibia* in South Korea (Ballestas, 2024; Choi et al., 2025).

ISSR (Inter Simple Sequence Repeat) and SRAP (Sequence-Related Amplified Polymorphism) marker systems are powerful genetic tools that complement and expand the capabilities of DNA barcoding. They are particularly effective in assessing and monitoring genetic and species diversity in plant taxa. While DNA barcoding is often limited to relatively conserved gene regions, ISSR and SRAP allow detection of a broader range of genetic variation, including intra- and interpopulation differences (Bornet & Branchard, 2001; Zietkiewicz et al., 1994). ISSR markers are based on multiple repeats in the genome and provide a high percentage of polymorphism, while SRAP analysis focuses on functionally significant coding regions, providing additional information on phenotypically related genetic variations (Budak et al., 2004).

Combining DNA barcoding with ISSR and SRAP analyses allows for more precise taxonomic differentiation and correct identification of complex species groups. This integrated approach facilitates the identification of critical species and genetic lineages that cannot be distinguished by barcoding alone. Furthermore, the combination allows for detailed assessment of genetic structure, phylogenetic relationships, and construction of dendrograms or geographic maps of kinship (Chen et al., 2023; Huang et al., 2023; Jiao et al., 2022).

The evolution of sex determination in the genus *Rumex* has been studied through phylogenetic analysis of nuclear and chloroplast sequences (Navajas-Pérez & al. 2005; Grant et al., 2022; Hibbins et al., 2025). In 2017, a comprehensive study of the genus *Persicaria* was carried out in Iran, combining morphological, karyological and ISSR markers (Mosaferi et al., 2018). Subsequent analyses of chloroplast gene sequences demonstrated bidirectional hybridization between *Rumex crispus* L. and *R. obtusifolius* L. (Bhandari & Park, 2022), and plastome phylogeny revealed divergent evolution within the genus (Koenemann, 2023).

The most recent studies on the entire chloroplast genome offer new phylogenetic solutions for the genus *Persicaria* (Kim et al., 2022; Zou et al., 2025; Chen et al., 2025; Li et al., 2026). In parallel, comparative analysis of the chloroplast and mitochondrial genomes in *P. maackiana* revealed a higher rate of nucleotide substitutions in mitochondrial DNA, which provides higher resolution for future evolutionary studies (Park et al., 2025). In conclusion, the higher mutation rate in the mitochondrial genome establishes it as a key tool for phylogenetic analyses with maximum resolution.

Phytochemical studies

Although a number of studies on the biologically active constituents of species from the Polygonaceae family can be found in the specialized literature (Bektašević et al., 2022; Khali, et al., 2023; Mohamed et al., 2025), these studies are limited to a relatively small number of taxa. This deficit is directly related to the debatable taxonomy and objective difficulties in precise species identification, which often deters large-scale phytochemical analyses. Similar systematic studies on representatives of the genera *Rumex* and *Persicaria* in Bulgaria and the Balkans are practically lacking, with the available data being limited mainly to the traditional ethnobotanical use of some species (Jarić et al., 2024).

This highlights the need for modern research, as the successful use of species-specific secondary metabolites proves to be key in resolving complex taxonomic problems in both genera. Evidence of the potential of the genus *Rumex* is research on 29 of its representatives, which identified 268 substances, including anthraquinones, flavonoids, stilbenes and tannins (Li et al., 2022). These compounds demonstrate a wide spectrum of bioactivities, from anti-inflammatory to antitumor properties, making the genus a promising drug source (Vasas et al., 2015).

The potential is similar in the genus *Persicaria*, where specific secondary metabolites such as flavonoids, sesquiterpenoids (e.g. polygodial) and phenylpropanoids show pronounced antibacterial, anti-inflammatory and cytotoxic properties (Huq et al., 2014; Seimandi et al., 2021). Due to the high degree of phenotypic plasticity and the presence of complex hybrid complexes in the genus (Sultan, 2001), its detailed chemical characterization has not only applied pharmacognostic value, but also crucial importance for elucidating the phylogenetic relationships between taxa. The use of these chemotaxonomic markers allows for an additional parameter for species diagnosis in addition to traditional morphological characters, which often vary under the influence of the environment.

Status of taxonomic research on the problem

In its nearly 250-year taxonomic history, the genus *Rumex* L. has been perceived with varying scope and boundaries. This is a result of the description of new taxa, the accumulation of new data about them, and differences in the authors' concepts of the boundaries of the genus. The most species-rich subgenus *Rumex*, Rechinger (1937) considered in two sections: sect. *Simplices* Rech. f. (according to modern nomenclature, a synonym of the typical section *Rumex*) and sect. *Axillares* Rech. f. The last section includes mostly American, continental neoendemic species – 20 for North America and 15 for South America (Rechinger, 1990). It has no natural distribution in Europe, where 3 naturalized species are known. The two sections are well differentiated based on a combination of growth characteristics and development of the fruiting perigone.

The systematic scheme of Rechinger (1949a) includes 4 subgenera well separated from each other: *Rumex* (=*Lapathum* (Mill.) Rech. f.), *Acetosella* (Meisn.) Rech. f., *Acetosa* (Mill.) Rech. f. and *Platypodium* (Willk.) Rech. f. This classification was also adopted in the development of the genus for Flora Europaea (Rechinger, 1964). After Rechinger's monographic works, the genus has not been the subject of in-depth biosystematic studies. His taxonomic and nomenclatural decisions were confirmed in subsequent generalizing works on the genus, treating the species diversity of European countries, and reflected in various publications. The author's concept of distinguishing within the genus four subgenera, adopted in the first edition of Flora Europaea (Rechinger, 1964), was also applied in the second edition (Rechinger & Akeroyd, 1993). The authors report 44 species for the territory of Europe, of which 4 species (*R. balcanicus* Rech. f., *R. azoricus* Rech f., *R. aquitanicus* Rech f., and *R. rupestris* Le Gall) and 3 subspecies are endemic to the continent, and the rest are more widely distributed. Of the 27 common species of the subgenus *Rumex*, 16 are known for the Bulgarian flora, i.e., 59% of the representatives of the subgenus in Europe.

