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Review paper

Toward the Annotated Checklist of Vascular Flora of Serbia – objectives, methodology and challenges –

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Summary. The upcoming "Annotated Checklist of Vascular Flora of Serbia 1", includes all new contributions and recent nomenclatural, taxonomic, chorological, phylogenetic and phylogeographic points of view on plant taxa distributed in the territory of the Republic of Serbia. The main objectives, working procedures and preliminary results are presented. More than 4200 confirmed taxa were recorded, including 3690 species.

Keywords: floristics, list of taxa, nomenclature, Serbia.

INTRODUCTION

More than 30 years have passed since the first edition of the "Flora of SR Serbia" (1–10, 1970–1986) was published, and continued with a new edition "Flora of Serbia" (1–2, 1992, 2012). In the meantime, a significant number of papers have been published with new taxa for science and new floristic records for Serbia. Bearing in mind certain taxonomic, chorological and floristic errors and inconsistencies in the mentioned editions, as well as new extensive floristic material collected over the last 30 years; there was a need for an "Annotated Checklist of Vascular Flora of Serbia", which would include all new contributions and recent nomenclatural, taxonomic, chorological, phylogenetic and phylogeographic points of view on plant taxa. The first volume (in press) includes vascular plants (Pteridophyta s.l., Gymnospermae and Spermatophyta – 'Monocotyledones') without 'Dicotyledones'. The most informative part of the Checklist would be a catalogue with citations from basic chorological and taxonomic-nomenclatural sources, including numerous relevant international plant lists and other publications.

Geographical and Phytogeographical Characteristics of Serbia

The territory of Serbia (88,361 km^2) occupies the north-central and most continental position on the Balkan peninsula and the south-eastern part of the Pannonian Plain in Vojvodina. The northern boundaries of the Balkan part of Serbia are represented by the Sava and Danube rivers, and the southern and southwest massifs of Šar Planina and Prokletije mountains and their branches. The eastern border consists of the mountains of the Carpathian Balkan and Rhodope systems, and the western river Drina with the eastern (or inner) Dinarides – Mts Tara, Ozren, Giljeva and Pešter Plateau. In this way, several parts are distinguished in Serbia: the lowland part of the Pannonian Plain in Vojvodina, the hill and valley regions of Peripannonian Serbia and the mountainous-valley region within the Carpathian Balkan, Rhodope, Scardo-Pindic and Dinaride mountain systems. According to Ducić and Radovanović (2005), about 37% of the relief of Serbia has an altitude of up to 200 m, about 2/3 has an altitude of up to 500 m and only 11% of the territory has an altitude of over 1000 m, including only two

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massifs over 2000 m. These basic eco-geographical features have determined the character of the flora and vegetation of Serbia and differences of floristic composition of these macro-regions of Serbia (Stevanović et al. 1999). In administrative terms, the territory is divided into Central Serbia, Vojvodina (in the north) and Kosovo and Metohija (K & M) (in the south).

Central Serbia (55,947 km²)

The northernmost part to some extent includes the Pannonian Basin, alluvial plains and river terraces along the Sava, Danube and Velika Morava rivers. The northern part is represented by the hill-and-plain Peripannonian region. The central part is a mountainous region with the dominant presence of mountain massifs in the south-western, southern and south-eastern parts. This area is basically composed of four mountain systems of different ages: a) Rhodope siliceous mountains, or branches of this system in northern, central and southern Serbia, broken in Tertiary on cliffs and rocks; b) Carpathian, predominantly limestone, a younger mountain chain whose southern branches reach north-eastern Serbia and naturally continue to the mountains of the Balkan system; c) Balkan mountain system (silicate and limestone) in eastern and south-eastern Serbia; d) Dinaric younger mountain ranges of Western Serbia, Stari Vlah and Raška area. They are mostly composed of limestone, but frequently there are also ultramafic massifs (Goč–Stolovi, Zlatibor, Pešter plateau) with specific flora. Part of the Pannonian basin, the Peripannonian periphery, Pomoravlje and Negotin Krajina in the northeast have a continental climate. The largest part of the mountainous region has characteristics of moderate-continental climate, but in the west, the average rainfall is much higher than in the east. Within this area, Pešter plateau in the southwest is especially distinguished with very harsh winters. The climate of the rest of Central Serbia varies from moderate in the valleys, to mountainous in higher areas. Submediterranean influences stretch along the rivers Južna Morava, Nišava and Pčinja and to less extent along the Ibar river valley. Central Serbia, according to its phytogeographical characteristics (Stevanović 2015), is highly diverse and belongs to four main phytogeographic regions. The far north-eastern part belongs to the Pontic-South Siberian region (Western Pontic sub-region and Vlaška province); the Central European region is the mostly represented in Central Serbia with the following phytochorias: the Central European-Pannonian sub-region and Pannonian province, Illyrian sub-region and the Eastern Illyrian province, the Balkan sub-region and the Western Moesian-South Carpathian province and Western Moesian province. The southernmost part of Central Serbia belongs to the Mediterranean-Submediterranean region (Submediterranean sub-region and Aegean-Thracian province). The highest mountain regions of eastern, south-eastern, central, western and south-western Serbia belong to the Central-Southern European mountain region (Dinaric-Balkan sub-region and the Dinaric mountain province and West Moesian mountain province).

Vojvodina (21,506 km²)

Almost all of this region includes the lowland Pannonian basin in which the following tectonic units can be distinguished: a) alluvial planes and river terraces along the Sava, Danube and Tisa rivers; b) loess plateaus (Banat, Titel, Telečka and Srem), with altitude between 100 and 140 m; c) sandy areas (Deliblatska Sands and Subotičko-Horgoška Sands) and d) hilly-mountainous areas represented by predominantly siliceous mountain islands (Fruška Gora and Vršačke Planine) up to 641 m high. The largest part of this unit has the characteristics of a continental climate. Phytogeographically, Vojvodina is under strong steppe and Central-European influence, and according to Stevanović (2015), this administrative unit belongs to the Pontic South Siberian region (Western Pontic sub-region and South Pannonian province) and the Central European region (Central European-Pannonian sub-region and the Pannonian province; Balkan sub-region and Carpathian province).