When studying the Bulgarian representatives of genus *Rumex*, the relations with the floras of the Balkan countries – Greece, Turkey, Macedonia, Serbia, Romania, as well as Russia – are of great importance. Some authors divide the genus *Rumex* into 4 independent genera: *Rumex* s.str., *Acetosa*, *Acetosella* and *Bucephalophora* based on clearly distinct morphological and karyological differences (Löve & Löve, 1961; Degraeve, 1975; Löve, 1983; Tzvelev, 1987; Kubát, 1990), which probably represent different phylogenetic lines of development. In general, the genus is best studied in European countries – 44–49 species of the genus are listed for the continent (according to various authors), and studied relatively poorly on the Balkan Peninsula. Data on the species composition are contained in regional floristic studies, but no intrageneric classification is indicated, and the variability in polymorphic groups is organized with different taxonomic statuses.

The most species-rich subgenus is *Rumex*. It includes 27 species, two of which are of American origin and naturalized in Europe. Four species and two subspecies of the taxa naturally distributed in Europe are endemic to the continent, while the rest are more widely distributed. Subgenus *Rumex* (*Rumex* L., Polygonaceae Juss.) is a taxonomically difficult group, due to the wide range of morphological variation, intraspecific variability, widespread hybridization, and introgression. This is typical for the European species of section *Rumex* (Rechinger, 1990). As noted by Campderá (1819) and Mosyakin (2005), species of the genus form groups with similar morphological characteristics, which makes their diagnosis difficult. Distinguishing species in this group is possible with fully developed valves during the fruiting period (Fig. 1).

Fig. 1. Diagnostic characters of the valves: A - *Rumex alpinus*; B - *R. crispus*; C - *R. obtusifolius*; D - *R. sanguineus*.

The number of taxa of the subgenus *Rumex* distributed in Bulgaria has historically changed. In the first edition of Flora of Bulgaria (Stojanov & Stefanov, 1924) the species were organized according to Meisner's system in 2 sections: *Lapathum* (Mill.) Meisn. (= subgenus *Rumex*) represented by 10 species, which is about 60% of those known for the subgenus today, and *Acetosella*

Meisn. – 3 species. In subsequent editions, the authors do not use the intrageneric taxonomic categories subgenus and section. The studies are mainly related to horology, and as a result, new species for the country have been identified. In the second edition of Flora of Bulgaria (Stojanov & Stefanov, 1933) the genus is represented by 16 species, of which 11 are from the subgenus *Rumex*. In the third edition, the authors (Stojanov & Stefanov, 1948) reported 17 species, 7 subspecies, and 7 varieties for the country. *Rumex dentatus* L. is reported for the first time in the Bulgarian flora. In the fourth edition Stojanov et al. (1966) list 18 species for the country, of which 12 species, 3 subspecies, and 6 varieties of the subgenus *Rumex.*

More detailed studies on the Bulgarian flora by Valev (1966) in the third volume of the multivolume edition Flora of the Republic of Bulgaria enrich the information on the species diversity in the genus. The author reports 20 species, 10 subspecies, 7 varieties and 2 forms for Bulgaria, and the number of species of the subgenus *Rumex* increases to 13, supplemented by *R. aquaticus* L. Recent research by the author's team contributes to the chorology of Bulgarian species. The intraspecific variability of *R. obtusifolius* and *R. pulcher* has been updated (Raycheva, 2009). As a result of revisions at the herbarium collections and field studies, new floristic records for *R. kerneri* Borbás have been added to the Bulgarian flora (Raycheva et al., 2021).

Taxa of the subgenus *Acetosella* show high morphological variability and complex relationships. In contrast to the diagnostic value of the valvae in the subgenus *Rumex*, in *R. acetosella* complex, the achenes are very small, and the perianth leaflets do not develop into the fruit and have no diagnostic value. The author's studies confirm the high morphological variability of leaves in *R. acetosella*, which indicates the lack of reliability of identification keys based on this feature. Other features, other than variable morphological appearances, should be sought to determine taxonomic units in this taxonomically complex group. The distribution and relationships between its members need further study and reassessment of taxonomic status. Leaf morphology and panicle branching are convergent characters, making them unreliable for the taxonomy of *R. acetosella* s.l.

Genus *Persicaria* Mill. is one of the large genera in the family Polygonaceae and belongs to the tribe Persicarieae. This tribe also includes the genera *Bistorta* Mill. and *Koenigia* L. (Galasso et al., 2009; Sanchez et al., 2009, 2011; Schuster et al., 2015). The genus has approximately 100 species, mostly annual or perennial herbaceous plants, widely distributed throughout the world (Brandbyge, 1993; Freeman, 2005; Galasso et al., 2009). Species of the genus *Persicaria* are annual, less often perennial macrophytes, with long, thin, creeping, branched rhizomes, characteristic of humid habitats, most of which are ruderal and segetal.

Within the genus, 6 sections are distinguished: sect. *Persicaria*, sect. *Amphibia* Tzvelev, sect. *Cephalophilon* (Meisn.) H.Gross, sect. *Echinocaulon* (Meisn.) H.Gross, sect. *Tovara* (Adans.) H.Gross, and sect. *Truelloides* Tzvelev (Galasso et al., 2009). This classification is well supported by molecular phylogenetic analyses (Min et al., 2013) and the monophyly of five of the sections, except for *Truelloides* Tzvelev, is well supported in molecular phylogenetic analyses (Kim & Donoghue, 2008; Schuster et al., 2015; Cao et al., 2022, 2023).

The systematics of the genus *Persicaria* is controversial and still unresolved, which is why several species have been reclassified and moved from the genus *Polygonum* or *Bistorta* to the genus *Persicaria* (Ciocârlan, 2009). Opinions differ considerably regarding the range and intrageneric classification of *Persicaria.* The concept used here generally follows Ronse DeCraene et al. (2000) and Haraldson (1978), with five sections. The genera *Aconogonon* (incl. *Pleuropteropyrum*) and *Bistorta* are often included, with a wider scope, within the genus *Persicaria* or *Polygonum*, but in a more specific case, they are treated in most classification schemes as separate genera.

Species of the genus *Persicaria* are considered in Flora Europaea (Webb & Chater, 1964) as part of the genus *Polygonum* L., in the sections *Persicaria* (Miller) DC. – 12 species, *Aconogonon* Meissner – 2 species, and *Bistorta* (Miller) DC. – 3 species. The same approach was used in Flora of Turkey (Coode & Cullen, 1967). The flora of Greece includes 12 species of the genus *Persicaria* (including *Bistorta*), localized only in the northern floristic regions (Dimopoulos et al., 2013, 2016, 2018).