Kosovo and Metohija (K&M) (10,908 km²)

In the macrorelief of this province, four areas are distinguished: a) western branches of the Rhodope mountain system; b) Kosovo and Metohija plateau in the northern, central and eastern part; c) Dinaric chain mostly consisting of younger limestone massifs of Metohija – Prokletije with the highest peak of Serbia, Đeravica (2,656 m); d) Scardo-Pindic younger mountain chain that includes Šar Planina mountains and its branches, Koritnik and Paštrik mountains, with the highest peak Peskovi (2,651 m). These mountains are predominantly siliceous, with the occasional appearance of limestone and ultramafic rocks. The lower part of the Drenica river allows for the domination of a Mediterranean climate that influences the Beli Drim valley and the northern part of Kosovo, while continental influences are more intense along the Prizrenska Bistrica river valley. In this area, the Metohija basin is separated, while Šar Planina and Prokletije are unique mountain climatic units. Phytogeographically, Kosovo & Metohija belongs to three main phytogeographic regions. The Central European region (the Illyrian sub-region and Eastern Illyrian province, the Balkan sub-region and the Western Moesian province and Scardo-Pindic province) is mainly present in the Kosovo plain and lowland parts of northern Metohija. The south-western part of K&M (Prizrenska Bistrica and Beli Drim river gorges) belongs to the Mediterranean-Submediterranean region (Submediterranean sub-region and Adriatic-Ionian province). The highest mountain regions of K&M belong to the Central-Southern

European mountain region (Dinaric-Balkan sub-region and the Dinaric mountain province and Scardo-Pindic mountain province) (Stevanović 2015).

History of vascular flora investigation in Serbia

Thanks to its specific geotopographic position, geological history and specific habitat diversity, the territory of Serbia has one of the highest plant diversities in Southeast Europe. The entire region has attracted the interest of botanists since the beginning of the 19th century, in what was then the Principality of Serbia, the territory of today's Vojvodina in the Austro-Hungarian Empire, and K&M and Southeast Serbia as part of the Ottoman Empire.

The first recorded data for a plant with scientific name from Serbia dates back to the medieval times when a Flemish doctor, horticulturists and one of the first botanists Carl Clusius in his extensive work "*Rariorum aliquot stirpium per Pannoniam, Austriam, and vicinas quasdam provincias observatarum historia*" mentioned a data for saffron from the vicinity of Belgrade ("*in the Servia siva Mœsia superiore sub Belgrado ... mense Martio 1583*") (Clusius 1583: 226). The collector was a certain Stefan von Hausen who went to visit Constantinople through Serbia, which then belonged to the Ottoman Empire, and in the vicinity of Belgrade in 1583 he collected several corms. Clucius later planted and cultivated this plant in his garden and called it "*Crocus vernus flavo flore*". This polynominal name of saffron at that time, long before the Linnaean binary nomenclature, corresponded to the species *C. flavus* Weston (fide Salisbury 1805, sub *C. aureus*).

Binary Latin and vernacular plant names (a few hundred species) appear only at the end of the 18th century in the textbook of the Serbian educator Zahari Orfelin (1873), as well as in his unfinished work "The Great Serbian herbalist". Since only the most important medicinal plants from Europe and exotic regions are mentioned in those tutorials, without specific data on their distribution, they can not be considered the first scientific floral works for these areas. But soon after this botanical 'predecessor', at the very end of the century, a period of great botanical discoveries in the unexplored areas occurred, and the entire history can be divided into six periods.

1799–1857

As already pointed out, the northern part of Serbia (Vojvodina) was in the eighteenth and nineteenth centuries under the rule of the Austro-Hungarian monarchy, and the first explorers of the flora of this area were the Hungarian and Austrian botanists. According to current knowledge, the first plant species mentioned and described from Vojvodina are *Kitaibelia vitifolia* Willd. and *Crataegus pentagyna* Waldst. & Kit. ex Willd. They were published in the edition of the famous German botanist Carl Willdenow (1799) based on the material collected by the Hungarian naturalist Pál Kitaibel in the Srem area. Then Waldstein & Kitaibel (1800, 1802, 1804) and Host (1802, 1805) described new species or provided the first data on the presence of some plants in Vojvodina. Some 20 years later, Rochel (1828) published the first detailed lists of plants with descriptions of new species from the Banat area, as well as parts of Hungary, Transylvania and Croatia, while Sadler (1830) also listed the first data for some ferns. Professor of Karlovac Gymnasium, Gregorius Lazics (1833) was the first Serbian botanist who presented a short list of the urban flora of Sremski Karlovci (formerly Austro-Hungarian, and today's Vojvodina) and its surroundings, with vernacular names. Two years later Heuffel (1835) published a list of plants from Hungary, which included present-day Vojvodina. The famous French geologist Ami Boué (1840), along with a review of the geology of the Balkan Peninsula, mentions several plants from Serbia, and Grisebach (1843, 1844, 1846) even described several plants that were new for science from Serbia (Kosovo and Metohija). Less well-known in the botanical circles, the director of the former gymnasium in Sremski Karlovci, Károly Rumy, was the author of one of the most valuable works dedicated to the flora of Serbia (Rumy 1846). A list of several hundred plants from Srem (mainly from the vicinity of Sremski Karlovci) is based on herbarium and the manuscript of his predecessor Andreas Wolny. However, this rare achievement did not have a major impact on botany in these areas. However, Josif Pančić is considered the founder of botanical science in Serbia: his pioneering paper from (Pančić 1856) is the first detailed list of plants and localities in 'proper' Serbia, and includes a description of several species new for science.

1858–1888

After publishing his first work, Pančić began very intensive and long-lasting research (spanning over 30 years) of the flora of Serbia, which was finalized by publishing the monographs "Flora of the Principality of Serbia" and "Addition to the flora of the Principality of Serbia" (Pančić 1874, 1884) in which he described 14 currently accepted species new for science. In this period, Pančić's cooperation with his Italian colleague and friend Robert Visiani is also significant, resulting in three co-publications (Visiani and Pančić 1862, 1865, 1870) describing 15 new, currently accepted species for science from Serbia. Along with Pančić's botanical work, flora of the region was also studied by foreign botanists (Borbás, Feichtinger, Godra, Heuffel, Kanitz, Knapp, Neilreich, Schlosser, Schneller, Schulzer, Vukotinović). However, it is interesting to note that in this period, besides Pančić, only Sava Petrović (1882, 1885) gave significant contributions to the flora of Serbia proper (in the surroundings of Niš). Some data from Pančić's herbarium were published in monographs of regional and European flora (Ascherson and Kanitz 1877; Nyman 1878–1882).

1889–1914

After Pančić's death (1888), in the following period there were floristic and taxonomic contributions from a number of domestic authors (Adamović, Ilić, Jurišić, Katić, Košanin, Ničić, Petrović, Ranojević), of which the most important for the flora of Serbia is Adamović, who thoroughly investigated the flora of southeastern Serbia. Significant contributions to the flora of Serbia were also given by foreign authors from Degen, Fritsch, Formánek, Vandas and Velenovský. Intensive botanical research in Vojvodina continued in this period (Bernátsky, Borbás, Degen, Kupcsok, Lányi, Prodán, Simonkai, Wagner, Zorkóczy), and it is interesting to note that in this period the first papers related to the flora of Kosovo and Metohija (Wettstein and Košanin) were published.

1915–1944

The period from the First World War to the end of the Second World War is very specific, since in the these 30 years there were very few floristic contributions from local botanists, of which Grebenščikov, Jurišić, Košanin, Rudski, Slavnić and Soška should be mentioned. Of botanists from surrounding countries, Beck, Malý, Murbeck and Urumov provided contributions for the border regions of Serbia proper with Bosnia and Herzegovina, Montenegro and Bulgaria, along with contributions by foreign authors Knapp and Novák. It is important to point out that in this period there were a large number of foreign botanists who studied the flora of Kosovo and Metohija (Bornmüller, Bošnjak, Hayek, Horvat, Kümmerle, Jávorka, Rechinger). For the area of Vojvodina, the flora in this period were mainly studied by Hirc, Jávorka, Kovács, Prodán, Soó, Tuzson and Wagner. During this period, the first monographs on the genera *Verbascum*, *Thymus* and *Hieracium* were given by Murbeck, Ronniger, Behr brothers and Zahn, in which they listed a significant number of new floristic and taxonomic data for Serbia.

1945–1986

The period after the Second World War was characterized by very intensive and diverse botanical studies of the flora of Serbia and the first vegetation papers according to the principle of the Zürich-Montpellier School of Phytosociology. In this sense, this period is specific in that the floristic research in the period 1945–1970. (Achtarov, Blečić, Broz, Černjavski, Čolić, Fukarek, Gajić, Kušan, Leute, Mayer, Obradović, Pavlović, Pulević, Rudski, Sigunov, Stanković-Tomić, Tatić, Urošević) was still very scarce. Nevertheless, Nikolić & Diklić, who started the publication of a series of floral contributions, as preparation for the "Flora of SR Serbia" gave the greatest contribution to the floristic of Serbia in this period. At the same time, vegetation-phytocoenological research in Serbia was developed, within which the following authors also provided floristic contributions: Bogojević, Cincović, Čanak, Glišić, Grebenščikov, Horvat, Janković, Jovanović B., Jovanović-Dunjić R., Kojić, Lakušić R., Mišić, Panjković-Matanović, Parabućski, Pavlović, Popović, Rajevski, Slavnić, Stanković-Tomić, Stjepanović-Veseličić, Stojanović, Tatić, Veljović, Vukićević, etc. However, the most significant period in the history of botanical research in Serbia, with exception of the time of Pančić, occurred in 1970–1986, when editions of the "Flora of SR Serbia 1–10" (Josifović 1970–1977; Sarić and Diklić 1986) was published by the Serbian Academy of Sciences and Arts. A large number of botanists from Serbia (more then 25) participated in the preparation of this monograph, in which the previous published works on the flora of Serbia were included, but also new floristic and chorological data was presented, based on field research and detailed inspections of herbarium collections.

1987–2018

The last 30 years of botanical research were marked by publication of two volumes of new editions of "Flora of Serbia" (Sarić 1992; Stevanović 2012), and at the same time by a large number of published papers on new species for science from Serbia and adjacent regions, as well as new floristic and chorological contributions. In this period, with their floristic and vegetation works, the following authors contributed to new knowledge about the flora of Serbia: Amidžić, Anačkov, Boža, Budak, Butorac, Čolić, Gajić, Hundozi, Igić, Jančić, Jovanović S., Jovanović V., Knežević, Krasniqui, Krivošej, Lakušić D., Lazarević, Markišić, Matović, Niketić, Obratov, Panjković, Perić, Petković, Ranđelović N., Ranđelović V., Rexhepi, Ružić, Stamenković, Stevanović, Stojšić, Tatić, Tomović, Vasić, Vukojičić, Wraber, Zlatković, etc. The monograph "The Red Data book of the flora of Serbia 1" (Stevanović 1999) was to some extent a milestone in botanical research in the territory of Serbia, because it represents a completely new and different point of view on the flora, primarily in terms of threat statuses and conservation.

Objectives of the Checklist

The main objectives of this Checklist are:

– to provide a critical floristic inventory and assessment of the complete vascular flora of Serbia, based on cumulative progress in floristics, taxonomy, nomenclature, informatics and overall knowledge of Serbian flora;

– to gain insight into progress in this area during the history of botany in Serbia, especially in relation to the "Flora of (SR) Serbia";

– to provide nomenclature as a working basis for further botanical research, biodiversity studies and conservation, including the next national publications ("Flora of Ser-

bia", "Red Data List of Flora of Serbia") and other projects (Natura 2000, etc.).

– to continue and improve upon the application of created software tools in different botanical databases.

MATERIALS AND METHODS

Literature sources

In choosing the nomenclature status and taxonomic concept for this list, the most recent papers related to the taxonomy and/or phylogeny of the taxa and the groups to which they belong were consulted. In the case of different approaches in the mentioned literature sources, the accepted relevant floristic Check list was chosen following consultation:

FSRS Flora of SR Serbia (1–10, 1970–1986) [for the first volume of the Checklist: FSRS 1 (1970), FSRS 7 (1975), FSRS 9 (1977), FSRS 10 (1986)]

FS Flora of Serbia (1–2, 1992–2012) [for the first volume of the Checklist: FS 1 (1992)]

EM Euro+Med (http://www.emplantbase.org/home.html)

FE Flora Europaea (1–5, 1964–1993)

GBIF Global Biodiversity Information Facility (https://www.gbif.org/)

ISF Index synonymique de la flore de France (https://www2.dijon.inra.fr/flore-france/consult.htm#Recherche)

PFPB Prodromus florae peninsulae balcanicae (1924–1933)

PL Plant List (http://www.theplantlist.org/)

WCSP World Check List of selected plant families (http://wcsp.science.kew.org)

VPR Vascular Plants of Russia and Adjacent States (the Former USSR) (Czerepanov 1995)

LDG Liste der Gefäßpflanzen Deutschlands (Buttler and Hand 2008)

CVC Checklist of vascular plants of the Czech Republic (Danihelka et al. 2012)

VPG Vascular Plants of Greece. An annotated checklist (Dimopoulos et al. 2013)

VFI An updated checklist of vascular flora native to Italy (Bartolucci et al. 2018)

VFIa An updated checklist of vascular flora alien to Italy (Galasso et al. 2018)

For many plants, the authors of this list chose the concept based on their own opinion, which in some cases did not coincide with any one concept from the sources mentioned. Additionally, for most unresolved taxa their protologues were inspected.