Initially, the genus *Persicaria* in our country was included in the scope of the genus *Polygonum* (Stojanov & Stefanov, 1924; Stojanov, 1933, 1948; Stojanov et al., 1966). However, due to significant differences in life forms and specific floral traits, section *Persicaria* of the genus *Polygonum* is classified as the taxonomic unit genus *Persicaria* (Ronse DeCraene & Akeroyd, 1988). The classification of this genus is supported by molecular phylogenetic studies using chloroplast (cpDNA) and nuclear (nrDNA) DNA markers (Kim et al., 2008; Galasso et al., 2009).

In the Bulgarian taxonomic literature, the genus *Persicaria* is distinguished in the work for Flora of the Republic of Bulgaria, vol. 3, by Asenov (1966). The author describes 7 wild and 1 cultivated species, accepting *Bistorta* (2 species) and *Pleuropteropyrum* (1 species) as independent genera. After this work on the Bulgarian flora, no taxonomic studies have been conducted in this taxonomic group. There are only individual reports on the chorology of known taxa and data for one taxon with an unclear position – *Persicaria pallida* (Dimitrov, 2021). A critical revision of this taxon is necessary to clarify whether it is an intraspecific taxon of *P. lapathifolia* or an independent species in the Bulgarian flora. Later, generalizing floristic publications adopted the same concept as in 1966 – 6 species in the genus *Persicaria*, 1 species in the genus *Pleuropteropyrum*, and 2 species in the genus *Bistorta* (Delipavlov & Chesmedjiev, 2003, Assyov & Petrova, 2012).

According to the latest data, 11 species have been identified in the country, including the following in the genus: *Persicaria bistorta* (l.) Samp (sub *Bistorta officinalis*), *P. alpina* (All.) H.Gross. (sub *Pleropteropyrum undulatum*) and data on the introduced *P. orientalis* (L.) Spach. Available data from territories neighboring Bulgaria allow the spread of the other two potentially new species on Bulgarian territory – *P. dubia* and the invasive *P. perfoliata*. The cultivated *P. orientalis* also exhibits an invasive nature, having been found with secondary spread in many places in Turkey - Asia Minor part (Özkan & Yazlık, 2020), and its seconddary spread on the Balkan Peninsula is likely to be predicted.

Despite the low scientific interest in this genus in Bulgaria, some of its representatives are a valuable resource that remains underexploited – 7 species are medicinal plants (such as *P. hydropiper* and *P. bistorta*), 3 are melliferous (e.g. *P. amphibia* and *P. alpina*), 3 have applications as food and fodder, and 2 are as ornamentals (*P. orientalis* and *P. bistorta*). In addition, this genus includes 5 indicator species for 5 habitat types of European importance (Natura 2000) – *P. amphibia* for slow-flowing waters (type 3150), *P. bistorta* for mountain meadows (type 6520), and *P. hydropiper*, *P. lapathifolia*, and *P. mitis* for riparian communities (type 3270), according Kavrakova et al. (2009).

One of the most complex groups in the genus, section *Persicaria*, is a taxonomic challenge due to its extreme morphological plasticity and frequent hybridization. In the taxonomic literature, the distinction of *Persicaria* species is based on overlapping and ambiguous characters such as pendulous inflorescences and dark leaf spot (Fig. 2). This is why convergent morphological characters are not convincing for distinguishing species and for clarifying the genetic relationships and phylogenetic connections between them.

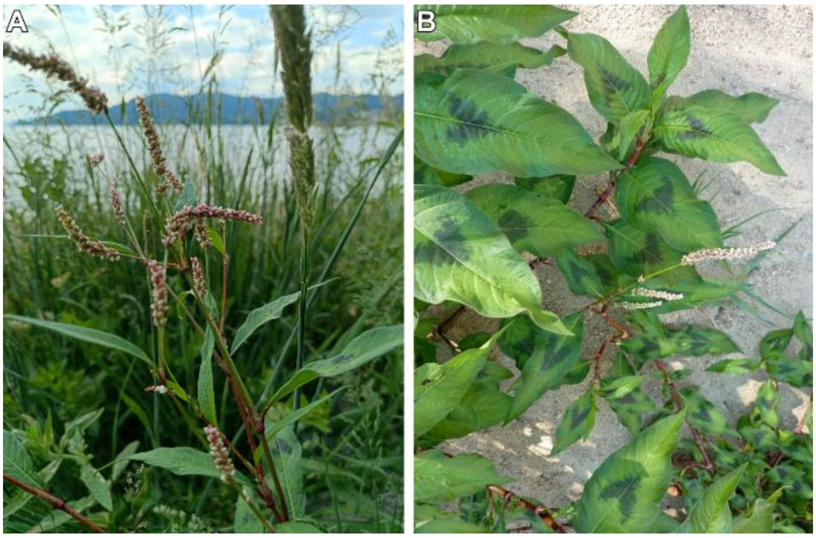

Fig. 2. Inflorescences and dark leaf spots in A- *Persicaria hydropiper* and B - *P. lapathifolia*.

The two genera represent a taxonomic challenge not only in our country but also worldwide. So far, in our country and in the Balkans, *Rumex* and *Persicaria* have not been studied purposefully, both taxonomically and phytochemically. To objectively address these problems, modern molecular methods have been widely applied over the past 15 years, leading to taxonomic revision in an effort to clarify the phylogenetic relationships between taxa.

Conclusion

The present work examines the current state of research, as well as the biological diversity of representatives of the genera *Rumex* and *Persicaria* in Bulgaria. A review of the available literature shows that they have not been the subject of targeted and in-depth taxonomic research, not only in Bulgaria, but throughout Europe. The lack of a generally accepted model for interpretation confirms that both genera are difficult polymorphic groups of higher plants, which is why each author applies a specific approach to the differentiation of their taxonomic structure, as a result of which there is extensive synonymy.