Electronic databases and their processing

Seven literary and herbarium databases with over 570,000 records were used to determine the presence of taxa in Serbia according to certain territorial units (Central Serbia, Vojvodina, Kosovo and Metohija). Older literature sources were inspected manually.

For processing data from database(s), the following groups of software tools were created: data crossing, navigation, correction, searching, status determination and sorting. The aforementioned seven databases contained over 15,000 names that needed to be aligned with the accepted nomenclature. These data were crossed with the main database to complement it. The main challenge was how to correct many type and format errors in columns and cells with mixed types of data, which can cause serious deviations in the output. For this purpose, a particular control was created that checks each word, character and format in specific fields, automatically correcting it or prompting the user. Similar controls refer to the verification of literary citations. Final checks of the data include controls of different data combinations (e.g. in the literature sheet, between colours and statuses of taxa, between statuses of data and distribution in administrative units, regarding the absence or presence of data from FSRS/FS, etc.). Preparation of the literature sheet was carried out, along with finding and selecting and sorting references.

The next step was generating output records. Applications for output reports can also be divided into six categories: a form for authors, catalogue, synonyms, comments, literature and a statistics form. Except for the authors' and statistics forms, all parts are integral chapters in the publication. Catalogues are the most informative and technically most demanding part of the publication. Tools for generating them include: initial transformation of colours and symbols, alignment of symbols, sorting of literature data into individual records, corrections and the final entry of family names in the header.

RESULTS AND DISCUSSION

Statistical analyses

Preliminary results[1] confirm the presence of 4246 taxa (species, subspecies and hybrids) for the territory of Serbia, of which 3690 species. Of these taxa, 192 (4.5%) are allochthonous, with the exception of plants that have escaped from cultivation, and are considered to be ephemeral aliens that are still not established as self-reproducing stable populations. There are 200 plant taxa described from Serbia, of which 51 species and subspecies are considered to be national endemics. For an additional 438 taxa, their presence

[1] The numbers presented in this paragraph are provisional and are based on a draft list. Therefore they should not be cited as the official data.

among Serbian flora is disputable, 44 taxa are considered to have disappeared, while 17.2% of the taxa were not mentioned in two editions of the "Flora of Serbia".

Currently, results from descriptive statistics can only be presented on the basis of a partial sample that includes taxonomic groups of vascular plants presented in the first volume of the Checklist of Vascular Flora of Serbia (Pteridophyta s.l., Gymnospermae and Spermatophyta), without 'Dicotyledones'. These analyses can be divided into two categories: the nomenclature status of taxa and the presence of taxa. The second category includes the following subcategories: the actual presence of taxa, a chronological overview and the accepted presence of taxa by administrative units.

In plant taxonomy, there have always been different approaches regarding the classification of groups, species and subspecies. Nowadays, with new research techniques, these differences are even more pronounced, and taxonomic concepts are changing rapidly. Based on data from recent relevant floristic Check lists (their abbreviations are given in the Material and methods section), each taxon was inspected to determine if there is a consensus on its name, status and position in the classification. Taxa with a stable status make up 65.3% (321 taxa) of the total sample (983 taxa) (Fig. 1). Following this step, erroneous or less reliable names from certain Check lists (122 taxa) were neglected, which in effect reduces this percentage. Other taxa include more than one-third of the sample, of which the vast majority belong to unresolved taxa (321), while doubtful and invalidly published taxa make up only 2% of the total sample.

Following analysis of taxa status based on literature sources, in addition to 321 taxa with unresolved status, there were also some generally accepted ('stable') taxa, which were incorrectly interpreted in some Check lists (usually those from older dates) (122 taxa). The number of such taxa is 443, which represents less than half of the total sample. The percentage of accepted names from some sources show that our list for the most part is in agreement with the WCSP (70.6% of accepted names), and PL (65.5%) (Fig. 2). These are two closely related electronic lists of the worldwide flora of vascular plants, with more regular updates in the WCSP. Unfortunately, ferns (from the first volume of our list) and a large number of 'Dicotyledones' (to be processed in the next volumes) are omitted in the WCSP. Unlike other electronic lists (e.g. EM 48.6%), WCSP's data updating process is far more regular, while in printed lists this percentage is expected to decline with the age of the list itself. The only exception is the list of German flora (LGD 60.5%), which is in third place even though it was published in 2008, supporting the quality of this list for taxa that are common for Germany and Serbia. Based on analysis of some larger families and groups, the first three dominant taxonomic sources are listed in the following series: Pteridophyta s.l. (VFI 96.4%, LGD, ISF), Gymnospermae (FSRS 71.4%, EM, WCSP), Cyperaceae (WCSP 68.1%, VFI, PL), Liliaceae s.l. (WCSP 62.5%, PL, EM), Orchidaceae (WCSP 89.6%, PL, EM), Poaceae (WCSP 70.6%, PL, LGD). A much smaller than average percentage was observed in PL for Pteridophyta s.l. (25.9%), LGD for Orchidaceae (25.0%) and Gymnospermae (20%), as well as CVC for Orchidaceae (15.0%).

The FSRS and FS editions contain a total of 770 taxa from the Checklist of Vascular Flora of Serbia (also including erroneous records), which makes up 78.3%, while 213 taxa (21.7%) were subsequently incorporated in this list. Most new records refer to the Cyperaceae (27.3%) and Poaceae

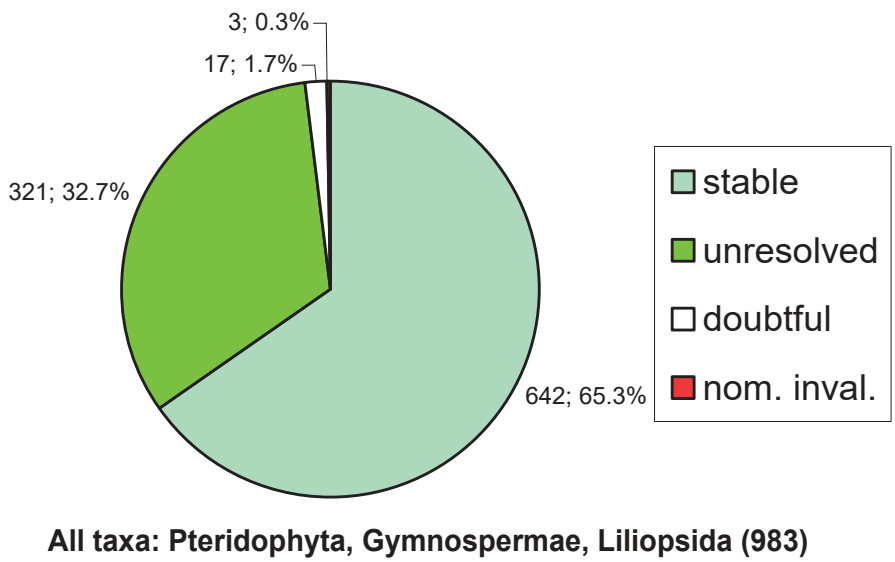


Fig. 1. Proportions of taxa with different nomenclature status (stable, unresolved, doubtful and not validly published taxa).

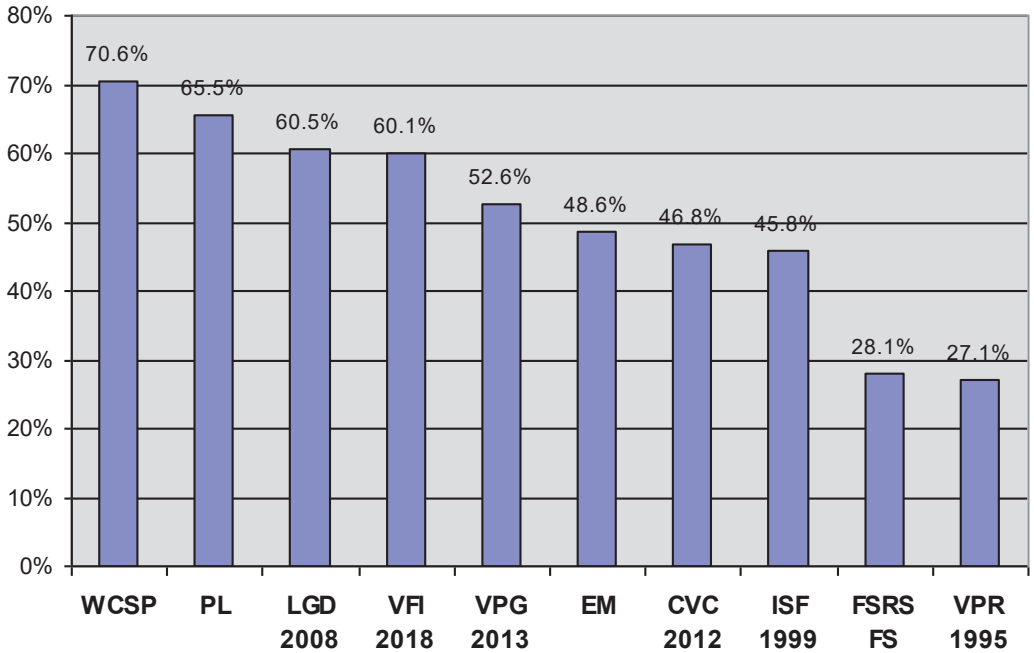
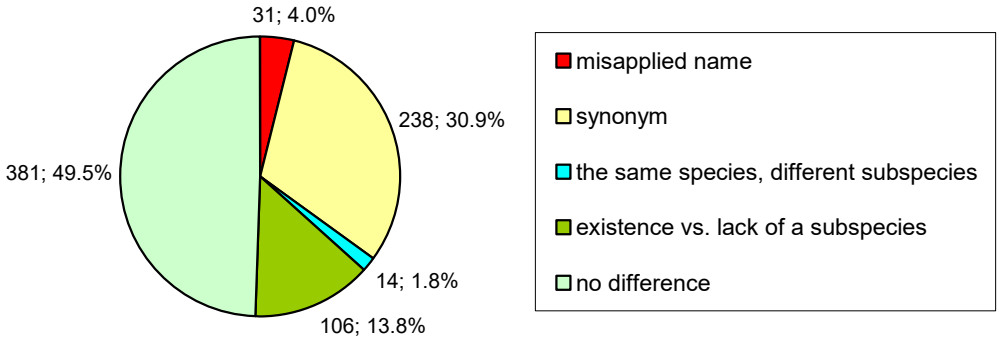


Fig. 2. Percentage of accepted names selected from relevant literature sources for 443 unresolved and differently interpreted taxa. Abbreviations of sources are given in the Material and methods.

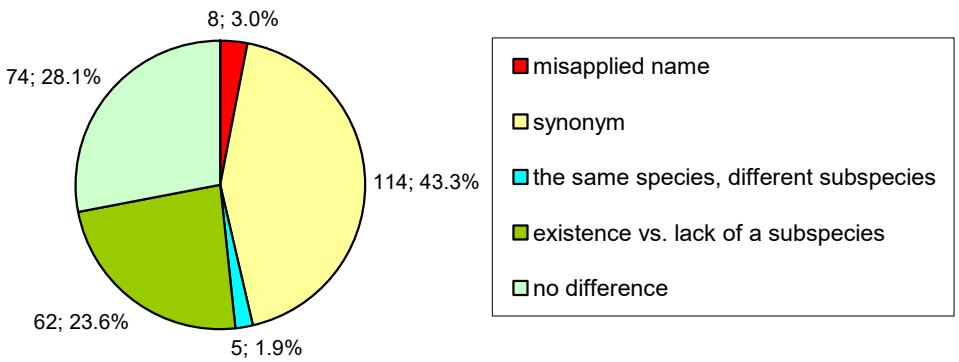
(24.90%) families. Comparison of the current nomenclature with the FSRS/FS, revealed a much higher percentage of matching names with the current nomenclature in the sample of all 770 taxa listed in the FSRS/FS (49.5%) compared to a sample of 263 unresolved taxa (28.1%) (Fig. 3). The largest number of synonyms and a significant increase of synonyms in the second sample (263 unresolved taxa) were observed in the families Orchidaceae (39.4%, 65.2%) and Liliaceae s.l. (29.2%, 53.3%), while the lowest number of synonyms were found in ferns (13.4%, 22.7%).