These factors stimulated scientific interest in *Rumex* and *Persicaria*, necessitating a multifaceted analysis of their variability and classification:

- high potential for reproduction and effective spread over large territories;
- complex morphological picture, highly pronounced variability and numerous transitions between individual morphological syndromes;
- active hybridization processes, making taxonomic interpretation difficult;
- lack of modern collections in Bulgarian herbaria;
- an unclear number of natural hybrids, as well as the evolutionary mechanisms and prerequisites for hybrid processes;
- the almost complete lack of molecular studies of taxa from the target genera, constituting a significant part of the volume of Polygonaceae;
- increasing number of invasive species in disturbed communities, acting as indicators of habitats of European importance, which requires reliable identification.

Combining conventional taxonomic methods with molecular and phytochemical analyses is an approach to clarifying the taxonomic and phylogenetic relationships between species and their biological potential.

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References

Asenov, I. (1966). *Polygonum* L., Bistorta Mill. and *Persicaria* H.Gross – In: Jordanov D. (Ed.), *Flora Reipublicae Popularis Bulgaricae, Vol. 3*. Sofia, Bulgarian Academy of Sciences, 232-257. [in Bulgarian]

Assyov, B., & Petrova, A.S. (eds.). (2012). *Conspectus of the Bulgarian vascular flora. Distribution maps and floristic elements. 4th edition*. Bulgarian Biodiversity Foundation, Sofia, 490 p.

Ballestas, G., Nobles, A., Hwang, Y., Kwak, M., & Yoo, M.-J. (2024). Evolutionary unraveling: new insights into the *Persicaria amphibia* complex. *Frontiers in Plant Science*, 15, 1408810. doi: 10.3389/fpls.2024.1408810

Bektašević, M., Oraščanin, M., & Šertović, E. (2022). Biological activity and food potential of plants *Rumex crispus* L. and *Rumex obtusifolius* L. A review. *Technologica Acta*, 15(1), 61-67. doi: 10.5281/zenodo.6923305

Bhandari, G.S., & Park, C.W. (2022). Molecular evidence for natural hybridization between *Rumex crispus* and *R. obtusifolius* (Polygonaceae) in Korea. *Scientific Reports*, 12, 5423. doi: 10.1038/s41598-022-09292-9

Bornet, B., & Branchard, M. (2001). Nonanchored inter simple sequence repeat (ISSR) markers: Reproducible and specific tools for genome fingerprinting. *Plant Molecular Biology Reporter*, 19(3), 209–215. doi: 10.1007/BF02772892

Brandbyge, J. (1993). Polygonaceae. In: Brandbyge, J., Kubitzki, K., & Bittich, V. (Eds), *The Families and Genera of Vascular Plants., vol. 2*. Springer, Berlin, Heidelberg, 531–544. doi: 10.1007/978-3-662-02899-5_63.

Bretagnolle, F., & Thompson, J.D. (2001). Phenotypic plasticity in sympatric diploid and autotetraploid *Dactylis glomerata*. *International Journal of Plant Sciences*, 162, 309–316. doi: 10.1086/319572

Budak, H., Shearman, R.C., Parmaksiz, I., & Dweikat, I. (2004). Comparative Analysis of Seeded and Vegetative Biotype Buffalograss Based on Phylogenetic Relationship Using ISSRs, SSRs, RAPDs, and SRAPs. *Theoretical and Applied Genetics*, 109, 280-288. doi: 10.1007/s00122-004-1630-z

Campderá, F. (1819). *Monographie des Rumex, précédée de quelques vues générales sur la Famille des Polygonées.* Paris, Treuttel et Würtz, 185 p. [in French]

Cao, D.L., Zhang, X.J., Qu, X.J., & Fan, S.J. (2023). Phylogenomics, divergence time estimation, and adaptive evolution in the Polygonoideae (Polygonaceae). *Journal of Systematics and Evolution*, 61(6), 1004–1019. doi: 10.1111/jse.12946

Cao, D.L., Zhang, X.J., Qu, X.J., & Fan, S.J. (2022). Plastid phylogenomics sheds light on divergence time and ecological adaptations of the tribe Persicarieae (Polygonaceae). *Frontiers in Plant Science*, 13, 1046253. doi: 10.3389/fpls.2022.1046253

Chase, M.W., Cowan, R.S., Hollingsworth, P.M., van den Berg, C., Madriñán, S., Petersen, G., Seberg, O., Jørgsensen, T., Cameron, K.M., Carine, M., Pedersen, N., Hedderson, T.A.J., Conrad, F., Salazar, G.A., Richardson, J.E., Hollingsworth, M.L., Barraclough, T.G., Kelly, L., & Wilkinson, M. (2007). A proposal for a standardised protocol to barcode all land plants. *Taxon*, 56, 295-299. doi: 10.1002/tax.562004

Chen, S., Yao, H., Han, J., Liu, C., Song, J., Shi, L., Zhu, Y., Ma, X., Gao, T., Pang, X., Luo, K., Li Y., Li, X., Jia X., Lin, Y., & Leon, C. (2010). Validation of the ITS2 region as a novel DNA barcode for identifying medicinal plant species. *PLoS ONE*, 5(1), e8613. doi: 10.1371/journal.pone.0008613

Chen, S., Wang, Y., Li, J., Wang, S., & Li, Y. (2023). Enhanced species delimitation in tropical tree families by combining DNA barcodes and ISSR markers. *Molecular Ecology Resources*, 23(4), 812–826. doi: 10.1111/1755-0998.13727

Chen, Y., Liu, Y., Li, J., Wei, Q., & Wang, J. (2025). The complete chloroplast genomes of *Persicaria hydropiper* and *P. pubescens* (Polygonaceae). *Mitochondrial DNA Part B*, 10(11), 1008–1011. doi: 10.1080/23802359.2025.2567461

China Plant BOL Group, Li, D.Z., Gao, L.M., Li, H.T., Wang, H., Ge, X.J., Liu, J.Q., Chen, Z.D., Zhou, S.L., Chen, S.L., Yang, J.B., Fu, C.X., Zeng, C.X., Yan, H.F., Zhu, Y.J., Sun, Y.S., Chen, S.Y., Zhao, L., Wang, K., Yang, T., & Duan, G.W. (2011). Comparative analysis of a large dataset indicates that internal transcribed spacer (ITS) should be incorporated into the core barcode for seed plants. *Proceedings of the National Academy of Sciences (PNAS)*, 108(49), 19641-19646. doi: 10.1073/pnas.1104551108