For analysis of the presence or absence of taxa, reliability parameters of floristic data were used, which are shown in the following ascending order: erroneous (–), doubtful (?), literature only (±) and herbaria records (+). The percentage of herbarium-checked findings is relatively high both in our list (72.5%) and in the FSRS/FS (81.2%) (Fig. 4a–b); in this list, the highest values are observed in Pteridophyta s.l. (83.3%) and Orchidaceae (78.2%). Due to our observation of a large number of erroneous literature records (150), their percentage (15.3%) is significantly higher in our list than in the FSRS/FS (8.4%). The highest percentage of these findings was recorded for Liliaceae s.1. (20.5%), and the smallest for Pteridophyta s.l. (3.8%). For similar reasons, the number of doubtful findings (38) is higher in the total sample (3.9%), compared to the FSRS/FS (2.6%). The highest percentage of doubtful findings was found in Poaceae (6.3%), and the lowest in Liliaceae s.l. (0.7%). If the same analyses are applied to 213 taxa (21.7%) not included in the FSRS/FS (Fig. 4c), it is obvious that the percentage of reliable records (herbaria and literature) would be halved (41.3%), while the percentage of erroneous (39.9%) and doubtful findings (8.5%) would be drastically increased. This can be explained by the fact that the two last types of records in the FSRS/FS were not predominantly related to the names of taxa, but were neglected or treated as misapplied names. The highest increases in erroneous taxa were recorded for Pteridophyta s.l. (0–27.3%) and Cyperaceae (3.5–42.3%).

If the first data on the presence of a taxon (correct or incorrect) are analyzed with respect to historical period (as referred to in the Introduction section), it can be seen that by far the largest number of new records originate from the initial period of floristic research in Serbia (1799–1857) (Fig. 5a), which is understandable considering the previous lack of exploration in this field. The largest number of new taxa for the flora of Serbia (242 or 24.6% for the given sample) was published in the first botanical paper by the "father of Serbian botany" (Pančić 1856). After this publication, the number of new taxa exponentially decreased until the period between the two world wars (1915–1944), which is analogous to the classical species–area relationship (Barbour et al. 1980), but further decreases were not so rapid since the territory of Serbia was expanded in the meantime. Thus in the next period (1945–2018), instead of the expected decrease to an asymptotic value, there was actually an increase in newly



a) All taxa mentioned in FSRS/FS (770, 78.3%)



b) 263 unresolved taxa mentioned in FSRS/FS

Fig. 3. Comparison of the current nomenclature with the nomenclature from the FSRS/FS: a) for all taxa mentioned in the FSRS/FS; b) for 263 unresolved taxa mentioned in the FSRS/FS.

registered taxa. This can be explained by a significant increase in the number of researchers, who often found new plant taxa in previously floristically unexplored areas. It is interesting that the percentage of reliable data (herbaria and literature) is by far the largest in the first two periods, and then continues to decline, while the percentage of doubtful and disputed data is rising (except for the last period) (Fig. 5b). A similar distribution pattern was observed in the analyzed families and groups, with the exception of Pteridophyta s.l. and Orchidaceae. The ferns practically began to appear in floristical papers mostly in the second period (1858–1888), so that their peak was recorded in that period. It is intriguing that in the next period (1889–1914) there followed a sharp decline (only three new species are listed), and then linear growth up to the present date (14 taxa). If the first two periods are excluded, in Orchidaceae most of the new taxa for the flora of Serbia (12) were recorded just in the period between the two world wars (1915–1944), which is quite surprising since in this period the smallest number of floristical novelties were recorded in the entire sample and also for certain groups and families.

The same analyses applied to the sample of 220 taxa omitted from the FSRS (but not from FS) show that almost half of the data refers to new records after the FSRS (Fig. 6a). The other records are almost identical in number per period, except that the number of records for the period 1945–1986, which is included in the FSRS itself, has increased somewhat. This increment is due to the fact that in the first volume of the FSRS (1970), data on ferns and gymnosperms were published, therefore in the period 1971–1986 several new taxa were registered that were not listed in the FSRS. The percentage of reliable data mostly increase over time (Fig. 6b).

Analyzing the presence of taxa with respect to the main administrative units, the largest number of registered taxa was recorded for Central Serbia (633, 43%), followed by K&M (453, 30%) and Vojvodina (403, 27%) (Fig. 7a). If these number are compared with the total number of registered taxa (795), percentages are as follows: Central Serbia 88.3%, K&M 66.4% and Vojvodina 58.4% of the total number (erroneous and doubtful records are omitted) (Fig. 7b). Since the territory of Kosovo and Metohija is twice as small as Vojvodina, and five times smaller than Central Serbia, floristic diversity is certainly the largest in this area, and can be explained by various biogeographical factors as outlined in the Introduction section. Given that the processed groups of plants in the first volume of the Checklist of Vascular Flora of Serbia predominantly include wetland and steppe plants, and less mountainous species, an increase in the percentage

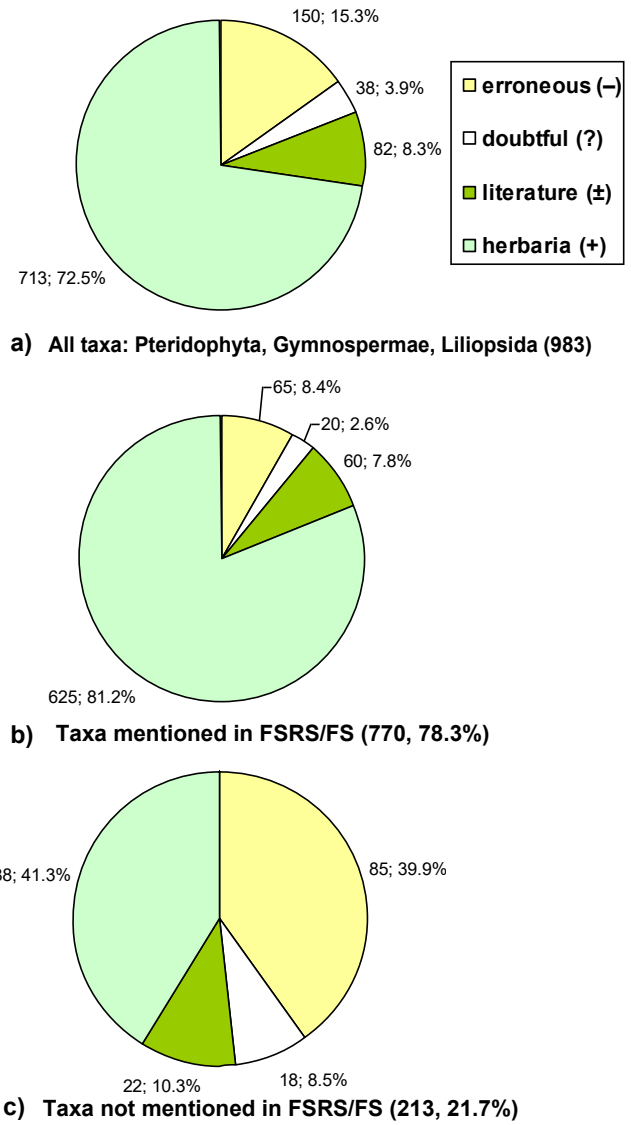


Fig. 4. The contribution of different floristic data according to their degree of reliability (presented in ascending order): a) for all processed taxa; b) for taxa mentioned in the FSRS/FS; c) for the taxa omitted in the FSRS/FS.

of the presence of taxa in K&M should be expected when the group 'Dicotyledones' is being processed.