Choi, K., Hwang, Y., Hong, J. K., Kim, Y.-I., Park, C. W., & Yoo, M.-J. (2025). Genetic diversity and structure of *Persicaria amphibia* (Polygonaceae) in South Korea using genotyping by sequencing. *Genes & Genomics*, 47, 11–18. doi: 10.1007/s13258-024-01571-1

Choudhary, R.K., Ajmal Ali, M., & Lee, J. (2011). Studies on genetic diversity among populations of *Persicaria barbata* (L.) H. Hara from India based on internal transcribed spacer sequences of nuclear ribosomal DNA. *Saudi Journal of Biological Sciences*, 18(2), 123-127. doi: 10.1016/j.sjbs.2010.12.010

Choudhary, R.K., Park, S.-H., & Lee, J. (2012). Phylogeny and systematics of Indian *Polygonum* sensu lato in the subfamily Polygonoideae based on ITS sequences of nuclear ribosomal DNA. *Genetics and Molecular Research*, 11(4), 4370-4382. doi: 10.4238/2012.October.4.1

Ciocârlan, V. (2009). *Illustrated Flora of Romania – Pteridophyta et Spermatophyta*. Editura Ceres Bucureşti. [in Romanian]

Comai, L. (2005). The advantages and disadvantages of being polyploid. *Nature Reviews Genetics*, 6, 836–846. doi: 10.1038/nrg1711

Coode, M.J.D., & Cullen, J. (1967). *Polygonum* L. In: Davis, P., Cullen, J., & Coode, M.J.E., (Eds.), *Flora of Turkey and the East Aegean Islands, Vol. 2.* Edinburgh: Edinburgh University Press, 581 p.

Cuñado, N., Navajas-Pérez, R., de la Herrán, R., Rejón, C.R., Rejón, M.R., Santos, J.L., & Garrido-Ramos, M.A. (2007). The evolution of sex chromosomes in the genus *Rumex* (Polygonaceae): Identification of a new species with heteromorphic sex chromosomes. *Chromosome Research*, 15, 825–833. doi: 10.1007/s10577-007-1166-6

de Wet, J.M.J. (1980). Origins of polyploids. In: Lewis, W.H. (Ed.), *Polyploidy: Biological Relevance*. Plenum Press, New York. pp. 3–15,

Degraeve, N. (1975). Contribution a l'etude cytotaxonomique des *Rumex*. I. Le gerne *Rumex* L. sensu stricto. *Caryologia*, 28, 187-201. [in French]

Delipavlov, D. & Chesmedjiev, I. (Eds.) (2003). *Key to the plants in Bulgaria*. Acad. Publ. House, Agronomic University, Plovdiv. [in Bulgarian]

Dimitrov, D. (2021). Report 32. In: Vladimirov, V., Aybeke, M., & Tan, K. New floristic records in the Balkans: 44. *Phytologia Balcanica*, 27(1), 127–150.

Dimopoulos, P., Raus, Th., & Strrid, A. (Eds.) (2018). *Flora of Greece web ver. VI. 2024*. Retrieved from: https://portal.cybertaxonomy.org/flora-greece/

Dimopoulos, P., Raus, Th., Bergmeier, E., Constantinidis, Th., Iatrou, G., Kokkini, S., Strid, A., & Tzanoudakis, D. (2013). *Vascular plants of Greece: An annotated checklist*. Berlin: Botanic Garden and Botanical Museum Berlin-Dahlem; Athens: Hellenic Botanical Society, Englera 31. doi: 10.3372/en.31

Dimopoulos, P., Raus, Th., Bergmeier, E., Constantinidis, Th., Iatrou, G., Kokkini S., Strid, A., & Tzanoudakis, D. (2016). Vascular plants of Greece: An annotated checklist. Supplement. *Willdenowia*, 46, 301–347. doi: 10.3372/wi.46.46303

Freeman, C.C. (2005). *Polygonaceae*. In: Flora of North America Editorial Committee (Eds). *Flora of North America*. Oxford University Press, New York, 574–594.

Galasso, G., Banfi, E., Mattia, F.D., Grassi, F., Sgorbati, S., & Labra, M. (2009). Molecular phylogeny of *Polygonum* L. s.l. (Polygonoideae, Polygonaceae), focusing on European taxa: Preliminary results and systematic considerations based on rbcL plastidial sequence data. *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, 150(1), 113–148.

Grant, K.D., Koenemann, D., Mansaray, J., Ahmed, A., Khamar, H., El Oualidi, J., & Burke, J.M. (2022). A new phylogeny of *Rumex* (Polygonaceae) adds evolutionary context to the diversity of reproductive systems present in the genus. *PhytoKeys*, 204, 57–72. doi: 10.3897/phytokeys.204.85256

Haraldson, K. (1978). Anatomy and taxonomy in Polygonaceae subfam. Polygonoideae Meisn. emend. Jaretzky. *Acta Universitatis Upsaliensis Symbolae Botanicae Upsalienses*, 22, 1-93.

Haussknecht, C. (1885). Beitrag zur Kenntnis der einheimischen Rumices. *Mitt. Geogr. Ges. (Türingen) Jena*, 3, 56-79.

Hebert, P.D.N., Cywinska, A., Ball,S.L., & de Waard, J.R. (2003). Biological identifications through DNA barcodes. *Proceedings of the Royal Society B: Biological Sciences*, 270(1512), 313–321. doi: 10.1098/rspb.2002.2218

Hibbins, M.S., Rifkin, J.L., Choudhury, B.I., Voznesenska, O., Sacchi, B., Yuan, M., Gong, Y., Barrett, S.C.H., & Wright, S.I. (2025). Phylogenomics resolves key relationships in *Rumex* and uncovers a dynamic history of independently evolving sex chromosomes. *Evolution Letters*, 9(2), 221–235. doi: 10.1093/evlett/qrae060

Hollingsworth, P.M. (2011). Refining the DNA barcode for land plants. *Proceedings of the National Academy of Sciences*, 108(49), 19451–19452. doi: 10.1073/pnas.1116812108

Howard, C., Lockie-Williams, C., & Slater, A. (2020). Applied Barcoding: The Practicalities of DNA Testing for Herbals. *Plants*, 9(9), 1150. doi: 10.3390/plants9091150

Huang, G., Wu, C., Li, T., Xu, Z., & Li, J. (2023). Phylogeography and genetic structure of wild camellia using SRAP and ISSR markers. *Tree Genetics & Genomes*, 19, 59. doi: 10.1007/s11295-023-01668-7