For analysis of the presence or absence of taxa for each administrative unit separately (Fig. 8), the same parameters of the reliability of floristic data were used as well as in Fig. 4, with the addition of the parameter "no data". This parameter refers to those taxa that are presumed to occur in a particular territory, but for certain reasons there are either no data or data has not been registered yet. This applies only to taxa already registered for the flora of Serbia in one of the neighbouring administrative units, and not to taxa that are not registered for the flora of Serbia but are present in some other neighbouring country. The highest percentage of reliable (herbaria) data was recorded for Vojvodina (73.4%), followed by Central Serbia (72.8%), and K&M (64.0%). The percentages for Central Serbia and Vojvodina are almost equal to the percentage for Serbia as a whole (72.5%) (Fig. 4a). A small percentage for K&M is due primarily to the unexplored nature of this area, as even 13.3% of the taxa have "no data" status. By registering most of these taxa in the field, which is a realistic expectation, the percentage of reliable floristic data in K&M should become equalized with the other administrative units. The largest number of erroneous records was recorded for Central Serbia (13.1%), which is much higher compared to K&M (8.8%) and Vojvodina (8.6%), and also in absolute amount (114) more than for both provinces combined (109). Such a large number can be explained by the fact that a larger number of botanists have surveyed the flora of Central Serbia, resulting in many more papers and books on the flora and vegetation in this area, leading to a cumulative increase in erroneous records.

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The Ministry of Education, Science and Technological Development of the Republic of Serbia supported this research through Grant 173030 "Plant biodiversity of Serbia and the Balkans - assessment, sustainable use and protection".

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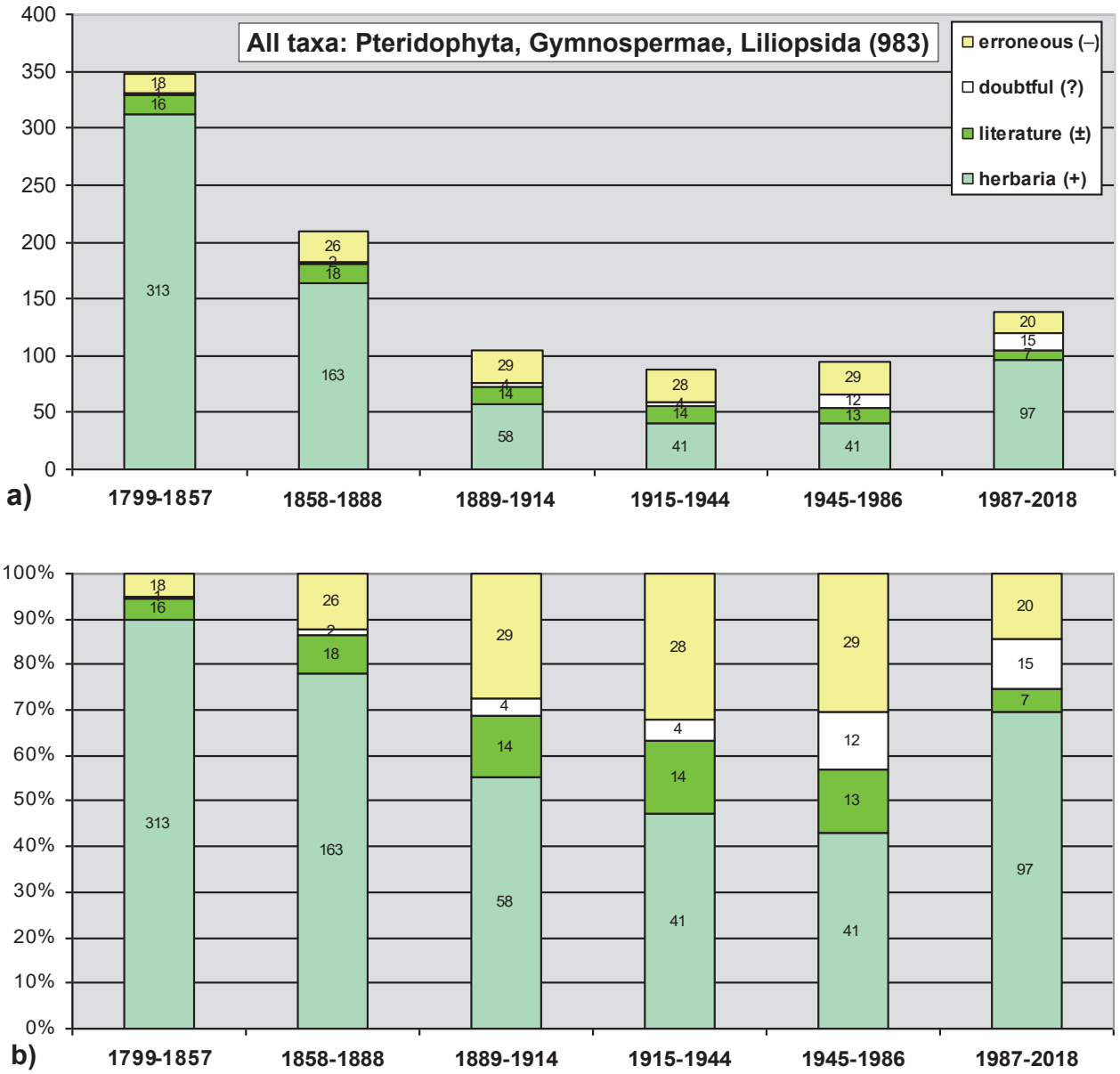

Fig. 5. Frequencies of recording new taxa for the Serbian flora in different botanical periods (degree of reliability of the records are presented in ascending order): a) number of records; b) percentage.