Huq, A.K, Jamal, J.A., & Stanslas, J. (2014). Ethnobotanical, Phytochemical, Pharmacological, and Toxicological Aspects of *Persicaria hydropiper* (L.) Delarbre. *Evid Based Complement Alternat Med.*, 2014, 782830. doi: 10.1155/2014/782830

Jarić, S., Kostić, O., Miletić, Z., Marković, M., Sekulić, D., Mitrović, M., & Pavlović, P. (2024). Ethnobotanical and ethnomedicinal research into medicinal plants in the Mt Stara Planina region (south-eastern Serbia, Western Balkans). *Journal of Ethnobiology and Ethnomedicine*, 20(1), 7. doi: 10.1186/s13002-024-00647-2

Jiao, L., Zhang, Y., Liu, Z., Wang, S., Li, M., Zhang, W., Wu, C., & Huang, G. (2022). Integrative assessment of SRAP, ISSR and barcoding markers reveals deep divergence in plant populartions. *Frontiers in Plant Science*, 13, 1061421. doi: 10.3389/fpls.2022.1061421

Jurado-Rivera, J.A., Vogler, A.P., Reid, C.A., Petitpierre, E., & Gómez-Zurita, J. (2009). DNA barcoding insect-host plant associations. *Proceedings B of the Royal Society*, 276(1657), 639-648. doi: 10.1098/rspb.2008.1264

Kavrakova, D., Dimova, D., Dimitrov, M., Tzonev, R., Belev, T. & Rakovska, K. (2009). *Manual for determination of habitats with European value in Bulgaria. Second edition.* World Wide Fund for

Nature, Danube-Carpathian Program and Federation “Green Balkans”, Sofia, Bulgaria, 131 p. [in Bulgarian]

Keshavarzi, M., Ebrahimi, F., & Mosaferi, S. (2018) Comparative anatomical and micromorphological study of some *Rumex* species (Polygonaceae). *Acta Biologica Szegediensis*, 62(1), 45–52. doi: 10.14232/abs.2018.1.45-52

Khali, T., Akhter, S., Sultan, P., &Hassan, Q.P. (2023). Critical review on *Rumex dentatus* L. a strong pharmacophore and the future medicine: Pharmacology, phytochemical analysis and traditional uses. *Heliyon*, 9(3), e14159. doi: 10.1016/j.heliyon.2023.e14159

Kim, S.T., & Donoghue, M.J. (2008). Molecular phylogeny of *Persicaria* (Persicarieae, Polygonaceae). *Systematic Botany*, 33(1), 77–86. doi: 10.1600/036364408783887302

Kim, S.T., Sultan, S.E., & Donoghue, M.J. (2008). Allopolyploid speciation in *Persicaria* (Polygonaceae): Insights from a low-copy nuclear region. Proc. Natl. Acad. Sci. U.S.A., 105(34) 12370-12375. doi: 10.1073/pnas.0805141105

Kim, K.R., Park, S.Y., Kim, S.Y., Oh, Y.T., & Yu, J.N. (2022). The complete chloroplast genome of *Persicaria maackiana* (Regel) Nakai ex T. Mori (Polygonaceae) in Korea. *Mitochondrial DNA Part B*, 7(9), 1669-1671. doi: 10.1080/23802359.2022.2119821

Kitchener, M.A. (2002). *Rumex* L. (Polygonaceae) hybrids in the British Isles. *Watsonia*, 24(2), 209–236.

Koenemann, D.M., Kistler, L., & Burke, J.M. (2023). A plastome phylogeny of *Rumex* (Polygonaceae) illuminates the divergent evolutionary histories of docks and sorrels. *Molecular Phylogenetics and Evolution*, 182, 107755. doi: 10.1016/j.ympev.2023.107755

Kong, M.-J., & Hong, S.-P. (2018a). The taxonomic consideration of floral morphology in the *Persicaria* sect. *Cephalophilon* (Polygonaceae). *Korean Journal of Plant Taxonomy*, 48(3), 185-194. doi: 10.11110/kjpt.2018.48.3.185

Kong, M.-J., & Hong, S.-P. (2018b). Comparative achene morphology of *Persicaria* sect. *Cephalophilon* and related taxa (Polygonaceae). *Korean Journal of Plant Taxonomy*, 48(2), 134−142. doi: 10.11110/kjpt.2018.48.2.134

Kowalczyk, T., Pliszko, A., & Drobniak, S.M. (2014). *Persicaria nepalensis* (Polygonaceae), a new potentially invasive anthropophyte in the Polish flora. *Polish Botanical Journal*, 59(2), 255–261. doi: 10.2478/PBJ-2014-0031

Kress, W.J., Wurdack, K.J., Zimmer, E.A., Weigt, L.A., & Janzen, D.H. (2005). Use of DNA barcodes to identify flowering plants. *Proceedings of the National Academy of Sciences*, 102(23), 8369–8374. doi: 10.1073/pnas.0503123102

Kress, W.J., & Erickson, D.L. (2007). A two-locus global DNA barcode for land plants: the coding rbcL gene complements the non-coding trnH-psbA spacer region. *PLoS One*, 2(6), e508. doi: 10.1371/journal.pone.0000508

Kubát, K. (1990). *Rumex* L. In: Hejný, S., & Slavík, B. (Eds.) *Květena České Republiky. Vol. 2.* Academia, Praha, pp. 311-339. [in Czech]

Li, G., & Quiros, C.F. (2001). Sequence-related amplified polymorphism (SRAP), a new marker system based on a simple PCR reaction: Its application to mapping and gene tagging in Brassica. *Theoretical and Applied Genetics*, 103 (2–3), 455–461. doi: 10.1007/s001220100570

Li, J.J., Li, Y.X., Li, N., Zhu, H.T., Wang, D., & Zhang, Y.J. (2022). The genus *Rumex* (Polygonaceae): an ethnobotanical, phytochemical and pharmacological review. *Nat. Prod. Bioprospect.*, 12(1), 21. doi: 10.1007/s13659-022-00346-z

Li, Z., Dai, Y., Zhai, S., Cao, Y., Cheng, J., Ni, M., Song, L., Tao, J., Zhang, D., Xu, Z., Lai, Y., & Tang, H. (2026). Chloroplast genomic characterization and phylogenetic analysis of eleven *Persicaria* medicinal plants from Guangxi, Southern China. *Frontiers in Plant Science*, 16, 1749088. doi: 10.3389/fpls.2025.1749088

Löve, Á., & Löve, D. (1961). Chromosome numbers of Central and Northwest European plant species. *Opera Botanica*, 5, 1-581.

Löve, Á. (1983). Polygonaceae. In: Löve, Á. (Ed.), IOPB chromosome number reports LXXX. *Taxon*, 32(3), 511.

Min, Y.J., Zhou, Z.Z., Zhao, X.X., Gao, P., & Long, C. (2013). Phylogenetic position of *Polygonum bungeanum* in *Polygonum* L. s. lat. (Polygonaceae) as evidenced from nrDNA ITS, cpDNA atpB-rbcL and trnL-F sequences. *Life Science Journal*, 10(2), 2664–2670.

Mohamed, G.A., Gohar, M., Ezzat, S.M., Yeskaliyeva, B., Al-Ghorab, S.A., Abd-Elkader, S.M., & Ibrahim, S.R. (2025). *Rumex* species: Phytochemistry, pharmacology and nutritional potential for food and health applications. *Food*

Science & Nutrition, 13(12), e71300. doi: 10.1002/fsn3.71300

Mosaferi, S., Sheidai, M., Keshavarzi, M., & Noormohammadi, Z. (2018). Species differentiation in annual *Persicaria* based on different markers. *Acta Botanica Hungarica*, 60(3–4), 401–417. doi: 10.1556/034.60.2018.3-4.10

Mosyakin, S.L. (2005). Polygonaceae Juss. In: Editorial Committee (Eds.), *Flora of North America, vol. 5.* New York & Oxford: Oxford University Press, pp. 216–601

Navajas-Pérez, R., de la Herrán, R., López González, G., Jamilena, M., Lozano, R., Ruiz Rejón, C., Ruiz Rejón, M., & Garrido-Ramos, M.A. (2005). The Evolution of Reproductive Systems and Sex-Determining Mechanisms Within *Rumex* (Polygonaceae) Inferred from Nuclear and Chloroplastidial Sequence Data. *Molecular Biology and Evolution*, 22(9), 1929–1939. doi: 10.1093/molbev/msi186

Otto, S.P., & Whitton, J. (2000). Polyploid incidence and evolution. *Annual Review of Genetics*, 34, 401–437. doi: 10.1146/annurev.genet.34.1.401

Özkan, N.G., & Yazlık, A. (2020). *Polygonum orientale* (≡*Persicaria orientalis*; Polygonaceae) in Turkey re-discovered after 73 years and considerations about its status. *Eurasian Journal of Forest Science*, 8(3), 302-308. doi: 10.31195/ejejfs.784137

Park, K.T., Kang, J.S., Kang, D., Lee, H.O., & Kim, C.K. (2025). Complete mitochondrial genome of *Persicaria maackiana* reveals genome features, phylogenetic relationships, and nucleotide substitution rates. *Scientific Reports*, 15(1), 42696. doi: 10.1038/s41598-025-26696-5

Raycheva, Ts. (2009). Critical reassessment of the distribution of some taxa of *Rumex subgenus Rumex* (Polygonaceae) in Bulgaria – 2. *Phytologia Balcanica*, 15(2), 155-169.

Raycheva, Ts., Stoyanov, K., & Stoyanov, P. (2021). *Rumex kerneri* Borbás (Polygonaceae) in the Bulgarian flora – Morphology, Leaf Epidermis, Pollen Morphology, and Karyology. *Ecologia Balkanica*, 13(1), 185–195.

Rechinger, K. (1891). Beitrag zur Kenntniss der Gattung *Rumex*. *Oesterr. Bot. Z.*, 41, 1-10. [in German]

Rechinger, K. (1892). Beitrag zur Kenntniss der Gattung *Rumex*. *Oesterr. Bot. Z.*, 42, 17-20. [in German]

Rechinger, K.H. (1937). Vorarbeiten zu einer Monographie der Gattung *Rumex*. V. The North American species of *Rumex*. *Field Museum of Natural History, Botanical Series*, 17(1), 1-151.

Rechinger, K.H. (1964). *Rumex* L. In: Tutin, T.G., Heywood, V.H., Burges, N.A, Noore, D.M., Valentine, D.H., Walters, S.M., & Webb, D.A. (Eds.), *Flora Europaea, vol. 1*. Cambridge: Cambridge University Press, pp. 99–107.

Rechinger, K.H. (1990). *Rumex* subgen. *Rumex* sect. *Axillares* (Polygonaceae) in South America. *Plant Systematics and Evolution*, 172, 151-192. doi: 10.1007/BF00937805

Rechinger, K.H., & Akeroyd, J.R. (1993). *Rumex* L. In: Tutin, T.G., & al. (eds.), *Flora Europaea. Ed. 2, vol. 1*. Cambridge Univ. Press, Cambridge, pp. 99-107.

Richards, C.L., Bossdorf, O., Muth, N.Z., Gurevitch, J., & Pigliucci, M. (2006), Jack of all trades, master of some? On the role of phenotypic plasticity in plant invasions. *Ecology Letters*, 9, 981-993. doi: 10.1111/j.1461-0248.2006.00950.

Rieseberg, L.H., & Willis, J.H. (2007). Plant speciation. *Science*, 317, 910–914. doi: 10.1126/science.1137729

Ronse DeCraene, L.P., & Akeroyd, J.R. (1988). Generic limits in *Polygonum* and related genera (Polygonaceae) on the basis of floral characters. *Botanical Journal of the Linnean Society*, 98, 321-371.

Ronse DeCraene, L.P., Hong, S.P., & Smets, E. (2000). Systematic significance of fruit morphology and anatomy in tribes Persicarieae and Polygoneae (Polygonaceae). *The Journal of the Linnean Society, London*, 134 (1–2), 301-337.