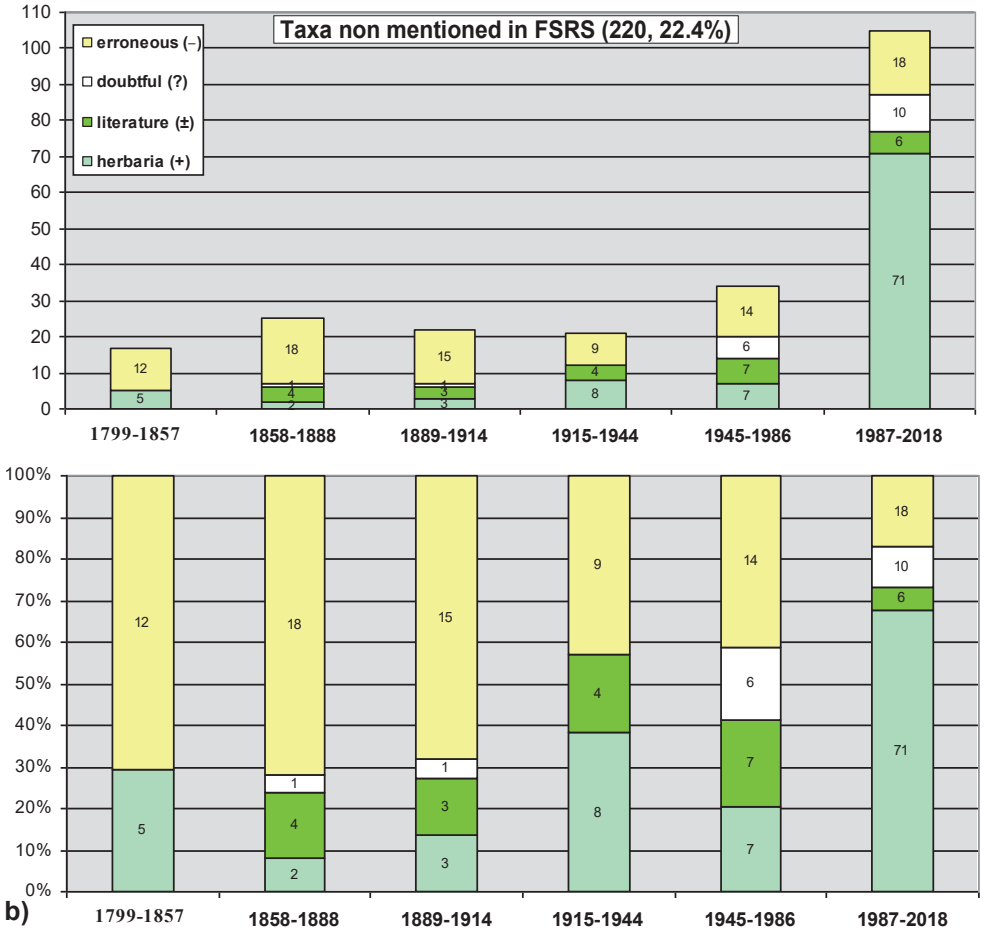

Fig. 6. Frequencies of recording new taxa for Serbian flora for 224 taxa omitted in the FSRS (degree of reliability of the records are presented in ascending order): a) number of records; b) percentage.

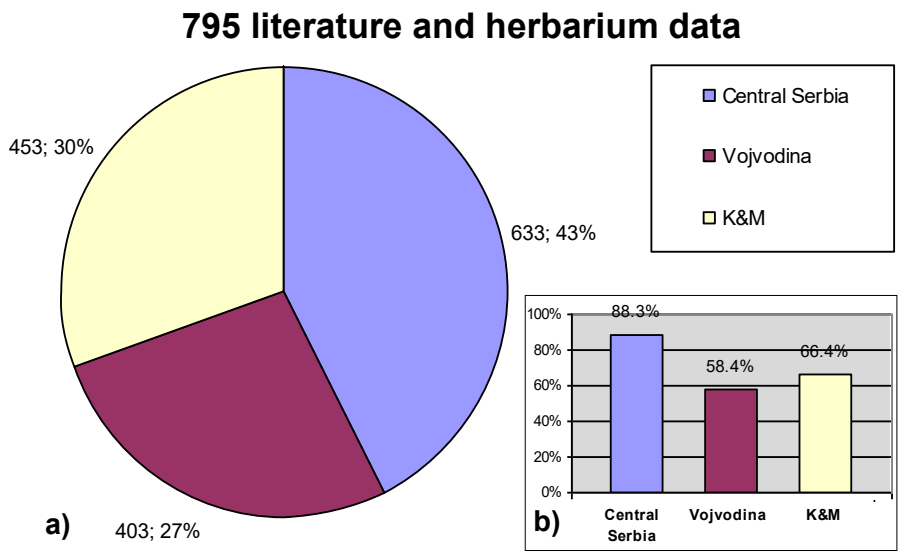

Fig. 7. Occurrence of taxa in three main administrative units (for 795 registered taxa, erroneous and doubtful records are omitted): a) number and percentage; b) percentage in relation to the total number of common taxa (795).

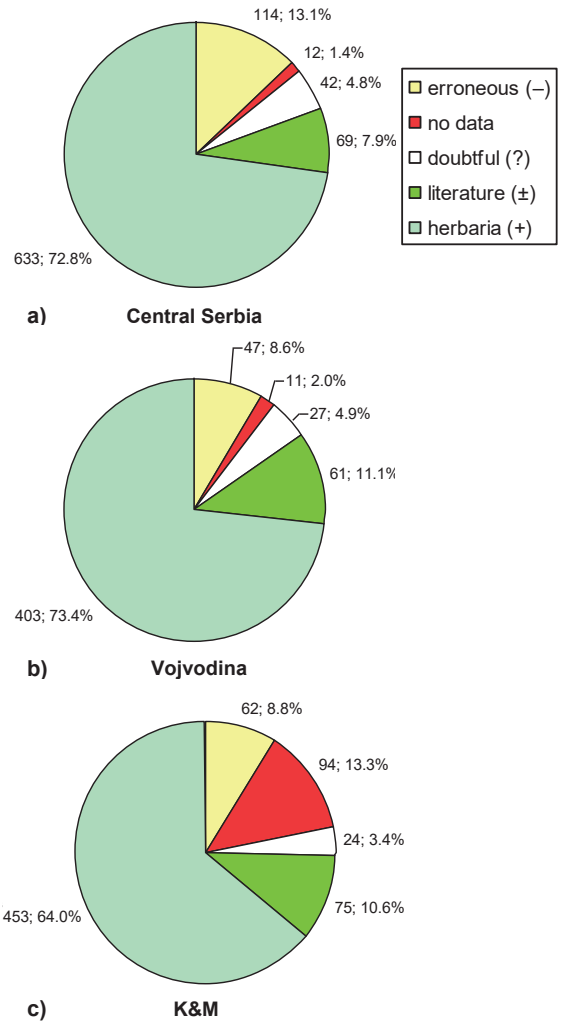

Fig. 8. The contribution of different floristic data according to their degree of reliability (presented in ascending order) for three main administrative units: a) Central Serbia; b) Vojvodina; c) Kosovo and Metohija.

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