Sanchez, A., Schuster, T.M., Burke, J.M., & Kron, K.A. (2009). A Large-Scale Phylogeny of Polygonaceae Based on Molecular Data. *International Journal of Plant Sciences*, 170(8), 1044-1055. doi: 10.1086/605121

Sanchez, A., Schuster, T.M., Burke, J.M., & Kron, K.A. (2011). Taxonomy of Polygonoideae (Polygonaceae): A new tribal classification. *Taxon*, 60(1), 151–160. doi: 10.1002/tax.601013

Schuster, T.M., Reveal, J.L., Bayly, M.J., & Kron, K.A. (2015). An updated molecular phylogeny of Polygonoideae (Polygonaceae): Relationships of *Oxygonum*, *Pteroxygonum*, and *Rumex*, and a new circumscription of *Koenigia*. *Taxon*, 64(6), 1188–1208. doi: 10.12705/646.5

Seimandi, G., Álvarez, N., Stegmayer, M.I., Fernández, L., Ruiz, V., Favaro, M.A., & Derita, M. (2021). An Update on Phytochemicals and Pharmacological Activities of the Genus *Persicaria* and *Polygonum*. *Molecules*, 26(19), 5956. doi: 10.3390/molecules26195956

Soltis, D.E., Soltis, P.S., & Tate, J.A. (2004). Advances in the study of polyploidy since plant speciation. *New Phytologyst*, 161, 173–191. doi: 10.1046/j.1469-8137.2003.00948.x

Steflova, P., Viktor Tokan, V., Vogel, I., Lexa, M., Macas, J., Novak, P., Hobza, R., Vyskot, B., & Kejnovsky, E. (2013). Contrasting Patterns of Transposable Element and Satellite Distribution on Sex Chromosomes (XY1Y2) in the Dioecious Plant *Rumex acetosa. Genome Biology and Evolution*, 5(4), 769–782. doi: 10.1093/gbe/evt049

Stojanov, N., & Stefanov, B. (1924). *Flora of Bulgaria. Ed. 1.* State Printing House, Sofia, Bulgaria. [in Bulgarian]

Stojanov, N., & Stefanov, B. (1933). *Flora of Bulgaria. Ed. 2.* Guttenberg, Sofia, Bulgaria. [in Bulgarian]

Stojanov, N., & Stefanov, B. (1948). *Flora of Bulgaria. Ed. 3.* Univ. Press, Sofia, Bulgaria. [in Bulgarian]

Stojanov, N., Stefanov, B. & Kitanov, B. (1966). *Flora of Bulgaria. Ed. 4, vol. 1.* Nauka i Izkoustvo, Sofia, Bulgaria. [in Bulgarian]

Sultan, S.E. (2001), Phenotypic plasticity for fitness components in *Polygonum* species of contrasting ecological breadth. *Ecology*, 82, 328-343. doi: 10.1890/0012-9658(2001)082[0328:PPFFCI]2.0.CO;2

Sultan, S.E. (2004). Promising directions in plant phenotypic plasticity. *Perspectives in Plant Ecology, Evolution and Systematics*, 6, 227–233. doi: 10.1078/1433-8319-00082

Tzvelev, N.N. (1987). Notes on Polygonaceae in the Flora of the Far East. *Novosti Sistematiki Vysshih Rasteniy*, 24, 72-79. [in Russian]

Valentini, A., Pompanon, F., & Taberlet, P. (2009). DNA barcoding for ecologists. *Trends in Ecology & Evolution*, 24(2), 110–117. doi: 10.1016/j.tree.2008.09.011

Valev, C. (1966). *Rumex* L. In: Jordanov, D. (Ed.). *Flora Reipublicae Popularis Bulgaricae, Vol. 3.* Sofia, Bulgarian Academy of Science, pp. 188-217.

Vasas, A., Orbán-Gyapaiq, O., & Hohmann, J. (2015). The Genus *Rumex*: Review of traditional uses, phytochemistry and pharmacology. *Journal of Ethnopharmacology*, 175, 198-228. doi: 10.1016/j.jep.2015.09.001

Verloove, F., Otto, R., Janssens, S., & Kim, S.-T. (2021). A Cryptic Invader of the Genus *Persicaria* (Polygonaceae) in La Palma and Gran Canaria (Spain, Canary Islands). *Diversity*, 13, 551. doi: 10.3390/d13110551

Wares, J.P., Hughes, A.R., & Grosberg, R.K. (2005). Chapter 9. Mechanisms that drive evolutionary change: Insights from species introductions and invasions. In: Sax, D.F., Staachowicz, J.J., Gaines, S.D. (Eds.), *Species invasions: insights into ecology, evolution, and biogeography.* Sinauer Associates, Sunderland, Massachusetts; 508 p.

Webb, D.A., & Chater, A.O. (1964). *Polygonum* L. In: Tutin, T.G., & al. (Eds.), *Flora Europaea, Vol. 1.* Cambridge University Press, U.K.

Xu, S., Li, D., Li, J., Xiang, X., Jin, W., Huang, W., Jin, X., & Huang, L. (2015) Evaluation of the DNA Barcodes in *Dendrobium* (Orchidaceae) from Mainland Asia. *PLoS ONE*, 10(1), e0115168. doi: 10.1371/journal.pone.0115168

Yasmin, G., Khan, M.A., Shaheen, N., & Hayat, M.Q. (2010a). Taxonomic significance of leaf epidermal anatomy of selected *Persicaria* Mill. species of family Polygonaceae from Pakistan. *African Journal of Biotechnology*, 9(25), 3759-3768. doi: 10.5897/AJB2010.000-3244

Yasmin, G., Khan, M.A., Shaheen, N., Hayat, M.Q., Zafar, M. & Ahmad, M. (2010b). Pollen morphological diversity in selected species of *Persicaria* Mill. (Family Polygonaceae). *Journal of Medicinal Plants Research*, 4(10), 862-870. doi: 10.5897/JMPR09.448

Zietkiewicz, E., Rafalski, A., & Labuda, D. (1994). Genome fingerprinting by simple sequence repeat (SSR)-anchored PCR amplification. *Geno-mics*, 20(2), 176–183. doi: 10.1006/geno.1994.1151

Ziqiang, G., Yang, L.-E., Chen, Z., & Chen, W. (2020). Comparative analysis of different DNA barcodes for applications in the identification and production of Pyropia. *Algal Research*, 47, 101874. doi: 10.1016/j.algal.2020.101874.

Zou, T., Li, D., Zhao, C.Y., Li, Z.Z., & Hu, G.W. (2025). Chloroplast whole genome assembly and phylogenetic analysis of *Persicaria criopolitana* reveals its new taxonomic status. *Scientific Reports*, 15(1), 19890. doi: 10.1038/s41598-025-02686-5

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